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Review

Why do Beijing Universities play important roles in regional innovation systems? Based on resource-based view

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Universities are not only the pool that generates graduates and technologies, but they are also important actors in industry by carrying out university-industry collaborations or creating new firms. Since Chinese openness and economic reform started in 1978, Beijing has achieved large successes in terms of knowledge creation, technology diffusion and university spin-offs (USOs), such as Tsinghua Tongfang of Tsinghua University and Founder Group of Peking University. The purpose of this study is to provide insight into the relationships between universities and regional innovation systems (RIS), based on the case of Beijing, China. Consequently, the authors discussed how and why Beijing universities might affect RIS in terms of academic resources, industrial resources, political resources, geographical proximity and academic entrepreneurship. Furthermore, several policy implications for universities and regional governments were drawn from the experience of Beijing.

Key words: University, regional innovation systems (RIS), university spin-offs (USOs), university-industry collaborations, Beijing.

INTRODUCTION

The invisibility of scientific research process indicates that new patents or inventions are not usually limited or opposed by laws or social ethics. However, the commercialization or application of these new inventions needs to obey laws or regulations, as well as consider social influences and ethics. For instance, the cloning technique has been regarded as an important invention for biology and there were some successful cases of animal cloning, such as the first female domestic sheep Dolly that was cloned from an adult somatic cell (McLaren, 2000), whereas human cloning has attracted many debates and opposition. Thus, how to effectively link scientific breakthroughs and industrial applications should be considered by academic institutions, industrial enterprises and policy-makers. In the case of universities, how to strengthen the applications of new knowledge and technologies is seen as a hot topic for universities and region policy-makers.

Since Freeman (1987) defined the National Innovation System (hereafter called NIS) as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies", NIS has been applied to analyze national innovation activities and economic growth (Intarakumnerd, 2002; Nelson, 1993). As research on NIS is deeply penetrated, some scholars have turned to focus on the roles RIS play in regional innovative competency and economic development since the early 1990s (Asheim and Isaksen, 1997; Cook, 2001; Cooke and Morgan, 1999; Debackere and Veugelers, 2005). Similar to NIS, RIS can be defined as the regional innovative network that undertakes innovative activities, referring to public agencies, industrial sectors, research institutions and universities (Doloreux, 2003; Gertler and Wolfe, 1998; Freel, 2002).

In these circumstances, the universities' roles are often

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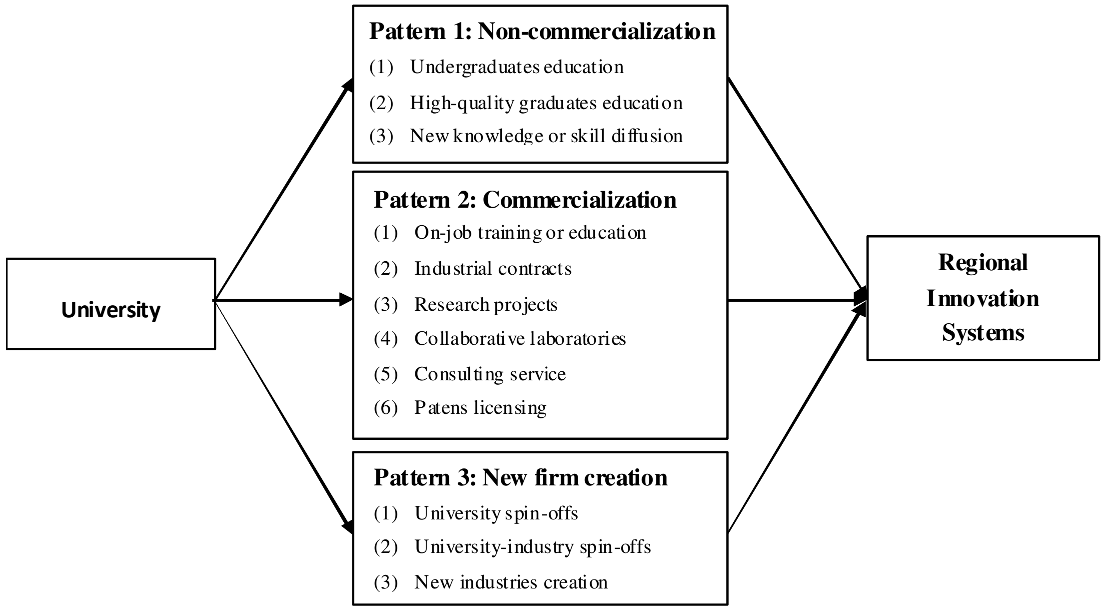

Figure 1. Three role patterns of University in RIS. Note: This model was complied by authors based on Etzkowitz et al. (2000) and Lendel (2010).

considered as a catalyst for driving the establishment of RIS (Gausdal, 2006). As an important part of RIS, universities are the crucial sources of economic growth not only for developed regions, but also for developing regions. As the main sector of knowledge creation and talent education, universities have been seen as an important part of the city or regional innovation network that improve innovation capability and facilitate regional economic growth through academic or related commercial activities (Klofsten and Jones-Evans, 2000). Recently, more and more universities have directly been involved in economic activities due to their knowledge advantages, including technology transfer, on-job training, technology consulting service, university-industry research projects and university spin-offs (Bekkers and Bodas-Freitas, 2008; Sohn et al., 2009). In the case of China, many Chinese universities have established a university technology transfer office aiming to facilitate technology transfer and the results of academic applications (Jia and Meng, 2009; Xia et al., 2010). For instance, Tsinghua University (hereafter called THU) has got 11578 patent applications (9940 inventions) and 6744 patent Registrations in total from 1985 to 2010. Meanwhile, THU applied 872 foreign patents, occupying 64% of 1915 of the foreign patent applications in 2010, and got 536 foreign patent registrations in 2010. In addition, THU focuses on the university-industry collaboration with 150 Chinese firms (such as Lenovo, China Mobile, Huawei) and 40 international firms (such as Intel, HP, Siemens and Samsung), while it has independently created a number of spin-offs in high-tech industries (such as Tongfang). Thus, the roles universities play in establishing an innovation system have attracted wide academic and managerial attention in China.

This paper, using Beijing as a case study, aims to examine the roles universities play in RIS as follows:

(1) We will review related studies to propose a model that describes the systematic functions of university in RIS (Figure 1).
(2) According to resource-based view, the advantages of Beijing universities related to RIS are discussed in terms of academic resources, industrial resources, policy resources, geographical localization and academic entrepreneurship.
(3) The impacts of Beijing universities and RIS are presented based on the databases published by Beijing Statistical Information Net or other organizations.
(4) Through analyzing Beijing experience, some policy implications are drawn and intended to be useful for other metropolitans, which might face similar situations.

PERSPECTIVE REVIEW

The relationships between universities and industries are seen as a key issue to understand why more and more universities focus on the commercial processes of research and development (R and D) results. We consider universities to have multiple statuses that can facilitate the exploitation of intellectual property rights as well as enhance collaboration between academic research and industrial applications.

Universities and regional innovation systems (RIS)

Not only enterprises and government, but also universities and research institutions are the key actors of RIS. In other words, regional innovation performance is the result of RIS that consist of universities, academic institutions, enterprises and government (Cook, 2001). As the crucial part of RIS, the roles universities do play should be discussed. Some scholars have argued that the major function of university is to supply science and technology-based "products" to the regional economy (Glaeser et al., 1992; Lendel, 2010). In an empirical study of 150 research-intensive universities that were "identified by average annual R and D expenditures", Lendel (2010) proved that the research orientation of universities can drive regional economic growth by universities' products, such as technology transfer, knowledge diffusion, high-quality workers supply and new firm creations. Through an empirical study on Canadian biotechnology industry, Hall and Bagchi-Sen (2002) found that similar to entrepreneurial resources, infrastructure, government and industry players, universities play an important role in supporting industrial growth. Chang and Shih (2004) suggested that in the age of economic knowledge, the accumulation of knowledge that can drive technical change and innovation plays a crucial role in economic growth. Technology innovation not only driven by research institutes but also driven by universities is considered to make up the gaps of existing industrial system and exploit new market to meet people's new demands.

In the case of China, there are several ways for university-industry collaboration in terms of R and D, including R and D contracts, joint research projects, joint laboratories and university-industry spin-offs (Wang and Ma, 2007). Many enterprises, particularly medium-sized and small enterprises, are unable to independently develop new technologies, and thus, they usually collaborate with universities or other research institutions that have a wealth of senior researchers, technical equipment and experience (Chesbrough and Crowther, 2006; Van de Vrande et al., 2009). Enterprises believe that cooperation with universities especially research-intensive universities would contribute to the advancement the technological foundation of firms, and result in the creation of competitive advantages, ultimately generating profitability by grabbing market share.

The university spin-offs (USOs) and regional innovation systems (RIS)

In a comparative study of Eastern and Western Germany, Legler et al. (2000) have proved that SMEs (spin-offs) mainly carry out innovation activities in the high technology-intensive industries of Eastern Germany, and therefore we need to emphasize the importance of SMEs (spin-offs) in the establishment of RIS. Furthermore, the involvement of university in the process of science and technology applications would create industrial technological gaps and perfect RIS (Debackere and Veugelers, 2005). Because they depend on a wealth of academic resources and technological assets, universities take advantage of the development and diffusion of new knowledge or technologies that would be applied in commercialization to improve the regional innovation competency. Once universities have created technologies with high market value, they are more likely to create new spin-offs that are seen as one major way to convert technological breakthroughs and scientific achievements into industrial outcomes (Gregorio and Shane, 2003). As an emerging phenomenon, spin-offs from universities have become the most popular pattern that contributes to the regional economic growth. In the case of Beijing, many universities are keen to create spin-offs relying on technical sources, policy support and university incubators (Chen and Kenney, 2007). For instance, enterprises of Peking University (hereafter called PKU) that focus on high-tech industries handed in taxation of 2.1 billion RMB from 2000 to 2005 and hired more than 20 thousands employees. In view of the importance of university in generating economic profitability, some Beijing universities have contributed to develop USOs that can imitate successful models such as Silicon Valley in US, Chennai in India and Kista in Sweden and thus, enrich RIS (Chen and Kenney, 2007; Liu, 2010; Tan, 2006).

In knowledge economy, start-ups (USOs) often need to face drastic competition with other big firms so that transforming from the "do things better" paradigm to "do more different things" has become a focus for USOs (Cooke, 2002; Ismail et al., 2010; Maeda, 2004). "Do things more differently" indicates that USOs need to focus on emerging industries or niche markets rather than mature or sunset industries. Thus, compared with industrial start-ups, universities spin-offs that own a wealth of academic resources (professors, students and facilities) to generate new knowledge or technologies prefer high-tech sectors with potentials, that is, 1) Pharmaceuticals (Ps), 2) Aircraft and spacecraft (AS), 3) Electronic and telecommunication equipments (ETE), 4) Computers and office equipment (COE), and 5) Medical equipment and meters (MEM) (O'Shea et al., 2005; Shane, 2004).

Gregorio and Shane (2003) suggested that universities can create one new start-up through a commercial patent or technology, so we can find that some USOs are created and operated independently or by their members (including staffs, students and laboratories). For example, Tsinghua Tongfang and Founder group are managed by academic entrepreneurs who also are the related university professors, while Lenovo founded by the Chinese Academy of Science (CAS) is still operated by

Table 1. A survey of universities in Beijing.

Item	University numbers			Full-time teachers			University staffs		
	2003	2008	2009	2003	2008	2009	2003	2008	2009
Universities	73	82	88	11628	55005	57133	26715	127593	129586

Source: Beijing Statistical Yearbook (2010).

its researcher Chuan-Zhi Liu.

Based on the above discussion, we can conclude that universities have three patterns of impact on RIS (Figure 1). The 1st and 2nd patterns are common for most universities and the 3rd pattern is often taken by some research-intensive universities (Landry et al., 2006). The essential tasks of universities are to train high-quality talents for a region or nation and facilitate new knowledge creation and diffusion. Furthermore, combined with essential education, more and more universities are directly involved in R and D activities, including supplying senior researchers to industrial firms, enhancing university-industry collaborations and patent licensing, while industry firms would offer technological equipments, research funding, entrepreneurial culture and market knowledge to universities. Once a series of conditions exist (such as university policy, academic entrepreneur, infrastructure and funding) to support new technology commercialization, some universities also tend to create new independent firms or in collaboration with other organizations. In conclusion, these contents of three patterns can be seen as "university products" that usually are consumed or absorbed by regional industrial sectors, and thus enrich RIS (Landry et al., 2006).

BEIJING UNIVERSITIES AND RIS

Traditionally, the roles universities play in region are to carry out academic education and new knowledge creation (Laukkanen, 2003; Wennberg et al., 2011). In the emerging knowledge economy, the positive effects of universities on the regional economic growth, considered as a "third-mission" of university, need to be recognized (Etzkowitz et al., 2000; Etzkowitz, 2003). Beijing has become one of the largest and most important cities in the World, not only in terms of politics and finance but also in terms of education and technological contents that can be crucial sources to high-tech industries according to the open innovation view (Chen and Kenney, 2007; Chesbrough, 2003; Filatotchev et al., 2011; Laursen and Salter, 2006). Compared with small regions, metropolitan regions such as Beijing with a complicated and dynamic network have larger advantage in innovative sources, including R and D personnel, universities, market scale and political support. Meanwhile, as a core part of RIS, universities often focus on performing technological innovation and labor education for stimulating regional economic growth (Brijlal, 2011). Next, we will examine the roles Beijing universities play in RIS according to the resource-based view.

The advantages of Beijing universities in terms of resource-based view

As known, Beijing has numerous top universities and research institutes so that this city has surpassed other Chinese regions by establishing a comprehensive and dynamic RIS in connection with R and D activities, political support and high-tech industries. Barney (1991) argued that strategic resources are the most important assets for firms to develop a competitive advantage. However, some papers have argued that due to the absence of resource support, universities' commercialization activities such as USOs often face difficulties and thus result in loss of academic resources (Frenkel, 2001; Gregorio and Shane, 2003; Zang, 2008). In view of the abundance of technologies, intellectual resources and information as well as policies' support, not only Chinese high-tech firms (such as Lenovo, Founder and Tongfang), but also many international high-tech firms (such as Nokia, HP, IBM and Microsoft) established headquarters, research institutes, branches or offices to exploit the emerging Chinese high-tech market. To analyze how Beijing universities enhance the interaction between the academic environment and industries, local government and region inhabitants, we will examine the strategic resources of universities: academic resources, industrial resources, political resources, geographical resources and academic entrepreneurs.

Academic resources

As the internal factors, academic resources that are the bases of new knowledge and technologies play the key role in connecting the regional spillover effects to economic activities, ultimately improving the regional innovative capabilities (Harhoff, 1999; Audretsch and Feldman, 1996). In the case of Beijing, there are a number of famous academic organizations, including universities (Table 1), public research institutes and private research institutes. In 2003, there were only 73 universities, 11628 full-time teachers and 26715 university

Table 2. Universities of Beijing ranked among the top 50 Chinese universities in 2011.

Universities	Rankings	Type	Science research	Personnel training	Composite reputation	Total score
PKU	1	Comprehensive	95.61	100	98.32	100
THU	2	Science and Technology	100	86.55	100	96.18
Renmin University of China	8	Comprehensive	28.11	36.52	73.38	36.61
Beijing Normal University	13	Pedagogic	28.32	23.87	39.58	27.95
Beihang University	22	Science and Technology	24.62	16.35	29.30	21.85
China Agricultural University	25	Agriculture and Forestry	21.33	14.46	31.39	19.60
Beijing Institute of Technology	30	Science and Technology	13.35	13.24	30.47	15.14
University of Science and Technology Beijing	33	Science and Technology	12.36	11.99	29.07	13.97
China University of Petroleum	41	Science and Technology	10.62	7.95	28.55	11.26

Source: China University Rankings Net (2011).

staff members in the Beijing region. However, in 2009, the numbers were respectively up to 88, 57133 and 129586, increasing by 120.55, 491.33 and 485.07% compared with 2003.

In contrast to the United States or South Korea, the majority of Chinese universities are public and supervised by government rather than private or independent, which means they enjoy involvement in official S&T activities and the Chinese government assigns a series of funds and research projects to them. Now, there are 23 universities in Beijing among 75 universities sponsored by the Chinese Ministry of Education. These kinds of universities are considered to have an abundance of excellent professors, smart students, strong R and D competency and comprehensive academic infrastructures (Xue, 2006).

According to the Chinese university rankings that were released by professional net, there were 9 Beijing universities ranked among the top 50 in 2010, and this number was equal to 18% of 31 provinces in Mainland China. Meanwhile, 3 Beijing universities ranked among the top 10 (Table 5) that means Beijing runs ahead of other Chinese regions in terms of academic resources and talent education.

One important role that university plays in regional economy is to generate well-trained talents who mainly undertake the tasks of economic development after graduation, and therefore enrich RIS through transferring human capital to the regional industrial sectors and non-industrial sectors. Furthermore, compared with research institutes, universities have a more opened and athletic academic environment, so they can continually generate a wealth of knowledge bases and new technologies as well as train well-educated undergraduates for advancing the regional economy. In the case of Beijing universities, Founder Group from PKU and Tsinghua Tongfang from THU (Table 2) are the most typical cases of USOs. Benefitting from pools of knowledge creation, technology transfer, high level professionals and well-trained workers, these two firms have grown into large high-tech groups rather than SMEs and become the industrial leaders in Chinese high-tech industries.

In November 2001, General Office of the State Council released “The Regulations about the Administrative System of University-run Enterprises of PKU and THU” aiming to enhance the USOs-industry linkages and normalize property relations between universities, spin-offs and inventors. Thus, in order to more effectively manage USOs as well as stimulate technologies’ transfer and diffusion, PKU established PKU assets Management Corporation in 2002 and THU established Tsinghua Holdings Company Limited in 2003.

Tsinghua Tongfang and Founder Group were small spin-offs, but now they are ranked among the Fortune China 500. By deploying universities’ R and D results, industrial collaboration, policy support and capital market, Tsinghua Tongfang spent 13 years and Founder Group spent 24 years to become the leading enterprises in China’s high-tech industry, especially in the computer and soft industry.

According to Table 5, we can find that the latter two USOs have achieved great successes in terms of sales and profit in 2010. As the enterprises of two top universities, Tongfang and Founder are benefiting from the R and D competencies of THU and PKU, which can help them develop new products or services for the new market. Thus, the network between universities and spin-offs is likely to enhance the university-industry collaboration and knowledge diffusion or technology transfer (Witt, 2004).

According to the statistic report of Chinese university-run enterprises investigated by the Technology Development Center of MOE, there were 4 Beijing universities among the top 14 rankings, while PKU and THU were the top two, far ahead of other universities. The success of university-run enterprises indicates that these universities focus on technology commercialization through their own firms, and therefore generate economic profit to enrich the financial assets of universities.

The advantages of academic resources of Beijing universities have contributed to the linking of the academic community to the industrial infrastructure, due to the transfer of high-quality talents, commercialization activities and new firm concentration.

Industrial resources

Due to the lack of essential industrial knowledge and market information, many universities tend to establish collaborative networks with industrial enterprises through patents licensing or common research projects that also can make universities obtain financial return and then make up the limitations of funding to start new business, technology exploitation or basic education (Shambare, 2011; Wang, 2011). To enhance the collaboration between university and industry, many universities have established incubators to offer a platform for linking knowledge production to industrial resources (Almeida et al., 2008).

Based on a review of the Chinese catch-up process, Xue and Liang (2010) suggested that “China’s patent system has played an important role in stimulating innovations for both multinationals and domestic firms”. In the global knowledge age, innovation has become an open and dynamic process rather than closed and static process so that it involves lots of technical uncertainty and creativity. In the open innovation age, the open business environment would facilitate the application of new technology so that universities are more likely to establish collaborative networks with outside partners, which can contribute to industry-university cooperation and undergraduate employment. As the economic and political center, Beijing has attracted many multinational firms to establish offices, factories or carry out other business affairs.

Table 7 shows a portion of all types of organizations in Beijing in 2008, indicating that the portion of firms that mainly undertake the economic activities was 91.3%, followed by public institutions and other organizations (2.9%). Thus, the large number of economic organizations would be the key market to consume “university products”, absorbing graduates and new technologies while purchasing the products or services supplied by USOs.

For example, THU which extremely emphasizes the linking of university-industry collaborations owns a wealth of commercial experiences and a mature university-industry collaborative network in China (Table 8). Table 8 shows that the number of results of university-industry collaboration was continually increasing from 2000 to 2005. In the case of patent Registrations, the number was only 135 in 2000 and fiercely up to 521 in 2005.

In the case of PKU, the technology contract was only 4 million RMB in 1995, but this number was up to 92.4 million in 2005. To enhance the university-industry collaboration, PKU, China Mobile and Asianfo Linkage jointly established “Mobile data storage joint laboratory” aiming to deploy academic resources and technological advantage of PKU, industrial networks and market knowledge of two firms (PKU net, 2011).

As for the commercial process of “university products”, universities need to get the support from industries which can consume undergraduates and new knowledge; meanwhile it can also offer markets for “university products”. In the case of Beijing universities (such as THU and PKU), they have formed a mature university-industry collaborative system so that the contributions to regional economic development will become more and more apparent.

Policy resources

We believe that in a healthy economy, government needs to focus on providing an economic environment by establishing correlative policies or regulations, and thus simplifying business formalities, rather than directly interposing economic activities. In view of the impact of governmental policies and university policies on entrepreneurial environment, one well-developed policy support system seems to be more exigent for universities participating in economic activities (Alam, 2009a; Alam et al., 2010). We discussed the impact of policy resources on university on 3 levels, including internal, local and national. First, through analyzing why some universities can create more spin-offs than others, Gregorio and Shane (2003) considered that university policy is the key factor for USOs creation. For example, “the distribution of royalty rates between inventors and university” would influence the willingness of entrepreneurs (they are either inventors or other persons) to explore new business. In the case of China, a series of universities’ policies of university-industry collaboration have been established (Zhang and Chen, 2011; Zhou and Dong, 2009).

Secondly, the local government needs jobs to achieve political gain, while new firms create jobs to realize firms’ growth (Dennis Jr., 2011) and people seek jobs to earn income. In other words, the contributions of high-tech start-ups to employment and industrial reorganizations have attracted policy-makers attention, which have focused on improving urban competitive advantage that can best realize resource integration or reconfiguration (including political resources, financial resources and human capital). Thus, how to generate more jobs is a crucial function of local government. Being cognizant of the roles of technological knowledge and innovation, Beijing Government has established “Medium-and-Long-Term High-tech Development Planning Outline from 2008-2020” (Table 9), aiming to improve the regional innovation capability and realize industrial structure optimization.

Regional policies dealing with the stimulating role universities play in knowledge creation and patent commercialization have attracted academic and entrepreneurial attention. During the establishment of

RIS, regional policy-makers should adopt open perspective to constitute correlative regulations, laws or policies so as to create the best entrepreneurial environment for industries. In the dynamic entrepreneurial environment, universities and their spin-offs are more likely to create intellectual property.

Being convinced that talents are the most valuable resources in the 21st century, China's central government has established "National Medium-and-Long-Term Talents Strategy" in 2010 (Table 10). As a centralization country, China's economic tendency is easily influenced by government policies or arrangements so that this strategy can be regarded as a roadmap for the next 10 years in china.

Note: The contribution rate of talent capital is the average values of certain years. For example, 2008 is the average value from 1978 to 2008; 2015 is the average value from 2008 to 2015; 2020 is the average value from 2008 to 2020.

To stimulate technology creation and transfer, China will gradually improve the proportion of R and D per GDP. It has increased the financial budget for developing new technologies and new industries, meanwhile the taxes imposed on (universities) spin-offs to facilitate technology commercialization are reduced, resulting in the creation for more jobs for solving severe employment stress. How to exert the roles of universities on economic development is not limited to universities, but it has also attracted the regional and central governments in China. While Beijing universities and political agencies focus on establishing a favorable political environment, the processes of academic education, commercial activities and new firm creation will be carried out by a more all-sided methodology.

Geographical localization

Many researchers have argued the relationships between geographical position and university (spin-offs) on regional economic development. Lendel (2010) argued that many international firms or organizations are more likely to establish their headquarters or offices in Metropolitan regions. Therefore, they are crucial markets or partners of "university products", including talent training, research projects and technology transfer. Sohn and Kenney (2007) found that Korean high-tech clusters, such as Daeduck and Seoul Kangnam, were formed around universities, public research institutes and private research institutes that create knowledge and exploit intellectual property and technological services.

Apparently, the geographic proximity of university can have positive impacts on the transfer of research results from the academic environment to industrial application (Adams et al., 2001). By investigating 54 biotech firms established by 445 university-based scientists, Audretsch and Stephan (1996) found that the biotech firms founded by university-based scientists have strong linkages to universities and focus on the geographic proximity of biotechnology data base, because the development of biotechnology firms strongly relies on the new knowledge and inventions. Florida and Kenney (1988) found that in the case of America, venture capital firms prefer to locate by high-tech clusters like Silicon Valley and Route 128, which are located near top US universities have created a large number of high-tech start-ups, some of them being from universities. Similarly in Beijing, many high-tech start-ups such as USOs select Haidian district as their business base where many venture capital, top universities and research institutes tend to locate. They believe that the geographic proximity of university can help them get more academic supports than others that are located away from universities. Meanwhile, the proximity of political center can help universities get more political resources for driving technology transfer and spin-offs' creation. Conversely, similar to USA and Korea, most China's high-level universities tend to locate in metropolitan areas with large economies and technological contents. Thus, in terms of geographical localization, the relationship between university and region is interactive rather than unidirectional. As China's economic, technology and political center, Beijing is more likely to offer geographical proximity to academic institutes so as to enhance the role universities play in regional economic development.

Academic entrepreneurship

The academic entrepreneurs not only need excellent insights and social network, but also need to be good at the process of technology transfer from university to industry. In other words, academic entrepreneurship is a key orientation to link faculty research results from an academic environment to industrial applications, and therefore generate revenue for the university (Laukkanen, 2003).

High-tech industries are characterized by high risk and high profitability (Witt, 2004; Wood, 2011). As one orientation of entrepreneurship, risk-taking is an important trait of entrepreneurs, which can help them exploit entrepreneurial opportunities more quickly than competitors (Lumpkin and Dess, 1996). Meanwhile, entrepreneurial orientation of researchers drives the commercial process of new technology and enriches regional technological bases (O'Shea et al., 2005; Zahra and Nielsen, 2002). As the core policy-makers of USOs, academic entrepreneurs need to be capable of developing skills, finance, industrial knowledge, market insight and guanxi (Liu et al., 2011). Although, there have been few studies on the impacts of academic entrepreneurs on university economic activities such as spin-offs in Beijing, some other regional experiences have confirmed the positive interrelationships between academic entrepreneurship and university economic activities (Bunderson and Sundcliffe, 2002; Lazear, 2004; Shane, 2004). In the case of Beijing, the largest Science Park Zhongguancun has become the glamorous base for returning entrepreneurs, who pursue education and learn advanced knowledge abroad, and are willing to start new business in high-tech industries in China (Filatotchev et al., 2011). Apparently, the experience of high-tech start-ups of those returning entrepreneurs can contribute to offer favorable benchmarking for local universities' entrepreneurs to create new firms in Beijing. Thus, we suggest that Beijing universities need to help academic entrepreneurs create new firms through providing or searching for financial aid, policies encouragement and infrastructure. For example, Zhi-Cheng, Lu who established Tsinghua Tongfang in 1997, was a professor of the thermal energy department of THU and was seen as a great academic entrepreneur rather than businessman. Early in 1989, he and his entrepreneurial team established the Artificial Environment Engineering firm in THU for enhancing the applications of research results. Furthermore, as the most successful academic entrepreneur, Chuan-Zhi, Liu who was the founder of Lenovo, has attracted more academic and industrial attention in China, aiming to examine the role academic entrepreneurship play in the process of transforming Lenovo from an academic spin-off (Chinese Academy of Sciences) into a global IT leader (Li and Xu, 2002).

Hence, as the most successful university/research institute spin-offs, Lenovo, Tongfang and Founder have provided important benchmarking and entrepreneurial experience to the Chinese academic entrepreneurs and universities to carry out the commercialization of new technologies.

Beijing Universities and regional innovation competency

In this part, we examine the impacts of R and D activities of universities on Beijing regional economic growth and the establishment of innovation system through reviewing the past statistical database released by Chinese statistical agencies.

R and D activities in Beijing

In view of the positive impacts of R and D on the improving innovation competency, the roles R and D activities play in regional innovative activities have been a focus of Beijing government (Table 11).

Although, the number of R and D organizations from 2004 to 2008 was not incremental, we do not think the number of R and D organizations have a direct relation with R and D competency, because R and D organizations can be either strong or weak in term of size, technical resources and R and D productions. On the contrary, the R and D human capital, patents' quantity and R and D expenditure are the direct indexes to measure the strength of R and D competency. According to Table 11, we can find that Beijing value the impact of R and D on regional economy development at all times. From 2004 to 2008, large and steady R and D expenditure (higher than 5% of GDP) was dedicated to develop new technologies. In term of R and D personnel, there were 200080, which were 1.32 larger than those of 2004. As the final production of R and D activities, patents mean the ability to create and apply new technologies.

In China, some regional governments establish science parks or high-tech zones around universities, such as Zhongguancun Technology Park (hereafter called ZTP) in Beijing, Xi'an high-tech industrial zone in Xi'an and Optics Valley of China in Wuhan. In the case of Beijing, ZTP has 39 universities (such as PKU and THU) and 213 research institutions (such as the Chinese Academy of Sciences). Meanwhile, there are 41 state Engineering Centers, 42 State Key Laboratories (by March 2008, there were 280 State Key Laboratories in China) and 10 State-Level Enterprise Technology Centers. The reason why Chinese government established ZTP located near academic institutions can be explained that the geographic proximity is more likely to convert new technologies or ideas into success through university-industry cooperation, technology-based spin-offs, and technology licensing. Location to universities plays vector effect, effectively linking to universities and industries. Today, ZTP has collected a large number of high-tech firms that positively undertake R and D activities independently, or collaborate with universities or other research institutions, and therefore it has become the largest science park in China (Cai et al., 2007; Filatotchev et al., 2011).

R and D activities of Beijing universities

In terms of numerous academic resources, the major performers of R and D in Beijing are universities, research institutions and big enterprises (Tables 13 and 14). As the most part of regional academic network, universities in Beijing need to undertake the tasks of higher education to train more excellent well-trained talents for industries. Meanwhile, in view of the numerous scientific and technological sources, they also need to carry out R and D activities to develop new technology and therefore improve regional innovation competency.

Despite the increase in "Personnel Engaged in Science and Technology", "Scientific Research Institutions" and "Full-time Scientific Research Persons" are small, but "the Scientific Research-oriented Expenditure Financing" and "The Appropriation Expenditure for Research and Experimental Development" are largely increased (Table 12).

The roles universities play in stimulating innovation activities are not limited to basic research, but also include patents development that leads to the enrichment of regional paten system of RIS. As the direct index which can reflect the outcome of R and D activities, patents (both applications and Registrations) can help improve the regional technological contents and innovative competencies, ultimately stimulating regional economic development. In the case of Beijing, universities have increasingly contributed to the patents applications and registrations in recent years (Table 13). In terms of patent applications, Beijing universities only applied 1699 (9.99%) in 2003, whereas they applied 5541 (12.74%) in 2009. Apparently, the numbers and portions of patent applications have increased to a certain extent.

Table 14 shows that universities as well as research institutions and enterprises are the major players in the Beijing regional R and D activities. The fact that 79 universities (Beijing had 82 universities in 2008, 96.34%) carried out R and D activities indicates that a majority of Beijing universities extremely focused on scientific and technological development, and therefore, enhance the relationship between academic research and industrial applications. In terms of R and D personnel, universities occupied 13.2% of the total. Despite the fact that his number was smaller than that of professional research institutions which main tasks are R and D activities and enterprises that need to develop new competitive advantages from R and D processes, the strength of investments in R and D activities of universities were apparent.

As the major actor of R and D activities in Beijing, universities have got large successes in patent applications and registrations (Table 15). The number of universities' patent applications and registrations were increasing more rapidly than the total number of Beijing regional patent applications from 2003 to 2009. The contributions of universities' patents to the regional patent system were also increasing, from 9.99% in 2003 to 13.80% in 2009.

Until now, we have discussed the positive impacts of Beijing universities on the improvement of RIS through discussion about the extent to which they participated in regional R and D activities. Beijing universities' R and D capabilities and the contributions to patents system have proved that they are directly linked to regional economic development.

DISCUSSION

Since Chinese openness and economic reform started in 1978, Beijing economy development and its innovation competency are closely linked to its universities. Rapid changes in Beijing regional economy, social infrastructure and technological environment provide opportunities for local universities to participate in economic growth and innovation activities. Likewise, while the importance of the traditional two missions (namely, academic education and knowledge creation) to the Beijing economy has been proved by many researchers (Chen and Kenney, 2007; Kondo, 2003; Matt and Tang, 2010), the third mission of Beijing universities also has achieved success in terms of USOs (Tables 2, 3 and 4).

In this paper, we have discussed why and how Beijing universities can take part in establishing a regional innovation system in terms of resource-based view. First, a wealth of academic resources such as a large number of high-quality graduates and high-level teachers (Tables 1, 5 and 6) offer inside conditions to enhance knowledge diffusion and university-industry collaborations for Beijing universities, as well as to supply academic entrepreneurs to USOs. Second, a relatively mature industrial system (Table 7) is more likely to offer industrial opportunities for Beijing universities, including undergraduates' employment, technological consulting and collaborations (Table 8, the case of THU). Meanwhile, universities also can gain financial return and market knowledge from industrial collaborators and therefore create USOs. Third, in order to solve the severe problems of undergraduates and improve innovation competency, the Chinese central government and Beijing metropolitan government have established a series of policies (Tables 9 and 10) aiming to facilitate middle-long term economy development. Thus, these policies might offer political support to universities to implement three patterns of universities in RIS (Figure 1). Fourth, location proximity to Chinese capital and the largest technology park ZTP offers geographical proximity to universities to stimulate knowledge diffusion and technology transfer as well as provide academic environment for firms to train workers and acquire academic support. In other words, the geographical proximity between universities and industry would contribute to forming a mature university-industry collaborative network aiming to continuously enrich Beijing metropolitan innovation system. Fifth, in the past several decades, some USOs have been created by universities' researchers or professors (such as Tongfang of THU and Founder of PKU) in Beijing. We view this kind of researchers of professors as academic entrepreneurs who are good at linking technologies to industrial applications. Based on an empirical study on ZTP, Filatotchev et al. (2011) suggested that a large number of returning entrepreneurs, who might affect the regional innovation system, also will offer favorable benchmarking on how to successfully combine academic results to markets for autochthonous academic entrepreneurs.

POLICY IMPLICATIONS FOR UNIVERSITIES AND REGIONAL GOVERNMENT

Innovation is an integrated process that refers to all sectors; not only industries and research institutions, but also universities and governments need to collaborate and harmonize with each other. In the case of Beijing, both central government and metropolitan government

Table 3. The number of higher-education students in Beijing in 2009.

Item	Graduation	Entrants	Current students
Graduates	58780	76010	209494
PhDs	12666	15376	58995
Masters	46114	60634	150499
Undergraduates	152336	158992	577154
Undergraduate education	109372	116158	451838
Vocational education	42964	42834	125316
Adult Undergraduates	123489	107039	281490
Undergraduate education	64106	55680	151000
Vocational education	59383	51359	130490
Oversea Students	18674	21889	30766

Source: Beijing Statistical Yearbook (2010); This data does not include informal education, such as online education, part-time education and job-training.

Table 4. The most successful cases of USOs in Beijing.

Year	Firms	Univer sities	Main business	Initial capital	Patent applications	Patents registration
1986	Founder Group	PKU	IT, pharmaceuticals	4.4 million RMB	N/A	N/A
1997	Tsinghua Tonfang	THU	IT, Energy, environment	N/A	1388	791[(1)]

Source: Su et al. (2011). [(1)], By June, 2008, there were 567 Chinese authorized patents (165 invention patents) and 59 foreign authorized patents. Meanwhile, 160 authorized patents were related to computer software.

Table 5. The rankings of Tsinghua Tongfang and Founder Group in the Fortune China 500 of 2010.

Rankings	Firms	Industry	Sales (Million RMB)	Profit in 2010 (Million RMB)	Market value (Million RMB)	Total assets (Million RMB)
164	Tsinghua Tongfang	Computers and Software	15,387.74	351.37	18,298.66	21,389.92
266	Founder Group	Computers and Software	7,789.56	98.00	8,891.41	5,622.90

Source: Fortune China (2011).

allocate resources and R and D assignments through establishing a series of S&T plans or policies (Chang and Shih, 2004). We have discussed how and why Beijing universities are contributing to the establishment of RIS and economic development. Thus, some policy implications for universities and regional governments can be concluded on the basis of Beijing experience.

Implication for financial policy

Due to the shortage of funding support for academic organizations, the regional government needs to assign S&T financial policies for technology transfer, diffusion and commercialization. Many researchers have argued that the obvious weakness of universities' spin-offs is lack of financial support to their development (Huggins, 2008). Macho-Stadler et al. (2008) suggested that by focusing the importance of universities and USOs on the regional innovation and economic growth, many EU countries have arranged a series of financial policies to achieve more flexibility of universities' commercialization. Landry et al. (2006) discussed that the stronger the ability to obtain financial support, the higher success the USOs can realize. Huggins (2008) found that owing to their inability to connect to regional financial networks (including banks and venture capitals), many universities in London have to solve intractable financial problems during the processes of universities' spin-offs, technology commercialization and others. Thus, how to assign a series of feasible and sustainable financial supporting policies to universities for new technology transfers or

Table 6. Chinese Universities-Run enterprises gross income ranking (unit: 10 thousand RMB).

Universities	Income	Rankings	Profit	Rankings
PKU	5,309,544.73	1	266,106.72	1
THU	3,086,309.07	2	91,496.58	2
Chinese University of Petroleum (Shan Dong Province)	576,876.41	3	30,210.69	6
Northeastern University	532,028.67	4	80,634.96	3
Tong Ji University	353,936.66	5	34,031.30	5
Huazhong University of Science and Technology	303,010.01	6	55,851.19	4
Sun Yat-Sen University	233,440.00	7	11,702.34	12
Wu Han university	210,925.61	8	16,863.04	9
Shanghai Jiao Tong University	144,802.49	9	15,729.16	10
ShanDong University	127,479.72	10	20,438.22	8
Beijing Foreign Studies University	118,820.40	11	27,677.51	7
Beijing Normal University	81,874.37	14	6,892.45	20

Source: MOE (2009).

Table 7. The numbers of organizations in Beijing in 2008.

Items	The numbers of organizations (10 thousands)	Portion (%)
Firms	34.5	91.3
Public institutions	1.1	2.9
Government departments	0.2	0.6
Social organizations	0.6	1.5
private non- enterprise organizations	0.3	0.8
Other organizations	1.1	2.9
Total	37.8	100.0

Source: Beijing Statistical Yearbook (2010).

Table 8. Overseas collaborative R and D and patents at THU from 2000 to 2005.

Years	Overseas collaborative R and D			Patents statistics	
	Projects	Contract value (Million $)	Funds received	Patents applications	Patents registrations
2000	124	13	8.7	344	135
2001	121	18	6.5	441	187
2002	134	15	5.9	583	164
2003	180	18	9.2	758	501
2004	277	19	12	824	537
2005	323	29	15	872	521

Source: Wang and Ma (2007).

commercialization should be an important focus of regional government. We believe that the diversification of financial support can increase the technological applications of universities or their individuals.

Implication for university policy

Policies that coordinate the distributions between patents' inventors (professors, researchers or students) and department of universities are very crucial for technology transfer and diffusion (Gregorio and Shane, 2003). The illogical distributions are more likely to restrain the application of licensing and patents and therefore impact the enthusiasm of professors or other inventors who are the main actors to create new knowledge and patents in the academic environment. We suggest that an effective incentive mechanism can contribute to stimulate the processes of knowledge creation and technology

Table 9. The stage goals of Beijing high-tech development in 2015.

Rank	classification	Goals
1	R and D expenditure	6.5% of GDP
2	Industrial R and D expenditure	55% of social R and D expenditure
3	Trade volume of technology transfer	150 billion RMB
4	Patents applications	15 per 10 thousands persons
5	Papers published in SCI, EI and ISTP	40 thousands
6	Products developed from proprietary intellectual property rights	45% of all products
7	High-tech industrial added value	25% of GDP

Source: Science and Technology Commission of Haidian District (2011).

Table 10. National Medium-and-Long-Term Talent Strategy from 2010-2020.

Classification	2008	2015	2020
Total talent resources number(10 thousands)	11385	15625	18025
R and D personals (per 10 thousands)	24.8	33	43
High technical personnel/the skilled personnel personals (%)	24.4	27	28
Major labor age personnel with higher education (%)	9.2	15	20
Investment in human capital /GDP (%)	10.75	13	15
The contribution rate of talent capital (%)	18.9	32	35

Source: The Central People's Government of the People's Republic of China (2011)

Table 11. R and D and patents from 2004-2009 in Beijing.

Classification	R and D				Patents	
	R and D organizations	The total R and D expenditure per GDP in Beijing (%)	The total R and D expenditure per GDP in China (%)	R and D personnel	Applications	Registrations
2004	4334	5.25	1.23	152132	18402	9005
2005	4887	5.45	1.34	177765	22572	10100
2006	4614	5.33	1.42	168875	26555	11238
2007	5607	5.35	1.49	204668	31680	14954
2008	3445	5.58	1.47	200080	43508	17747
2009	-	-	1.62	-	50236	22921

Source: Beijing Statistical Yearbook (2010) and China Statistical Yearbook (2010).

diffusion from universities to industrial environment.

In addition, similar to Beijing experience (such as PKU and THU), universities need to establish technology licensing offices and incubators which can provide access to strategic resources for fostering technology transfer, knowledge diffusion or new firms' creation (Gregorio and Shane, 2003; Matt and Tang, 2010).

Implication for academic entrepreneurship

The academic entrepreneurial environment that can facilitate the transfer and diffusion of academic achievements (well-trained graduates, new knowledge, publications, conferences and technological outcomes) from academic environment to applications needs to be established (Alam, 2009b). In an economy, most sectors do not directly participate in R and D activities, whereas they need R and D results or its derivative products, such as new technologies, new processes, and new machines which are derived from R and D processes. Chang and Shih (2004) suggested that despite that fact that traditional manufacturing and service sectors may not be involved in R and D processes, technologies are also extremely crucial for them to improve production efficiency and develop competitive advantages. Thus, universities, research institutions and other academic organizations have become the most important leaders of supplying new knowledge or technologies for industries.

In addition, academic entrepreneurship also can

Table 12. R and D activities of Beijing universities.

Classification	2008	2007	2004
Personnel Engaged in Science and Technology (person)	49853	46988	45093
Scientists and Engineers (person)	42315	40200	37617
Scientific Research Institutions	481	443	394
Full-time Scientific Research Persons (person. year)	26397	24837	23603
Scientists and Engineers in R and D	25928	24417	23005
Basic Research	8909	8139	8485
Applied Research	15986	12330	11647
Experimental Development	1503	4368	3471
Scientific Research-oriented Expenditure Financing (10 thousands RMB)	1225189	1055870	612870
Government Appropriate Funds	762062	630364	360240
Corporation	376861	336845	199111
Loans of Banks	-	13	-
The Appropriation Expenditure for Research and Experimental Development (10 thousands RMB)	556812	476567	282867
Basic Research	155520	144520	87642
Applied Research	347287	252714	144357
Experimental Development	44588	75858	44947

Source: Beijing Statistical Yearbook (2010).

Table 13. Patent applications and registrations in Beijing.

Item	Applications			Registrations		
	2003	2008	2009	2003	2008	2009
Grouped by type						
Invention	7833	29326	28394	2261	9157	6478
Utility model	6665	15424	11157	4244	10141	8776
Design	2505	5486	3957	1743	3623	2493
Grouped by applicator						
Industrial enterprises	5253	26725	22792	2778	10749	7518
Universities	1699	6935	5541	634	3997	2268
Research institutions	1952	5783	5341	864	2666	1991
Other organizations	154	490	501	36	273	172
Individuals	7945	10303	9333	3936	5836	5798
Total	17003	50236	43508	8248	22921	17747

Source: Beijing Statistical Yearbook (2010) and Beijing Statistical Yearbook (2005).

contribute to the creation of USOs and University-industry spin-offs (UISOs) for universities. Compared with industrial start-ups, USOs and UISOs not only need to focus their growth, but also need to effectively deal with the relationships between university and industrial application. Thus, universities that are desired to carry out the three patterns (Figure 1) should pay more attention to the establishment of academic entrepreneurial environment.

Implication for Korea

Furthermore, Beijing's experience is similar to that of the USA (Gregorio and Shane, 2003; Lendel, 2010) and Canada (Hall and Bagchi-Sen, 2002; Landry et al., 2006), but differs from the Korean experience, which Sohn and Kenney (2007) have proved that Korean universities are not directly linked to economic development and that universities or private institutes have weaker contributions to the creation of clusters than public research institutes in Korean high-tech cluster Daeduck. In Korea, research institutes of large firms (such as Samsung, Hyundai and LG) and public research institutes are the main actors to carry out innovative activities and technology applications rather than universities. However, in Korea many international prestigious universities (such as Seoul National

Table 14. R and D Personnel sources in 2008.

Item	R and D organizations	R and D personnel in 2008			
		Basic research	Application research	Experimental development	Total
Grouped by sectors					
Scientific research institution	306	15366	25077	25761	66204
Universities	79[(1)]	8909	15986	1503	26398
Enterprises	2899	1047	10359	91564	102970
Others	161	336	1696	2476	4508
Grouped by affiliations					
Central government	748	22485	39888	49840	112213
Beijing government	2697	3173	13230	71464	87867
Total	3445	25658	53118	121304	200080

Source: Beijing Statistical Yearbook (2010). [(1)]: this number is the number of universities that carry out R and D activities, rather than the total number of R and D institutions in universities.

Table 15. Universities patents applications.

Year	Universities patents applications (A)	Portion (B=A/C) (%)	Total patents applications (C)	Total patents registrations
2003	1699	9.99	17003	8248
2004	1847	10.37	18402	9005
2005	2535	11.23	22572	10100
2006	2819	10.62	26555	11238
2007	4207	13.28	31680	14954
2008	5541	12.74	43508	17747
2009	6935	13.80	50236	22921

Source: Beijing Statistical Yearbook (2010).

University, Korea University, Yeonsei University and KAIST) have a wealth of academic resources and are good at technology innovation. If these universities simply focus on academic education or knowledge diffusion rather than technology commercialization or creation of USOs, the possibilities of universities that contribute to economic development will be ignored and therefore waste crucial academic resources. Thus, we believe that the Beijing experience can become an important benchmarking on how to closely link academic achievements to industrial market for Korean universities, and thereby contributes to economic development and technology advancement, while obtaining financial rewards. When one successful model about how to facilitate university-industry-market collaborations is developed, Korean universities can generate profit and therefore overcome the gradually rising tuition that has become a focus in Korea.

CONCLUSION

This study systematically examines the roles Beijing universities play in RIS. The knowledge economy asks that all actors of economic development should form a dynamic and interactive system, and therefore universities cannot be independent of industries. In the presence of many top universities in Beijing metropolitan, their roles are not only limited to train high-quality workers or facilitate knowledge diffusion that may be the basic tasks of all universities, but they also include carrying out commercialization activities that are very obvious in research universities, such as university-industry research projects, collaborative laboratories and technology licensing (Lendel, 2010). In addition, many Beijing universities are also keen to the creation of USOs and UISOs (such as THU and PKU).

Finally, we cannot simply consider university as a pool of new knowledge, high-quality workers, and it is also a crucial actor for knowledge-based economic development and the center of emerging knowledge economy (Cortright and Mayer, 2002; Nelson, 1986). Universities are the important pools for industrial firms through technologies' transfer or diffusion, human capital supply, research projects and consulting. On the other hand, universities are also the important complementary part of regional economic sectors through the establishment of

USOs and UISOs.

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