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Determinants of industry–academy linkages and, their impact on firm performance: The case of Korea as a latecomer in knowledge industrialization☆

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ABSTRACT

This paper utilizes the Korea Innovation Survey data to identify the determinants of industry–university and industry–government research institute (IUG) cooperation, and its impact on firm performance. First, we find that among the determinants of IUG cooperation, traditional firm characteristic variables of size and R&D intensity are not significant, while participation in national R&D project turns out be most significant and robust in both cooperation modes. This is in contrast to the results from the cases in European countries and reflects the significance of government policies in promoting IUG cooperation in latecomer economies. Second, with regard to the impact of IUG cooperation, we conspicuously find no significant impact on the innovation probability of firms when we control the possible endogeneity, such that already innovative firms would participate more at such cooperation modes. This implies that the IUG cooperation cannot guarantee the success of a firm in technological innovation. Rather, it may have an influence on the selection or direction of the research projects of a firm. When we limited the analysis to innovative firms, we do find a positive impact of the IUG cooperation on patents generated from new product innovation but find none in terms of volume of sales or labor productivity. These results seem to reflect the still transitional nature of the national innovation system (NIS) and knowledge industrialization in Korea.

1. Introduction

With the arrival of the knowledge-based economy, the role of university as a source of new knowledge has become more important than in the past (Etzkowitz et al., 2000). Fast-paced global competition and technological change also add significance to the linkage of firms to universities not only to discover knowledge but also to aid in industrialization (Bettis and Hitt, 1995; Etzkowitz and Leydesdorff, 1997; Hwang et al., 2003). The universities and public research institutes have emerged as key components of the national innovation system (NIS).

According to Freeman (1987), the NIS is "a network of institutions in the public and private sectors whose activities and interactions initiate, import, modify, and diffuse new technologies." Lundvall (1992) defined it as the "elements and relationships which interact in the production, diffusion, and use of new, and economically useful, knowledge. . .and are either located within or rooted inside the borders of a nation state." He broadened the concept of Freeman to include economic structure and institutional setup that affect searching, learning, and adapting. In a book comparing the NIS of 15 countries, Nelson (1993) pointed out that the performance differences among the countries reflect different institutional arrangements. In the NIS literature, one of the roles of universities and research institutes is to channel their knowledge to firms, and universities function as a knowledge diffuser by producing quality students and by interacting with firms through cooperative programs.

With regard to the role of a university, two contrasting views exist: the Triple Helix thesis and the New Economics of Science. Etzkowitz and Leydesdorff (1997) introduced a triple-helix model of industry–university–government relations, emphasizing both the social and economic roles of a university. Here, the interactions among the three are key to facilitating the conditions for innovation. The Triple Helix thesis argues that a university needs to be directly linked to the industry to maximize the industrialization of knowledge. This emphasizes the "third mission" of the university, that is, serving for economic development aside from teaching and research (Etzkowitz and Leydesdorff, 2000). On the

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other hand, the New Economics of Science (Dasgupta and David, 1994) emphasizes education as an innate function of a university. This view is concerned with the relationship between university and industry becoming too close, arguing that it may be detrimental to the scientific potentials of a nation and that a proper division of labor between these actors is needed. Criticizing the inappropriateness of the two in their applications to developing countries, Eun et al. (2006) suggested a "contingent or context-specific" perspective on industry–university relationships. Each country has its own NIS, and it is natural that the industry–university linkages of each country take various forms, assuming different functions in a nation. This paper takes the case of Korea to investigate the role of universities and government research institutes (GRIs) in the NIS of a latecomer and fast catching-up economy, with a focus on the determinants of the university–academy linkages and their impact on firm performance.

One of the most important characteristics of the Korean NIS is the "twin dominance" of big businesses (so-called *Chaebols*) and the government, which also implies the relatively weak role of the universities and small and medium enterprises (SMEs) (Kim, 1993; Lim, 2006; Choi et al., 2007). For instance, universities, and industries employ around 70% and 20% of all doctorates in Korea and yet paradoxically conduct only 10% and 77% of research in Korea, respectively (OECD, 2008). In addition, as of 2005, 39.7% of researchers and 52.2% of Ph.D. researchers belonged to the top 20 firms (MOST, 2007). While big business groups have dominated the NIS of Korea through their large in-house R&D since the mid 1980s, it was the government and GRIs that have initially led the NIS of Korea during its early take-off period in the 1960s and 1970s. In the 1970s, Korea was in transition from light to heavy and chemical industries, but its national R&D base was weak. The Korean government thus tried to promote national R&D capacity by establishing GRIs: a number of GRIs were established based on the *Special Research Institute Promotion Law* of 1973 in the fields of machinery, shipbuilding, chemical engineering, marine science, and electronics.

Noticeably, from the mid-1970s, *Chaebol* firms have started to grow rapidly with diversity or entries into heavy and chemical industries. Afterward, the government played a significant role by providing a selected number of big firms with some privileges such as bank loans and access to foreign exchanges. Even in the 1980s and 1990s, big business groups or *Chaebols* were aided by the government-led public–private research consortia in achieving key R&D goals, with such examples of TDX (a system of telephone switches), memory chips development, and digital TV projects (Lee and Lim, 2001; Lee et al., 2005). According to a study by OECD (2003), Korea is the only country where the GRI rather than the university has a relatively greater role in national R&D.

In the context of the above discussion, one of the additional contributions of this study is that it examines the role of government policy in promoting the collaboration of firms with universities and GRIs, whereas the existing studies tend to focus more on firm-level and sectoral level characteristics, such as R&D intensity, firm size (Santoro and Chakrabarti, 2002), science-basedness (Meyer-Krahmer and Ulrich Schmoch, 1998), and intellectual property right (IPR) regimes (Cassiman and Veugelers, 2002). Moreover, as GRIs have been the key participants in these national R&D projects that involved private firms, it is important to examine the impact of collaboration with GRIs on firm performance. This is one of the distinctive features of this study.

In contrast to GRIs, universities have played a minor role in boosting R&D performance of the private sector in Korea. Big private firms rely more on foreign knowledge sources than local sources and universities, as they hire quality scientists and engineers from abroad or acquire technology in collaboration with foreign partners. Kim (1993) argued that the lack of interaction between university and industry, which is due to the nature of Korean universities as being teaching-oriented, is one of the greatest weaknesses of Korea's national system. Research has been given increasing priority in universities in Korea since the 1990s. Only since then that the ranking of Korea has risen in terms of the number of Science Citation Index (SCI) papers written by university professors. Korea ranked the 19th in 1996, with universities accounting for 83.0% of the contributions (Lee, 1998). From the late 1990s onward, policy agenda has finally shifted towards the entrepreneurial role of universities.

The enactment of the *Technology transfer Promotion Law* in 2001 symbolizes this transition of interests towards knowledge industrialization. This *Law* prescribes that public universities should establish units or institutions, such as Technology Licensing Offices (TLOs), which are in charge of technology transfer and training of specialists. Promotion of the industry–university cooperation obtained more momentum as the universities began to establish the so-called "industry–university cooperation foundation" in 2004 after the enactment of the *Law on Industrial Education and Industry–University Cooperation* in 2003. However, with this law, the intellectual property rights of the research outcomes of university professors began to belong formally to universities, whereas in the past, individual professors tended to file patents as their personal ownership. As of 2007, 134 universities have established industry–university cooperation foundations within their campuses, out of which 59.8% (80 universities) have TLOs. The number of TLOs increased rapidly, especially in 2004, with 43 being newly established, as there were only 32 until 2003 (KRF, 2006). The above discussion indicates that the knowledge industrialization involving universities is a recent phenomenon, and it has not progressed much. Thus, it is interesting to examine its impact on firm performance and compare the results with those from advanced or mature countries with longer history of the collaboration. According to the 2000–2001 data, collaboration with universities does not significantly enhance the probability of innovation success and has not led to sales increases but only in the increase of patents, which is in contrast to the results of the study on the cases in Europe conducted by Belderbos et al. (2004a,b) and Faems et al. (2005).

While this paper addresses the questions on what determines the industry–university/GRIs (IUG) linkages and how the linkages affect firm performance, it also achieves some methodological improvement. Some studies, for instance that by Monjon and Waelbroeck (2003), show that examining the impact on firm performance does not control for possible endogeneity, such that better performing firms may be more inclined to pursue collaboration with universities. Thus, we conduct a two-step approach. We first estimate the determinants of IUG cooperation using the probit model regressions and estimate the impact of this cooperation on innovation performance, where a possible endogeneity of IUG cooperation was controlled by using the results of the first-step estimations. We find that controlling for endogeneity is important because we have obtained contradictory results; when endogeneity is controlled, collaboration with universities is now shown to significantly increase the probability of innovation.

Moreover, when we examine the impact of the IUG cooperation on firm performance, we control for a possible sample selection bias using Heckman's 2SLS method, and the types of innovation are differentiated into product versus process innovation. The empirical analysis utilizes the data from the *2002 Korean Innovation Survey* (*KIS*), which was conducted by the Science and Technology Policy Institute (STEPI). The *KIS* comprises of firm-level data on technological innovation in the manufacturing sector. To allow for use of more variables and data credibility, the *Survey* data are merged with the standard financial statements of the firms compiled by a credit rating agency.