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Analysing knowledge capture mechanisms: Methods and a stylised bioventure case

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ABSTRACT

Knowledge transfer between science and technology has been studied at micro- and macro-levels of analysis. This has contributed to the understanding of the mechanisms and drivers, but actual transfer mechanism and process, be they through codified or tacit sources, have very rarely been mapped and measured to completeness and remain, to a large extent, a black box. We develop a novel method for mapping science–technology flows and introduce 'concept clusters' as an instrument to do so. Using patent and publication data, we quantitatively and visually demonstrate the flows of knowledge between academia and industry. We examine the roles of exogenous and endogenous knowledge sources, and of co-inventors and co-authors in the application of university-generated knowledge. When applied to a stylised case, we show that the method is able to trace the linkages between base knowledge and skill sets and their application to a technology, which in some instances span over twenty-five years.

1. Introduction

Knowledge transfer between universities and firms has become increasingly institutionalised (Geuna & Muscio, 2009) as universities look for novel, more insightful, ways to enhance their economic and societal value through new technology spin-offs or start-ups (Audretsch, Lehmann, & Warning, 2005; Tijssen, 2006). Much of the previous literature has focussed on the facilitating actions and conditions for knowledge transfer such as scientific publications, conferences, informal interactions, collaborative and contract research, IP licensing, personnel exchanges and hiring – each with varying significance for industry (Ponomariov & Boardman, 2012).

A major challenge to evaluating these knowledge transfer routes and mechanisms is that of uncovering meaningful linkages between the technological outputs and scientific inputs. Knowledge transfer occurs most often at both the codified and tacit level, and the transfer processes and motivations within academic research versus those in industry settings are complex and evolving. However, what is not discussed in detail in the extant literature is the demarcation and measurement

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of the knowledge that is transferred (Bozeman, 2000). This is of utmost importance as the facilitation of transfer has been investigated but the question of *whether* knowledge has been transferred can only be answered by (a) being able to demarcate the object of transfer, and (b) measuring its point of inception, evolutionary path and eventual application.

Specific quanta of knowledge evolve along developmental paths, shaped by not only the scientific and technological developments of the laboratory in which it was conceived, but also by the further learning and skill sets of the scientists and inventors involved. By exploring the routes of codified knowledge transfer from inception to exploitation, we can begin to understand the processes and mechanisms of knowledge transfer. These include interactive knowledge production, the role a scientist's skill set plays, the effect of a scientist's peers – be they in the university or in the lab – and the transformative nature of science itself.

Whilst there have been substantive efforts at examining the facilitation processes and end-utilisation in an isolated sense – in that each step in the overall development process of a technology is analysed – a novel methodological approach is necessary to address the question of whether the whole transfer process has occurred. As mentioned previously this requires a method to both demarcate and track specific quanta of knowledge. In doing so, a clear view on the effectiveness of the facilitating conditions is possible.

In this paper we use and modify available tools and models, and integrate those with newly developed tools to provide a clearer and detailed picture of knowledge transfer, from start to finish. This paper starts with a discussion of the role of the scientist/entrepreneur, and that of his surroundings, in developing the necessary skill sets and knowledge for eventual transfer and application in industry. We then translate these insights into our methodology, which is described in detail. A crucial step in the methodology is the introduction of the idea of 'concept clusters', which refers to a small, cognitively cohesive agglomeration of scientific peer-reviewed publications. As an illustration, we apply the methodology briefly on a case. In the conclusions, we summarise the potential benefits, open methodological issues, and routes for further research.

2. Conceptual framework

The codification of knowledge takes two primary forms, patents and scientific publications. The use of patents as indicators was pioneered by Schmookler (1966) with many applications following (for examples, Schmoch (1993) and Fleming (2001)). However, many aspects of their indicator-oriented uses do have drawbacks (Pavitt, 1998), for example, not all innovations are patented (Arundel, 2001; Arundel & Kabla, 1998) with many innovations kept under a veil of secrecy (Brouwer & Kleinknecht, 1999) leading to underestimation of innovative potential or capacity. Analyses using patent indicators are typically based on the meta-data found in patents. Title words, abstract words and keywords (Courtial, Callon, & Sigogneau, 1993; Engelsman & van Raan, 1994), patent classifications (Leydesdorff, 2008; Tijssen & Van Raan, 1994), and patent/non-patent citations (Karki, 1997; Meyer, 2001) have all been used extensively. Many patent databases exist from which we extract the meta-data used in analyses, each with their own idiosyncratic advantages and disadvantages. These include disclosure requirements of prior art ('duty of disclosure'), wherein the USPTO requires an exhaustive list whereas the EPO requires a minimal listing. Differences also stem from the databases themselves, in terms of their formatting, whilst others relate to the practices of applying for patents through different national or supranational patenting offices. Despite the mentioned shortcomings, patents can be used for mapping knowledge transfer in a large part of the knowledge intensive economy because patent documents are highly detailed descriptions of the processes, applications and necessary information required for a technology. Citations within a patent document, either to other patent documents or scientific literature, add to this wealth of data. Patent documents encompass a wide range of technological fields and the major patenting offices (such as the USPTO or EPO) cover patent data from all countries (Tijssen, 2001).

Publications serve as the primary indicators for the defining characteristics and development of science. They are the most visible outcome of scientific endeavours, with an extensive range of indicators and methodologies developed. The analysis of publications shares a number of analytical approaches with patent analyses, such as word mapping (Callon, Courtial, & Laville, 1991) and citation analysis (Garfield & Welljams-Dorof, 1992; White & McCain, 1998). Using co-occurrences of combinations of words and cited references in publications is also becoming a common technique (Braam, Moed, & van Raan, 1991; van den Besselaar & Heimeriks, 2006).

The act of publishing itself is subject to a complex system of social and scientific norms, practices and reward systems (Merton, 1957). Publishing behaviours and patterns of scientists are governed in large part by these norms and practices, as well as by serendipity. The development of a university scientist's profile and portfolio are the result of search strategies (Horlings & Gurney, 2012) employed by the scientist. University-based scientists publish primarily to extend their professional and intellectual prowess, and regular publishing is considered a requirement. Industry based scientists are governed by similar constraints, and the firm benefits from publishing too – by becoming intimately involved with the basic science behind the technologies (Rosenberg, 1990), and their publications serve as a signal of their capabilities to the outside world (Hicks, 1995).

The conditions required for facilitating the development and transfer of knowledge depends heavily on the recipient knowledge platform. Knowledge assets (Nonaka, 1994), sector roles (Baba, Shichijo, & Sedita, 2009) and science-push and demand-pull concepts (Langrish, Gibbons, Evans, & Jevons, 1972), factor into a knowledge base's receptivity. In this manner – external knowledge sources, taking into account demand and current capabilities, are readily absorbed and entrained into stock knowledge bases and practices. This receptivity is known as 'absorptive capacity' (Cohen & Levinthal, 1990) and can best be described as "[t]he ability of a firm to recognize the value of new, external information, assimilate it, and apply it to