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ESSENTIAL INTELLIGENCE

Metrics for the Evaluation of Knowledge Transfer Activities at Universities

A Report Commissioned by

unico

Commercialising UK Research

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1 Executive Summary

Knowledge transfer from academic research into the commercial sphere is an important part of the innovation ecosystem which has large economic and societal impacts.

Until now, however, it has been difficult to measure how successfully universities engage in such transfer activities, mainly because there was no agreed set of measurement tools. To improve this situation, the stakeholders involved in the process of knowledge transfer need to find and agree on a common way to define, quantify and qualify the performance of knowledge transfer activities of universities. This report, commissioned by Unico, the UK's leading Technology Transfer association, is a first step towards such a solution.

We have developed here a new set of robust metrics for the evaluation of knowledge transfer activities at UK universities, in a five-step process. First, we identified the major stakeholders of knowledge transfer: the research funders, who fund the research that creates the knowledge to be transferred, the senior university management who represent the academics who perform the research, and the business community who are the recipients of the knowledge. We then invited them to focus groups to discuss their currently used definitions of knowledge transfer, their views on the objectives and mechanisms of the process, and how to measure the success and impact of these knowledge transfer activities.

Following these discussions, the participating stakeholders defined in step three a framework of the key mechanisms of knowledge transfer and associated measures of their quantity and quality. Importantly, this framework reflected the views of all three stakeholder groups and was not biased towards any particular one of them.

Fourth, we populated this new framework with publicly available data from UK universities and with commercial data to perform an initial benchmark analysis, focusing on a subset of 20 universities. Finally, we carried out an international comparison with the US and Canada to determine how UK universities perform at knowledge transfer relative to these countries.

The most important result of this report is a new tool to measure knowledge transfer. It offers specific metrics to assess both the quantity and the quality of nine different facets of knowledge transfer from UK universities. These metrics are shown in Table I.

Additionally, the development of this framework, together with our initial benchmark analysis, has led to four important conclusions about the UK knowledge transfer process:

1) Our results clearly show that universities should focus on directly measuring the knowledge transfer activities that they undertake, which are represented in the grey box in the Knowledge Transfer Model outlined in Figure I. More specifically, universities should concentrate on measuring the outputs (direct

Mechanism of Knowledge Transfer	Measures of Quantity	Measures of Quality
Networks	# of people met at events which led to other Knowledge Transfer Activities	% of events held which led to other Knowledge Transfer Activities
Continuing Professional Development (CPD)	Income from courses, # of courses held, # people and companies that attend	% of repeat business, customer feedback
Consultancy	# and value/income of contracts, % income relative to total research income, market share, # of client companies, length of client relationship	% of repeat business, customer feedback, quality of client company, importance of client relative to their company
Collaborative Research	# and value/income of contracts, market share, % income relative to total research income, length of client relationship	% of repeat Business, customer feedback, # of products successfully created from the research
Contract Research	# and value/income of contracts, market share, % income relative to total research income, length of client relationship	% of repeat Business, customer feedback, # of products successfully created from the research
Licensing	# of licenses, income generated from licenses, # of products that arose from licenses	Customer feedback, quality of licensee company, % of licenses generating income
Spin-Outs	# of spin-outs formed, revenues generated, external investment raised*, market value at exit (IPO or trade sale)	Survival rate, quality of investors, investor/ customer satisfaction, growth rate
Teaching	Graduation rate of students, rate at which students get hired (in industry)	Student satisfaction (after subsequent employment), employer satisfaction of student
Other Measures	Physical Migration of Students to Industry, Publications as a Measure of Research Output	

* this measure was analysed in the report using an internal Library House data set

Table I – Knowledge Transfer Framework (measures that are not currently collected are highlighted in blue)

products of the knowledge transfer), outcomes and gross economic impact of their knowledge transfer activities (both are changes resulting from the knowledge transfer), rather than the net economic impact. This is because outputs, outcomes and gross economic impact can be directly measured, unlike net economic impact, which includes an estimate of what would have happened had there been no knowledge transfer, and as such would be difficult to measure. This approach is explained in detail in the report.

2) The UK is on the right track with regards to measuring knowledge transfer and ahead of the US and Canada. There is good agreement between UK stakeholders on what should be measured and several organisations already collect relevant data. These include governmental organisations such as the Higher Education Funding Council for England (HEFCE) and the Higher Education Statistics Agency (HESA), the Scottish Funding Council (SFC) for its Knowledge Transfer Grant scheme, and other organisations such as UNICO. In contrast, in the US, no such governmental equivalents exist, with only one organisation, the Association for University Technology Managers (AUTM), actively collecting knowledge transfer data on US universities through its annual licensing survey.

3) Measures of the quantity of knowledge transfer are already good, but data for measures of quality needs to be improved. Some of this data could be collected in future surveys, whilst in other cases, further work should be done in collaboration with all stakeholders to determine the best ways of measuring and collecting indicators of knowledge transfer quality.

4) The UK is actively involved in knowledge transfer activities and competitive with US and Canadian universities. Most universities in the UK appear to be particularly active in one or two areas of knowledge transfer, whilst still pursuing others to some extent. A smaller number are active in many areas of knowledge transfer.

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.

In summary, both the amount of knowledge transfer and the ability to measure it are well developed in the UK. With a few minor additions to the data already collected by HEFCE, HESA, SFC and UNICO, and an explicit agreement on using a common measurement framework, the UK should have a world class set of knowledge transfer measures that will accurately assess the impact and success of knowledge transfer, and that other countries will aim to follow.

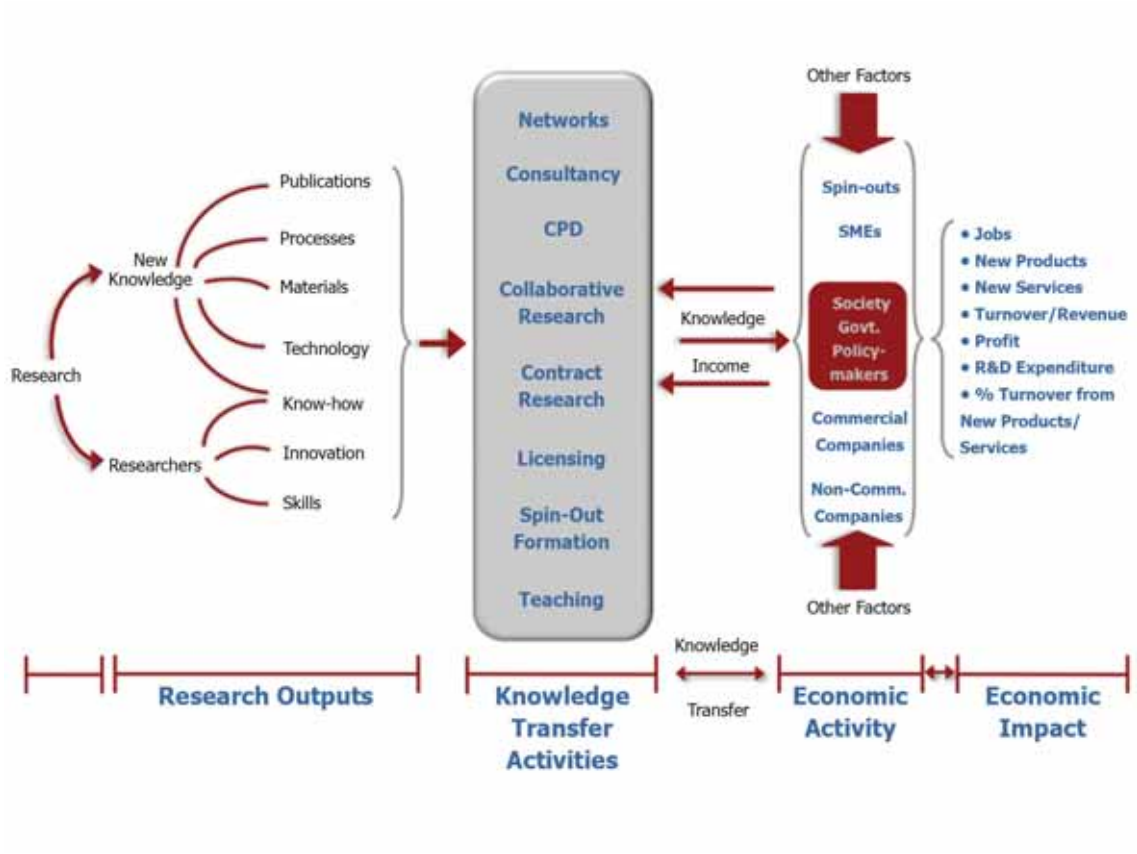


Figure I – Model of Knowledge Transfer within the Innovation Ecosystem (Source: University of Glasgow)

2 Introduction

The UK Government, academic institutions, organisations and the public in general have become more concerned about the economic impact of publicly funded research. The 1993 White Paper, 'Realising Our Potential', first recognised the importance of academic research in 'wealth creation' and 'quality of life', and resulted in these criteria becoming important factors in the allocation of research funding[1].

These themes were reinforced in the July 2002 Spending Review, 'Investing in Innovation: A Strategy for Science, Engineering and Technology', which recognised the importance of scientific research in delivering economic growth and enriching the quality of life[2]. However, the Review also suggested that the full benefits of scientific innovation had not yet been realised. Among the measures proposed to remedy this was the consolidation of the Higher Education Innovation Fund (HEIF) that provides resources for technology transfer and entrepreneurship training, for example, as a permanent third stream of funding for universities.

The increasing importance of the engagement of universities with business was recognised in the 2003 Lambert Review of Business-University Collaboration. Like the 2002 Review, the Lambert Review also suggested initiatives to increase the HEIF to better facilitate knowledge transfer between academia and business[3]. The recommendations in these reviews were successfully incorporated in 2004 into a 10 year Governmental 'Science and Innovation Investment Framework' by the Government, which outlined explicit targets for each research council to increase the rate of knowledge transfer and level of interaction with business[4].

More recently, the 2006 Warry Report, 'Increasing the economic impact of Research Councils', recognised the increasing importance of knowledge transfer between universities and businesses, and measuring its economic impact[5]. The report contained several important recommendations, including suggesting that the Research Councils firstly influence universities and funding councils to reward business interactions when allocating resources, and secondly, incorporate an analysis of economic importance and impact in peer review panels involved in funding research in the UK.

Finally, in May 2007, the Department of Trade and Industry published a report that dealt with the challenges of measuring the economic impact of investment in the science and innovation system[6]. One of the main comments in this report was a call for a clear framework to measure such economic impact. Various frameworks have evolved over the last decade, but opinions are still divided over their constituents, definitions and usability.

An important component of this science and innovation knowledge economy is economic development through knowledge transfer, which also incorporates technology transfer. However, the relationship between research, knowledge and technology transfer and economic development is complex, with many different avenues of knowledge transfer and associated income flows streaming in multiple directions. This makes knowledge transfer, and its success and impact, difficult to measure and quantify.

For these reasons, it is important that a consensus be reached between all stakeholders involved in the process of knowledge and technology transfer about the use of metrics to measure the performance of the knowledge and technology transfer activities of national and international universities, both in terms of quantity and quality.

Different approaches to knowledge transfer measurement have been developed around the world, but most have built upon the US model below developed by the Association of University Technology Managers' (AUTM). The key measure of the success of knowledge transfer in this model is the collection of revenues obtained from Intellectual Property (IP) by AUTM through its Annual Licensing survey[7]. However, it has recently been recognised that measurement of income from IP is an incomplete and poor measure of knowledge transfer performance. For this reason new approaches have been developed.

For example, in the UK, the approach to knowledge transfer measurement has been widened with the Higher Education-Business and Community Interaction (HE-BCI) Survey[8], which began in 2001 and now recognises a broad spectrum of activities with both financial and non-financial objectives. Similarly, the Knowledge Transfer Grant (KTG) scheme[9] was created by the Scottish Funding Council in 2001-02 to allocate grant funding for knowledge transfer activities in Scottish universities using a metrics-based system[10].

In the US, AUTM has carried out the 'Better World' project[11], which was designed to capture examples and case studies of university research being transferred into the economy and society to deliver benefits other than or in addition to financial benefits. This was part of an effort to demonstrate qualitative benefits in the absence of quantitative data or evidence.

It is still recognised, however, that these approaches do not fully cover or capture the benefits or impacts of knowledge transfer. The current project was thus initiated to identify the gaps and to seek to build a coherent framework of metrics that could be used to both measure absolute performance and to benchmark performance between universities internationally.

1 Realising Our Potential (1993 White Paper), William Waldegrave

2 Investing in Innovation: A strategy for Science, Engineering and Technology (2002) – http://www.hm-treasury.gov.uk/media/F/D/science_strat02_ch1to4.pdf

3 Lambert Review of Business-University Collaboration (2003) – http://www.hm-treasury.gov.uk/media/9/0/lambert_review_final_450.pdf

4 Science and Innovation Investment Framework 2004 -2014 – http://www.hm-treasury.gov.uk/spending_review/spend_sr04/associated_documents/spending_sr04_science.cfm

5 Increasing the economic impact of Research Councils (2006) – http://www.berr.gov.uk/files/file32802.pdf

6 Measuring economic impacts of investment in the research base and innovation – a new framework for measurement – www.berr.gov.uk/files/file39754.doc

7 http://www.autmsurvey.org/

8 http://www.hefce.ac.uk/econsoc/buscom/hebci/

9 http://www.sfc.ac.uk/information/information_research/knowledge_transfer.htm

10 http://www.sfc.ac.uk/information/info_circulars/sfc/2005/sfc0505/sfc0505.html

11 http://www.betterworldproject.net/

3 Background and Aims of this Project

This project is a result of discussions between Library House, UNICO (UK), AUTM (US), the Alliance for Commercialization of Canadian Technology (ACCT) and a range of funders including the Department for Innovation, Universities and Skills (DIUS), Research Councils UK (RCUK), the Scottish Funding Council (SFC) and the Higher Education Funding Council for England (HEFCE). These departments and organisations decided to undertake a project to define new metrics for the evaluation of technology transfer at universities.

As a result of these discussions, UNICO commissioned Library House to undertake a project to define new metrics for the evaluation of knowledge transfer activities in universities. The aims of the project, as defined by Kevin Cullen, Director of Research and Enterprise, University of Glasgow, were:

- To develop an understanding of what is currently measured and the definitions of the currently used metrics for knowledge transfer in the UK
- To conduct an investigation (via focus groups) into what important stakeholder groups view as knowledge transfer, what they think it sets out to achieve, and how we should measure knowledge transfer both in terms of quantity and quality
- To use the feedback from the focus groups to create a framework of metrics that would cover the majority of needs for measuring knowledge transfer in the UK
- To conduct an initial benchmarking for UK universities using both public and private data to determine the effectiveness of the developed framework and identify any gaps in the availability of knowledge transfer data
- To use this framework to perform an international comparison of UK universities with those in the US and Canada to determine how the UK compares internationally with regards to knowledge transfer

Given the increasing focus on knowledge transfer by universities, funding bodies, and the business community, the findings of this report will enable these stakeholders to more effectively measure the success of knowledge transfer of universities, both in the UK and internationally, using a unified set of properly defined metrics.

4 Methodology and Data Collection

A detailed description of our methodology for measuring the knowledge transfer activities of UK universities and our approach towards collecting data on knowledge transfer is shown below.

4.1 Definitions of currently used Knowledge Transfer Metrics

We first determined the existing metrics and definitions in current use by researching the published literature, reviews and internal documents from key stakeholder organisations, academic journals, and online sources.

We next determined the most important stakeholders of knowledge transfer who would participate in the focus groups. We identified three separate groups, the research funders (i.e. UK Research Councils and other charitable funding bodies such as Cancer Research UK or the Wellcome Trust) who fund the research in the UK which underpins knowledge transfer, the senior university management, who represent the academics that create this research, and the business community such as individuals from commercial and non-commercial organisations who are the recipients of the knowledge transfer.

We conducted separate focus groups with representatives from all three stakeholders in order to determine their views on knowledge transfer. More specifically, our aim was to determine what they believed to be knowledge transfer, what key mechanisms underpin it, and how to measure both the quantity and quality of knowledge transfer.

Participants in the focus groups included senior executives from key UK research funding councils and charities, vice-chancellors and senior management from several UK universities, and senior managers responsible for the research activities in leading UK companies.

The information obtained from the focus groups and interviews was then used to develop a metrics framework in order to analyse knowledge transfer data. It is important to note that the knowledge transfer mechanisms, and the measures of their quantity and quality that make up the framework were suggested by the different stakeholders in the focus groups, and not by Library House. The role of Library House was instead focused on moderating discussions amongst the stakeholders of knowledge transfer.

Such an approach allowed us to consider the views of all of the main stakeholders of knowledge transfer during the construction of the framework, hopefully eliminating any potential bias from particular stakeholders.

This would thus allow the development of a uniform metrics framework that best represented the views of all the important stakeholders of knowledge transfer, and would accurately measure the success and impact of knowledge transfer activities in UK universities.

4.2 Initial Benchmark Analysis

We then populated the newly established metrics framework with data (see Section 4.3 below) to perform an initial benchmark analysis. Given that the focus of the report is on the development of the knowledge transfer framework, a subset of 20 UK universities were selected for our analysis. The selection methodology for these universities are described in detail in the Analysis section of this report (section 5.2).

4.3 Data Collection

We sourced data from publicly available sources for our analysis. These were chosen for their ease of availability, but importantly because of their accountability, due to the data being present in the public domain. Sources included the Higher Education–Business and Community Interaction (HE-BCI) survey carried out by HEFCE from 2007, data from the Higher Education Statistics Agency (HESA), and internal data from Library House on spin-out companies.

5 Analysis

5.1 Classification of the different Types of Income of Universities

Universities receive income from many sources, of which research income is a sub-set. Described below are the sources of the overall income, and the total research income of UK universities.

5.1.1 Overall Income of Universities

University income originates from five main sources according to the HESA classification system:

- Funding Council grants (e.g. for teaching, research, and buildings)
- Tuition fees and education grants and contracts
- Research grants and contracts
- Other income (e.g. from residences and catering operations, grants from local authorities, income from licences and patents)
- Income from investments and endowments

5.1.2 Total Research Income of Universities

UK universities can receive research income from several sources, including governmental and other sources such as charities. With regards to governmental funding, the UK has a dual support system where funding is provided in two streams.

The first is provided by UK Funding Councils such as HEFCE, with the aim of supporting the research infrastructure of universities as well as enabling research of their choosing. This funding can also be used to undertake research commissioned by the private

University	Total Income (£000s)	Total Research Income (£000s)	Recurrent Research Income from Funding Council Grants (£000s)	Total Income from Research Grants and Contracts (£000s)
University of Cambridge	**694,624**	270,739	82,028	188,711
University of Manchester	**539,982**	191,491	60,609	130,882
University of Oxford	**530,171**	263,218	79,649	183,569
University College London	**516,274**	248,880	81,455	167,425
Imperial College	**458,522**	248,342	71,637	176,705
University of Edinburgh	**401,015**	153,766	49,797	103,969
University of Leeds	**366,606**	110,996	36,321	74,675
King's College London	**363,972**	143,990	42,527	101,463
University of Birmingham	**334,413**	107,762	34,153	73,609
The Open University	**333,230**	14,254	5,834	8,420
University of Nottingham	**320,286**	92,673	30,373	62,300
Cardiff University	**314,735**	100,730	34,691	66,039
University of Sheffield	**301,341**	113,535	35,912	77,623
University of Glasgow	**291,466**	112,666	35,673	76,993
University of Southampton	**287,435**	113,830	36,458	77,372
University of Warwick	**283,587**	81,248	22,628	58,620
University of Newcastle	**276,099**	83,072	27,524	55,548
University of Bristol	**262,077**	99,313	32,542	66,771
University of Liverpool	**244,742**	84,442	23,468	60,974
Queen's University of Belfast	**209,634**	69,845	25,592	44,253
University of Strathclyde	**179,134**	43,133	16,843	26,290
Queen Mary and Westfield College	**174,744**	57,510	14,188	43,322
Manchester Metropolitan University	**172,802**	10,077	2,877	7,200
University of Surrey	**167,961**	43,099	15,196	27,903
University of Leicester	**167,456**	48,669	13,700	34,969
University of Durham	**164,503**	49,292	17,649	31,643
University of Ulster	**156,711**	34,984	13,962	21,022
University of Reading	**156,465**	41,558	17,497	24,061
University of Dundee	**154,936**	56,659	15,012	41,647
Loughborough University	**153,039**	41,099	12,245	28,854

Table 1 – Highest Ranked UK Universities by Total Income in 2004-05 (Source: HESA, HE-BCI Survey; Scottish Universities are highlighted in blue, Welsh Universities in orange, and Northern Irish Universities in green)

sector, Government Departments, charities, the European Union and other international bodies.

The second stream of funding is provided by the Research Councils, who allocate grants for specific projects and programmes based on a rigorous selection criteria. Funded by the Department for Innovation, Universities and Skills (DIUS), there are seven research councils:

- Biotechnology & Biological Sciences Research Council
- Natural Environment Research Council
- Engineering & Physical Sciences Research Council
- Economic & Social Research Council
- Science and Technology Facilities Council
- Medical Research Council
- Arts and Humanities Research Council

Several other organisations also fund research in UK universities, which HESA classifies into different groups. These are:

- UK-based charities such as the Wellcome Trust and Cancer Research UK
- UK central government bodies/local authorities, health & hospital authorities
- UK industry, commerce and public corporations
- EU government bodies
- Other non-government EU bodies
- Overseas bodies operating outside the EU

5.2 Selection of Universities

Following close consultation with the different project collaborators, and given that the focus of this report is on the development of metrics to measure knowledge transfer, we chose to select a subset of UK universities for our initial benchmarking of the state of knowledge transfer activities. To ensure we were not excluding any outstanding universities in our analysis, we also examined the performance of all UK universities for each knowledge transfer mechanism.

Such an approach should provide a useful first analysis of knowledge transfer activities in UK universities using the newly developed knowledge transfer framework. However, we recommend that future studies include an analysis of all UK universities to provide a complete picture.

In the first stage of our selection of universities, we classified all UK universities by total income using the most recent data obtained from HESA. We used this metric as a selection measure as universities with a high total income are likely to be involved in a wide range of research activities. The 30 most active UK universities by this measure are shown as a representative sample in Table 1, though all UK universities were considered for selection.

To ensure that the top ranked universities from different fields of knowledge transfer were included in our analysis, we examined data from the HE-BCI survey, which contains knowledge transfer data on UK universities. From this data, we selected the top ranked universities based on total income obtained from Continuing Professional Development (Cardiff, which was already included), collaborative research (Cambridge), consultancy (Surrey), contract research (Imperial College), and from licensing (Birmingham) for our cohort.

We next examined spin-out data from the HE-BCI survey in terms of the number of active spin-outs in 2004-05, which revealed that Imperial College, already included in our analysis, was ranked first.

In order to fairly represent the universities selected for our analysis geographically, we next classified the English universities by region as defined by the Regional Development Agency (RDA), and included the largest universities by total research income from each region that were not already included in our list (Nottingham (East Midlands) and Leeds (Yorkshire and Humber)).

Finally, we included any universities in the top ten as classified by total research income that had not previously been included (University College London, ranked 3rd, and the University of Sheffield, ranked 10th), making a total of 20 universities for our analysis (see Table 3).

University	Country	RDA Region (England Only)
University of Birmingham	England	West Midlands
University of Bristol	England	South West
University of Cambridge	England	East
Imperial College	England	London
King's College London	England	London
University College London	England	London
University of Leeds	England	Yorkshire and the Humber
University of Manchester	England	North West
University of Newcastle	England	North East
University of Nottingham	England	East Midlands
University of Oxford	England	South East
University of Sheffield	England	Yorkshire and the Humber
University of Southampton	England	South East
University of Surrey	England	South East
Queen's University Belfast	Northern Ireland	
University of Ulster	Northern Ireland	
University of Edinburgh	Scotland	
University of Glasgow	Scotland	
University of Cardiff	Wales	
University of Wales, Swansea	Wales	

Table 2 – List of UK Universities selected for our Analysis (Northern Irish Universities are highlighted in Purple, Scottish Universities in Blue, and Welsh Universities in Orange)

6 Results

6.1 Existing Definitions and Metrics of Knowledge Transfer

To establish a firm baseline for the evaluation of knowledge transfer, we first determined the existing metrics and definitions in current use by researching the published literature, reviews and internal documents from key stakeholder organisations, academic journals and online sources.

Our initial analysis yielded a list of thirty commonly used knowledge transfer metrics. To define these metrics more precisely we used further analysis of the sources and decided on a consensus definition for each one. The resulting knowledge transfer metrics and their definitions are presented in Table 3.

6.2 Selection of Mechanisms of Knowledge Transfer

We next used a focus group approach to select and further develop from this baseline the most promising knowledge transfer mechanisms. We identified three separate groups as the most important stakeholders of knowledge transfer and invited them to participate in focus groups. These were:

1. Research funders
2. Senior university management
3. The business community

Our focus group analysis identified the following eight mechanisms that each group believed would be sufficient to accurately measure knowledge transfer:

- Networks (specifically social, for example, between academics and the business community)
- Continuing Professional Development (CPD)
- Consultancy
- Collaborative Research
- Contract Research
- Licensing
- Spin-Outs
- Teaching

There was also a ninth category for other mechanisms such as the access of academics to high technology equipment.

We then completed the framework to measure the knowledge transfer activities of universities in the UK by devising in close collaboration the stakeholders a set of measures of the quantity and quality of these nine metrics. Table 4 lists the details of the framework and each metric is discussed in full in the next section.

6.3 Evaluation of the Mechanisms

To validate our framework, we next populated it with publicly available knowledge transfer data from universities to perform an initial benchmark analysis. Before this, it was first necessary to evaluate each of the mechanisms that comprise the framework, with regards to their definition, and the availability of data from public sources.

There are several sources of publicly available knowledge transfer data in the UK, including HEFCE, which currently publishes the Higher Education–Business and Community Interaction (HE-BCI), the Higher Education Statistics Agency (HESA), which has its own data set, but will also begin administering the HE-BCI survey in 2-3 years, UNICO, and the SFC, which publishes data on Scottish universities for its Knowledge Transfer Grant Scheme.

We decided to use the HE-BCI Survey and HESA data for the 2004-05 academic year for our analysis, as the UNICO and KTG data were subsets of the HE-BCI data. In addition, we used internal data from Library House on spin-out companies, as this provides quantitative data on the investment received by spin-outs, which supports the data from the HE-BCI survey.

The consultation of these sources for the 20 selected universities yielded the following insights into the nine mechanisms of our knowledge transfer measurement framework:

6.3.1 Networks

Networks, or specifically, social/professional networks were the most important mechanism of knowledge transfer that was selected by the three stakeholder groups.

After examination of the different definitions of social/professional networks from the various sources we researched, we defined social/professional networks as:

A social structure made of nodes (which are generally individuals or organisations such as universities and businesses) that are tied by one or more specific types of interdependency, such as values, visions, ideas, knowledge, technology or financial exchange, or friendship.

Such networks, although informal, can be an important measure of the knowledge transfer activities of a university, as they directly facilitate the exchange of knowledge between individuals. Importantly, they can also result in other downstream activities of knowledge transfer, such as collaborative research.

Unfortunately, due to its informal nature, measuring the quantity and quality of networking is difficult. Consistent with this, none of the focus groups were able to suggest any measures of the quantity and quality of networking. We propose that one measure of the quantity of networking could be the number of downstream knowledge transfer activities (such as collaborative research) that arose from networking events, for example. Measures of quality of networking could include the percentage of networking events which led to other downstream knowledge transfer activities, for example. Both however, could be difficult to measure directly because they require that networking events be accurately captured and their outcomes documented. More work is required to determine how such documentation might be achieved in the future.

Metric	Consensus Definition
Academic Research	A scholarly or scientific investigation or inquiry, usually undertaken within a Higher Education Institution, that is based on intellectual investigation, and is aimed at discovering, interpreting, and revising knowledge on different aspects of the world.
Citation	A reference to a authorative source, such as a previously published article, book, web page, or other published item, used for substantiation of an idea, process or comment, and with sufficient detail to identify the source uniquely. Unpublished writings or speech, such as working papers or personal communications, can also be cited.
(Social) Networks	A social network is a social structure made of nodes (which are generally individuals or organizations such as universities and businesses) that are tied by one or more specific types of interdependency, such as values, visions, ideas, knowledge, technology or financial exchange, or friendship.
Collaborative Research	A structured research project that involves two or more partners in addition to the Higher Education Institution, where all parties work together toward a common goal by sharing knowledge, learning and building consensus.
Contract Research	Research arising from collaborative interactions that specifically meets the research needs of the external partners.
Commercialisation	The process through which research discoveries are brought to the market place and new ideas or discoveries are developed into new products, services or technologies that are sold around the world.
Consultancy	The provision of expert advice and work which, while it may involve a degree of analysis, measurement or testing, is crucially dependent on a high degree of intellectual input from the Higher Education Institution to the client (Commercial or Non-Commercial), but without the creation of new knowledge (although new understanding is the main desired impact).
Continuing Professional Development (CPD)	The means by which members of professional associations maintain, improve and broaden their knowledge and skills and develop the personal qualities required in their professional lives, usually through a range of short and long training programmes, some of which have an option of accreditation.
Economic Development	The development of economic wealth of countries or regions for the well-being of their inhabitants. The economic development process supposes that legal and institutional adjustments are made to give incentives for innovation and for investments so as to develop an efficient production and distribution system for goods and service. Economic development is a sustainable increase in living standards that implies increased per capita income, better education and health.
Economic Impact	A process which leads to significant changes in the welfare of consumers, the profits of firms or the revenue of government. Economic impacts range from those that are readily quantifiable, in terms of greater wealth, cheaper prices and more revenue, to those less easily quantifiable, such as effects on the environment, public health and quality of life.
Equipment and Facilities Services	The use by an external party (that is not another Higher Education Institution) of the physical academic resources of the Higher Education Institution. This could range from electron microscopes to performance space. Provision of such resources may include a degree of, for example, technician support.
Full-Time Equivalent (FTE)	A method to measure a worker's involvement in a project, or a student's enrolment at an educational institution. An FTE of 1.0 means that the person is equivalent to a full-time worker, while an FTE of 0.5 signals that the worker is only half-time. Typically, different scales are used to calibrate this number, depending on the type of institution (schools, industry, research) and scope of the report (personnel cost, productivity).
Intellectual Property Rights (IPR)	Such rights protect the creator's right to be appropriately acknowledged for their work, such as an invention or a manuscript. IPR gives the creator a means of controlling how their protected work is exploited, thereby ensuring that they are properly rewarded for their creative endeavours. This includes patents, registered trademarks and copyright.
Invention Disclosure	A document that describes a discovery or a development, names the contributors to that discovery, and provides many other key pieces of information needed to determine if an invention - a discovery that can be protected under patent law - has been made.
Investment (In Spin-Outs)	An outlay of a sum of money to be used in such a way that a profit or increase in capital may be expected.
IP Protection Expenditure	Costs incurred in protecting IP, including those from patenting, external legal and other protection fees, and specialist IP consultancy advice.
Joint Venture	A contractual agreement resulting in the formation of an entity between two or more parties to undertake economic activity together. The parties agree to create a new entity by both contributing equity, and they then share in the revenues, profits or losses, expenses, and control of the enterprise.
Knowledge Transfer	The process by which the knowledge, expertise and intellectually linked assets of Higher Education Institutions are constructively applied beyond Higher Education for the wider benefit of the economy and society, through two-way engagement with business, the public sector, cultural and community partners.
License Agreement	A formal agreement that allows the transfer of technology between two parties, where the owner of the technology (licensor) permits the other party (licensee) to share the rights to use the technology, without fear of a claim of intellectual property infringement brought by the licensor.

Metric	Consensus Definition
Licensing Income	Income which includes: license issue fees, payments under options, annual minimums, running royalties, termination payments, the amount of equity received when cashed-in, and software and biological material end-user license fees equal to GBP £500 or more. Licensing Income does not include research funding, patent expense reimbursement, a valuation of equity not cashed-in, software and biological material end-user license fees less than GBP £500, or trademark licensing royalties from university insignia, or any income received in support of the cost to make and transfer materials under Material Transfer Agreements.
Option Agreement	An option agreement grants the potential licensee a time period during which it may evaluate the technology and negotiate the terms of a license agreement. An option agreement is not constituted by an option clause in a research agreement that grants rights to future inventions, until an actual invention has occurred which is subject to that option.
Patent	An exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem. A patent gives an inventor the right for a limited period to stop others from making, using or selling the invention without the permission of the inventor.
Patent Filed / Granted	A process by which a patent is filed with the patent office. After the patent is granted, the invention becomes the property of the inventor, which - like any from of property or business asset - can be bought, sold, rented or hired.
Proof of Concept	Evidence that demonstrates that an experimental or business model, or an idea is feasible.
Publication	The act of publishing novel ideas or outcomes of research and business projects, for example in periodicals such as scholarly journals, newspapers and magazines, or in books and websites. Publications can be peer-reviewed (for example in many academic journals), or not.
Research Funding (Income)	Any funding for scientific research awarded to a Higher Education Institution. Research funding is often awarded through a competitive process, in which potential research projects are evaluated and only the most promising receive funding. Such processes are usually run by governmental funding and research councils, industrial corporations or foundations and non-commercial organisations.
Secondment	The detachment of a person from their regular organization for temporary assignment elsewhere, for example in industry.
Spin-out (Spin-off)	"From a Higher Education perspective, spin-offs are defined as companies set-up to exploit IP that has originated from within the Higher Education Institute. From a business perspective, a spin-off occurs when a a division of a company or organisation becomes an independent business. The newly formed company usually obtains the assets, intellectual property, technology, and/or existing products from the parent organisation.
Start-Up Company	A newly-formed company that has a limited operating history. These companies, generally newly created, are in a phase of development and research for markets. Start-up companies can have a high element of risk associated with their development, but this can be balanced by their high potential rate of growth and scalability.
Technology Transfer	The process of developing practical applications for the results of scientific research. This usually involves the identification of research, typically by dedicated technology transfer offices in universities, governmental organizations, and companies, which has potential commercial interest and the design of strategies for how to exploit it. Such strategies can include the creation of licensing agreements or joint ventures, partnerships, or spin-out companies to develop the new technology and bring it to market.

Table 3 – Consensus Definitions of Metrics commonly used when discussing Knowledge Transfer (Source: Library House)

Although it would be desirable to accurately measure networking, in the short term, we propose that a good approximation of its effect would be to measure its downstream collaborative results.

Specific measures could include the creation of collaborative research, consultancy, or contract research between academia and industry.

6.3.2 *Continuing Professional Development*

Continuing professional development, or CPD, was another mechanism of knowledge transfer that was agreed in consensus by the different stakeholder groups. We defined CPD as:

The means by which members of professions maintain, improve and broaden their knowledge and skills and develop the personal qualities required in their professional lives, usually through a range of short and long training programmes, some of which have an option of accreditation.

CPD can thus be an important part of the sphere of knowledge transfer activities of a university, as it can be a means of directly enabling the transfer of new knowledge from its academics to individuals from other professions, who may not ordinarily have access to such knowledge.

Although conceptually similar to teaching, another mechanism of knowledge transfer proposed by the focus groups that will be discussed in a later section of this report, we have treated both as separate mechanisms for the purposes of our analysis. This is because CPD and teaching differ in that CPD deals with individuals from other professions that are not affiliated with the university, whereas teaching primarily involves students enrolled in the university.

				Measures of Quantity			Measures of Quality		
Mechanism of Knowledge Transfer	Proposed by Research Funders	Proposed by Business Community	Proposed by Senior University Management	Research Funders	Business Community	Senior University Management	Research Funders	Business Community	Senior University Management
Networks	Yes	Yes	Yes	n/a	n/a	n/a	n/a	n/a	n/a
Continuing Professional Development (CPD)	Yes	Yes	Yes	Income from courses	n/a	Income from courses	n/a	n/a	n/a
Consultancy	Yes	Yes	Yes	# of innovative businesses that evolve from consultancy contracts, % of turnover from services/products	# and value of contracts	# and value of contracts	Repeat business	Customer feedback	Customer feedback
Collaborative Research	Yes	Yes	Yes	# and value of contracts, market share	# and value of contracts	# and value of contracts	Repeat Business, customer feedback	Quality of partner company, longevity of partnership, customer feedback	Longevity of partnership, customer feedback
Contract Research	Yes	Yes	No	# and value of contracts, market share	# and value of contracts	# and value of contracts	Repeat Business, customer feedback	Quality of partner company, longevity of partnership, customer feedback	Longevity of partnership, customer feedback
Licensing	Yes	Yes	Yes	# of licenses, income generated from licenses	# of licenses, income generated from licenses	# of licenses, income generated from licenses	Case studies, repeat business, customer feedback	Customer feedback	Customer feedback
Spin-Outs	Yes	No	Yes	External investment raised, revenues generated, market value at flotation	# of spin-outs formed, external investment raised, revenues generated, flotation/exit value	Revenues generated, external investment raised	n/a	Survival rate/ viability, growth rate, customer feedback	Survival rate/viability
Teaching	No	Yes	Yes	n/a	n/a	n/a	n/a	Commercial skill sets of academics (i.e. marketing, legal, commercial training)	n/a
Other Measures	Yes	No	No	Access of academics to high technology equipment, measure of user investment as indicator of success	n/a	n/a	n/a	n/a	n/a

Table 4 – Consensus Knowledge Transfer Mechanisms and Measures of their Quantity and Quality

6.3.2.1 Measures of CPD Quantity

As a result of our focus groups, both the research funders and senior university management proposed the **income from CPD courses** as an important quantitative measure of CPD success.

We were able to collect this data for the 20 universities selected for our analysis from the HE-BCI survey in 2007 for the 2004-05 academic year. However, it is important to note that the income from CPD that is recorded by the HE-BCI survey does not include that from the NHS (which could be used for training nurses), or the Training and Development Agency for Schools (which trains teachers). This is because income from these sources is primarily used for internal training required for their professions rather than professional development, which is outside the scope of CPD using the consensus definition described at the beginning of this section.

Furthermore, it is important to note that the HE-BCI survey collects income from CPD and continuing education (CE, i.e. from individuals attending courses held by a university) and classifies them together in one group, without any delineation between the two. As a result, the figures that are analysed in this section will also include income from CE.

6.3.2.2 Measures of CPD Quality

Having a set of measures of the quality of a knowledge transfer mechanism is also important to determine the success and impact of that mechanism. For example, it would be more desirable to have a university that holds many CPD courses with high quality than one which holds many but of lower quality, as the former is likely to be more successful and have more impact.

Although no measures of the quality of CPD were proposed by any of the focus groups, we propose that customer feedback surveys conducted after CPD courses that measure the quality and usefulness of the courses could be used as such a measure.

It is likely that universities actively collect this data. As a result, it should be possible for future surveys by HEFCE and HESA to include this data in order to provide new tools that we believe are necessary to comprehensively measure the success and impact of CPD as a mechanism of knowledge transfer.

6.3.3 Consultancy

Consultancy was proposed as an important mechanism of knowledge transfer by all of the stakeholder groups. In order to come up with a consensus definition for consultancy, we researched the various definitions from the sources listed in Table 1. From these, we defined consultancy as:

The provision of expert advice and work that is crucially dependent on a high degree of intellectual input from the higher education institution to the client (commercial or non-commercial). The main desired impact of consulting is not the creation of new knowledge, but the creation of new understanding (see Table 6).

Consultancy is an important aspect of the knowledge transfer activities that are undertaken by universities. In addition to enabling the direct interaction between academics and non-academic professionals, consultancy can also lead to a development of these initial relationships into longer-term partnerships, through other knowledge transfer mechanisms such as collaborative or contract research, or licensing.

6.3.3.1 Measures of Quantity of Consultancy

To determine the success and impact of consultancy as a mechanism of knowledge transfer, several key measures of its quantity and quality were proposed by the different stakeholders. Those of quantity are described below, whilst those of quality that were proposed will be discussed in the next section.

The research funders proposed:

- The number of innovative businesses that evolve from consultancy contracts
- The percentage of turnover from services/products that arose from the consulting project
- The business community and senior university management proposed:
- The number of consultancy contracts
- The value (income) of consultancy contracts

Unfortunately, no data for either of the measures of quantity proposed by the research funders can be directly collected from public sources. To collect data on the number of innovative businesses that evolve from consultancy contracts, a consensus would need to be reached on what constitutes an innovative business by all universities before this data can be recorded/collected. The percentage of turnover from services/products that arose through the consulting projects is likely to be measured by the client companies. However, as individual companies would need to be contacted to obtain this data, it would be difficult to collect by HEFCE and HESA.

We were however able to collect data for the measures of quantity proposed by the business community, the number and value (income) of consultancy contracts, for the 20 universities selected for our analysis from the HE-BCI survey in 2007 for the 2004-05 academic year.

6.3.3.2 Measures of Quality of Consultancy

To measure the quality of consultancy, the research funders proposed:

- Repeat business

The Business Community meanwhile proposed:

- Customer feedback

Both of these cannot be directly obtained using available data sets. However, universities actively collect this data in some form, so this information could be incorporated into future HE-BCI surveys.

Given that customer feedback can be subjective in nature, for it to be successfully incorporated into future surveys, it would ideally have to be measured in a fashion that can be benchmarked between universities. This could for example involve a survey-type system that is completed by the clients during or after the consulting project, where their satisfaction is measured through a series of well-defined questions that are scores using a scale-based system. Such a survey could

be performed on-line across all Higher Education Institutions using the approach pioneered by the National Student Survey developed by HEFCE, which gathers feedback on the quality of students' courses, and is run throughout England. Further consultation with the stakeholders would be required to properly define appropriate survey questions, and how the survey is performed.

6.3.4 Collaborative Research

Collaborative research is a key mechanism of knowledge transfer that was suggested by all stakeholder groups as important in evaluating the success and impact of knowledge transfer. We defined collaborative research as:

A structured research project that involves two or more partners in addition to the higher education institution, where all parties work together toward a common goal by sharing knowledge, learning and building consensus.

The reason for having two or more partners in addition to the higher education institution is because collaboration by nature requires the input of many individuals, usually with different backgrounds, and three parties is generally the minimum for such a mechanism to be meaningful.

Collaborative research can be an important conduit of knowledge transfer between academia and industry, government and business, in both directions. Collaborative research can be longer term than consulting for example, involving bigger projects. Furthermore, collaborative research can lead to other knowledge transfer activities such as licensing or spin-out formation.

6.3.4.1 Measures of Quantity of Collaborative Research

Several key measures of the quantity of collaborative research were proposed by the stakeholders during the focus groups. All groups proposed in consensus:

- The number of collaborative research contracts/grants
- The value/income of collaborative research contracts/ grants

The research funders additionally proposed:

- Market share (of collaborative research income)

No data on the number of collaborative research contracts/ grants was available from public sources at present, but it is likely that universities already collect this data and as such could be incorporated into future data sets such as the HE-BCI Survey. In the meantime, data was available on the value and income of collaborative research contracts from the HE-BCI Survey, which was used to calculate the collaborative research income market share.

6.3.4.2 Measures of Quality of Collaborative Research

Assessing the quality of collaborative research is also important, as it is a proxy for the success and impact of this mechanism of knowledge transfer. Four measures of the quality of collaborative research were proposed in consensus by the stakeholder groups (see Table 7):

- Repeat business
- Customer feedback
- Quality of the partner company
- Longevity of the partnership

Data on these measures are not currently present in publicly available data sets. However, following discussions with several officials from different UK universities, it is clear that this data is actively collected, albeit in a subjective, narrative fashion. Nonetheless, any relevant numerical data (i.e. repeat business and longevity of the partnership) could be incorporated into future HE-BCI surveys in their current form.

Although we cannot directly determine measures such as customer feedback, market share (based on collaborative research income) can be treated as a proxy for it. Universities with higher market share would tend to have better customer feedback than those with smaller market share, and hence be sought after by potential collaborators. As with consulting, customer feedback could also be incorporated into future HE-BCI Surveys if a quantitative approach is taken toward its measure, through the adoption of a well defined scale-based survey, for example.

Market share could also be used as an indirect downstream indicator of repeat business, as universities with good customer feedback would tend to attract repeat business.

6.3.5 Contract Research

Contract research was selected by all stakeholder groups as a key mechanism of knowledge transfer. We defined contract research as:

Research arising from collaborative interactions that specifically meets the research needs of the external partners

Contract research is fundamentally different to collaborative research, which is more focussed on meeting the needs of all concerned parties through collaboration rather than satisfying the external partner first and foremost. In addition, with contract research, the Intellectual Property tends to remain with the client company rather than the higher education institution.

6.3.5.1 Measures of Quantity of Contract Research

In order to evaluate the success and impact of contract research as a mechanism of knowledge transfer, it was important to determine measures of both its quantity and quality. The measures of the quality of contract research will be discussed in the next section, whilst those of quantity are described below. Interestingly, the measures proposed by the stakeholder groups were identical to those proposed for collaborative research.

All groups proposed in consensus:

- The number of contract research contracts
- The value (income) of contract research contracts

The research funders additionally proposed:

- Market share

We were able to collect data on these measures from the 2007 HE-BCI survey for the 2004-05 academic year for the analysis.

6.3.5.2 Measures of Quality of Contract Research

Assessing the quality of contract research is also important, as it can be an accurate indicator of both the success and impact of contract research as a knowledge transfer mechanism. Several measures of the quality of contract research were proposed by the stakeholder groups. All proposed:

- Customer feedback

The research funders also proposed:

- Repeat business

In addition, the business community proposed:

- The quality of the partner company
- The longevity of the partnership

As discussed for collaborative research in the previous section, none of these can currently be collected from currently available data sets, but many universities collect internal data on these measures which could be incorporated into future surveys by HEFCE and HESA.

6.3.6 Licensing

Licensing was selected by the stakeholder groups as one of the eight key mechanisms of knowledge transfer. We defined licensing as:

A formal agreement that allows the transfer of technology between two parties, where the owner of the technology (licensor) permits the other party (licensee) to share the rights to use the technology, without fear of a claim of intellectual property infringement brought by the licensor.

Licensing, along with spin-outs, which will be discussed in section 6.3.7, is a valuable method of exploiting the IP that is generated from universities. Furthermore, the licensing of technology and IP to an organisation, whether it is a small or medium enterprise (SME), a large commercial or a non-commercial organisation, can also lead to other downstream knowledge transfer activities such as consultancy, collaborative research, or the formation of a spin-out/joint venture.

6.3.6.1 Measures of Quantity of Licensing

Having a set of measures on the quantity of licensing is important to assess both the impact and success of this mechanism of knowledge transfer. As a result of the focus group meetings with the three stakeholder groups, they all proposed:

- The number of licences
- The income generated from these licences

Data on both of these measures was available from the HE-BCI survey.

6.3.6.2 Measures of Quality of Licensing

Following the focus groups with the three major stakeholders of knowledge transfer, a set of measures of the quality of licensing was also proposed in addition to those of quantity described above. Having a set of measures of quality is important, as they can be good indicators of the success and impact of licensing as a mechanism of knowledge transfer.

All of the stakeholders proposed:

- Customer feedback

The research funders also proposed:

- Case studies (e.g. of licensing success stories)
- Repeat business

None of these can be collected from currently available data sets such as those from HESA and HEFCE (HE-BCI Survey). Measures such as repeat business are already collected internally by some universities, and as such could be incorporated into future surveys by HEFCE and HESA. Case Studies could be more difficult to incorporate into future surveys unless some sort of standardisation is adopted. However, one approach could be for each university to submit a case study to HEFCE, for example, which could be collated and published as a supplement.

Customer feedback could also be difficult to incorporate unless a quantitative approach is taken toward its measure, for example through a yearly on-line survey of the licensees/customers, with a series of well-defined questions using a scale-based system. However, further consultation with the stakeholders would be required for such a system to be developed.

6.3.7 Spin-Outs

Spin-outs, the formation of companies that have been spun-out from higher education institutions, is an essential mechanism of the knowledge transfer activities of universities, particularly with regards to IP exploitation.

The definition of spin-outs however can differ depending on whether its source was higher education or business-oriented. We thus came up with two definitions, depending on the perspective.

From a higher education perspective, we defined spin-outs as:

Companies set-up to exploit IP that has originated from within the higher education institution.

From a business perspective, we defined spin-outs as:

The formation of a new company that occurs when a division of a company or organisation becomes an independent business. The newly formed company usually obtains the assets, intellectual property, technology, and/or existing products from the parent organisation.

6.3.7.1 Measures of Quantity of Spin-Out Activity

To assess the success and impact of spin-out activity as a mechanism of knowledge transfer, it was important to determine a set of measures of spin-out activity. Through the focus groups, several indicators of the quantity and quality of spin-out activity were proposed by the stakeholders. The measures of quality that were proposed will be discussed in the next section, whilst those of quantity are listed below. All groups proposed in consensus:

- External investment raised

- Revenues generated
- Market value at flotation (or initial public offering)

The business community additionally proposed:

- Number of spin-outs formed
- Exit value (i.e. at trade sale or buy-out)

We were not able to collect data on the market value at flotation (IPO) and exit value from publicly available sources such as the HE-BCI survey. We were, however, able to collect data on the number of spin-outs formed and estimated generated revenues from the HE-BCI survey.

With regards to the HE-BCI survey data, an important distinction needs to be made between spin-outs and start-ups. The HE-BCI survey records both spin-outs and start-ups, but classifies spin-outs into two types, those with some higher education institution (HEI) ownership, and those with none. In addition, the start-ups are divided into two types, staff start-ups and graduate start-ups.

The distinction between spin-outs and start-ups for some universities however can be different. For example, a university might only class a company as a spin-out if they retain some ownership (otherwise calling it a start-up if no ownership is retained). However, given the clear definitions of spin-outs and start-ups that are used in the HE-BCI survey, we will assume that universities in the case above will have included these "start-ups" as spin-outs without HEI ownership.

Given that most of the universities in our cohort did not have any staff or graduate start-ups officially recorded in the HE-BCI survey, we did not analyse this data. However, the low numbers could be due to the definitions of both in the HE-BCI survey, and the different ways that universities collect this data. For example, staff start-ups are defined as companies set-up by HEI staff but not based on the IP from the HEI, whilst graduate start-ups are companies formed by recent graduates regardless of where any IP resides. The graduate start-ups must also have received some sort of formal business/enterprise support from the HEI. Thus some universities could include staff start-ups as spin-outs without HEI ownership, and some graduate start-ups included as spin-outs with some HEI ownership.

In terms of the other measures of the quantity of spin-out activity, we were also able to collect data on the external investment raised per company using our internal Library House data set on venture-backed companies within the UK. This is also shown in Table 13.

6.3.7.2 Measures of Spin-Out Quality

In addition to determining the quantity of spin-out activity, having a set of measures of spin-out quality is important to comprehensively evaluate the success and impact of spin-outs as a mechanism of knowledge transfer.

Although none were proposed by the research funders, several were proposed by the business community and the senior university management. They both proposed:

- Survival rate/viability

The business community additionally proposed:

- Customer feedback
- Growth rate

Most of these are not directly collected by public organisations such as HEFCE with its HE-BCI survey. Although the number of spin-outs that are still active which have survived at least three years is published in the HE-BCI survey, the survival rate/viability cannot be calculated as a corresponding value for the total number of firms formed over the three years is not provided. However, given that universities already provide data on the number of active spin-outs for the HE-BCI survey, it is likely that they also collect data on the total number of spin-outs formed over three years, which could be provided for future surveys, allowing the calculation of the survival rate.

Customer feedback was another measure of spin-out quality that was suggested by the business community. Unfortunately, this would be technically challenging to incorporate into future surveys, as the clients of the spin-outs would have to be contacted.

However, the external investment received by a spin-out could be used as a proxy for customer-feedback, as venture capital firms and business angels would not invest in a spin-out unless they believed that the company would be successful and have an impact, implying a level of customer satisfaction with the spin-out.

The final measure of spin-out quality proposed by the business community, growth rate, unfortunately also cannot be determined using any data from public sources. Such a measure could be difficult to incorporate without further clarification by the stakeholders as to how it should be measured, as many possible measures could be used. These include the growth in profit, revenues or number of staff, the amount of external investment raised in each funding round, or a combination of these.

6.3.8 Teaching

Teaching is an important mechanism of knowledge transfer that was proposed by the business community and senior university management. Teaching is also considered by universities to be an extremely important channel for the transfer of knowledge into the economy. However, standard university teaching was considered to be sufficiently different from the other knowledge transfer mechanisms considered here and to be assessed in such different ways that it would not be covered in depth in this report.

No measures of the quantity of teaching were proposed by the business community, though one of teaching quality was proposed, which was:

- Commercial skill sets of academics (i.e. marketing, legal and commercial training)

These are not currently available in publicly-available data sets such as the HE-BCI or HESA surveys. Due to the subjective nature of what constitutes the commercial skill set of an academic, especially with regards to marketing, legal and commercial training (e.g. does this constitute a course, a degree, or previous interactions with commercial organisations without any formal training), it is likely to be very difficult to collect in

future surveys, unless consensus definitions are reached by the stakeholders.

Given the importance of teaching in the knowledge transfer activities of universities, further consultation with the stakeholders should be undertaken with regards to determining a set of measures of its quantity and quality that could be incorporated into the knowledge transfer framework.

6.3.9 Other Mechanisms

Other channels of knowledge transfer that did not fall into the other eight mechanisms were proposed by the research funders. These included:

- The access of academics to high technology equipment
- Measure of user investment as an indicator of success

Unfortunately, data on neither of these measures is available from public sources such as the HE-BCI or HESA surveys. However, both measures are likely to be collected by universities in one form or another, and as such could be incorporated into future surveys.

6.4 Summary of the Availability of Metrics

Our analysis suggests that UK universities appear to collect a wide variety of data on the eight knowledge transfer mechanisms that were suggested by the stakeholders. Data on these mechanisms are incorporated into annual surveys such as the HE-BCI Survey currently published by HEFCE (soon to be published by HESA).

The availability of measures of the quantity of knowledge transfer is particularly good, with few gaps existing in the framework, except for data on the number of collaborative research contracts, and the flotation and exit values of spin-outs.

However, the data set is currently weighted towards measures of quantity, with very few measures of the quality of the eight mechanisms of knowledge transfer currently collected. Given that some of these such as repeat business for consultancy, collaborative and contract research, and the survival rate/viability of spin-outs are currently collected by universities, these could be incorporated into future surveys. Data on more subjective measures such as customer feedback for consultancy, collaborative and contract research, licensing, and spin-outs, and the quality of the partner companies for contract research, may however turn out to be more difficult to collect. Further consultations with knowledge transfer stakeholders are required to design appropriate measuring instruments.

6.5 Initial Benchmark Analysis of UK Universities

To provide an initial benchmark analysis of UK universities using our new knowledge transfer framework, we created a spider-graph representation of the most active UK universities in our cohort of 20 universities in key measures of each mechanism of knowledge transfer. This allowed us to provide a top-down perspective of the knowledge transfer activities of these universities in one graph. After evaluating the availability of data on the knowledge transfer mechanisms and their measures, we selected several key indicators to include in the spider-graph analysis. These were:

- For CPD:
  - Income (CPD (£))
- For Consultancy:
  - Income/Value of Contracts (Consulting (£))
  - Number of Contracts (# of Consulting Contracts)
- For Collaborative Research:
  - Income/Value of Contracts (CollabRes (£))
- For Contract Research:
  - Income/Value of Contracts (ConRes (£))
  - Number of Contracts (# of ConRes Contracts)
- For Licensing:
  - Income Generated from Licences (Licences (£))
  - Number of Licences (# of Licences)
- For Spin-Outs:
  - Total Number of Active Spin-Outs Formed (# of Active Spin-Outs)
  - Estimate Revenue Generated from the Active Spin-Outs (Active Spin-Out Revenue (£))
  - External Investment/Funding Raised per Spin-Out (Spin-Out Funding (£))

Teaching and networking were not considered because no data on the measures of quantity that were suggested by the stakeholders were available.

In order to reduce any bias related to the size of the universities, we also included the normalised score relative to the number of Full Time Equivalent (FTE) research staff in each university, which was obtained from HESA. In these cases, the measure is followed by an FTE acronym (e.g. Normalised Contract Research Income is referred to as ConRes FTE (£)). We were unfortunately unable to include any measures of knowledge transfer quality as these are presently not available from any public sources.

We created spider-graphs for the most active universities in each of the indicators listed above, which were:

- **Surrey** (Consulting Income)
- **Cardiff** (CPD Income and Number of Consulting Contracts)
- **Cambridge** (Collaborative Research Income)

- **Imperial** (Contract Research Income and Number of Contracts, Number of Active Spin-Outs)
- **Birmingham** (Licensing Income)
- **Southampton** (Number of Licences)
- **Queen's Belfast** (Estimated Revenue Generated from Active Spin-Outs)
- **University College, London** (External Investment Raised by Spin-Outs).

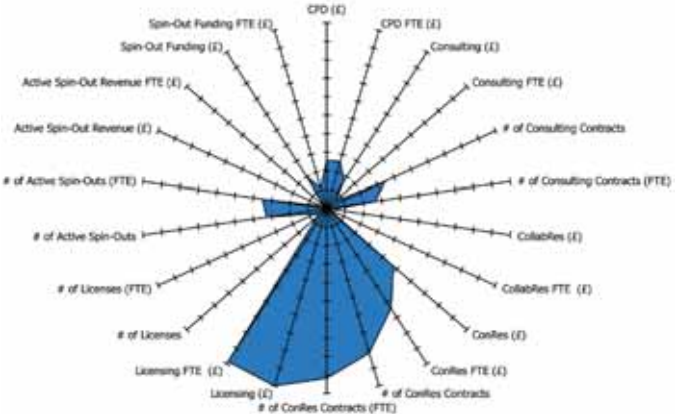
In addition, we also included **Oxford**, as it was ranked 2nd in terms of total research income, **Manchester**, as it was just behind Cambridge in Collaborative Research Income, and **Swansea**, as its total research activities were heavily focused on collaborative research. We also included **Bristol** as it was active at consultancy in terms of income, being ranked 2nd behind Surrey, with a significant gap between it and 3rd ranked Imperial (40% more income than Imperial). Finally, we included **Glasgow** as it was particularly active in terms of the external investment raised per spin-out company.

We created the spider-graph by assigning a score of 1 to the most active university in each measure. The remaining 19 universities were then assigned a score between 0 and 1 relative to the most active university. For example, if the most active university receives £35m in collaborative research, then it will be assigned a score of 1. Another university which receives £20m in funding will receive a score of 0.57. Similarly, if the most active university receives 697 consultancy contracts, it will receive a score of 1. A university which receives 550 contracts will receive a score of 0.79. These scores will be represented on the radial spokes that make up the spider graph.

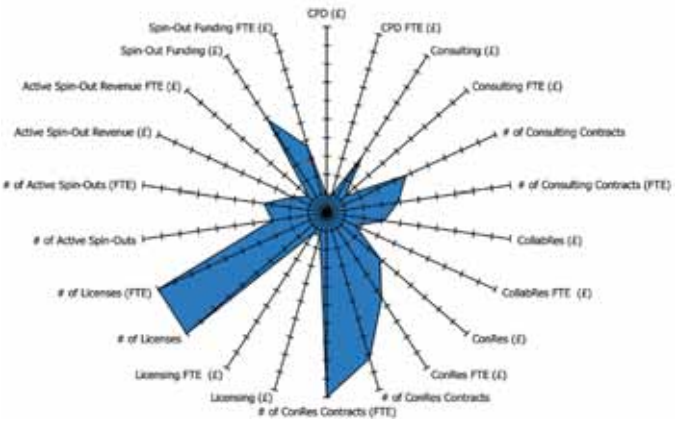
We also classified similar mechanisms of knowledge transfer together, in order to reduce any bias based on the position of mechanisms in the spider graph. For example, collaborative research and contract research are grouped together, whilst licensing and spin-outs are also grouped together.

Each of the spider graphs for these 13 universities is shown in Figure 1.

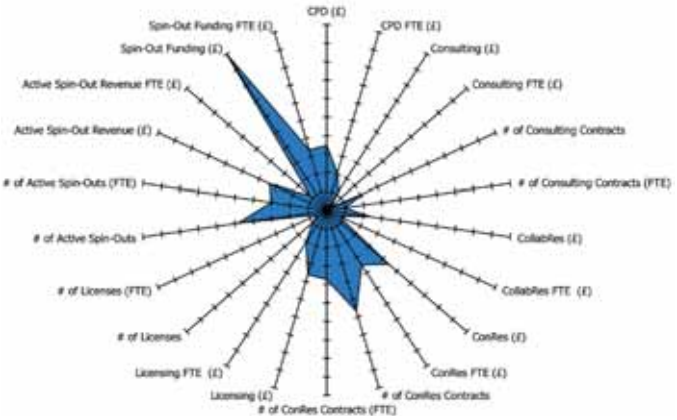
University of Birmingham



University of Southampton



University College London



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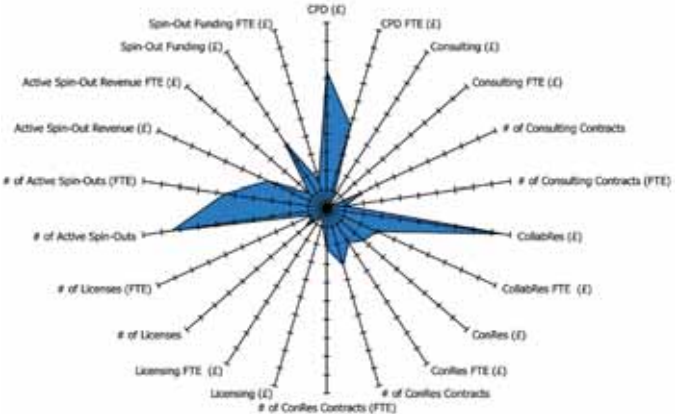

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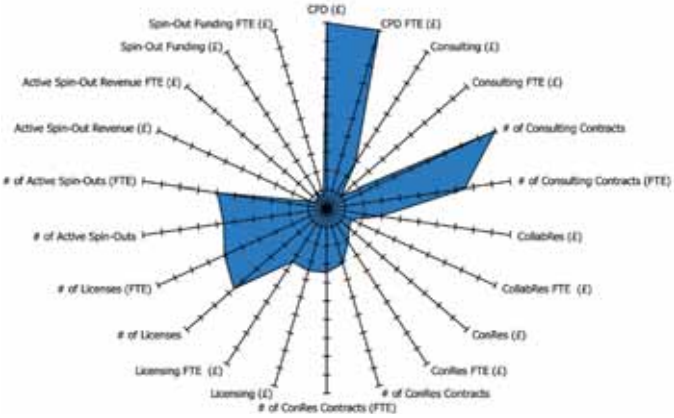

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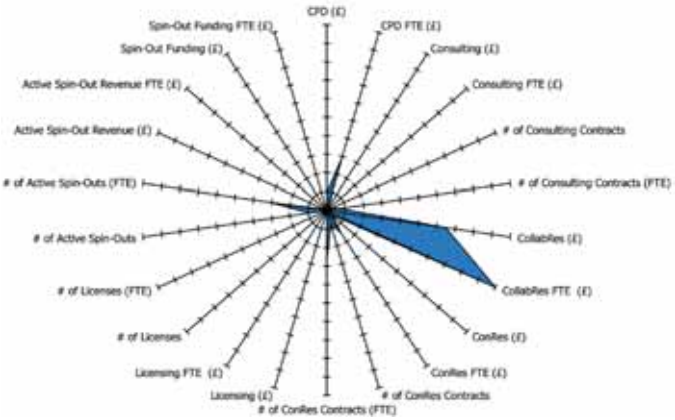

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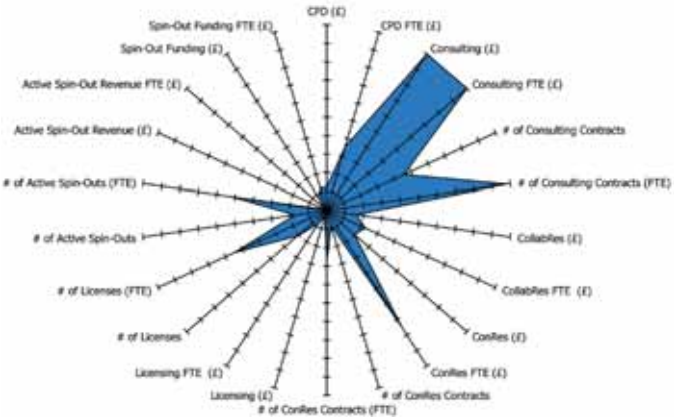

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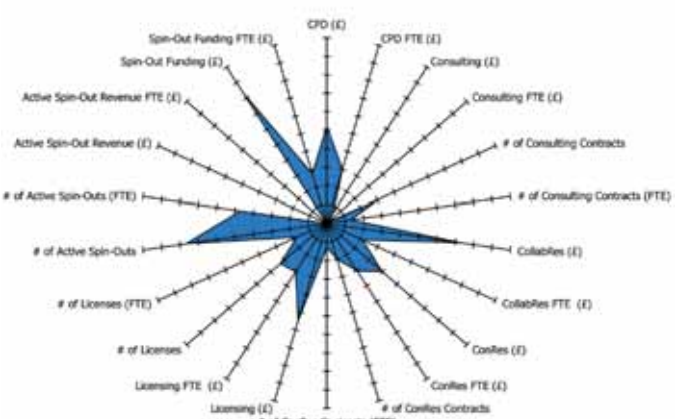
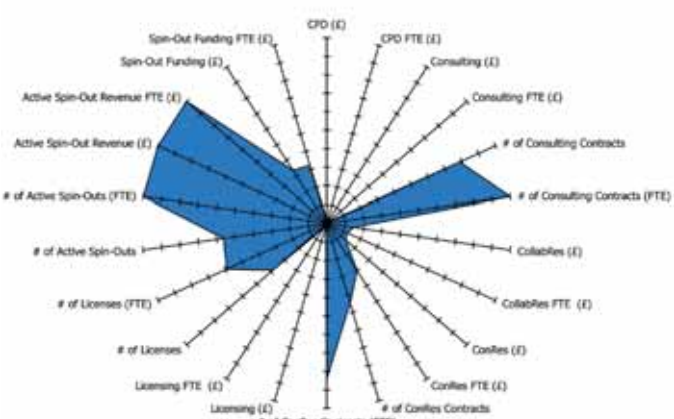


Queen's University, Belfast



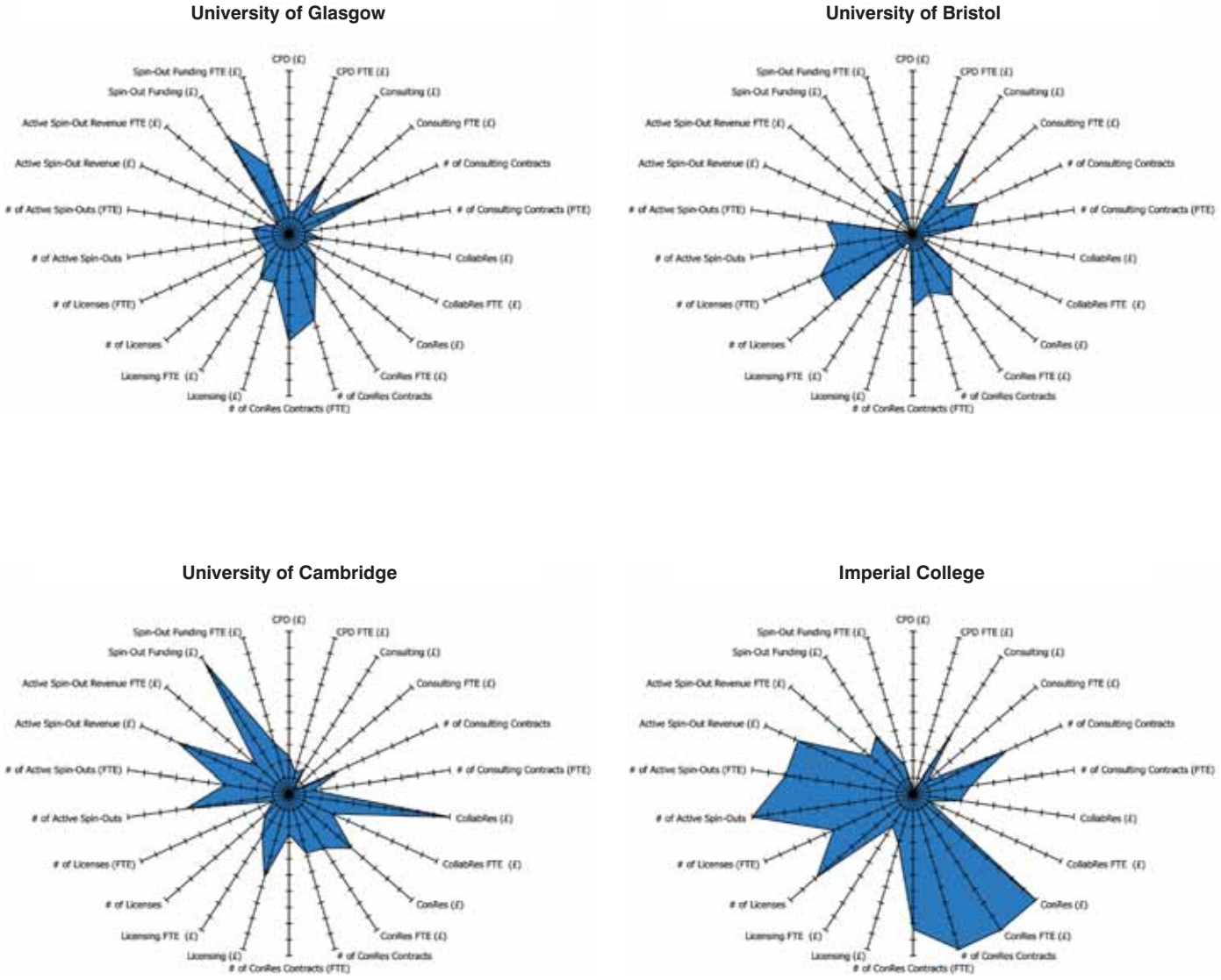


Figure 1 - Spider Graphs for 13 of the 20 UK Universities in our Cohort

The spider graphs reveal that, in general, most of the universities shown tend to focus on a particular measure of one or two different knowledge transfer mechanisms, resulting in a graph area with one to two main peaks.

Examples of these are Birmingham (licensing income and contract research contract number), Southampton (license and contract research contract number), and University College London (spin-out funding).

Cardiff is similar to these universities, being active in one measure of two knowledge transfer mechanisms (CPD income and the number of consulting contracts). However, Cardiff is also half as active as the highest ranked university in terms of the number of active spin-outs, and the number of licences. Manchester, meanwhile, is active in one measure of three knowledge transfer mechanisms (collaborative research income, the number of active spin-outs, and CPD income).

Several universities are more focussed on one area/mechanism of knowledge transfer, to varying degrees. The most extreme example of this is Swansea, which is active at collaborative research, but not much else. This is also true of Surrey, but to a lesser extent than Swansea. Surrey is actively involved in consulting (income (with or without normalisation), and normalised number of contracts). However, Surrey is also 70% as active as the highest ranked university in terms of normalised contract research income, and half as active in the un-normalised consulting contract number, and normalised number of active spin-outs and licenses.

Oxford was actively involved in spin-out activity (the number of active spin-outs, and the funding raised per spin-out), and collaborative research, whilst also moderately active in terms of licensing income. However, it should be noted that, although Oxford performed well in terms of absolute values, it performed less well after normalisation by the number of FTE research staff.

Other universities tend to be active in more than two mechanisms of knowledge transfer. A good example of this is Queen's Belfast, which is actively involved in spin-outs (revenue generated from its active spin-outs and the number of active spin-outs after normalisation), consulting (contract number), and contract research (contract number after normalisation).

This was also true of Glasgow, but to a lesser extent than Queen's Belfast. Glasgow was most active in spin-out activity (funding raised by its spin-outs), contract research (contract number with or without normalisation), and consulting to a lesser extent (contract number).

The University of Bristol was a good all-rounder, being involved in many knowledge transfer mechanisms (i.e. consulting income and contracts, number of licences, and active spin-outs), whilst not being outstanding in any particular one. Amongst all knowledge transfer areas, Bristol was actively involved in consultancy in terms of income (ranked 2nd behind Surrey, and significantly ahead of the others in our cohort). In addition, Bristol was 60% as active as the highest ranked university in the number of licences, nearly half as active in the number of consulting contracts and active spin-outs, and 40% as active in the number of contract research contracts respectively.

Imperial and, to a lesser extent, Cambridge, were particularly good all-rounders, being actively involved in several knowledge transfer mechanisms, whilst still moderately involved in others. For example, Cambridge was active in terms of collaborative research income, and both the funding raised, and revenue generated by its spin-outs. In addition, Cambridge was 60% as active as the highest ranked university in terms of the number of active spin-outs, half as active in licensing and contract research income, 40% as active in the number of contract research contracts, and 35% as active in the number of consulting contracts. However, it should be noted that after normalisation, Cambridge became less active in all of these measures. Nonetheless, Cambridge still appears to be outstanding at knowledge transfer in certain areas, particularly in collaborative research and spin-outs, whilst it is still competitive in other areas such as Licensing and Contract Research.

However, Imperial is perhaps even more consistent than Cambridge in terms of the knowledge transfer activities that it undertakes. Imperial was the most active university in terms of both contract research income (with or without normalisation) and contract number, and the number of active spin-outs. In addition, it was 80% as active as the highest ranked universities in the number of licences and revenue generated from its active spin-outs, 60% as active in the number of consulting contracts, and 55% as active in consulting income. Even in other areas such as collaborative research and licensing income, Imperial was still 30% as active as the highest ranked universities in both areas. Imperial was also generally less active after normalisation, contract research income excepted, but to a lesser extent than Cambridge. Nonetheless, taken together, this suggests that Imperial is a good all-rounder, being actively involved in contract research, spin-outs, and to a lesser extent licensing, whilst still being competitive in consulting and collaborative research.

In conclusion, our results suggest that most of the universities in our cohort are active in one or two mechanisms of knowledge transfer, whilst Imperial, and to a lesser extent, Cambridge, are all-rounders.

It should be noted, however, that a number of university interviewees expressed some concern over these findings, suggesting that the data did not match their own experience or perceptions. We will discuss this in more detail with Unico and seek to understand what some suggest to be a difference between the data and reality.

6.6 Comparison of UK and North American Universities

Our initial benchmark analysis suggests that UK universities are actively involved in knowledge transfer activities.

But how do UK universities compare to those in the US and Canada? A common perception amongst many individuals in both universities and commercial organisations is that the UK is behind the US, which is particularly active at technology and knowledge transfer.

To evaluate how the UK performs relative to the US and Canada in terms of knowledge transfer, we decided to undertake a comparison of the 20 UK universities in our dataset with those in North America. As part of our analysis, we performed a series of telephone interviews with Senior Technology Transfer Officials (STTOs) in 6 US universities. We specifically targeted US rather than Canadian STTOs as there is a perception that US universities are leaders at technology and knowledge transfer and we were thus keen to get their perspectives on how the UK compares with the US. We selected STTOs that have been involved with the Association of University Technology Managers (AUTM) for the interviews as they were one of the partners of this project. Furthermore, these STTOs are likely to be well placed to comment on the state of knowledge transfer activities in US universities, as they are actively involved in the US knowledge/technology transfer landscape through their work with AUTM. The STTOs that were interviewed included the past three AUTM presidents, the current AUTM president and president-elect. We also interviewed an STTO from the Association of American Universities to get a non-AUTM perspective. A full list of the universities and associations that were represented is shown in Table 5.

University/Organisation
University of Yale
University of Arizona
University of North Carolina
Florida State University
Portland State University
Orgeon Health and Science University
Association of American Universities (AAU)

Table 5 – List of US Universities and Organisations whose STTOs participated in the Telephone Interviews

6.6.1 Metrics/Mechanisms of Knowledge Transfer Activities at US Universities

We first sought to determine which mechanisms of knowledge transfer were important for the US STTOs that we interviewed, and whether this differed from those proposed by the UK focus groups. A list of the mechanisms and measures of their quantity and quality that were suggested by our US interview partners is presented in Table 7. The mechanisms and measures that were proposed by the UK focus groups are also included as a comparison.

All of the mechanisms of knowledge transfer that were proposed by the UK focus groups except networks were proposed by at least one of the US STTOs that were interviewed. In addition, publications and the physical migration (movement) of students to industry were also proposed by the STTOs as mechanisms of knowledge transfer. Interestingly, amongst several US STTOs, collaborative and contract research were perceived to be the same thing, as were teaching and CPD, whereas there is a distinct difference between these mechanisms in the UK. As a result, many US STTOs stressed the need for consistency of definitions of the various knowledge transfer metrics between the UK and US.

From our analysis of the definitions of the various metrics used in the knowledge transfer framework, we propose that an international consensus be adopted using the definitions outlined in the framework. This is because there are fundamental differences between collaborative and contract research (e.g. the aim of the research, and the distribution of IP), and teaching and CPD (e.g. the differing aims of each; with teaching focused towards students, and CPD towards professionals seeking development in a specific area), that would be lost if they were amalgamated into groups.

In summary, the US STTOs suggested very similar mechanisms as the UK stakeholders, indicating a high level of concordance as to what should be measured with regards to knowledge transfer. There are differences in the definitions of some knowledge transfer metrics between the UK and US however, which could be addressed by the adoption of a consensus set of definitions along the lines of that suggested in the knowledge transfer framework devised in this report.

6.6.2 Availability of North American Data

Our analysis of UK universities in this report revealed that a significant volume of data on the knowledge transfer mechanisms in our framework is already collected by public sources such as HESA and HEFCE, with only the availability of measures of quality being incomplete.

In contrast, there is no equivalent governmental body such as HEFCE which actively collects publicly available data on the knowledge transfer activities of US or Canadian universities. Given the Bayh-Dole Act of 1980[13], which encouraged universities to participate in technology transfer activities by allowing the retention of IP generated by federally funded research programs as long as they filed a patent, it is likely that US governmental organisations (such as the patent office) collect knowledge transfer data. However, to our knowledge, this data is not publicly available. The only organisation that actively collects data that is publicly available is the Association of University Technology Managers (AUTM), a private, non-profit organisation, through its annual licensing survey. However, this is focused on licensing, although the number of spin-outs formed is also collected.

The Alliance for Commercialization of Canadian Technology (ACCT) performs a similar role in Canada, though the data that is collected is less quantitative than that of AUTM, focusing more on case studies, for example. However, given that data on Canadian universities in also collected in the AUTM licensing survey in a quantitative fashion, we decided to use this data for both the US and Canadian portion of the analysis.

Given that only one US organisation publishes data on a limited range of knowledge transfer mechanisms, the UK appears to be ahead of the US in terms of collecting and publishing a broad range of data on knowledge transfer activities in this respect.

6.6.3 Comparative Analysis of Licensing

Licensing is the main mechanism of knowledge transfer which has data actively collected on US and Canadian universities. We used the AUTM Statistics Analysis for Tech Transfer (STATT) database, which contains data on 214 US and Canadian universities, for our analysis.

6.6.3.1 Measures of Licensing Quantity

In order to measure licensing as a mechanism of knowledge transfer, it was important to have a set of measures of their quantity and quality. Of the metrics proposed by US STTOs (see Table 6), the measures of licensing quantity included:

- Income generated from licences
- Number of licences

Both of these measures were also proposed by the UK focus groups. In addition, the following measures were also proposed by the US STTOs:

- Number of licences to start-ups/spin-outs
- Number of licences to existing companies
- Number of products that arose from licences

We were able to collect data on all of these measures from the AUTM STATT database except for the number of products that arose from licences. Unfortunately, we were unable to source any information about the number of FTE research staff in US and Canadian universities as we were able to do with the UK universities using data from HESA. As a result, we were unable to normalise the US data by dividing university wide figures by the number of FTE staff and thus could not provide a comparison with the normalised UK values. We thus only used values without any normalisation for our analysis.

[13] http://www.autm.net/aboutTT/aboutTT_supportInfo.cfm

Mechanism of Knowledge Transfer	Proposed by US Senior Technology Transfer Officials (STTOS)	Importance	Measures of Quantity	Measures of Quality	Proposed by UK Focus Groups	
					Measures of Quantity	Measures of Quality
Networks	No	9	# of people met at events which led to other Knowledge Transfer Activities	# of people met at events which led to other Knowledge Transfer Activities	n/a	n/a
Continuing Professional Development (CPD)	Yes	5	# of CPD Courses and people that attend, # of companies attending CPD courses	Repeat business, customer feedback	Income from courses	n/a
Consultancy	Yes	4	# and value/income of contracts, # of client companies, hours spent consulting	Repeat business, customer feedback, quality of client company, and importance of client relative to company (i.e. Senior Management or junior employee)	# and value/income of contracts, # of innovative businesses that evolve from consultancy contracts, % of turnover from services/products	Repeat business, customer feedback
Collaborative Research	Yes	7	# and value/income of contracts, geographical proximity of clients to university, % income relative to total research income, length of client relationship	Repeat Business, customer feedback, # of products successfully created from the research, # of licenses that originate from the research	# and value of contracts, market share	Repeat Business, customer feedback, quality of partner company, longevity of partnership
Contract Research	Yes	5	# and value/income of contracts, geographical proximity of clients to university, length of client relationship	Repeat Business, customer feedback	# and value of contracts, market share	Repeat Business, customer feedback, quality of partner company, longevity of partnership
Licensing	Yes	3	# of licenses, # of licenses to start-ups, # of licenses to existing companies, income generated from licenses, # of products that arose from licenses	Quality of Licensee company, potential impact of the technology, repeat business in the form of other knowledge transfer activities, customer feedback	# of licenses, income generated from licenses	Case studies, repeat business, customer feedback
Spin-Outs	Yes	8	# of spin-outs formed, survival rate, amount of external investment raised, quality of investors, # spin-outs that are geographically close to the university	Investor satisfaction, survival rate, amount of external investment raised	# of spin-outs formed, external investment raised, revenues generated, flotation/ exit value	Survival rate/ viability, growth rate, customer feedback
Teaching	Yes	1	Graduation rate of students, rate at which students get hired (in industry)	Student satisfaction (after subsequent employment), employer satisfaction of student, # of podcasts of lectures (or other course material) downloaded	n/a	Commercial skill sets of academics (i.e. marketing, legal, commercial training)
Other Measures	Yes	2	Physical Migration of Students to Industry, Publications as a Measure of Research Output	n/a	Access of academics to high technology equipment, measure of user investment as indicator of success	n/a

Table 6 – Consensus Knowledge Transfer Mechanisms proposed by US University Senior Technology Transfer Officials and Measures of their Quantity and Quality (including those proposed by UK focus groups as a comparison)

6.6.3.2 Measures of Licensing Quality

In addition to the measures of quantity described in the previous section, the US STTOs that were interviewed also suggested several measures of the quality of licensing. These included:

- Quality of the licensee company
- Potential impact of the technology
- Repeat business in the form of other knowledge transfer activities
- Customer feedback

Unfortunately, no data on any of these measures are currently collected by public or private sources in the US or Canada. Although AUTM publishes an annual "Better World Report", which provides case studies on the impact of technologies that arose from universities, these are more descriptive, and as such, would be difficult to use to benchmark a wide sample of universities.

Measuring the quality of the licensee company could also be difficult as it can be subjective. This is also true of customer feedback, though a survey with a scale-based system along the lines of those suggested for the UK in sections 6.3.3.2 and 6.3.6.2 of this report could help to address this. Collecting data on the repeat business in the form of other knowledge transfer activities could also be difficult to achieve, due to the diversity of both the activities that are undertaken and the university departments that measure them.

A proxy of the potential impact of the technology however could be the proportion of licences that generate income/revenue. For example, a university that has a high proportion of licences that generate income suggests that the licensed technologies are having an impact as they are already generating income. One caveat is that this measure does not take into account how much revenue is being generated from the licences. However, this can be addressed if other measures such as the licensing income, number of licences and the average value of each licence, are also taken into account as part of the overall analysis.

6.6.4 Comparison of Licensing Measures

The AUTM licensing survey contains data on licensing measures that are not collected in the UK, such as the number of active licences and licences generating income. However, the UK data set is in a sense more complete, as it includes a breakdown of licensing by sector (i.e. non-commercial, SME, and commercial). Such a breakdown is important in order to provide a more in depth understanding of which universities are the most active in each sector, and how each sector contributes to licensing as a whole.

Furthermore, because the AUTM licensing survey is voluntary, the data set on North American universities can be incomplete. For example, no data was available on Stanford, and given its good reputation in terms of licensing and spin-outs, it is likely to be active in this regard.

Although submission of data by UK universities for the HE-BCI survey is also voluntary, given that HEFCE is a governmental body, universities that do not submit any data may be disadvantaged in the allocation of grants that are partly influenced by such data. In addition, a common opinion of many US STTOs that were interviewed was that there appears to be a general culture of UK universities submitting data to governmental organisations, which is perhaps different to that in the US, where many universities are less willing to submit such data.

As a result, the licensing data for UK universities in the HE-BCI survey is more complete than those available on US and Canadian universities. Nonetheless, given the current state of the US knowledge transfer landscape, AUTM deserves high praise for being the only organisation that collects such a detailed data set.

Our comparison of all of the US and Canadian Universities represented in the AUTM dataset with all UK universities in the HE-BCI survey was limited given the unavailability of data on the number of FTE research staff in US and Canadian universities. Nonetheless, using the available measures, when compared to the UK, although the values for the US universities are generally higher, given the difference in population size and stronger entrepreneurial culture in the US , the UK is competitive.

This is especially the case in terms of the number of licences, the importance of licensing income to the total research income, and market share (in terms of licensing income). For example, three UK universities were ranked in the ten most active US, Canadian and UK universities in terms of the number of licences granted, and four UK universities amongst the ten most active in terms of the importance of licensing income to the total research income of all US and UK universities. In terms of the licensing income market share, four UK universities were ranked in the five most active US, Canadian and UK universities, with six UK universities amongst the ten most active.

This suggests that, although the licensing income received by UK universities is lower in absolute value, which is likely to be influenced by size, in other measures where the absolute value is less important, such as market share, and the importance of licensing income to the total research income, the UK performs competitively with the US and Canada.

6.6.5 Spin-Outs

Spin-outs are an important mechanism of knowledge transfer that was suggested by both the US STTOs and UK focus groups.

6.6.5.1 Measures of Quantity of Spin-Out Activity

Several terms of measures of the quantity of spin-out activity were suggested by both groups. These were:

- Number of spin-outs Formed
- External investment raised

The US STTOs additionally proposed:

- Survival rate
- Number of spin-outs that are geographically close to the university

There are no surveys done by governmental organisations in the US and Canada that collect spin-out data, like HEFCE and its HE-BCI Survey. AUTM is the only organisation that collects any data on spin-outs (number of spin-outs formed) through its annual licensing survey.

Some of the measures proposed by the US STTOs such as the survival rate, the external investment raised and number of spin-outs that are geographically close to the university could however be incorporated into future surveys.

The number of spin-outs that are geographically close to the university is an interesting measure of quantity that was proposed by the US STTOs. This theme also extends to many other knowledge transfer measures such as collaborative and contract research (see Table 7). One explanation for the focus of US STTOs on geography is the different structure of research funding in the US compared to the UK. In the UK, the bulk of research funding is provided by the UK government through national research councils such as the Medical Research Council and Economic and Social Research Council etc. In comparison, US universities can receive funding through their state governments in addition to the federal government (and other sources such as charities).

As a result, there tends to be a greater focus on the geographical location of client companies or spin-outs, because it is in the best interests of the funding bodies to ensure that the impacts of their funding, economic or societal, stay within the region. In the UK, this is less of an issue, given the geographical independence of the funding bodies, and its smaller geographical size.

6.6.5.2 *Measures of Spin-Out Quality*

Several measures of spin-out quality were suggested by the US STTOs that were interviewed. These were:

- Investor (customer) satisfaction
- Quality of investors
- Survival rate
- Amount of external investment raised

None of these measures are collected by any governmental or other organisations in the US and Canada. The measures were similar to those proposed by the UK focus groups, except for growth rate, which was not proposed by the US STTOs.

Interestingly, the amount of external investment raised, which was proposed as a measure of quantity by the UK focus groups, was proposed as both a measure of quality and quantity by some of the US STTOs. This is an important distinction, as a spin-out that raises a high amount of external investment is likely to be of high quality, since an external company would not have invested that amount of funding unless it believed the company will be successful and make an impact (and also generate a significant return on investment). In fact, given this, one of the US STTOs, Jon Soderstrom of Yale University, likened external investment to be the equivalent of peer review for spin-outs, which is an interesting and innovative interpretation of external (i.e. venture capital) funding.

The quality of investors can also be a good measure of the potential impact of a spin-out. For example, a high quality venture capital firm would be unlikely to invest in a spin-out that it didn't perceive as eventually being successful and making an impact in its respective sector. However, given that this measure is subjective, collecting such data could be difficult. A potential solution could be to classify investors based on the number of deals they have had, the number of successful companies they have invested in, or the average return on investment, although this could also be difficult to collect given that most investors are in the private sector.

Investor/customer satisfaction is another measure of spin-out quality that was suggested by the US STTOs (and UK focus groups). As discussed in our analysis of UK spin-out activity (see section 6.3.7.2), such a measure would be challenging to incorporate into future surveys, as the clients of the spin-outs would have to be contacted, which would likely be difficult to achieve.

6.6.5.3 *Comparison of Available Data and Spin-Out Activity of North American Universities with the UK*

Compared to the UK, our analysis suggests that the volume of data currently collected on the spin-out activity in North American universities could be improved. Only AUTM publishes any data on spin-outs (the number of spin-outs formed) through its licensing survey. In comparison, HEFCE, through its HE-BCI survey, collects a wide variety of data such as the number of spin-outs formed, the number of active spin-outs, and the estimated revenues generated. This suggests that the UK is ahead of the US and Canada in this regard at this point in time. It should be noted that AUTM is actively moving to collect more spin-out data in future surveys, having collected more comprehensive spin-out data in this year's survey compared to previous surveys. This will improve the volume of data that is available on North American universities in the future.

A comparison of North American universities with their UK counterparts suggests that the UK performs competitively, though we were unable to provide any normalisation by university size due to the lack of available data on the number of North American FTE university research staff. Nonetheless, our analysis suggests that the top five UK universities in terms of spin-out formation would be ranked in the top ten US and Canadian universities, with Imperial, the most active UK university, being ranked joint 5th. However, given the lack of available measures, we were unfortunately unable to make any further comparisons between the US and the UK.

6.6.6 *Views of US STTOs on the State of Knowledge Transfer Activities*

As part of the interviews with the US STTOs, we asked them what they thought of the state of knowledge transfer activities in the US compared to the UK. Interestingly, the consensus opinion from the STTOs that were interviewed was that although the US has traditionally been perceived to be more advanced than the UK, this is no longer true. In fact, many believed that the US should now be following the UK in terms of how knowledge transfer is conducted.

Mark Crowell of the University of North Carolina stated that he believed that the UK government has played an important role in the development of knowledge transfer in the UK, through the commissioning of reports such as this one, for example, as well as through its funding of research, which doesn't happen to the same extent in the US. In addition, he believed that the UK was better in terms of forming spin-outs, and in networking.

John Fraser of Florida State University stated that in general, the UK is more active at knowledge transfer than the US. In addition, Dana Bostrom of Portland State University stated that whilst the US tends to only focus on technology transfer rather than knowledge transfer, the UK measures more knowledge transfer mechanisms. In that sense, she believed that the US can learn from the UK, and is "quite excited about the state of knowledge transfer in the UK". The more advanced state of measuring knowledge transfer activities in the UK compared to the US was echoed by Pat Jones of the University of Arizona, who also stressed the need of the US to clearly define a set of metrics of knowledge transfer and the best ways to measure them.

Taken together, these views suggest that, compared to the US, the UK is advanced in both the measurement and variety of knowledge transfer activities that are undertaken in UK universities.

7 Summary and Conclusions

This study arose from a need to define a framework to measure the success and impact of knowledge transfer activities in UK universities. The need to measure knowledge transfer is growing more important given the focus of funding bodies in the UK, and even society in general, to determine the success and impact of knowledge transfer in the broader economic landscape.

Furthermore, the lack of any studies that directly deal with the complete sphere of knowledge transfer activities in UK universities adds to the need to determine metrics to measure the impact and success of these activities. We believe that this report will have wide reaching implications in the way that knowledge transfer is measured in UK universities and the way that they are collected in surveys such as those done by HEFCE, as well as affecting public policy development.

7.1 A Model of Knowledge Transfer within the Innovation Ecosystem

One of the original aims of this report was to determine metrics to measure the success and impact of knowledge transfer in the broader economic landscape. But where does knowledge transfer fit in this landscape? To that end, Kevin Cullen, Director of Research and Enterprise at the University of Glasgow, has proposed a model of knowledge transfer to place it within the broader economic and research (or innovation) landscape. This model is shown in Figure 2.

In this model, knowledge transfer activities are effectively in the middle of this innovation system, with research, from which knowledge originates, at one end, and economic activity and impact at the other.

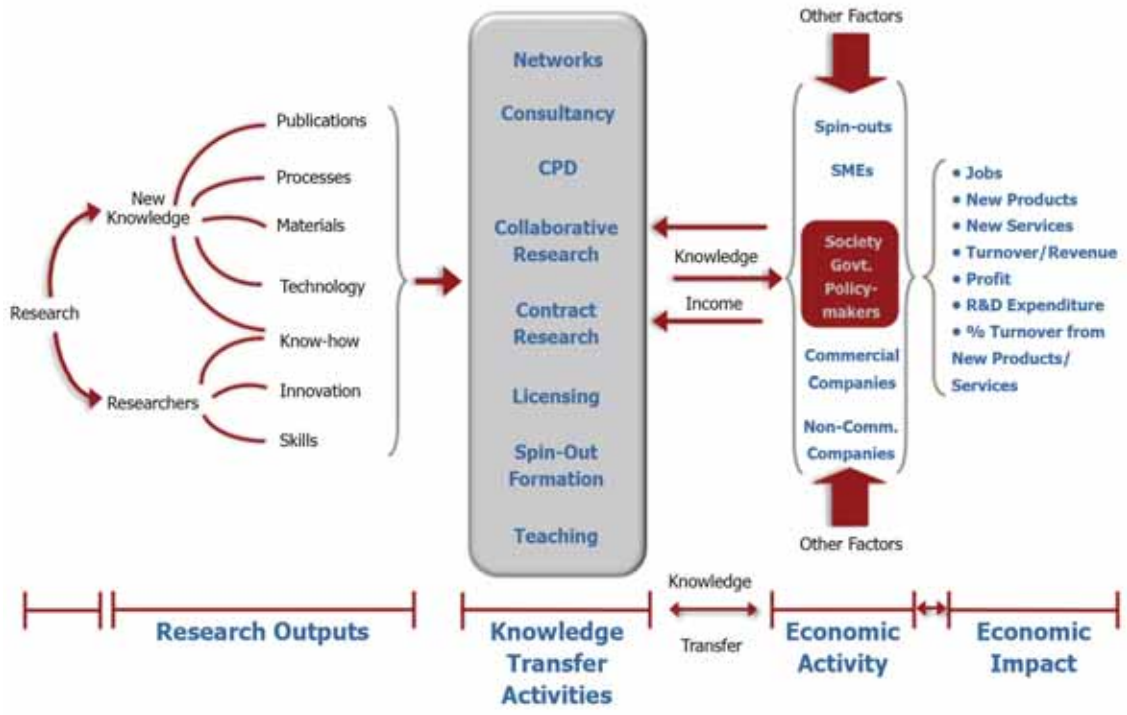


Figure 2 – Model of Knowledge Transfer within the Innovation Ecosystem (Source: University of Glasgow)

Research at universities has two major outcomes, the creation of new knowledge, in the form of publications, new processes, materials, technology and "know-how", and an increase in the knowledge of researchers through enhanced skills, innovation and "know-how" that arose from the research that was undertaken.

All of these are types of research outputs, and form the basis for knowledge transfer. Through networks, consultancy, CPD, collaborative research, contract research, licensing, spin-out formation and teaching, this knowledge can be transferred to other sources such as SMEs, commercial and non-commercial organisations, spin-outs, government, policy-makers, and society in general. This typically involves a flow of income, resulting in economic activity.

Importantly, the knowledge transfer can occur in both directions between universities and organisations. In addition, there are a myriad of other external factors that can impact on the economic activity related to knowledge transfer, such as the general economic climate, market forces, competition within the industry, and consumer sentiment.

The economic activity that results from the knowledge transfer activities with spin-outs, government, commercial organisations, etc. can then create an economic impact, in the form of job creation, new products and services, research and development expenditure, turnover and profits for organisations, and the percentage of turnover that arises from new products/services.

This model shows that there is a clear link between university research and economic impact, but that this link is non-linear and extremely complex, being subject to major external influences. Furthermore, the model also shows that university knowledge transfer activities do not directly create economic impacts, but rather help other actors in the system to create economic impacts. This explains why a simple measurement of the economic impact is far from straightforward within what is effectively a 'chaotic' system which can operate over years or even decades. The model also explains why case studies (looking back down the system from economic impacts) are relatively straightforward to do, but that they are very limited in helping to predict future outcomes or inform policy.

From these considerations, the important question that arose from our focus groups was what universities should measure, the knowledge transfer activities themselves, or their economic impact? The common consensus amongst all stakeholders is that universities should focus on measuring the knowledge transfer activities that they undertake, using the quantity and quality of these as the key measures. This is a key conclusion from this work and the degree of consensus from the focus groups was very strong. It confirms, to a significant extent, the approach to measuring knowledge transfer that has been adopted in the UK to be the best approach available.

To provide a balanced analysis as to what universities should measure with regards to knowledge transfer, we next determined what is meant by impact in the context of knowledge transfer. This is discussed in the next section in more detail.

7.2 Defining and Measuring Impact in the Context of Knowledge Transfer

To determine what is meant by impact in terms of knowledge transfer, it was necessary to firstly define impact and secondly place it in the context of knowledge transfer. To that end, we have we have built on work previously done by the New Economics Foundation (NEF) and London Business School (LBS) to define and measure social impact and the social return on investment (SROI) in the not-for-profit sector[17]. The NEF/LBS study further developed work done by the original creators of the SROI concept, the Roberts Enterprise Development Fund, a US not-for-profit organisation[18].

We have adapted this social impact model to clarify what is meant by impact in the context of knowledge transfer, and how to measure it. This knowledge transfer impact model, which is shown in Figure 3, is from the perspective of the universities, given that they are responsible for performing the actual knowledge transfer.

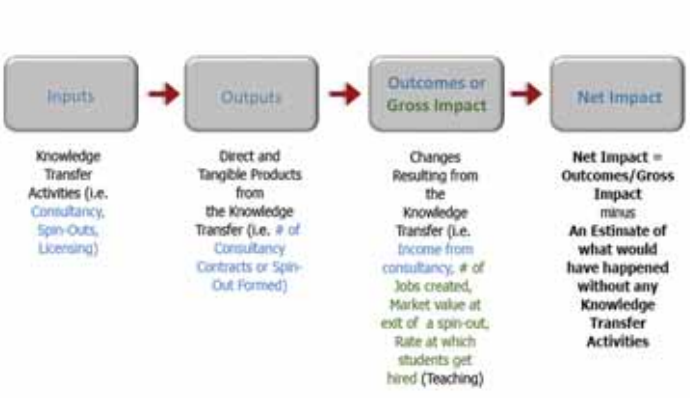


Figure 3 – Model of Impact in the Knowledge Transfer Ecosystem

This shows that impact can be split into two types, gross impact and net impact. Both originally result from an input, which, in this case, is a particular knowledge transfer activity of a university, (e.g. consulting or licensing). This input results in an output, which is defined as a direct and tangible product from the knowledge transfer, for example, the number of consultancy contracts.

The output then results in either an outcome or gross impact. Both are defined as changes resulting from the knowledge transfer, but differ in terms of their aim. Outcomes tend to be more direct, for example, the income that a university receives from a licence, whilst gross impact is more indirect, and tends to be more downstream. If we take the case of licensing, an example of gross impact would be the number of products that arose from licensing, which is one of the measures in our knowledge transfer framework. Other examples in our knowledge transfer framework are the market value at exit of a spin-out, the rate at

[17] http://www.neweconomics.org/gen/newways_socialreturn.aspx
[18] http://www.redf.org/publications-sroi.html

which students get hired (with respect to teaching) and market share from the income of knowledge transfer activities.

Although market share (i.e. from collaborative research, consulting or licensing income), is classified as gross impact, the income that it underpins is instead an outcome. This is because the income directly benefits the university, whereas a large market share that arises from that income, for example, suggests that the university is having an impact in the particular knowledge transfer mechanism, something which is not reflected in the income alone.

Finally, outcomes or gross impact result in net impact. Net impact is defined as the outcomes or gross impact subtracted from an estimate of what would have happened had there not been any knowledge transfer (i.e. any input, output, outcome or gross impact). For example, if the formation of a spin-out results in the creation of fifteen jobs, then the gross impact would be fifteen jobs. However, if ten of these employees would have been employed elsewhere regardless of whether the spin-out was formed or not, then the net impact is only five jobs.

This makes net impact difficult to measure, as it is difficult to estimate what would have happened had the knowledge transfer not taken place. If we take the example of a spin-out, if the company had never been formed, and the technology had instead been licensed to a commercial organisation, for example, would more jobs have been created? How do we measure or estimate this? This suggests that measuring gross impacts and outcomes would be significantly easier and more accurate, as they are not subjected to factors that are estimated.

The general consensus amongst the different stakeholders was that although measuring economic impact could be desirable, given the significant number of external variables that could influence economic impact, universities should primarily focus on measuring the knowledge transfer activities which they are directly involved in.

However, what sort of economic impact is meant, gross economic impact or net economic impact? Our analysis suggests that if impact is measured, then gross economic impact, which is significantly easier to measure than net economic impact, should be used.

Interestingly, a closer examination of the knowledge transfer framework devised by the stakeholders reveals that many measures of what is defined as “economic impact” in Figure 2 will actually be measured by the knowledge transfer framework, as gross economic impact. This includes measures such as the revenues generated and the market value at exit of spin-outs, the rate at which students get hired (teaching), and the number of products that arose from licences.

Taken together, this suggests that, using the framework devised by the knowledge transfer stakeholders themselves, universities should focus on directly measuring outputs and outcomes of knowledge transfer, as well as some aspects of gross economic impact, but not net economic impact, as it is subjected to factors that are estimates at best.

7.3 Developing a Sufficient Framework

An important part of this study was developing a framework to directly measure the impact and success of the knowledge transfer activities in UK universities. To determine a consensus set of knowledge transfer mechanisms and measures that would comprise the framework, we held focus groups with the three major stakeholders of knowledge transfer activities in universities, the research funders, the senior university management, and the business community. As a result of these focus groups, an unbiased framework representing the views of all stakeholders was created that was sufficient to measure the knowledge transfer activities in universities.

Interestingly, the set of mechanisms of knowledge transfer that were proposed independently by the three stakeholders were highly similar, suggesting a high level of concordance between the stakeholders as to what we should measure. Furthermore, data on many of these knowledge transfer mechanisms are already available from public sources (e.g. HE-BCI survey), suggesting that the UK is on the right path with regards to the measurement of knowledge transfer.

As part of our analysis, we also included a comparison of the UK with the US and Canada. This included interviewing several Senior Technology Transfer Officials (or STTOs) in the US, resulting in the creation of a separate knowledge transfer framework. This framework was similar to that developed with the UK focus groups, with only minor differences in the measures suggested.

Following our analysis of the available UK data and both frameworks, we have come up with a set of measures of both the quantity and quality of the knowledge transfer mechanisms, which is presented in Table 7. We believe that this framework should be sufficient to accurately evaluate the knowledge transfer activities in UK universities and measure their success and impact.

7.4 Conclusions from Analysis of UK Universities and their Comparison to the US

To test the validity of this knowledge transfer framework, we performed an initial benchmarking analysis on a sub-set of 20 UK universities using available data sets. These included data from public sources such as HESA, UNICO and HEFCE, which publishes the HE-BCI Survey, and from private sources such as our internal Library House dataset on spin-out companies. We also compared these UK universities with those in the US and Canada, using privately available data published by AUTM in its annual licensing survey.

7.4.1 Performance of UK Universities in Knowledge Transfer Activities

Our analysis of the knowledge transfer activities in UK universities using our framework suggests that the UK is actively involved in knowledge transfer. From the 20 universities in our cohort that geographically represent the most active universities in research and knowledge transfer, most tend to focus on one or two mechanisms of knowledge transfer (e.g. Surrey, Swansea,

Birmingham, Southampton, and University College London), whilst others (e.g. Manchester and Queen's Belfast) are focused on three mechanisms. Universities such as Imperial, and Cambridge, to a lesser extent, were good all-rounders.

However, we were unable to make a complete evaluation of the knowledge transfer activities of UK universities due to the lack of availability of measures of quality on these activities. Thus, our analysis is currently biased towards the quantity of knowledge transfer, though as more data on quality becomes available in the future, a full evaluation of both the quantity and quality of knowledge transfer should become possible.

7.4.2 Comparison of Knowledge Transfer Measures collected in the UK with the US

Our evaluation of the availability of knowledge transfer measures in the UK suggests that a significant amount of data is already collected, with the UK ahead of the US in this regard. Only one US organisation (AUTM) collects any form of knowledge transfer data compared to several in the UK, such as HEFCE, HESA, UNICO and the Scottish Funding Council (KTG Scheme).

Furthermore, as the organisations that collect knowledge transfer data in the UK are governmental bodies that fund academic research, the variety and volume of available data is significantly more than that collected by AUTM, which, being a private organisation, cannot apply any such governmental pressure.

However, AUTM should be commended for providing the only source of data on knowledge transfer on US and Canadian universities. AUTM is also in close collaboration with UNICO, and could thus broaden its survey to include more mechanisms of knowledge transfer following the outcomes of this report. Such a move could greatly increase the volume of available data to measure knowledge transfer activities in universities in the US.

7.4.3 Performance of UK Universities compared to those in the US and Canada

As part of our analysis, we also included an international comparison with US and Canadian universities. Unfortunately, it was difficult to comprehensively compare the UK to the US and Canada due to a lack of available data on the knowledge transfer mechanisms and the number of full time equivalent research staff in North American universities. We were only able to analyse data on licensing and spin-out formation, which we obtained from the AUTM licensing survey.

Nonetheless, from the available measures of licensing and spin-out formation, our analysis suggests that the UK is competitive given its size. In terms of licensing, although the absolute values for the most active North American universities were 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 with the US and Canada. The UK was also competitive in terms of spin-out formation.

Mechanism of Knowledge Transfer	Measures of Quantity	Measures of Quality
Networks	# of people met at events which led to other Knowledge Transfer Activities	% of events held which led to other Knowledge Transfer Activities
Continuing Professional Development (CPD)	Income from courses, # of courses held, # people and companies that attend	% of repeat business, customer feedback
Consultancy	# and value/income of contracts, % income relative to total research income, market share, # of client companies, length of client relationship	% of repeat business, customer feedback, quality of client company, importance of client relative to their company
Collaborative Research	# and value/income of contracts, market share, % income relative to total research income, length of client relationship	% of repeat Business, customer feedback, # of products successfully created from the research
Contract Research	# and value/income of contracts, market share, % income relative to total research income, length of client relationship	% of repeat Business, customer feedback, # of products successfully created from the research
Licensing	# of licenses, income generated from licenses, # of products that arose from licenses	Customer feedback, quality of licensee company, % of licenses generating income
Spin-Outs	# of spin-outs formed, revenues generated, external investment raised*, market value at exit (IPO or trade sale)	Survival rate, quality of investors, investor/ customer satisfaction, growth rate
Teaching	Graduation rate of students, rate at which students get hired (in industry)	Student satisfaction (after subsequent employment), employer satisfaction of student
Other Measures	Physical Migration of Students to Industry, Publications as a Measure of Research Output	

* this measure was analysed in the report using an internal Library House data set

Table 7 – Knowledge Transfer Framework sufficient to measure the Success and Impact of Knowledge Transfer Activities in UK Universities (measures that are not currently collected are highlighted in blue)

7.5 Potential Measures to be collected

Although the data that is currently collected from public sources such as HEFCE and HESA is already particularly good, the measures that are available are however mostly of quantity. The measures in our set of metrics where data are not collected are italicised in blue in Table 7. Notable exclusions from the current measures of quantity data set include the number of collaborative research grants, the external investment raised by spin-outs and their value at exit, and the length of the client relationship for consultancy, collaborative and contract research.

Although more focus has been evidently placed on measurements of the quantity of knowledge transfer activity, measuring quality is also important in order to provide a comprehensive view of the knowledge transfer activities of a university. In many cases, measuring quality can be a good indicator of the success and impact of the knowledge transfer activities undertaken by universities, and as such, should be incorporated into future surveys.

Measures of quality such as the percentage of repeat business, the number of products successfully created from the research, the percentage of licences generating income, and the survival rate of spin-outs are already collected by universities, and as such could be incorporated into future surveys with little difficulty. However, as discussed in the next section, more subjective measures such as customer feedback and the quality of the client company may be more difficult to include in future surveys without adopting a more quantitative approach to measuring these.

7.6 Next Steps towards refining the Measures

This report has provided a useful first step in determining a set of metrics to measure the knowledge transfer activities undertaken in UK universities, including measures of their quantity and quality. In order to build on the work done in this report, we propose that further analysis of the measures of quantity and quality of the knowledge transfer mechanisms suggested by the stakeholder groups should be performed in collaboration with the stakeholders.

More specifically, in terms of the measures of quantity in our knowledge transfer framework, a time series analysis should be performed to better understand any limitations in these measures. For example, measures such as licensing income and spin-out formation can vary over time, so would more appropriate measures of these be an average income or the number collected over several (e.g. 2, 3, 4 or 5) years?

With regards to the measures of quality, further work should be performed in collaboration with the stakeholders to determine how best to collect the outstanding measures of quality. This is especially important with regards to more subjective measures such as customer feedback. This could include further consultation with stakeholders as to how customer feedback should be measured, for example, through the creation of a consensus set of well defined questions designed to evaluate customer feedback in a quantitative fashion. This could also be administered on-line across all UK Higher Education Institutions in a similar fashion to the National Student Survey developed by HEFCE, which measures the quality of students' courses. A pilot test of these new measures of quality should also be undertaken to validate their usefulness and suitability in the broader knowledge transfer ecosystem.

7.7 Final Conclusions

The UK is well placed with regards to both the pursuit and measurement of knowledge transfer activities in our universities. A significant volume of data is already collected on a wide variety of knowledge transfer mechanisms, with UK universities being active at many of these mechanisms. Furthermore, the UK is ahead of the US and Canada in terms of measuring knowledge transfer activities, and is also competitive in terms of licensing and spin-outs, which were the only two measures where North American data was available and a comparison thus possible.

In this report, we have created a knowledge transfer framework to measure the knowledge transfer activities in UK universities. This framework arose through focus groups with the three major stakeholders of knowledge transfer in the UK, and telephone interviews with several senior technology transfer officials (STTOs) in the US. Importantly, the metrics and measures of knowledge transfer quantity and quality were suggested by the stakeholders, allowing the creation of a consensus framework that best reflected the views of all those most closely involved with knowledge transfer.

With a few minor additions to the measures of knowledge transfer activities already collected by these organisations, the UK should have a world class set of measures and metrics that will measure the impact and success of knowledge transfer, and that other countries will follow.

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Abbreviations

ACCT	Alliance for Commercialization of Canadian Technology
AUTM	Association for University Technology Managers
CE	Continuing Education
CPD	Continuing Professional Development
DIUS	Department for Innovation, Universities and Skills
FTE	Full Time Equivalent
HE-BCI	Higher Education - Business and Community Interaction
HEFCE	Higher Education Funding Council for England
HEI	Higher Education Institution
HEIF	Higher Education Innovation Fund
HESA	Higher Education Statistics Agency
IP	Intellectual Property
IPO	Initial Public Offering
KTG	Knowledge Transfer Grant
RCUK	Research Councils UK
SFC	Scottish Funding Council
SME	Small to Medium Enterprise
STATT	Statistics Analysis for Tech Transfer
STTO	Senior Technology Transfer Official
UNICO	The University Companies Association