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The technology networks and development trends of university-industry collaborative patents

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ABSTRACT

In recent years, the number of studies pertaining to university-industry collaboration (UIC) has increased exponentially apace with the increasing attention attached to UIC issues and the development of UIC. However, the majority of previous UIC studies pertaining focus on investigating the motivations of UIC, types of collaboration, and UIC performance, and studies that highlight the focal technology fields, technology development trends, and technology network distribution of UIC remain scarce. Moreover, previous studies seldom mention the position and ranking of countries in technology networks. The present study employed a two-mode network analysis (countries and technology fields) method to highlight the pivotal role of various countries in technology networks. Finally, the dynamic analysis method was employed to analyze data in different periods to determine technology development trends. Findings revealed discrepancies between the focus of technologies over time. The key technologies in the more recent UIC technology network were largely in the fields of measurement and chemistry, which are characterized as basic sciences with cross-disciplinary traits. In addition, the development of these technology reflects the recent efforts of various countries promoting emerging technology fields. Findings also indicated that Japan and the United Stated served crucial roles in UIC technology networks.

1. Introduction

Recent studies have indicated that a country's university-industry research and development collaboration benefits its national innovation capacity and economic growth (Schofield, 2013; Temel and Glassman, 2013). Through university-industry collaboration (UIC), university researchers are able to gain research funding while offering their views and skills to companies. Firms can utilize and internalize these views and skills to promote scientific advancement and product innovation (Link and Scott, 2005; Veugelers and Cassiman, 2005). Since the passing of the Bayh-Cole Act in the United States in 1980, which changed previous policies that obligated inventors to assign inventions produced through federal funding over to the federal government, university patent applications and efforts to gain industrial support have increased exponentially (Baldini, 2009; Feller and Feldman, 2010; Tantiyaswasdikul, 2012). Thereafter, methods to promote UIC and the application and expansion of relevant research outcomes gradually attracted global attention (Bodas Freitas et al., 2013; Rasmussen and Sørheim, 2012)

UIC research has gained considerable attraction in recent years, where progress can be observed in three primary directions. The first group of studies is based on the triple helix model and relevant theories, and advocates increased association between universities, government departments, and private businesses (Etzkowitz, 2003). These studies further investigate the mechanisms and motives for promoting UIC (Rasmussen and Sørheim, 2012; Schofield, 2013; Temel and Glassman, 2013). The next group of studies is prompted by the increasingly important function of universities in the creation of new systems. They primarily investigate the patterns of UIC (Ngar-yin Mah and Hills, 2014; Powers and McDougall, 2005; Santoro and Chakrabarti, 2002). The final group of studies focuses on the complementary assets and knowledge of UIC, which create more opportunities for research partners to share knowledge and exchange resources. Therefore, these studies largely assess the output and performance of UIC (Al-Ashaab et al., 2011; Lee et al., 2012; Rigby and Edler, 2005).

However, the aforementioned studies failed to elaborate which technology fields are central to UIC, and studies that focus on the technology fields relevant to UIC and the industries that are potentially affected by UIC remain scarce. The present study endeavors to mitigate this research gap by examining emerging UIC technologies based on UIC patents. A two-mode network analysis method is employed to separately analyze the technology fields of UIC patents and the nationalities of assignees. The analysis results are then used to create UIC patent technology networks and highlight the differences in the UIC technology fields in various countries. Data from different time periods are then examined to track the development trends of UIC technologies.

Focusing on the technology networks of UIC, the present study adopts a patent analysis method to establish a network model for UIC

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technologies. Patents directly reflect innovative output. Therefore, they can serve as an indicator for measuring national technology output (Eaton and Kortum, 1996) and UIC achievement industrialization (Casper, 2013; Lee et al., 2012; Okamuro and Nishimura, 2013; Ponomariov, 2013). Moreover, numerous previous studies have adopted patent-analysis methods to measure technology transfer (Branstetter et al., 2006; Feller and Feldman, 2010; Park et al., 2012), and thus patent data can serve as an indicator for measuring technology development. Hence, the present study analyzes patent data to determine the development trends of UIC technologies and identify key technology fields.

In brief, the distinction of the present study from previous UIC mechanism and performance evaluation studies is that the present study aims to examine the key technologies of UIC, where prominence is attached to establishing a technology network model and determining technology development trends. In addition, the present study adopts a longitudinal research design, where patent data from different periods are analyzed to determine the development trends of UIC technologies. The findings of the present study can serve as a reference for the government, relevant industries, and academic institutes.

2. Literature review

The literature review performed in the present study is largely characterized into three parts, namely, investigating UIC and technology industrialization, collaborative patents, and patent network analysis.

2.1. UIC and technology industrialization

UIC research has gain a steady annual growth, particularly following the introduction of the triple helix model (Calvert and Patel, 2003; Etzkowitz and Leydesdorff, 2000). Many countries endeavor to strengthen interdepartmental relationships between helices, which include the collaboration of universities and industries. An increased number of funding projects are introduced for collaborative research projects. For example, the "SIGNO Germany" project endeavors to reinforce the innovation activities in small and medium enterprises (SMEs). Subsequently, the "SIGNO University" sub-project focuses on promoting the mid- and long-term collaboration and partnerships between universities and industries, and supports the technology transfer between the two sectors (BMWi, 2014). Another example is the Israeli "Magnet Project." This particular project encourages paired collaboration between universities and industries of the same discipline through government funding. Within a two-year collaboration period, industries are not only able to materialize university achievements, but also develop their research and development capabilities (The Office of the Chief Scientist, 2013). Under the consensus of all membership countries, the Framework Programmes: 2007–2013 (FP7) introduced the European Technology Platforms (ETPs) to reinforce narratives between interested academic and industrial parties, greatly improving the effectiveness of the Research Joint Venture.

From the preceding descriptions, it is evident that establishing close collaborative relationships through university-industry exchange has become a common practice for various countries in improving their national innovation capacity. The importance of UIC research partially reflects universities' demand for industry funding to conduct research (Powers, 2003), and partially reflects industries' demand for the industrialization of university research achievements. Since the 1980s, universities in the United States have attached increasing value to patent and authorization strategies. This increased value has elevated the importance of UIC research in universities such as the University of California and Stanford University and prompted the emergence of various integrated technology transfer strategies (Mowery, 2007). A number of universities have attempted to transition into "entrepreneurial universities" in the active promotion of UIC research and pursuit of establishing and solidifying their market knowledge and innovation networks (Guerrero and Urbano, 2012; Powers and McDougall, 2005).

In fact, numerous studies have proposed evidence supporting the benefits of increased university-industry relationships on the industrialization of academic research and development (O'Shea et al., 2005; Powers, 2003), and that the provision of industrial funding into academic research positively affects development of patents and spin-off companies (Di Gregorio and Shane, 2003; O'Shea et al., 2005; Powers, 2003; Powers and McDougall, 2005). Relative to government-funded research, UIC research achievements are typically more practical and easier to industrialize (Di Gregorio and Shane, 2003; Powers, 2003). Di Gregorio and Shane (2003) found that industry-funded studies are typically more risk averse, and are thus more market-friendly, and that the lack of information asymmetry in terms of market demands in industry-funded studies renders the research achievements easier to industrialize. Additionally, UIC enables the interaction between university scientists and industry researchers. Such channels and networks of communication benefit the industrialization of research achievements. Festel (2013) found that UIC enables university research and development achievements to gain a diffusion effect, which increases the opportunity for universities to attract external resources and form new start-ups. The application of an open UIC model facilitates researchers in identifying potential and novel business opportunities and applying for patents to protect their research achievements (Okamuro and Nishimura, 2013; Ponomariov, 2013; Tantiyaswasdikul, 2012).

2.2. Collaborative patent

Patent data are an open and available data source. Numerous previous studies have used patent data to evaluate technology transfer (Branstetter et al., 2006; Feller and Feldman, 2010; Park et al., 2012) and UIC achievements (Casper, 2013; Lee et al., 2012; Okamuro and Nishimura, 2013; Ponomariov, 2013), confirming that patents are key indicators of national innovation performance and industrial technology development (Casper, 2013; Lee et al., 2012; Okamuro and Nishimura, 2013; Ponomariov, 2013). Patent analysis is a tool or technique employed in numerous studies to measure innovation (Branstetter et al., 2006; Casper, 2013; Feller and Feldman, 2010; Tantiyaswasdikul, 2012). In actuality, patent application information provides data concerning the inventors and assignees of technology collaborations and inventive processes. A number of studies have used patent analysis to examine the technology collaboration efforts and relevant information (Etemad and Seguin-Dulude, 1987; Hong and Su, 2013). Ma and Lee (2008) primarily analyzed the techno-globalism phenomenon through patent data, where the co-assignee index was used to measure the level of technology collaboration between the United States and other countries. Patents with shared ownership between technology collaborators are known as joint patents (Kim and Song, 2007). The present study evaluated patents with joint university-industry ownership, or collaborative patents, to measure the development trends of UIC technologies worldwide.

Evaluating collaborative patents facilitates researchers in gaining a better understanding of the expansion of knowledge (Guan and Chen, 2012), the collaboration networks within innovation systems (Fleming et al., 2007), and innovation performance of research and development alliances (Lin et al., 2012). The objectives of UIC are to promote the expansion of knowledge, establish collaboration networks between academia and industries, and form research and development alliances to enhance overall innovation performance. Therefore, using collaborative patents to evaluate UIC technology development satisfies the objectives of establishing UIC. In addition, the technology fields jointly emphasized by academia and industries can be identified by observing the key technologies in collaborative patents. Based on the preceding descriptions, the present study plotted the development trends of UIC technology networks through the analysis of collaborative patents.