Technological Forecasting & Social Change 92 (2015) 25–39

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

Toward successful commercialization of university technology: Performance drivers of university technology transfer in Taiwan

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ARTICLE INFO

Article history:
Received 16 September 2013
Received in revised form 27 September 2014
Accepted 5 November 2014
Available online 9 December 2014

Keywords:
University technology transfer
Performance drivers
Fuzzy Delphi method
Interpretive structural modeling
Analytic network process

ABSTRACT

The transfer of university technology[2] to industry involves a multitude of mechanisms which can be broken down into an even larger number of activities. These mechanisms and activities include launching technology-oriented start-ups, and providing the following: collaborative research, contract research, consulting services, technology licensing, graduate education, advanced training for enterprise staff, exchange of research staff, and other forms of formal or informal information transfer. Taking Taiwan's universities as a research base, this study intends to identify the critical drivers affecting the performance of university technology transfer. The Fuzzy Delphi method, interpretive structural modeling (ISM), and the analytic network process (ANP) are employed sequentially to derive the relative importance of the various performance drivers. Human capital and institutional/cultural resources are the two most emphasized resources for the improvement of university technology transfer in Taiwan. Some policy implications are derived on the basis of these results.

1. Introduction

Knowledge spillovers are regarded as one of the important sources of a country's economic growth (Romer, 1986, 1990). Gibbons et al. (1994) indicated that there are two modes of knowledge generation. In the first mode, knowledge production is motivated by autonomous universities, with self-defined and self-sustaining disciplines and specialties. And in this mode, there is nearly no interaction between academia and industry. This is the so-called "Mode 1" of knowledge production. The "Mode 2" paradigm describes knowledge production which relies on interdisciplinary teams collaborating together for short periods to work on specific problems in the real world (Gibbons et al., 1994). "Mode 2" knowledge production is conceptualized in terms of university–industry–government relations, i.e. the Triple Helix model (Etzkowitz and Leydesdorff, 1995, 2000). The Triple Helix system illustrates the interaction among university, industry, and government for cross-sector knowledge generation.

From the perspective of the Triple Helix model, the interactions between these institutions for boundary-spanning knowledge production and dissemination are the catalytic regime that stimulates knowledge-based economic development for newly industrializing, deindustrializing or reindustrializing nations (Leydesdorff and Etzkowitz, 1996). The institutions generating knowledge play an important role in the networks woven by university, industry, and government. The interactions among the three actors are increasingly overlapping (Etzkowitz and Leydesdorff, 1995). In the Triple Helix model, universities increasingly take part in the business functions and the incubation of small technology-based

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[2] This study adopts the definition of university technology transfer suggested by Siegel et al. (2003).

http://dx.doi.org/10.1016/j.techfore.2014.11.002
0040-1625/

companies. This is in addition to their primary missions of creating human capital and conducting basic research. Industrial corporations increasingly use universities' infrastructure to engage their R&D activities, and transfer part of their R&D expenditures to universities in the form of funding for academia. Governments deploy policy measures to encourage the development of small innovative companies both through the funding of universities and through the enactment of legislative regulations designed to stimulate the development and implementation of new technologies in industry. Universities and industry can partially substitute for the state in the creation of an innovation infrastructure (Leydesdorff and Etzkowitz, 1996). Therefore, both the university–industry relationship and the university–government relationship lead to activities which bring innovations to the market.

The objective of the Triple Helix approach is to realize an innovative environment for knowledge-based economic development through trilateral coordination (Etzkowitz and Leydesdorff, 2000). While the university–industry and university–government relations may require corresponding catalysts, many regulations tend to shape the university into a constituent part of the corresponding innovation system. Regarding the experience of United States, in the 1980s, the U.S. government sequentially passed the Bayh–Dole Act, the Stevenson–Wydler Technology Innovation Act, the National Cooperative Research Act, the Federal Technology Transfer Act, and the Technology Transfer Improvement and Advancement Act. These acts collectively built an environment conducive to university–industry collaboration and technology transfer thereby improving the contribution of the system of higher education to industrial technology innovation (Ken et al., 2009). For developing countries such as Taiwan, an important strategy for catching up is enhancing the role of universities in building a nation's innovative capacity, since universities are, in general, seen as a source of knowledge flow (Mathews and Hu, 2007). Inspired by the U.S. experience, Taiwan has sought to enhance its national innovation capacity by encouraging domestic universities and public research institutes to diffuse their inventions to public use. Taiwan's Fundamental Science and Technology Act, passed in 1999, defines the intellectual property rights of government-funded academic research studies at universities or research institutes, removing them from regulation under the National Property Act. With the enactment of the Fundamental Science and Technology Act, researchers are motivated to commercialize their academic research to take advantage of royalties, licensing income, and equity participation for their institutes (Chang et al., 2009). Many Taiwan universities have begun to establish technology transfer offices to facilitate their technology licensing and transfer.

Owing to diversified forms of industry–science linkage (Debackere and Veugelers, 2005), a university might find it difficult to manage outcomes per se owing to the multitudinous outputs of university technology transfer, unless it finds the influencing factors and then allows administrators to contribute ideas for their improvement. Organizational scholars suggest that the key performance drivers provide an opportunity to enhance an organization's outcomes through improving its internal processes (Kaplan and Norton, 1992; Walsh, 1996). Using Taiwan as a test case, this study aims to define the performance drivers of university technology transfer.

There are plenty of quantitative studies which attempt to identify the critical factors on the outcome of university knowledge transfer by applying econometric regression models (Landry et al., 2007; González-Pernía et al., 2013; Rizzo and Ramaciotti, 2014) or data envelopment analysis (DEA) (Chapple et al., 2005; Anderson et al., 2007; Ho et al., 2014). A few qualitative studies use case studies to clarify the factors which effect technology transfer in the case of a specific institution (O'Shea et al., 2007; Swamidass, 2013; Guerrero et al., 2014). Nevertheless, one may need several econometric models to reflect the myriad outputs of the university technology transfer process, since one regression model estimates the influence of independent variables on only a single dependent variable. While data envelopment analysis (DEA) can measure the efficiency of university technology transfer through multiple input and output indicators, it may none-the-less miss some factors that are difficult to quantify. These might include the history and culture of a university (O'Shea et al., 2007) and the value of its informal networks, for example (Geuna and Muscio, 2009). Whereas multi-criteria decision-making (MCDM) techniques are able to quantify the elements for which it is difficult to obtain quantitative data or numeric proxies (Antonio Cortés-Aldana et al., 2009), this study by contrast intends to pioneeringly bridge the gap between qualitative and quantitative methodologies in the field of university technology transfer with MCDM approaches. Hence, this study attempts to construct a comprehensive framework to not only identify the performance drivers but also determine the relative weighting to attribute to each of these drivers, based on the clarification of each driver's contribution to the improvement of university technology transfer. To accomplish this end, this study intends to employ a series of three techniques. First, the fuzzy Delphi method is used to verify the appropriateness of each performance driver in the context of Taiwan's university research. Second of all, Interpretive Structural Modeling (ISM) is used to detect the interdependence among the performance drivers. Finally, Analytic Network Process (ANP) methodology is adopted to determine the proper weighting to assign to each performance driver.

The organization of the text, for the remainder of this paper, is as follows: Section 2 presents the various forms of university technology transfer. Section 3 briefly covers some theoretical background and extracts the performance drivers of university technology transfer from existing literature. Section 4 describes the ISM and ANP methods employed in this study. Section 5 presents the empirical analysis. Finally, Section 6 provides the conclusions and policy implications derived from the results in Section 5.

2. The diversified forms of university technology transfer

University scientists are regarded as the suppliers of innovation, in the sense that the new knowledge and technology created in the university are expected to be transferable to industrial use. The transfer of knowledge and technology from university to industry appears in diverse forms, such as technology startups, collaborative research, contract research and know-how-based consulting, the development of intellectual property rights serving as a base for licensing technologies to enterprises, cooperation in graduate education, advanced