8

China

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8.1 Introduction

China is an emerging economy with a rapidly growing technology market. Both the central and provincial governments have supported knowledge transfer activities and directed technology development, initiating regional innovation collaboration and promoting entrepreneurship, innovation, and economic growth. As in other countries, many of these activities are geographically concentrated. For example, five provinces (Beijing, Guangdong, Shanghai, Shandong, and Jiangsu) accounted for half of total R&D expenditure in China in 2011, while the top ten provinces accounted for 70 percent of total R&D expenditure that year (Wang et al. 2015a).

In recent decades, Chinese universities and public research institutes have made tremendous progress in the fields of research and education. This progress is reflected in the increasing number of scientific publications and patent applications originating in the country. The technology market, spinoff companies from universities and public research institutes, cooperation between academy and industry, and patent transfer and licensing have all developed rapidly in China. Yet several issues have resulted in lower than possible rates of knowledge transfer from universities and public research institutes to firms, resulting in substantial amendments in 2015 to the Law on Promoting the Transformation of Scientific and Technological Achievements (PTSTA). These amendments removed legal barriers to knowledge transfer and provided incentives for universities and public research institutes to engage more actively in knowledge transfer activities.

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However, several factors are likely to continue to hinder the growth of knowledge transfer from universities and public research institutes to firms. Challenges include the immaturity of technology markets, the inadequate R&D capabilities and investments of Chinese companies, the historical legacy of past policies that failed to provide sufficient incentives for patenting and transfer activities, ambiguous corporate governance and regulations, and underdeveloped intermediary agencies such as knowledge transfer offices.

This chapter looks at these issues in detail. Section 8.2 describes how the role of Chinese universities and public research institutes has evolved in recent decades with the transition to a market economy. Section 8.3 outlines changes in the main laws and policies governing knowledge transfer activities. Section 8.4 examines the knowledge transfer activities of Chinese universities and public research institutes, while Section 8.5 analyzes ongoing barriers to knowledge transfer. Last, a short concluding section summarizes our main findings.

8.2 The Role of Universities and Public Research Institutes in China

Since the 1980s, China's universities and public research institutes have undergone fundamental changes as part of the country's economic transformation from a centrally planned system to a market-based economy.

In March 1985, the Central Committee of the Communist Party of China issued a Decision on Reforming the Science and Technology System (CCCPC 1985), which emphasized the economic orientation of the science and technology (S&T) system by introducing elements of competition and market discipline. Research institutions formally under the administration of central or local governments were encouraged to join large and medium-sized enterprises and become responsible for their own profits and losses (Baark 2001; Huang et al. 2004; OECD 2008).

R&D investment made up approximately one-third of total S&T expenditures in the 1990s. Government R&D expenditures have increased steadily since then (Baark 2001). However, as Huang et al. (2004) note, compared to the European Union member states and other Organisation for Economic Co-operation and Development (OECD) countries, China's innovation system was underdeveloped in the 1990s, partly as a consequence of insufficient support from legislative actions, inadequate policies to support innovation, human resources and finance, and low levels of business innovation.

In 1993, the State Council promulgated the National Outline for Educational Reform and Development (CCCPC 1993), with the goal of raising the quality of teaching and research at Chinese universities to among the world's best through funding to create an elite group of universities and to support key disciplines. Subsequently, the Ministry of Education launched the "211 Project" to support the development of 100 leading universities. In 1995, China announced the Strategy of Invigorating China through Science and Education, emphasizing the role of science and education in economic and social development. The country's higher education sector developed rapidly thereafter. The 1998 Law of Higher Education established three basic functions for Chinese universities: cultivating talent, scientific research, and social services.

In 1999, the Ministry of Education initiated the "985 Project" supporting the development of world-class research universities. By 2015, China had 2,852 universities, 1.57 million faculty members, 9.75 million undergraduate students and 6.45 million graduate students, of whom 74,000 were PhD students. Today, China has 112 universities supported by the 211 Project and thirty-seven supported by the 985 Project.

In 2006, the government issued its National Plan for Medium and Long-Term S&T Development (CCCPC 2006), which further defined the functions of universities and public research institutes in the national innovation system. The Plan states that universities are "important bases for cultivating high-level innovation talents," "one of the most important forces for basic research and high-technology innovations," and "an emerging force for solving important science and technology problems, promoting technology transfer." The roles of public research institutes were to conduct basic research, cutting-edge technological research and social science research.

Due to recent efforts, China's innovation activities have intensified substantially and attracted the return of highly skilled workers from overseas. Combined with a growth in R&D investments, this has led to increased scientific publications and patent applications, as shown in the following section.

8.2.1 Investment, Scientific Publications and Patent Applications

R&D Investment

China has become a powerhouse in R&D spending since the 2000s. In 2012, its gross expenditure on R&D (GERD) passed 1 trillion renminbi

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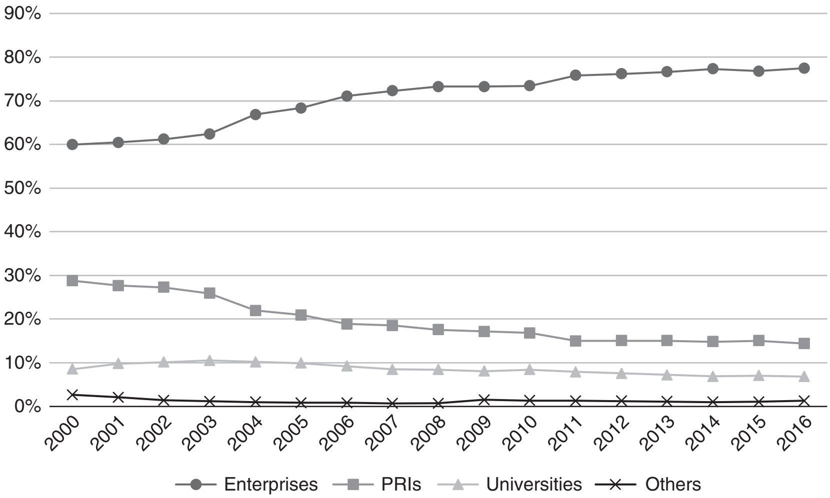

Figure 8.1 Share of total R&D expenditures by enterprises, public research institutes, and universities in China, 2000–16
Source: China Statistical Yearbook on Science and Technology (2017)

(CNY) (USD 163 billion), third behind only the U.S. and the European Union. In 2017, this number rose to a record CNY 1.76 trillion (USD 254 billion), ranking China as second in the world in terms of R&D spending after the U.S. (National Bureau of Statistics 2018). R&D intensity, the ratio of R&D expenditure divided by gross domestic product (GDP), hit a record high of 2.12 percent – a rise of 0.01 percentage points compared to 2016.

As Figure 8.1 demonstrates, the share of business R&D spending out of total R&D expenditures has kept increasing throughout the past twenty years, rising from 60 percent in 2000 to 77 percent in 2016 (China Statistical Yearbook on Science and Technology 2017).

All types of organizations devote most of their R&D investment to experimental development or applied research (Figure 8.2), but universities are the primary performer of basic research, accounting for 49.3 percent of total basic research expenditures of CNY 82.3 billion.[1]

[1] R&D includes basic research, applied research and experimental development. Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view. Applied research is also original investigation

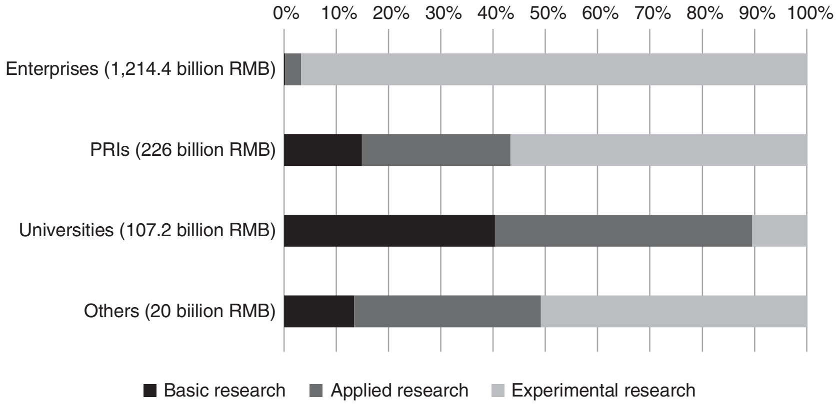

Figure 8.2 Share of 2016 R&D expenditures in China by application
Source: China Statistical Yearbook on Science and Technology (2017)

Scientific Publications

China has become the world's second largest producer of scientific publications (Institute of Scientific and Technical Information of China 2018). In 1989, the number of Science Citation Index (SCI) papers by Chinese authors was only 3 percent of the number of papers written by US authors. By 2008, this proportion had risen to 30 percent. Based on the data in Table 8.1, universities and public research institutes accounted for 85.9 percent and 10.2 percent respectively of all SCI-indexed papers published by Chinese researchers in 2017.

Patent Applications

Since the 2000s, China has experienced a surge of patent applications. The total number of invention patent applications[2] filed with China's State Intellectual Property Office (SIPO) increased from 51,747 in 2000 to

undertaken to acquire new knowledge, but directed primarily toward a specific practical aim or objective. Experimental development is systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed toward producing new materials, products or devices, performing new processes, systems and services, or substantially improving those already produced or installed.

[2] An invention patent is granted for new technical solutions for a product, process or the improvement thereof, provided that the technical solutions have a practical applicability. A utility model patent is granted for new and practical technical solutions relating to the shape and/or structure of a product. In general, the inventive step required for a utility model patent is less than that required for invention patents. On average, invention patents can require three to five years from application to grant, while utility patents require one year.

Table 8.1 *Number of SCI-indexed papers by different organizations in China, 2003–17*

Quantity/year	2003	2005	2010	2015	2017
Universities	63,672	125,814	100,772	219,957	273,337
PRIs	15,840	25,010	18,941	29,749	32,370
Medical institutions	455	1250	342	8,973	11,208
Enterprises	550	756	1,340	744	1,149
Total	80,517	152,830	121,395	259,423	318,064

Source: Various issues of Statistical Data of Chinese S&T Papers Compiled by the Institute of Scientific and Technical Information of China

1,338,503 in 2016. In 2017, more patent applications were filed with SIPO than the filings for the United States of America (U.S.), Japan, Republic of Korea, and Europe combined. Figure 8.3 shows domestic invention patent applications by type of entity. Enterprises have the most rapid growth in patent filings. The share of university and public research institutes in total invention patent applications increased from 14.4 percent in 1995 to 22.9 percent in 2005, before declining to approximately 19 percent from 2014. Zhang and Wan (2008) analyzed the ownership of Chinese patents and found that public research institutes have a higher efficiency (measured by the number of patents per unit of R&D expenditure) in generating invention patents, while enterprises have higher efficiency in generating utility model patents.

8.3 Laws and Policies Relevant to Knowledge Transfer

8.3.1 The Legal Framework for Knowledge Transfer in China

One of the most important laws governing knowledge transfer activities in China is the 2007 Science and Technology Progress Law, which provides the legal framework for the management of scientific and technological achievements. According to Article 20 of the Science and Technology Progress Law, intellectual property rights (IPRs) that are generated from government funding by a university or public research institute belong to the institution, except when the IP rights involve national security, the national interest, or other major social and public interests. IPRs include patents, copyrighted software, integrated circuit designs, and new plant variety rights.

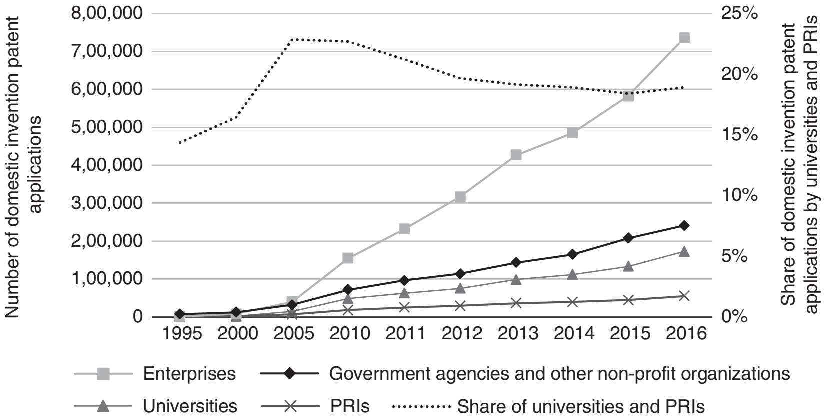

Figure 8.3 Domestic invention patent applications by different types of organization, 1995–2016

Source: China Statistical Yearbook on Science and Technology (2017)

While the concept of patents dates to the fifteenth century in Europe, the introduction of a system of intellectual property laws in China is very recent (Kafouros et al. 2015). China joined the World Intellectual Property Organization in 1980, paving the way for the creation of an IP system that complies with international standards (Bosworth and Yang 2000). Five years later, in 1985, China signed the Paris Convention for the Protection of Industrial Property and established a Patent Office, the predecessor of the current SIPO. The Chinese Patent Law was enacted in 1984 and is the governing legislation for the protection of technological inventions in China. The Patent Law came into effect in 1985 and has been amended three times, in 1993, 2001, and 2009.

Article 6 of the 2009 Patent Law regulates the ownership of inventions created by academics and researchers at universities and public research institutes during their work, or when they use materials, facilities, or equipment provided by a university or public research institute. According to the Patent Law, the inventor of inventions created as part of their work or using workplace assets has the right to be acknowledged on the patent document and receive a reward or compensation from their employer, but the employer owns the invention.

Another essential law governing knowledge transfer in China is the Law on Promoting the Transformation of Scientific and Technological Achievements (PTSTA), promulgated in 1996 and amended in 2015. The

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Law covers rights to scientific and technological achievements, rewards for R&D and knowledge transfer personnel, and requires universities and public research institutes to establish or obtain access to knowledge transfer agencies.

Contract law and company law also regulate knowledge transfer in China, as the relationship between the parties to a knowledge transfer agreement reflects basic contractual relations and knowledge transfer often involves enterprises as technology buyers or collaborating partners.

8.3.2 Amendments to the PTSTA Law in 2015

The PTSTA Law of 1996 was amended in 2015 for three reasons. First, several articles of the Law were outdated as a result of significant changes in the Chinese economy. Second, many provinces had experimented with various policies to stimulate knowledge transfer and the amendments were designed to enact the most effective policies into law. Third, universities and public research institutes in China lacked adequate incentives to transfer technology because of the institutional setting and rules defined in the 1996 Law.

Under the 1996 Law, a university or public research institute was required to report to and obtain approval from the Ministry of Finance or the State-Owned Asset Supervision and Administration Commission in order to license or otherwise dispose of IP. Universities and public research institutes did not have full owner's rights, and consequently were less motivated to promote knowledge transfer. Furthermore, after they transferred IP assets, any revenue they earned from the transfer had to be paid to the Ministry of Finance.

The amendment dealt with these issues. Under Article 18 of the amended PTSTA Law, universities and public research institutes established by the state have the right to dispose of their scientific and technological achievements, including the right to transfer technologies. However, the price agreed on by both parties in negotiation or auction and the name of the scientific and technological achievements must be disclosed to the public. Furthermore, universities and public research institutes can keep the revenue from knowledge transfer and are not required to pay it to the Ministry of Finance.

Before the amendment, knowledge transfer was not used as a performance measure for universities and public research institutes. In contrast, the amendment has made knowledge transfer a legal

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obligation for Chinese universities and public research institutes. Article 17 of the amended Law stipulates that public research institutes and universities established by the state are required to strengthen the management, organization and coordination of the transformation of scientific and technological achievements, prepare an annual report on their achievements in transforming science and technology, and set up a knowledge transfer organization and process.

In May 2016, the State Council announced implementation details for the PTSTA Law in a Program on Promoting Scientific and Technological Achievements, Transfer and Transformation to promote the disclosure and exchange of information on scientific and technological achievements. Specific actions under this program included:

- Setting up a coordination mechanism for industry, universities and public research institutes so they can cooperate fully to promote knowledge transfer.
- Creating a commercialization base for scientific and technological achievements.
- Strengthening the transfer of scientific and technological achievements into market-oriented services, including building a national technology trading network platform and offering knowledge transfer services at the regional level.
- Promoting scientific and technological innovation and entrepreneurship through the development of "maker spaces" to open up the scientific and technological resources of universities and public research institutes to the public.
- Training professional knowledge transfer personnel.

Almost every provincial government has enacted regulations to implement the provisions of the amended PTSTA Law. For example, several provinces increased the proportion of knowledge transfer revenue that can be used to reward R&D and knowledge transfer or set up special scientific and technological achievement funds. In Jiangsu Province the fund was valued at CNY 2 billion in 2014. Provincial governments were often bolder than the central government in promoting knowledge transfer because they considered knowledge transfer to be an important driver of local economic growth.

To fulfill the legal obligations stipulated in the amended PTSTA Law, China's universities and public research institutes adopted up to seven actions to facilitate knowledge transfer, although some universities and public research institutes implemented some of these actions before the

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amended Law, for instance, to reflect provincial policies or known best practice.

1. *Increasing rewards and compensation for inventors and knowledge transfer contributors*. Article 45 of the amended Law requires that no less than 50 percent of the net profit from knowledge transfer should be given as a reward or compensation by universities and public research institutes to the inventors and others who made significant contributions to the transfer, including knowledge transfer officers. This provision greatly incentivized knowledge transfer by universities and public research institutes. Nearly all universities and public research institutes have reformed their reward regulations since 2015. Many now give up to 70 percent of net profits from successful transfer to the inventors and related contributors. In 2015, the Drug Research Institution of the Chinese Science Academy paid nearly CNY 12 million to inventors and knowledge transfer contributors.
2. *Setting up knowledge transfer organizations*. China's public research institutes have set up knowledge transfer organizations that are either associated with several national-level organizations, such as the National Technology Transfer Center or the National Technology Transfer Demonstration Institution, or cofounded with local governments or enterprises. Successful examples include the Hunan University of Chinese Medicine, which transferred its newly developed Chinese traditional medicine to pharmaceutical enterprises and earned revenue of CNY 68 million. The transfer eventually resulted in the development of enterprises with annual revenues of several hundred million renminbi and created several leading brands of biomedical products in Hunan Province. Another example is the Central South University of Forestry and Technology. The University provided a feasibility study of bamboo plywood production, factory planning, process design for workshops, technical training, preproduction technical guidance and many other technical services to more than 400 bamboo plywood enterprises which together achieved total output valued at more than CNY 20 billion. A third example is Changzhou University, which signed twenty-two knowledge transfer agreements with twenty major manufacturers of phosphorus chemical products and obtained a total income of over CNY 20 million.
3. *Implementing performance evaluation systems*. Many universities and public research institutes have established performance

evaluation systems to motivate knowledge transfer staff. By contributing to knowledge transfer, staff can be promoted to senior management positions and have the opportunity to pursue a promising career path.

4. *Marketing of information on scientific and technological achievements.* Universities and public research institutes participate in exhibitions organized by governments and other commercial organizations to exchange information with enterprises and investors, introduce their scientific and technological achievements, negotiate with potential buyers, and disseminate information about their scientific and technological achievements on their websites to attract potential partners.
5. *Permission for academics to take a leave of absence to start a business.* Before the 2015 amendment to the PTSTA Law, universities and public research institutes did not encourage academics to work part-time to assist a firm to transfer licensed university technology or take a leave of absence to start their own businesses. However, the 2016 implementation details to the PTSTA Law allow academics to do so. The policy requires universities and public research institutes to establish their own systems to manage academics while they are on leave, and should keep the faculty position of academics for up to three years for those who take a leave of absence to create new businesses.
6. *Policies on spinoffs*. Many universities and public research institutes have introduced new initiatives to permit and encourage students to start their own businesses. On-the-job and off-the-job entrepreneurship by professionals and technicians in universities and public research institutes are also encouraged. For example, according to the Knowledge Transfer Regulation of Zhejiang University, faculty and students can invest in companies, using their scientific and technological achievements and proprietary technology.
7. *Strengthening cooperation between universities, public research institutes and local industry*. In addition to the policies identified above to provide incentives for academics to engage in knowledge transfer, policy has also encouraged knowledge transfer via university–industry collaboration. A common channel is to establish a joint research institute that offers technology services to local industries. In this collaborative model, local governments offer land, funds, and buildings while universities and public research institutes offer their scientific and technological achievements, R&D capabilities, management teams, and

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equipment. Local governments are eager to support this model due to expectations that collaboration will promote local economic growth.

China has formulated four other types of policy to promote university–industry research linkages. One consists of policies to establish strategic alliances for industrial technology innovation. The first fifty-six alliances were set up in 2010 and focused primarily on promoting industrial technology innovation. Many were led by universities and public research institutes. Once scientific and technological progress was made, new technologies could be transferred smoothly from universities and public research institutes to industry through the alliances.

The second policy type relates to the reform of the National Science and Technology Plan. Industrial development projects that are funded under the Plan are required to include enterprises in the research and in the development of research agendas. Currently, enterprises participate in nearly 90 percent of projects under the Plan and lead nearly 50 percent of science and technology projects.

The third policy category establishes national technology innovation platforms or Innovation Centers to promote university–industry research cooperation on nationally strategic industrial technologies. The first center, the National High-Speed Train Technology Innovation Center, located at Qingdao City in Shandong Province, was established in September 2016. In the same year, the Ministry of Industry and Information began creating other National Manufacturing Innovation Centers to advance industrial innovation capacity. Nearly fifteen such centers were planned to be established by 2020.

The fourth policy category consists of science parks, which are an important tool for Chinese innovation policy (Lai and Shyu 2005; Jongwanich et al. 2014). In 1991, the State Council established the Torch Program, which accelerated the establishment of science and industry parks across China. The number of university science parks increased from forty-two in 2004 to 115 in 2014 (Torch Report 2016). These science parks offer various incentives to encourage investment and the formation of new firms:

- New firms are exempt from corporate income tax for two years.
- Licenses are waived for the importation of materials and parts used in producing products for export.
- Revenue from knowledge transfer is only taxable after the first CNY 300,000.

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- Intangible assets such as intellectual property can be factored into a company's registered capital.
- The science parks can provide professional intermediary services such as legal services, human resource management services, and marketing support.

Several studies have confirmed the contribution of university–industry research cooperation in China to universities' revenue, firms' innovative capacity and regional economic development (Liu and Shi 2009; Ng and Li 2009; Yang and Ling 2009; Li et al. 2010; Kafouros et al. 2015; Fu and Li 2016; Hao et al. 2016).

Quan (2010) surveyed R&D laboratories in companies that interact with universities in Beijing. His results show that firms have different motivations that prompt different collaboration activities. The most frequently cited incentive for firms to collaborate with universities is to build a positive public image. In addition, companies sponsor research projects as a cost-effective way of keeping abreast of relevant new discoveries in China. Companies will outsource R&D to a university to reduce costs. But the most attractive factor for cooperation, according to the survey, is access to high-quality graduates. A large proportion of employees and interns in corporate R&D laboratories are graduates of partner universities. Wang et al. (2015a) conducted a survey on the factors that affect the success of academic–industry collaborations. They found that collaboration output was affected by not only the university's reputation and research capability, but also by the breadth and depth of the collaboration.

8.4 Data and Research on Knowledge Transfer from Universities and Public Research Institutes

Other than making new knowledge publicly available at no cost, universities and public research institutes can transfer technology through cooperative arrangements, including contract research and collaboration, licensing, and establishing spinoff enterprises. Many of these transfers occur through the technology market.

8.4.1 The Technology Market

Recently, China has made great progress in developing its technology market. Based on information from the technology trading information service platform and Innovation Relay Center networks, China has

Table 8.2 *Share of transaction value of knowledge transfer contracts by seller types, 2009–16 (%)*

	2009	2010	2011	2012	2013	2014	2015	2016
PRIs	6.3	5.1	5.5	6.3	6.7	5.3	5.7	6.2
Universities	4.4	5.0	5.2	4.6	4.4	3.7	3.2	3.2
Enterprises	86.4	85.5	86.5	86.5	86.2	87.6	86.2	86.6
Others	2.8	4.3	2.8	2.6	2.7	3.3	4.9	4.0

Source: China Statistical Yearbook on Science and Technology (2017)
PRI = public research institute.

established a unified and open platform to publish information about resources for knowledge transfer. In 2016, universities and public research institutes signed 90,573 contracts for knowledge transfer and research cooperation. The total value of these contracts was CNY 106.52 billion. Between 2009 and 2016, universities and public research institutes combined accounted for approximately 10 percent of the total value of knowledge transfer contracts (see Table 8.2).

There are several successful examples of the development of technology markets. The Xi'an S&T Market opened in 2011 and has facilitated knowledge transfer transactions worth more than CNY 110 billion, organized information exchange activities, and served more than 25,000 enterprises. The Zhejiang Online Technology Market, opened in 2002, uses network information technology and e-commerce technology to disseminate information on the supply of and demand for technologies. By the end of November 2013, Zhejiang Online Technology Market had 94,319 members, including enterprises, universities, and public research institutes; listed 63,944 technical problems from enterprises, and published 153,771 scientific and technological achievements. The number of signed contracts from the period of 2002–2013 amounted to 28,929, worth CNY 25.245 billion. The Online Technology Market has become an important platform for technology trading in Zhejiang Province.

8.4.2 University–Industry Research Cooperation

Brehm and Lundin (2012) explored university–industry collaboration activities and innovation outputs in China between 1998 and 2004 involving 20,000 large and medium-sized companies. They found that

Chinese universities' revenue from knowledge commercialization activities has increased over time.

Lan (2006) categorizes research contracts between universities and public research institutes and companies in China into four types: contracts for technology development, knowledge transfer, technology consulting, and technology services. Among the four types of contract, technology development was the most common, accounting for more than 30 percent of the total contract value. Liu and Jiang (2001) discuss the methods obtained by Tsinghua University to pursue knowledge transfer since 1995, which include establishing a university–industry cooperation committee to provide services for member companies, setting up funding for collaborative research, and building an online information system to update research findings and enterprise requests. Wang and Ma (2007) researched how Tsinghua University dealt with the IPRs created through collaborative R&D projects with multinational companies. They describe four types of contract: (1) commissioned projects, in which an enterprise provides the research funding and the university conducts the research using its own equipment and manpower; (2) joint research projects, in which senior researchers from the university participate in the research and the enterprise provides research funding, equipment and engineers; (3) joint development projects, in which the university provides researchers and an enterprise provides equipment and engineers, with development funding coming from a third party; and (4) joint research organizations, in which both parties provide funds, equipment, and researchers.

The most recent data for 2015 show that universities and enterprises in China jointly performed more than 88,000 R&D projects for a total value of CNY 66.65 billion (Ministry of Science and Technology 2017). The universities and enterprises established 2,276 post-doctoral fellowships and 10,191 joint research institutions between them. According to the Ministry of Commerce (2015), by 2015, foreign firms had established more than 2,400 R&D laboratories in China. Many foreign firms established joint R&D programs, laboratories, training centers, technical innovation alliances, and so on with universities and public research institutes. These institutions play an increasingly important role in the Chinese innovation system, and an indispensable role in knowledge transfer.

8.4.3 Patent Transfer and Licensing

Scholarly studies have identified a positive correlation between government expenditures on science and technology at the provincial level and the number of patent licensing contracts held by local universities in the same region (Rao et al. 2013). This supports the efforts of provincial governments to fund local research capabilities and suggests that proximity may influence knowledge transfer in China, as found in the U.S. and Europe.

Wang et al. (2015b) argue that licensing universities' technologies can contribute substantially to the subsequent innovation performance of licensee firms. The more licensing activities a licensee firm performs, the greater its subsequent innovative performance.

The sale (assignment) and licensing of patents owned by Chinese universities has increased steadily. The number of patent ownership transfers and licenses grew from 1,810 in 2010 to 4,839 in 2016 (Figure 8.4), with a notable increase between 2014 and 2016 that could be due to the implementation of the 2015 PTSTA Law. The total value of transactions increased from CNY 359 million in 2010 to CNY 1215.43 million in 2016 (Figure 8.5), and the average transaction value increased from CNY 198,000 to CNY 251,000.

The total number of knowledge transfer agreements (including the sale or assignment of patents, patent licensing, and other non-patent-related knowledge transfer activities) showed a similar upward trend (Figures 8.6 and 8.7). The total number of knowledge transfer agreements by universities increased from 8,408 in 2008 to 10,517 in 2014 and the total annual value of transactions in the same period grew from CNY 3.05 billion to CNY 4.01 billion, with the average transaction value increasing from CNY 3.63 million to CNY 3.82 million (Figure 8.7). A comparison between Figures 8.4 and 8.6 suggests that non-patented knowledge transfer accounts for the majority of the agreements, which include contract research and consulting services. In addition, a comparison of Figures 8.5 and 8.7 indicates that non-patent-related knowledge transfer is a considerably larger income source for universities than patent-related knowledge transfer.

Table 8.3 shows the patenting activities of the most important 1,497 universities in China in 2015. These universities applied for 109,445 invention patents, were granted 54,868 invention patents and signed 2,695 contracts involving patent transfer with a total value of CNY 2.77 billion. Over the period 2011–15, the total value of all types of knowledge transfer transactions exceeded CNY 19.6 billion.

Although universities and public research institutes have made tremendous progress in terms of knowledge transfer, they are still challenged by relatively low efficiency in terms of the amount of knowledge

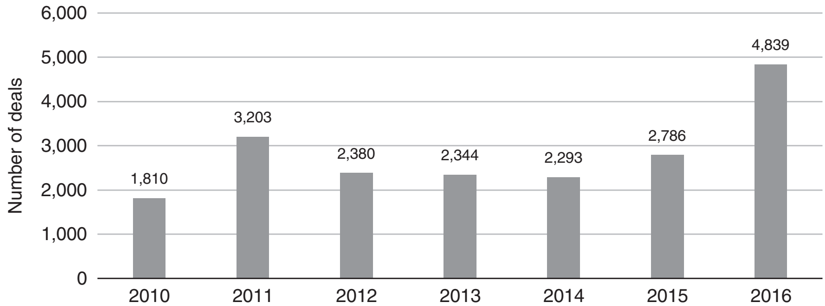

Figure 8.4 Number of patent transfers and licenses by universities, 2010–16
Source: China Statistical Yearbook on Science and Technology (2017)

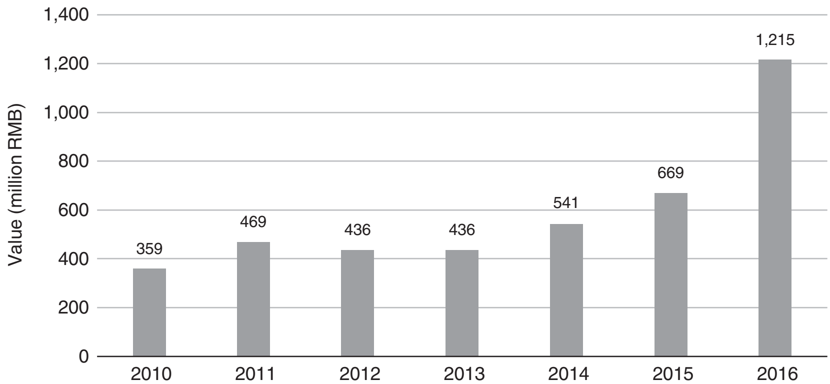

Figure 8.5 Value of patent ownership transfers and licenses by universities, 2010–16 (million CNY)
Source: China Statistical Yearbook on Science and Technology (2017)

transferred per unit of R&D expenditure, understaffing and a lack of knowledge transfer professionals. The Patent Investigation Report (2015) surveyed 7,424 enterprises, 436 universities and 455 public research institutes in China. More than half of the surveyed universities and public research institutes categorized themselves as "carrying out basic research, obtaining a few patents" and that "patent licensing is limited" (Table 8.4). Approximately 25.4 percent of universities and 32.4 percent of public research institutes surveyed responded that they "carry out applied

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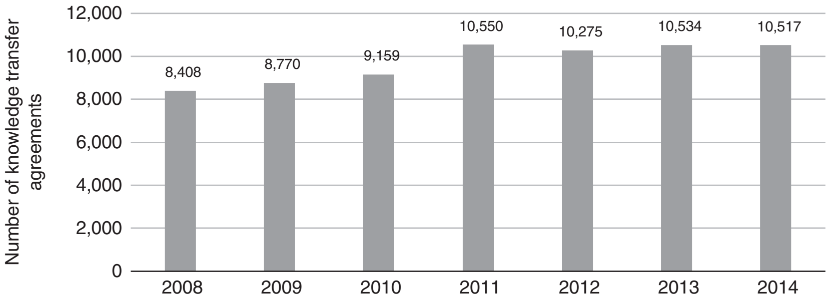

Figure 8.6 Total annual knowledge transfer agreements by universities, 2008–14
Source: Statistical Data of Science and Technology Activities in Colleges and Universities

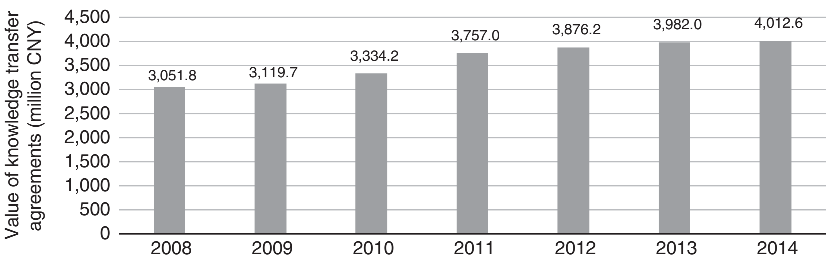

Figure 8.7 Total annual value of knowledge transfer agreements by universities, 2008–14 (million CNY)
Source: Statistical Data of Science and Technology Activities in Colleges and Universities

research, obtain many patents, and obtain revenue from patent licensing."

Table 8.5 gives the "exploitation rate" for patents owned by enterprises, universities, public research institutes, and individuals, which is defined as the number of patents used to make, use, offer to sell, sell, or import patented innovations or being sold to others divided by the total number of patents. Table 8.5 shows a clear difference between universities, public research institutes, and enterprises. In 2014, the average exploitation rate of patents in force was 57.9 percent, but the rate among enterprises exceeded that average by approximately 10 percentage points. The exploitation rate of public research institutes was 16 percentage

Table 8.3 *Patent applications, grants, and transfers by 1,497 universities in 2015*

	Patent applications		Patents granted		Patents transferred[1]		Number of other types of IP rights[2]
University type	All	Invention	All	Invention	Contract (item)	Amount (CNY 1,000)	
Comprehensive	54,977	34,530	35,723	17,302	858	627,056	4,143
Engineering	99,185	59,802	65,272	30,701	1,410	1,911,766	5,682
Agricultural and forestry	11,071	6,248	7,800	3,079	252	61,363	1,045
Medicine	5,202	2,683	3,625	1,249	46	147,108	75
Normal	11,737	5,182	7,971	2,011	102	21,176	799
Others	2,231	1,000	1,590	526	27	6,270	208
Total	184,423	109,445	121,981	54,868	2,695	2,774,739	11,952

Source: Statistical Data of Science and Technology Activities in Colleges and Universities (2016)

[1] Includes sales (assignments) and licenses.

[2] Other IP rights include new plant varieties, software copyright, and layout design of integrated circuits.

points lower than the average at 41.6 percent, while the rate for universities was only 9.9 percent. The low exploitation rate by universities (which includes patents that are only offered for sale) may be due to the low quality of patents, a lack of professionals specialized in knowledge transfer, and/or the lack of incentives to transfer technology before the 2015 amendments to the PTSTA Law.

The same study also provides data on the rate of patent sales and licensing (Tables 8.6 and 8.7), defined respectively as the number of patents sold or licensed divided by the total number of patents. This may be a better indicator of the use of university patents because it excludes patents that are only offered for sale and possibly never taken up. The results demonstrate the relatively low efficiency of knowledge transfer through patents by universities and public research institutes. In 2014, the average rate of patent sales was 5.5 percent. The rate of patent sales by enterprises and individuals exceeded 5 percent, while the rate of sales was 3.5 percent for public research institutes and 1.5 percent for universities. The average rate of patent licensing was 9.9 percent. The rates of licensing by enterprises and individuals were equal to or slightly higher than the national average, compared to 5.9 percent for public research institutes and just 2.1 percent for universities. The total of patent sales and licensing rates is only 3.5 percent for universities (suggesting

Table 8.4 *R&D and licensing modes of universities and public research institutes (%)*

	Universities	PRIs
Develop better technical solutions in scientific research projects, obtain patents and set up new enterprises.	31.1	38.8
Cooperate actively with enterprises, commissioned by enterprises to carry out specific research, cooperate with enterprises to produce products.	60.9	34.4
Carry out applied research, obtain a lot of patents, obtain revenues from patent licensing	25.4	32.4
Carry out basic research, obtain a few patents, patent licensing is limited	58.2	50.4

Source: Patent Investigation Report of China (2015)
Note: Multiple responses were possible so the percentages sum to more than 100 percent.

Table 8.5 *Patent exploitation rates in 2014 (%)*

	Enterprises	Universities	PRIs	Individuals	Total
Invention patents in force	67.5	13.5	28.2	40.0	50.9
Utility model patents in force	68.2	9.3	43.3	36.5	59.0
Design patents in force	70.3	9.0	46.7	47.4	60.1
Total	68.6	9.9	41.6	40.0	57.9

Source: Patent Investigation Report of China (2015)

Table 8.6 *Patent sales (assignments) rates in 2014 (%)*

Type of patent[1]	Enterprises	Universities	PRIs	Individuals	Total
Invention patents	6.7	1.9	3.2	4.8	5.2
Utility model patents	5.6	1.4	3.4	4.7	5.2
Design patents	5.8	1.2	3.8	7.5	6.4
Total (all patents)	5.9	1.5	3.5	5.4	5.5

Source: Patent Investigation Report of China (2015)
[1] Limited to valid patent rights in force in 2014.

that only 3.5 percent of university patents were taken up by companies), but considerably higher for public research institutes, at 9.4 percent.

Tan et al. (2013) studied patent licensing contracts signed by Chinese universities in 2011. There were 1,359 licensing contracts involving 1,352 university patents, of which 1,202 (88.4 percent) were invention patents. Most licensing contracts were exclusive, and licensed patents were mostly for inventions in the field of chemistry (organic chemistry, polymers), physics and instruments. Additionally, only 10 percent of Chinese universities had licensing activities, and most were affiliated with the 211 Project. Other universities, which received less government financing and support, cannot be compared to 211 Project universities in terms of patenting

Table 8.7 *Patent licensing rates in 2014 (%)*

Type of patent[1]	Enterprises	Universities	PRIs	Individuals	Total
Invention patents	9.6	3.3	5.5	13.0	8.2
Utility model patents	9.7	1.9	5.4	10.3	9.3
Design patents	10.7	2.0	7.2	14.7	12.1
Total (all patents)	9.9	2.1	5.9	11.9	9.9

Source: Patent Investigation Report of China (2015)
[1] Limited to valid patent rights in force in 2014.

activities. Most licensees were enterprises and were located in the eastern regions, including Shanghai, Jiangsu, and Guangdong provinces.

8.4.4 Science Parks

In 1988, the first Chinese national-level science park was established in Beijing, which is the predecessor of the Zhongguancun Science Park. After thirty years' development, the number of national-level science parks had increased to 168 by the end of 2018. By the end of 2017, the gross domestic product produced within the national-level science parks amounted to CNY 9.52 trillion, accounting for 11.5 percent of the Chinese total GDP. In 2017, there were 52,000 high-tech companies operating in the 168 national-level science parks, 38.2 percent of the national total. Half of the incubators and "maker spaces" are located in national-level science parks (Zhang 2018).

Zou and Zhao (2014) discuss a typical university science park in China, TusPark, which is tied to the top university in China, Tsinghua University. TusPark is considered to be part of the Zhongguancun High-Tech Science Park (the first and largest cluster of semiconductor, computer, and telecommunications firms in China) and therefore enjoys many preferential policies thanks to the established relationship between Zhongguancun High-Tech Science Park and the government. However, TusPark has its own strategy and preferences. For example, bolstered by the university's reputation and research capacity, TusPark is home to joint R&D laboratories between Tsinghua University and world-renowned enterprises.

Tan (2006) and Todo et al. (2011) studied the evolution and achievements of Zhongguancun Science Park. Tan (2006) argues that the Zhongguancun Science Park has been an example of innovation driven by knowledge transfer from leading research institutions to companies. Groups of professionals acted as risk takers and were involved in an early experiment to establish non-state-owned firms in the region. Todo et al. (2011) emphasize the role of science parks as an efficient channel to promote technology diffusion from multinational enterprises to domestic firms in China. As Todo et al. (2011) note, Zhongguancun Science Park has become a cluster of R&D centers for multinational enterprises. By the end of 2005, forty-three of the top 500 corporations worldwide had located their R&D centers in the Zhongguancun Science Park, and most of them had a collaborative R&D laboratory with local universities.

Cai and Liu (2015) discuss another successful university science park, Tongji University Creative Cluster. It is separate from Zhangjiang Hi-Tech Park in Shanghai, which is the state-level high-tech park in Shanghai, hosting many high-tech manufacturing firms just as Zhongguancun Science Park does in Beijing. Playing to the advantages of Tongji University and the characteristics of the enterprises in the cluster, Tongji Creative Cluster targets startups active in knowledge-intensive services. Once these startups become larger and mature, they may be integrated into the Zhangjiang Hi-Tech Park.

A few studies provide evidence regarding the contribution of science parks to knowledge flow and regional innovation capacity. For example, Jongwanich et al. (2014) used a provincial-level panel data set over the 1997–2009 period to study links among firms, public research institutes, and science parks. They found that science parks had a significantly positive impact on regional innovation capacity in terms of various measures, including a positive innovation-enhancing effect from R&D cooperation between industries and universities.

8.5 Barriers to Knowledge Transfer from Universities and Public Research Institutes to Firms

Four barriers to the technology and transfer activities of universities and public research institutes in China have been identified in the scholarly literature.

First, on the demand side, the technology market is not mature, so there have been few licensing opportunities for leading technologies. Most licensing contracts have involved traditional industries, with only a few involving emerging industries such as new energy and biological technologies (Wang et al. 2015a; Zhang 2016). Additionally, experienced licensees have been limited in number. Most state-owned enterprises were required to complete a complicated approval process before signing a licensing agreement. Even if they licensed a patent, they lacked the research capabilities to effectively use a patent and realize its market value quickly. A representative example is the licensing agreement between Fudan University and Huya Bioscience International regarding IDO (indoleamine 2,3-dioxygenase) inhibitors. Since domestic drug firms had little incentive to innovate due to high risk, a long development cycle, and the complex approval processes for new medicines, Fudan University licensed its patents to a US bioscience company using international capital (Zhang 2016), earning USD 65 million. Since many Chinese firms lack research capabilities to effectively use patents, more than half of all university patent licenses in China have been granted to foreign investors (Tan et al. 2013).

The limited R&D capacity of Chinese domestic enterprises is a significant barrier for knowledge transfer to domestic firms. Many industries in China are still at the middle or low end of global value chains, and the R&D intensity of Chinese enterprises is low, with an average of only 0.9 percent for industrial enterprises with annual revenue over CNY 20 million. In several provinces in the central and western regions, approximately 90 percent of industrial enterprises with revenue more than CNY 20 million have no R&D activities. Without R&D, these enterprises lack the ability to create and absorb the scientific and technological achievements generated by universities and public research institutes.

The second barrier is a lack of long-term financial support. As Tan et al. (2013) observe, most government patent subsidy programs provide funding to patent owners for under five years, which is not long enough to develop and commercialize an invention. Thus, many patents owned by universities, even potentially valuable ones, expire quickly after being granted. Additionally, although many university spinoffs have sufficient initial capital, they lack sustained investment for continuing operations.

The third barrier is ambiguous corporate governance and regulations. Kroll and Liefner (2008) studied knowledge transfer activities in three major research universities in China: Tsinghua University, Zhejiang University, and Wuhan University. They found that universities were only moderately oriented toward the needs of the market. In much of China, the absorptive capacity of spinoff enterprises was low.

Although the 2015 amendment to the PTSTA Law has removed the major legal barriers to knowledge transfer, implementation of the Law has not been without challenges. If academics and researchers from universities and public research institutes receive a share of a newly founded company in return for contributing their technologies, this knowledge transfer is subject to additional approvals because the technology would be considered as state-owned assets. Another challenge is that the calculation of "net profit" in the transformation of scientific and technological achievements is not clearly defined in the Law, and this hinders the provision of rewards and remuneration to inventors and knowledge transfer contributors.

The final barrier is that an underdeveloped intermediary agency sector results in high transaction costs. Zhang (2016) found that many university professors do not license their technology because they do not have the time and experience necessary to conduct business negotiations and perform marketing tasks. There are a limited number of intermediary agencies capable of providing such services to academics.

8.6 Conclusion

Since the 1980s, Chinese universities and public research institutes have been dramatically transformed in order to meet government policy goals of producing cutting-edge scientific and technological developments to support economic and social advancement. In 1985, the Chinese government emphasized the economic orientation of the S&T system by introducing competition and market discipline. In the 1990s, investment in R&D was made a priority in the central and local government budget appropriation and outlays. In 1993, the Chinese government announced a plan to build and develop approximately 100 world-class universities and key academic disciplines through the 211 Project. In 1998, the Chinese government intensified the development of world-class universities by starting the 985 Project. With continuous and strengthened funding, Chinese universities and public research institutes were able to make progress in knowledge and technology production, reflected in an increasing number of scientific publications and patent applications.

The basic legal framework governing knowledge transfer from universities and public research institutes to industry in China includes the Science and Technology Progress Law, Patent Law, the PTSTA Law, Contract Law, and Company Law. The PTSTA Law was enacted in 1996 and substantially amended in 2015. The amendment is seen as an important development of the legal system governing knowledge transfer in China. It has made knowledge transfer a legal obligation for Chinese universities and public research institutes. Additionally, it gives universities and public research institutes established by the state the right to dispose of their scientific and technological achievements, including transferring technologies, as long as the price agreed on by both parties in negotiation or auction and the name of the scientific and technological achievements are disclosed to the public. The Law states that no less than 50 percent of the net profit from the knowledge transfer should be given as a reward or compensation to the university or public research institutes inventors and knowledge transfer contributors. These new regulations remove the legal barrier to knowledge transfer in China and provide incentives for inventors within universities and public research institutes to engage more actively in knowledge transfer activities. The full impact of the amendment will be seen in years to come and will deserve further evaluation and study.

With several reforms since the 1980s, the technology market, cooperation between universities and public research institutes with industry, patent transfer and licensing, and spinoff companies from universities and public research institutes have developed rapidly in China. This rapid development was aided by government funding of and support for knowledge transfer and policy measures, such as establishing science parks. However, remaining challenges lie in areas such as the immaturity of technology markets, inadequate research capabilities and R&D investment by Chinese companies, a lack of long-term financial support for patenting and transfer activities, ambiguous corporate governance and regulations, and underdeveloped intermediary agencies.

References

Baark, E. (2001). "The making of science and technology policy in China." *International Journal of Technology Management*, 21(2): 1–21.

Bosworth, D.Y. and D. Yang (2000). "Intellectual property law, technology flow and licensing opportunities in the People's Republic of China." *International Business Review*, 9(4): 453–77.

Brehm, S. and N. Lundin (2012). "University-industry linkages and absorptive capacity: An empirical analysis of China's manufacturing industry." *Economics of Innovation and New Technology*, 21(8): 837–52.

Cai, Y.Z. and C. Liu (2015). "The roles of universities in fostering knowledge-intensive clusters in Chinese regional innovation systems." *Science and Public Policy*, 42(1): 15–29.

CCCPC (1985). *Decision on Reforming the Science and Technology System*, 中共中央关于科学技术体制改革的决定. Central Committee of the CPC.

CCCPC (1993). *The National Outline for Educational Reform and Development*, 《中国教育改革和发展纲要》Central Committee of the CPC.

CCCPC (2006). *The National Plan for Medium and Long-Term S&T Development*, 国家中长期科学和技术发展规划纲要(2006—2020年). Central Committee of the CPC.

China Statistical Yearbook on Science and Technology (2017). 中国科技统计年鉴. China Statistics Press.

Fu, X. and J. Li (2016). "Collaboration with foreign universities for innovation: Evidence from Chinese manufacturing firms." *International Journal of Technology Management*, 70(2–3): 193–217.

Hao, Y., J. Pan and F. Zhao (2016). "Effects of cooperative knowledge transfer on high-tech enterprise independent innovation ability." *Science and Technology Management Research*, 36(16): 17–21. 郝英杰,潘杰义,赵飞;产学合作知识转移对高新技术企业自主创新能力影响;《科技管理研究》2016, 36(16): 17–21.

Huang, C., C. Amorim, M. Spinoglio, B. Gouveia, and A. Medina (2004). "Organization, programme and structure: An analysis of the Chinese innovation policy framework." *R&D Management*, 34(4): 367–87.

ISTIC (2018).《2018年中国科技论文统计结果》. Institute of Scientific and Technical Information of China.中国科学技术信息研究所.

Jongwanich, J., A. Kohpaiboon, and C. H. Yang (2014). "Science park, triple helix, and regional innovative capacity: Province-level evidence from China." *Journal of the Asia Pacific Economy*, 19(2): 333–52.

Kafouros, M., C.Q. Wang, P. Piperopoulos, and M.S. Zhang (2015). "Academic collaborations and firm innovation performance in China: The role of region-specific institutions." *Research Policy*, 44(3): 803–17.

Kroll, H. and I. Liefner (2008). "Spinoff enterprises as a means of technology commercialisation in a transforming economy: Evidence from three universities in China." *Technovation*, 28(5): 298–313.

Lai, H.C. and J.Z. Shyu (2005). "A comparison of innovation capacity at science parks across the Taiwan strait: The case of Zhangjiang High-Tech Park and Hsinchu Science-based Industrial Park." *Technovation*, 25(7): 805–13.

Lan, X. (2006). "Universities in China's national innovation system." Paper presented at the UNESCO Forum on Higher Education, Research and Knowledge, November 27–30, 2006, Paris, United Nations Educational, Scientific and Cultural Organization.

Li, J., L. Ren, and C. Wu (2010). "Research on R&D expenditure and patent output of scientific research institutions, universities and enterprises." *Science & Technology Progress and Policy*, 2010(10): 103–8. 李娟,任利成,吴

翠花.科研机构、高校、企业R&D支出与专利产出的关系研究.《科技进步与对, 2010(10): 103–8.

Liu, H. and Y. Jiang (2001). "Technology transfer from higher education institutions to industry in China: Nature and implications." *Technovation*, 21(3): 175–88.

Liu, H. and J. Shi (2009). "An empirical study of the relationship between university technology transfer and China's economic growth." *Science and Technology Management Research*, 29(8): 244–6. 刘和东,施建军.大学技术转移与中国经济增长关系的实证研究.《科技管理研究, 29(8): 244–6.

Ministry of Commerce (2015). Director of the Foreign Investment Department of Ministry of Commerce Introduces the Foreign Investment in China in 2015. Available at http://bgt.mofcom.gov.cn/article/c/e/201601/20160101234256.shtml. Accessed March 6, 2019.

Ministry of Science and Technology (2017). *R&D Statistics*, unpublished document.

National Bureau of Statistics (2018). *China's R&D Intensity Is 2.12 Percent in 2017*. Available at www.stats.gov.cn/tjsj/zxfb/201802/t20180213_1583420.html. Accessed December 31, 2018.

Ng, Y.C. and S.K. Li (2009). "Efficiency and productivity growth in Chinese universities during the post-reform period." *China Economic Review*, 20(2): 183–92.

OECD (2008). *OECD Reviews of Innovation Policy: China*. Paris, Organisation for Economic Co-operation and Development.

Patent Investigation Report of China (2015).《中国专利调查数据报告》 State Intellectual Property Office of the People's Republic of China (SIPO).

Quan, X.H. (2010). "Knowledge diffusion from MNC R&D Labs in developing countries: Evidence from interaction between MNC R&D Labs and local universities in Beijing." *International Journal of Technology Management*, 51 (2/3/4): 364–86.

Rao, K., X. Meng, and L. Xu (2013). "The impact of R&D investment on patent technology transfer in local universities: An empirical analysis based on provincial panel data." *Business Review*, 25(5): 144–54. 饶凯,孟宪飞,徐亮,Andrea Piccaluga.研发投入对地方高校专利技术转移活动的影响——基于省级面板数据的实证分析.《管理评论, 25(5): 144–54.

Statistical Data of Science and Technology Activities in Colleges and Universities (2016). Ministry of Education. www.moe.edu.cn/s78/A16/A16_tjdc/201703/t20170303_298076.html. 《*2016* 年高等学校科技统计资料汇编》.

Tan, J. (2006). "Growth of industry clusters and innovation: Lessons from Beijing Zhongguancun Science Park." *Journal of Business Venturing*, 21(6): 827–50.

Tan, L., Y. Liu, and Y.Y. Hou (2013). "Empirical analysis on Chinese universities' patent licensing and its inspiration." *R&D Management*, 25.

Todo, Y., W. Y. Zhang, and L.A. Zhou (2011). "Intra-industry knowledge spillovers from foreign direct investment in research and development: Evidence from China's 'Silicon Valley'." *Review of Development Economics*, 15(3): 569–85.

Torch Report (2016). *Main Economic Indicators of National University Science Parks*. www.chinatorch.gov.cn/kjb/tjnb/201603/261a95cb17f54 2f1a2ec89486709c150.shtml.

Wang, B. and J. Ma. (2007). "Collaborative R&D: Intellectual property rights between Tsinghua University and multinational companies." *Journal of Technology Transfer*, 32(4): 457–74.

Wang, Y.D., D. Hu, W.P. Li, Y.W. Li, and Q. Li (2015a). "Collaboration strategies and effects on university research: Evidence from Chinese universities." *Scientometrics*, 103(2): 725–49.

Wang, Y.D., M.J. Liu, Q.W. Ma, and J. Chen (2015b). "Analysis on strategic emerging industries' patent licensing of Chinese universities." *R&D Management*, 27.

Yang, T. and W. Ling (2009). "Granger causality analysis of technology transfer in universities and economic growth in Guangdong Province." *Science and Technology Management Research*, 29(11): 215–17. 杨廷钫,凌文铨;广东省高校技术转移与经济增长的协整和Granger因果关系分析;《科技管理研究》2009 29(11): 215–17.

Zhang, C. and X. Wan (2008). "A comparative study of the efficiency of patent output between public R&D institutions and enterprises in China." *Science Research Management*, 29(5): 167–72. 张传杰,万小丽;我国企业与公共研发机构专利产出效率的比较研究,《科研管理》29(5): 167–72.

Zhang, M.X. (2016). "University-industry collaboration in the biological medicine industry – based on Fudan University academic research." *Science & Technology Industry of China*, 2016(4): 76–7. 从复旦大学药物专利授权看生物医药产业的产学研合作,《中国科技产业》.

Zhang, W. (2018). The Meeting on the 30 Years' Development of National Science Parks Held in Beijing. 国家高新区建设30周年座谈会在北京召开。Available at www.chinatorch.gov.cn/gxq30/gxyw/201812/b56174a275e6419281f818356e897b91.shtml.

Zou, Y.H. and W.X. Zhao (2014). "Anatomy of Tsinghua University Science Park in China: Institutional evolution and assessment." *Journal of Technology Transfer*, 39(5): 663–74.