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Monitoring the knowledge transfer performance of universities: An international comparison of models and indicators

by

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Abstract

This paper discusses how to appropriately monitor and assess the performance of universities' knowledge transfer activities. We argue that different knowledge transfer activities, based on different models of how knowledge flows from university to industry, require different indicators for monitoring. We then compare, in light of these different models, four monitoring exercises currently implemented in the UK, US and Canada, Australia and Europe. We derive some specific implications for the measurement of universities' performance as well as some more general implications for the assessment of policies in support of knowledge production and transfer.

Key words: University-industry knowledge transfer, knowledge transfer indicators, models of knowledge transfer, Higher Education Business Interaction survey, Association of University Technology Managers survey.

JEL codes: O31 Innovation and Invention: Process and Incentives, O32 Management of Technological Innovation and R&D, O33 Technological Change: Choices and Consequences Diffusion Processes, O34 Intellectual Property and Intellectual Capital

Introduction

At least since the 1980s, a consensus has emerged among economists and policymakers on the central role of knowledge production and accumulation as a key stimulus to economic growth (Romer 1990). In the new knowledge based economy, intangible investment in the production of knowledge – through the funding of R&D and human capital formation – plays a crucial economic role in order to increase the economy's productive resources, just as physical capital did in the old industrial economy.

Public intervention is often required to ensure that a sufficient amount of knowledge is produced and transferred[1]. For example, governments often fund research carried out in universities and in public research organizations, support firms' investment in innovation and research, promote various kinds of dissemination and knowledge transfer activities in order to ensure that new scientific discoveries are diffused and implemented. Evaluating the success of these government interventions is therefore a very important issue in the knowledge-based economy. It is not coincidental that a policy debate has emerged about how to set up appropriate systems to monitor the extent to which the beneficiaries of public funds are able to produce and transfer knowledge successfully, and to assess the impact of their activities.

This is, however, a complex task. Not only is knowledge intangible and inherently difficult to measure, but different views and theories about 'what is' knowledge and how best it should be produced and transferred coexist, each of which would suggest different approaches to measuring success in knowledge production and transfer. Choosing the appropriate metrics for performance measurement is particularly crucial because indicators are recognized to play a performative role (Merry 2011; Davis et al. 2010): they signal which behaviours are considered important by policymakers, and which ones may carry implicit rewards, such as better reputation and prestige. As such, they can potentially influence the behaviour of the organizations that are monitored.

[1] '…Knowledge transfer is about transferring good ideas, research results and skills between universities, other research organisations, business and the wider community to enable innovative new products and services to be developed' (Department for Trade and Industry, UK 2006).

This paper discusses how to appropriately measure the effectiveness of public interventions in support of knowledge production and transfer, by focusing on the monitoring and performance assessment of universities' knowledge transfer activities. This analysis allows us to derive some specific implications for the measurement of universities' performance as well as some more general implications for the assessment of policies in support of knowledge production and transfer.

Models of knowledge transfer and their implications for the choice of performance indicators

The increasing importance and visibility of universities' knowledge transfer activities

As universities are among the most important producers of new knowledge, their contribution to processes of economic growth and development in the knowledge-based economy has become more prominent and more debated. Universities are no longer seen as 'ivory towers' where knowledge production is sought purely as an intellectual endeavour detached from practical and commercial applications, but as active agents of economic development (Etzkowitz and Leydesdorff 2000). For most universities, knowledge transfer has become a 'third mission' which complements the traditional research and teaching activities and has gained increasing prominence.

Consequently, ensuring the efficient transfer of academic knowledge to the economic system - so that it can be productively incorporated into the knowledge bases of firms and other organizations and used to generate further innovations, driving productivity increases and opening up new markets - has become an important policy objective. For example, in the United Kingdom, the government has launched a stream of funding (the Higher Education Innovation Fund, or HEIF, appropriately referred to as 'third stream' funding) in order to promote knowledge transfer from universities (Kitagawa and Lightowler 2012; Molas Gallart and Martinez 2007). In other countries, support for knowledge transfer activities takes place through national project-based funding (for example in Spain; Molas et al. 2007) and support for the development of a knowledge transfer infrastructure, whether at national level (as in Sweden; Sellenthin 2006), at regional level (as in Germany; Sellenthin 2006) or at State level (as in the US; PACEC 2010).

In order to evaluate the impact of public programmes and to identify whether further interventions are required, policymakers in many countries have launched monitoring and assessment initiatives, which often consist of systematic data collection exercises requiring universities to provide quantitative information about their engagement in several activities. In the US and Canada, the Association of University Technology Managers (AUTM) runs a yearly survey of the technology transfer offices of about 200 research universities, mainly focused on technology commercialization activities. In Europe, several associations of technology transfer professionals such as the European Knowledge Transfer Association (ProTon) and the Association of European Science and Technology Transfer Professionals (ASTP) organize their own surveys, usually addressed to the associations' members. Individual countries in Europe organize data collection exercises too. For example, in Spain the Conference of University Rectors distributes an annual survey to the technology transfer offices of universities and public research organizations (Molas Gallart and Martinez 2007). In the UK a comprehensive survey (Higher Education Business and Community Interaction survey, henceforth HE-BCI) currently managed by the Higher Education Statistics Agency is distributed yearly to all universities in the country; the results are used to allocate third stream funds to universities. The Australian government runs a biannual survey of universities and public research institutes, and it is currently debating the implementation of indicators similar to those used in the UK (Jensen et al. 2009) [2].

Despite the importance of this issue, the choice of appropriate indicators is largely shaped by practical and empirical considerations. In this section, we propose a theoretical discussion both of the different views of knowledge that often implicitly drive the choice of current indicators, as well as of what are the desirable features of indicators. In the following section, we then examine, in light of this theoretical analysis, the indicators currently used by several international data collection exercises.

[2] See European Commission (2009) for a comprehensive international list of current university knowledge transfer data collections.

Different knowledge transfer models

Universities transfer knowledge to external stakeholders in many ways. Even in abstract terms, several possible models of knowledge production and transfer have been identified, according to the nature and properties of knowledge considered (Wang and Peng 2009).

When knowledge is perfectly codified (that is, it has the nature of ‘information’; Stiglitz, 2000), and therefore easily transferrable from one person to another, it shares some features with public goods: differently from tangible goods, it is non rival, because its use on the part of one person does not prevent another person from using it at the same time; and it can be difficult to prevent anyone, including those who have not paid for it, from using it, since it can be transferred rapidly and its marginal cost of reproduction is almost zero (Arrow 1962). This generates a market failure: as knowledge creates positive externalities in the economy, competitive markets do not create sufficient incentives for private agents to produce the amount of knowledge that would be optimal for society (Nelson, 1959).

The market failure in knowledge production can be overcome through government intervention: the government provides public funding for research (by funding universities and public research institutes), and demands that the outputs that result from it are openly disseminated, in the form of publications, reports, books, blueprints, manuals, computer codes, presentations and so on (Antonelli 2008b; Dasgupta and David 1994). This model – which we can call the *public knowledge* model – is consistent with the objective to maximize knowledge externalities, and with the assumption that no support mechanisms are needed in order to incentivize knowledge transfer: as knowledge is considered akin to perfectly codified information, economic agents are assumed to be perfectly able to understand it and implement it once it is placed in the public domain.

Another approach to overcoming the market failure in knowledge production is the set up of a system of intellectual property rights. The intellectual property rights system generates at least two types of incentives (Andersen 2004; Mazzoleni and Nelson 1998): the incentive to invest resources in knowledge production (by allowing those who produce knowledge to obtain an adequate economic reward for their efforts) and the incentive to transfer knowledge from one agent to another (by allowing knowledge to be commercialized, for example in the form of patents, copyright, trademarks, design rights that can be sold or licensed). The second incentive is the most relevant in the case of university-generated knowledge (Mowery and Sampat 2005; Schacht 2005). Once intellectual property rights are applied, knowledge is transformed into a quasi-private good for which markets arise spontaneously (Dasgupta and David 1994)[3] – we can call this the *proprietary knowledge* model of knowledge transfer.

The view of knowledge as information conceptualizes knowledge transfer as a uni-directional and linear process where the knowledge creator (the university) provides certain ‘output’ to another party. Therefore, measuring knowledge transfer performance involves quantifying that output – how much output is transferred, to how many users, what is its value. Since this approach presumes that information does not change in the course of the transfer process, the amount of information that is made available and the number of users who have accessed it are considered good measures of the amount of information that is actually received: this suggests that appropriate metrics for universities’ intensity and impact of knowledge transfer would be, for example, the number of publications made, accessed and cited, the number of patents and other IPR filed, sold and licensed. It also presumes that the price at which knowledge is sold (or, in case of publicly funded knowledge, the price that the government pays in order to fund it) clearly reflects its value to the user, hence the income that universities derive from knowledge transfer is considered a good measure of its value to society.

Knowledge, however, is not always codified and transmissible like pure information: very often, the transmission of knowledge requires practice, active participation and complementary knowledge on the part of the person who is supposed to receive it (Ryle, 1949; Polanyi, 1966; Stiglitz, 1999). Indeed, some levels of tacitness are intrinsic even in codified knowledge so that “a fully codified knowledge that can be easily transmitted and communicated does not exist” (Antonelli, 2008a). When knowledge is prevalently characterized by tacitness (Polanyi 1966; Ryle 1949), specialization (Dosi et al. 2006; Cowan and Van der Paal 2000; Cowan et al. 2000)

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[3] Whether these markets are efficient and work well, however, is a debated issue: evidence suggests that markets for intellectual property rights suffer from numerous inefficiencies (Andersen and Rossi 2012; Andersen et al. 2012).

and cumulativeness[4], knowledge transfer unfolds over a longer time and usually involves direct interactions between the knowledge holder and the knowledge receiver, in which knowledge is actively constructed rather than simply transmitted (Wenger, 1998; Nooteboom, 2002) – a model of knowledge transfer that we can call *interactive*.

If knowledge can only be properly transferred by means of direct interactions, it can be difficult for free riders to acquire it, even in the absence of intellectual property rights, and this weakens the 'market failure' rationale for public funding: the more knowledge is excludable, the greater are the incentives for its co-production on the part of private firms, as shown by much empirical evidence (Cohen et al. 2000; Levin et al. 1987; Mansfield 1986).

However, even when markets create sufficient incentives to invest in knowledge production, the economic system may fail to provide sufficient opportunities or resources for agents to interact with other agents (that is, there is a 'system failure'; Klein Woolthuis et al. 2005). Appropriate interventions to support interactions may be needed to ensure that knowledge is diffused sufficiently in the economy; since those interactions in turn promote the recombination of existing knowledge, they are potentially able to stimulate the further production of new knowledge.

When interactions are crucial for knowledge transfer, the measurement of knowledge transfer performance should not simply focus on the amount and value of outputs that are transferred, but also on the *interaction processes* themselves: that is, the frequency, characteristics and quality of the interactions and the (short and long term) learning processes that all participants in the interactions experience (emphasizing bidirectional 'knowledge exchange' rather than unidirectional knowledge transfer).

The following table summarizes the main characteristics of the different views of knowledge and their implications for knowledge transfer.

[4] Since the search for new solutions is strongly driven by the knowledge that individuals and organizations already possess, the existing knowledge base is both a driver and a constraint to the development of new knowledge; Lundvall, 1988; Nelson andand Winter, 1982).

Table 1: Different views of knowledge and their implication for knowledge transfer

View of knowledge	**Knowledge as information**	**Knowledge as interactive process**
View of process of knowledge production and transfer	Linear process	Complex, systemic process involving interactions between different knowledge holders
Appropriate way to support knowledge production on the part of universities	Public funding due to market failure in funding of knowledge production	Public or private funding, or a combination thereof
Appropriate way to transfer knowledge on the part of universities	Open dissemination of knowledge outputs *or* assignment of intellectual property rights and trade in IPR markets	Implementation of mechanisms to foster interactions between universities and external agents ("system failure")
Appropriate indicators of knowledge transfer performance	Output-oriented indicators: amount, diffusion and value of outputs transferred	Process-oriented indicators: Number, duration, intensity, characteristics and quality of interactions; learning on the part of all sides of the interaction; involvement of additional beneficiaries; development of further interactions
Theoretical references	• Economics of information • Linear model of innovation • New institutional economics	• Economics of knowledge • Resource theory of the firm and other heterodox approaches to firm theory • Non-linear models of innovation • National systems of innovation
Reference period	Since 1950	Since 1990

Source: Authors' own elaboration

Implications: choosing indicators for different knowledge transfer activities

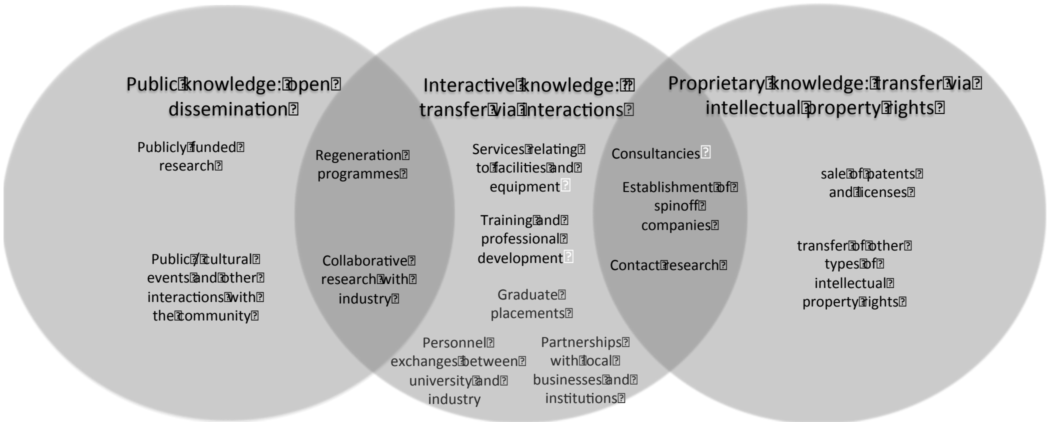
Some knowledge transfer activities fall quite neatly within one of the models identified in the previous section. The view of knowledge as information is particularly appropriate to describe basic research, which is far from any potential implementation. In this case, the market failure in knowledge production is particularly serious (Nelson 1959): most basic research is indeed publicly funded (Haskel and Wallis 2013) and its outcomes are disseminated openly through books, publications, presentations, talks, performances etc., in line with the *public knowledge* model of knowledge production and transfer (for example, much research produced in the natural sciences and in the humanities may fall within this description). Instead, forms of knowledge that are very tacit and specific to particular users generate very little externalities (Holi et al. 2008). Here we find that private organizations are willing to pay universities for contract research, consultancies, the provision of certification and testing services, the provision of training and continuing professional development courses (CPDs), and similar, as in the *interactive knowledge* model described earlier. In other cases, the transfer of knowledge from university to industry occurs via the sale of a patent or the licensing of a piece of software or other technology, as in the *proprietary knowledge* model.

But many knowledge transfer activities involve a combination of these approaches. Publicly-funded projects like regeneration programmes and community and cultural events can give rise both to openly disseminated outputs and to interactions with the local communities. Sometimes the effective transfer of knowledge that is codified into a book, or even a patent, requires direct interactions with the researchers who produced it (Cohen et al. 2002); hence very often informal or even formal interactions develop around the use of published results or around the implementation of a patent licensed from the university[5]. The creation of spinoff companies to exploit the IPR created by universities is another example of a situation where knowledge that is codified into a patent requires the setup of a system of stable interactions to implement it and commercialize it. In the opposite case, the interactions developed around contract research and consultancy may give rise to patents that can be traded and licensed. It is also possible that some interactions between universities and businesses are very standardized and do not involve the production or transfer of new knowledge (for example the rental of rooms and equipment).

The following figure illustrates how different types of knowledge transfer activities relate to the three models of knowledge transfer identified in the previous section.

[5] Thursby et al. (2001), in a survey of 62 US universities, found that 71 per cent of the inventions licensed from the university to firms required interactions with the inventor in order to be subsequently commercialized.

Figure 1: Models of knowledge transfer and types of knowledge transfer activities



Source: Authors' own elaboration

Because there is no one-to-one correspondence between knowledge transfer activities and theoretical models (and corresponding indicators) of knowledge transfer, the appropriate indicators for each activity must be considered carefully, based on an in-depth understanding of its nature and the channels through which it generates impact.

Implications: choosing indicators for different types of knowledge transfer profiles

The arguments presented suggest that not all knowledge transfer activities can be appropriately measured with the same indicators. For example, the more such activities involve the transmission of tacit knowledge through interactions, the more the characteristics of such interactions matter for the ability of the knowledge transfer process to generate impacts. The more knowledge transfer generates large externalities, the more difficult it is to quantify its impact, and the less likely are private organizations to pay for it: hence, income is less likely to be a good proxy for the value of the knowledge transferred.

A fair and accurate system of assessment of universities' knowledge transfer performance should allow the transfer of different forms of knowledge to be represented and assessed comprehensively (Rossi and Rosli, 2014). First, the range of knowledge transfer activities considered must be broad enough to reflect the variety of activities undertaken by universities. If the choice of activities to be measured is not comprehensive enough, the performance of universities that engage in activities that are not measured may be undervalued, and vice versa, those universities that focus on the activities that are best measured by the chosen indicators may enjoy an advantage.

Second, for many activities, both output-oriented and process-oriented indicators should be included: the focus on output-oriented indicators may penalize universities that transfer knowledge whose social and economic impact is not accurately reflected by the measurable outputs it generates[6].

Third, the system should be structured in such a way as to avoid the creation of perverse behavioural incentives. If the chosen indicators specifically measure only some knowledge transfer activities and not others, this creates implicit incentives for universities to engage only in the activities that are measured, but these activities may not necessarily be the most effective ways to transfer knowledge for all universities.

These problems are particularly relevant in highly differentiated university systems. Here, in fact, universities tend to engage in different types of knowledge transfer activities, for example according to their research orientation (basic vs. applied), their research intensity (research-intensive or teaching-intensive; Wright et al. 2008), their subject mix (science, technology, medicine or the arts and humanities; Albert, 2003;), their geographic localization (urban or peripheral) and their knowledge transfer policies (Di Gregorio and Shane 2003).

In the next section, we show that the monitoring systems implemented in several countries (UK, US, Canada, Australia and Europe) in order to assess universities' knowledge transfer performance, generally adopt rather narrow views of what constitute relevant knowledge transfer activities and their impacts. This leads to the selection of indicators that might not allow all institutions to accurately represent their knowledge transfer performance, and in turn it may incentivize universities to focus on the types of knowledge transfer activities whose impacts are measured more extensively.

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[6] In particular, the assumption that the value of knowledge to those that receive it can be accurately captured by the income that the university accrues from it is debatable: more prestigious institutions may be able to charge more for their services because of reputation, and not because of the value of the knowledge is greater; certain forms of knowledge may be transferred for free or at a very low price with the objective to achieve greater diffusion or because they are aimed at people who cannot pay for them, but their value can be high from a social viewpoint; some forms of knowledge may not attract a lot of funding because of their high uncertainty and potential large externalities (Nelson 1959), but they may turn out to have important impacts in the long run. A more extensive discussion is presented in Rossi and Rosli (2014).

Case studies: indicators of universities' knowledge transfer performance used in the UK, US and Canada, Australia and Europe

Models of knowledge transfer and choice of indicators in international surveys

In order to showcase the relationship between theoretical knowledge transfer models and the choice of indicators to assess universities' knowledge transfer performance, we consider several surveys implemented in the United Kingdom, US and Canada, Australia and Europe.

United Kingdom. In the late 1990s, England's main funding agency (the Higher Education Funding Council for England, HEFCE) introduced a systematic UK-wide survey aimed at capturing the exchange of knowledge between higher education institutions, the business community and society at large (the Higher Education – Business and Community Interaction Survey, HE-BCI). Since its existence, the historical HE-BCI data has been used for reference towards grants allocations supporting knowledge exchange. The survey consists of two parts: Part A for strategic and infrastructural data and Part B for financial numeric data, concerning a specific year. The survey has evolved over time, since its inception in 1999. We focus on the indicators contained in the 2010/11 edition of the survey.

United States and Canada. Since the early 1990s, The US-based Association of University Technology Managers (AUTM), a non-profit organisation, has surveyed North American universities, hospitals and research institutes on their formal knowledge transfer activities. The survey (called AUTM Annual Licensing Activity Survey) focuses on technology transfer activities in the US and Canada, and captures the activities that offices engage in rather than the impact or results of licenses (AUTM 2011). The survey consists of 19 sub-headings and covers six core measures of knowledge transfer activities. We analyse the structure of the survey implemented in the 2011 fiscal year.

Australia. Since 2002, the Australian Government, through the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education has conducted a biennial survey (National Survey of Research Commercialisation, NSRC) of 70 Australian publicly funded research organisations (PFROs: universities, publicly funded research agencies and a range of medical research institutes) concerning research commercialisation inputs, activity and outputs (NSRC 2012). It consists of two parts: Part 1, which covers the preliminaries of the surveyed institution, and Part 2 for financial and numeric data, concerning a specific year. We focus on the indicators contained in the 2010/2011 edition of the survey.

Europe. Created in 2003 by the European Commission, ProTon Europe, a European Knowledge Transfer Association, coordinates an annual survey of its members across multiple European countries (managed through collaboration with national networks). The survey has evolved over time. Since 2005, it has focused on the performance of technology transfer offices. The survey consists of two parts: Part 1 for mandatory questions with three subsections, and Part 2 for optional questions that focus on profiling knowledge transfer activities. We consider the survey implemented in the 2011 fiscal year.

Table 2 summarises the general areas of knowledge transfer engagement included in each of these four surveys. The HE-BCI survey is the most comprehensive in terms of areas considered, although not all of them are investigated with a similar level of detail, as it will be clear from our subsequent analysis. The AUTM and NSRC surveys focus very strongly on spinoffs and intellectual property (and to some extent research collaborations, contracts and consultancies) and neglect most of the other areas (the AUTM includes a question on clinical trial services which we consider part of 'facilities and equipment related services' activity; it is however very marginal in this survey). The ProTon survey also focuses mainly on spinoffs, intellectual property, research collaborations, contracts and consultancies, and includes some background information about institutional strategies and infrastructures.

Table 2: General areas of knowledge transfer activity investigated in the four surveys

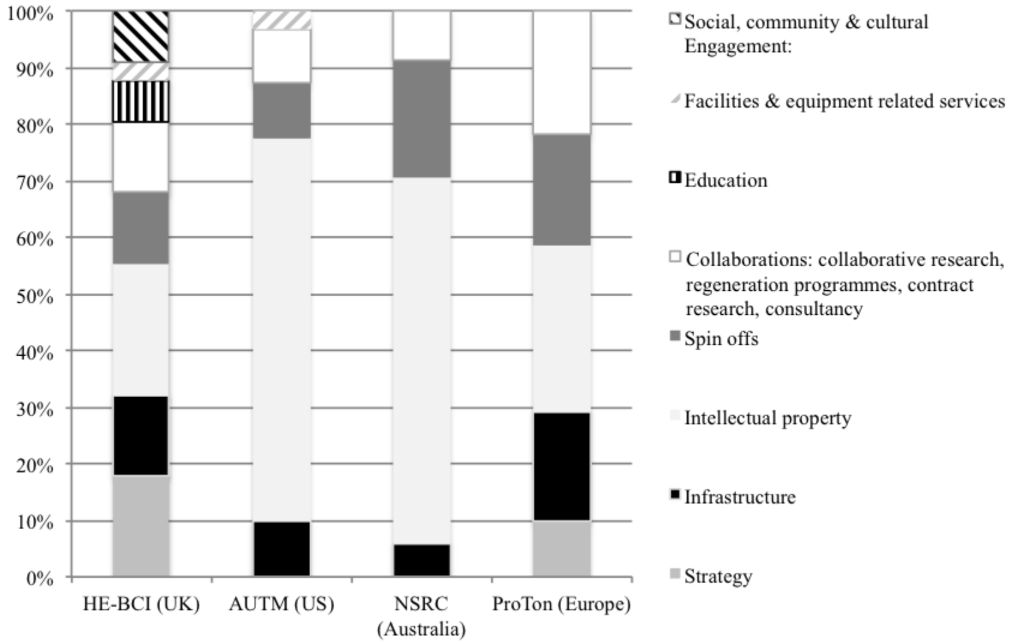
Areas of knowledge transfer activity	*HE-BCI (UK)*	*AUTM (US/Canada)*	*NSRC (Australia)*	*ProTon (Europe)*
Strategy	x			x
Infrastructure	x	x	x	x
Intellectual property	x	x	x	x
Spin offs	x	x	x	x
Collaborations[*]	x	x	x	x
Education	x			
Facilities and equipment related services	x	x		
Social, community and cultural engagement	x			

[*] This category includes collaborative research, regeneration programmes, contract research, consultancy

Source: Authors' own elaboration

The following figure shows the shares of questions concerning each area of knowledge transfer activity included in each survey. Questions related to intellectual property (and to a lesser extent, spinoff companies) are prevalent in both the AUTM and NSRC surveys, while the HE-BCI and ProTon survey present a more balanced focus on the different areas, with the HE-BCI being more comprehensive in terms of coverage. Even in the HE-BCI and ProTon surveys, however, intellectual property and spinoffs are relatively more intensely investigated than the other activities.

Figure 2: Shares of questions relating to each knowledge transfer area



The next table compares the four surveys in terms of the models of knowledge transfer represented, and of the types of indicators used. We do not consider questions relating to the institutions' strategies and their infrastructures for knowledge transfer, since these do not relate to specific activities but rather provide the general context in which these activities are performed.

Instead, we focus on the questions concerning the knowledge transfer activities that universities perform. In Table 3, we have mapped each activity included in the surveys onto the three possible models of knowledge transfer, described in section 2: the *public* model, where knowledge is transferred via open dissemination, the *proprietary* model where knowledge is transferred via trade of intellectual property rights and the *interactive* model, where knowledge is transferred via direct interactions. As illustrated in Figure 1, intellectual property-related activities reflect the proprietary model; social, community and cultural engagement activities and regeneration programmes mainly follow the public model (public financing with open dissemination); the transfer of knowledge via education channels (mostly student placements and CPD), and the provision of facilities and equipment-related services follow the interactive model. The other activities combine different models, for example spinoffs combine the exploitation of intellectual property with the setup of stable interactions around its commercialization; collaborations involve the setup of qualified interactions, but sometimes also open dissemination combined with public funding (in the case of collaborative research) or the creation and transfer of intellectual property (contract research, consultancies).

Table 3: Knowledge transfer activities included in the four surveys, by model of knowledge transfer

Knowledge transfer activities	***Number of surveys that measure the activity***	***Model of knowledge transfer***		
		Public knowledge	***Proprietary knowledge***	***Interactive knowledge***
Intellectual property	4		x	
Spin offs	4		x	x
Collaborations[*]	4	x	x	x
Education	1			x
Facilities and equipment related services	1			x
Social, community and cultural engagement	1	x		x

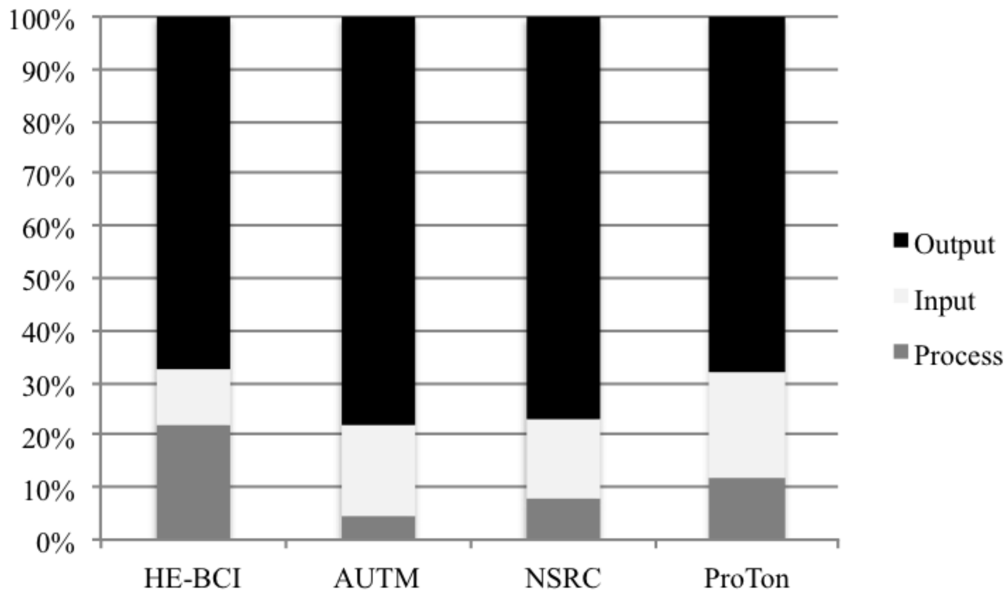
[*] This category includes collaborative research, regeneration programmes, contract research, consultancy

Source: Authors' own elaboration

All four surveys focus on the knowledge-transfer activities that follow the proprietary model. The activities that mainly reflect the interactive model, whether on its own (education-related activities, facilities and equipment-related services) or in combination with the public knowledge model (regeneration programmes, social, community and cultural engagement) are present only in one survey. Collaborations with external stakeholders are present in all four surveys, but if we break them into specific types (collaborative research, regeneration programmes, and contract research and consultancy) we find that only one survey, the HE-BCI, includes all three; the ProTon has some questions on contract research and consultancy while the other two only ask for some general information about research expenditure.

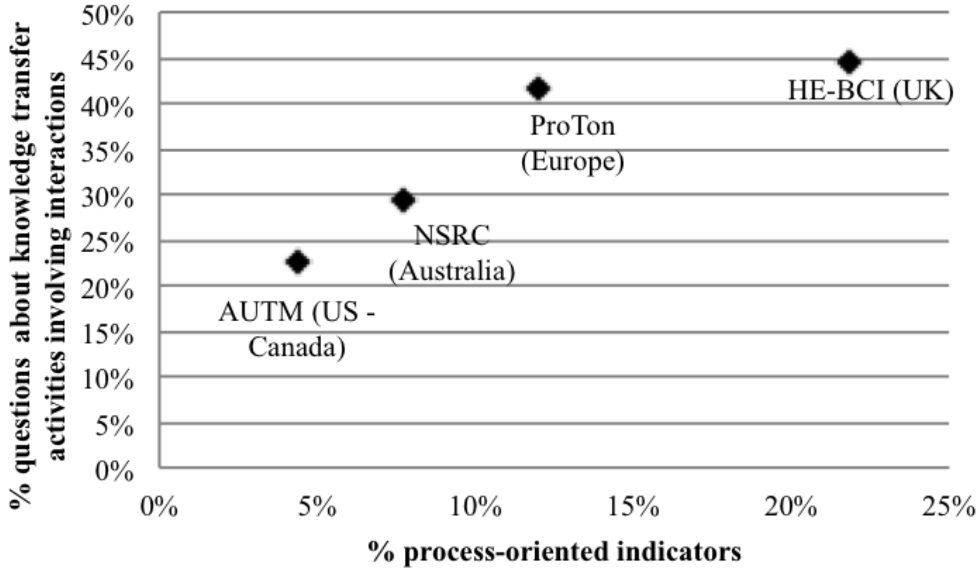
Since most activities combine elements of two or more knowledge transfer models, and most of them are at least partly inspired by the interactive view of knowledge, we would expect the surveys to include a mixture of output-oriented and process-oriented indicators, in order to capture both the outputs transferred as well as the characteristics of the interactions through which the transfer took place. Instead, as shown in the following figures 3 and 4, the majority of indicators capture only the outputs of the knowledge transfer process, whether in the form of knowledge produced (number of disclosures, patents applied and granted, events organized), of income received from the exchange of knowledge, of impact made upon the business environment (number of licenses executed, number of technologies commercialised, number of companies created, employment in companies, etc.). Some indicators capture the cost of the knowledge transfer activity to the university (patent fees, academic staff days invested, etc.) or the inputs in the knowledge transfer process (research personnel, research expenditure). Very few indicators aim to capture some features of the process of knowledge transfer itself; the only information in this sense concerns the number of interactions (in very general terms: number of contracts activated, number of training days delivered) and the identity (SMEs versus other commercial and non commercial organizations, for example) and location (regional versus non-regional) of some of the knowledge transfer partners, as well as some more specific information about the features of the activity performed.

Figure 3: Shares of indicators of different types



Source: Authors' own elaboration

Figure 4: Shares of process-oriented indicators vs shares of questions about knowledge transfer activities involving interactions



Source: Authors' own elaboration

General patterns

Several patterns emerge from our mapping of the knowledge transfer activities and the indicators considered in each survey. No survey is fully comprehensive in terms of the activities considered, and in particular the following critical points emerge.

(1) *The measurement of knowledge transfer via intellectual property rights is attributed high importance* in all surveys, as clearly shown in Figure 2, particularly in the AUTM and NSRC surveys. This is despite evidence that shows that only few universities use this model with appreciable intensity and success (Litan et al. 2008), as it suitable to a limited number of scientific fields (Brouwer and Kleinknecht 1999; Harabi 1995). Moreover, the indicators are strongly biased towards patents and software licenses, further skewing the outcomes in favour of a few fields that produce patentable outputs, or software. Little attention is paid to other types of intellectual property rights (design rights, trademarks), to intellectual assets protected by open source or creative common licenses (such as open source software, blogs, wikis, open source film, open source media, open source pharmaceuticals, etc.) and to inventions (for example materials and artefacts) not protected by intellectual property rights (Andersen et al. 2012; Baghurst and Pollard 2009). Hence, institutions that are

relatively more focused on fields, such as the arts and humanities, that are unlikely to generate patents but may generate other forms of intellectual assets, may be unable to correctly represent the amount of intellectual property they produce and transfer.

(2) *The public knowledge model is mostly overlooked*, especially in the AUTM, NSRC and ProTon surveys, where the only examples of activities that fall within this model are publicly-funded collaborative research projects (usually grouped with other types of research activities under the heading 'research expenditure'). In the HE-BCI survey, a few more activities are considered: regeneration programmes as well as knowledge-dissemination activities in the humanities and social sciences. However, these activities represent, together, only around 20 per cent of the overall questions and their impact is mostly measured on the basis of the funding they attract, neglecting other potential outputs[7]. This approach may reflect a concern with keeping a clear distinction between outputs that result from research activities (such as publications) and outputs from knowledge transfer activities, where in practice such distinction is not so easy to make (for example, collaborative and contract research activities and regeneration programmes often have both research and knowledge transfer components). Finding ways to measure the universities' engagement in the open dissemination of scientific outputs resulting from publicly-funded research, and to identify their impact more accurately, would be important in order to more precisely assess the outcomes of universities' knowledge transfer engagement. Indeed, empirical evidence shows that 'open science' channels are firms' preferred way to access academic knowledge (Bruneel et al. 2009; Abreu et al. 2008; D'Este and Patel 2007; Mowery and Sampat 2005; Arundel and Geuna 2004).

(3) In most surveys, *very little attention is paid to interactions with different types of external partners* (businesses, private non commercial organizations, public organizations, specific communities and even individuals). In the AUTM, NSRC and ProTon surveys, the only interactions considered involve university spinoffs and start-ups and different types of research contracts; in most cases the indicators only quantify the number of companies established and the number of agreements and contracts signed. The HE-BCI is the only survey that attempts to measure numerous

[7] For example, collaborative research can produce joint university-industry publications, support joint workshops and other openly disseminated outputs, and regeneration programmes can have many valuable impacts on the community.

types of interactions. Nonetheless, several important direct interactions between university and industry personnel are not included, such as recruitment of university staff members to industry positions, academics' participation in industry conferences and workshops, placements of entrepreneurs and industry personnel in universities, visiting scholarships, and more. Company surveys have shown that firms consider these interactions as important in order to benefit from academic knowledge (Hughes et al. 2011; Dutrénit et al. 2010; Jensen et al. 2010; Boardman and Ponomariov 2009; Bekkers and Bodas Freitas 2008), particularly for applied subjects such as architecture, design, engineering, medicine. Furthermore, students are important vehicles through which knowledge transfer processes occur, and yet no efforts are made to monitor the extent to which graduate students contribute to enhancing business innovation and competitiveness (see, for example, Toner, 2011 and Jones, 2014). Finally, interactions around production and service activities, such as prototyping, clinical trials, testing and design services, would fall within the very generic area of 'Facilities and equipment related services' where they would be grouped with standardized, non-knowledge producing services like room and equipment rental activities. The minor importance attributed to all of these activities (if they are considered at all) suggests that the view of knowledge as codified information, easily transferred through economic transactions, is still prevalent, leading policymakers to overlook many activities where the transfer of knowledge occurs in the context of complex, often long term interactions which may not even involve a monetary exchange.

Similarly, the view of knowledge as information shapes the choice of indicators, since all surveys are strongly biased towards output-oriented measures. Knowledge transfer is seen as a linear transmission of information from the university to its external partners, rather than an interactive process that can generate short and long term benefits for both parties and whose outcomes depend on the quality of the interactions themselves. The characteristics and quality of the interactions through which knowledge transfer takes place are not considered. Moreover, the indicators in place only represent uni-directional knowledge transfer from the universities, and no attempts are made to explore the (often non-monetary) benefits that universities derive from these activities.

Conclusions

Performance measurement exercises adopt a narrow view of what constitutes knowledge transfer, and consequently focus on a limited range of activities and impacts. We have illustrated this with reference to four surveys implemented in different international contexts (the UK, the US and Canada, Australia and Europe). In all these surveys, the choice of areas of knowledge transfer to be measured: (i) is strongly inspired by the proprietary model of knowledge transfer based on intellectual property rights, in particular emphasizing patents and software licenses; (ii) it only marginally includes activities based on the public model of knowledge transfer (only in relation to the funding attracted to the university and not to the knowledge outputs generated and openly disseminated); (iii) it is partly inspired by the interactive model but not inclusive of all possible interactions. Even in the most comprehensive survey (the UK's HE-BCI) not all possible types of knowledge transfer activity are included, and not all of activities are considered with a similar level of detail.

This rather narrow focus implies that some universities may be at an advantage and others at a disadvantage in representing their knowledge transfer activities, depending on their knowledge transfer strategies. Moreover, universities may be incentivized to focus more on the activities that are measured more extensively, even if this may not be particularly effective for some institutions. Performance measurement exercises should recognize that universities are different, and possibly use different sets of indicators for different groups of institutions, rather than apply the same model of knowledge transfer to all of them. An alternative approach could be to develop a very broad range of indicators taking into account all possible activities, and let universities themselves choose the profile of knowledge transfer engagement that suits them best (adopting a flexible approach to measurement as suggested, in the more general case of innovation policy indicators, by Rafols et al. 2012).

The paper has also argued that output oriented indicators alone are inadequate to capture the impact of universities' knowledge transfer activities. In particular, the impact of knowledge transfer is not fully captured through monetary measures. Further research should strive to identify indicators that are better able to capture procedural aspects of knowledge transfer rather than just narrowly defined outputs, and that better reflect the multi-directional nature of 'knowledge exchange' processes involving multiple stakeholders rather than unidirectional transfer of knowledge from university to industry[8]. A range of outcome indicators capturing a variety of bidirectional impacts are already deployed in practice, for example by universities attempting to measure their economic and social impacts; these could provide a basis to develop indicators to be adopted more systematically.

We can also derive some implications for the more general issue of identifying appropriate indicators in order to evaluate the impact and success of policies in support of knowledge production and transfer activities. First, different theories of what is knowledge, how it is produced and how it is transferred carry different implications in terms of what indicators should be used to measure relative success. Hence, the choice of indicators needs to be in harmony with the nature of the knowledge whose production and transfer is being monitored. When a wide range of knowledge production and transfer activities are considered the range of indicators should be broad enough to accurately capture performance in the production and transfer of different types of knowledge. Second, not only indicators should be sufficiently comprehensive, but care should be taken in order to avoid problems of lack of comparability across organizations and of creation of counterproductive behavioural incentives. Third, countries considering the implementation of performance measurement systems need to be cautious when emulating existing data collection exercises. As this analysis has shown, current exercises suffer from numerous limitations in the scope and types of indicators used. Moreover, each national system is characterized by specific socio-cultural arrangements, organizational structures, funding structures, relationships between universities and industry that should be taken into account when designing appropriate systems of performance measurement and assessment.

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[8] For example, some questions could focus on the interactions' duration, the number of partner organizations and people involved, their satisfaction with the interactions, their perception of what they learned from the interactions and the short and long term benefits they received, the long term effects in terms of further interactions generated and of involvement of additional beneficiaries.

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