The Trajectory of University Science Parks (USPs) in China: Institutional Evolution and Assessment†

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Abstract

This study aims to identify the chronological trajectory of university science parks (USPs) in China and to discuss the roles of government-driven science and technology (S&T) policies in the development of USPs and the future directions of these entities. Our study shows that USPs in China have undergone two development waves: The first from the late 1980s to the late 1990s, when research universities expected to directly participate in economic activities, and the second from 2000 when the Ministry of Science and Technology (MOST) and the Ministry of Education (MOE) jointly enacted the Proposed Regulation of State-level USPs Management to guide and regulate the development of USPs. The development trajectory highlights that USPs are effective platforms that link scientific research, knowledge spillovers and industrial system. However, Chinese USPs still need to confront some conundrums which may influence the processes and outcomes of UILs. Finally, we also summarize the major issues inherent in the development of USPs to guide policymakers to enact more effective policies.

Keywords
USPs, state-level USPs, S&T policies, conundrums, China

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1. INTRODUCTION

Edquist (1997) defined national innovation systems as "all important economic, social, political, organizational, institutional and other factors that influence the development, diffusion and use of innovations (p. 14)." The key role of a national innovation system is to underpin innovation activities and technological progress based on the result of a complex set of universities, research institutes, firms, governments and other actors (Barbero, Casillas, Wright, & Garcia, 2014). As a crucial part of any national innovation system, universities are the primary source of producing, distributing, and applying new knowledge in the knowledge-based economy. Universities may also exert positive influence on technological progress and economic growth by enhancing university-industry linkages (UILs), including supply of well-educated talents, the generation of cutting-edge knowledge, collaborations with industrial sectors, and even spin-offs (Fukugawa, 2013; Nerkar & Shane, 2003; Wood, 2011).

In the light of the importance of UILs, they have become important predictors of technological progress and economic growth in a country (Zou & Zhao, 2014). From the perspective of UILs, the geographical proximity to universities is very important for industrial sectors for the sake of various opportunities such as face-to-face communications with respect to technology transfer, collaboration research, and new result applications, which helps develop technological capabilities and first-mover advantage in a rapidly changing business environment (Bonardo, Paleari, & Vismara, 2011; Fukugawa, 2013; Kim, 2013; Schwartz, 2009). Closely linking to industrial system in turn helps universities easily access strategic resources for high-quality talents' education and cutting-edge scientific research. Furthermore, effective interactions between university and industrial sectors may narrow the gap between scientific research and market demand, and therefore make new research results generate economic profits. In this regard, a university may benefit from successful UILs by continuously enriching its research funds and support the sustainable creation of new knowledge and the development of cutting-edge technologies (Motohashi, 2006).

To stimulate UILs more effectively and successfully, universities are required to found professional departments, such as technology transfer offices, research parks, and even USP (Liberati, Marinucci, & Tanzi, 2016). As a platform linking scientific research, knowledge spillovers and industrial systems, a growing number of research-intensive universities not only in developed countries (such as USA, UK, Italy and Spain) but also in emerging countries (such as Brazil, Russia, India, China and South Africa) have established numerous university science parks (USPs) or research parks. On the one hand, the cases of developed economies such as the Stanford Research Park,[1] the Research Triangle Park,[2] the Cornell Business and Technology Park in the USA, the Manchester Science Park in the UK and the Daedeok Innopolis[3] in Korea suggest that USPs could provide initial

[1] The first technology-based industrial park—the Stanford Research Park—was built in 1951. It attracted high-profile technology companies such as Varian Associates, Eastman Kodak, and General Electric, contributing to the formation of Silicon Valley.

[2] This science park in North Carolina provides an array of services for the utilization of research results by Duke University, North Carolina State University, and the University of North Carolina.

resources for launching knowledge-based ventures closely related to universities and their faculty, promoting the development of potential high-tech clusters and generating agglomeration economy (Powers & McDougall, 2005; Sofouli & Vonortas, 2007; Sohn & Kenney, 2007; Tan, 2006). Additionally, some emerging countries also encourage and guide universities to establish science parks by providing abundant financial or political support. For instance, a range of science and technology (S&T) policies were enacted to promote the establishment and development of USPs in the past few decades. That is because the Chinese government believes that USPs may be effective platforms for universities participating in technological progress and economic growth.

As academic entrepreneurship is currently a critical issue in the development of the emerging economies' high-tech industries, this study investigates the trajectories of Chinese USPs and discusses the roles of government-driven S&T policies in the development of USPs as well as highlighting the major conundrums of Chinese USPs. This study aims to enhance our understanding of how USPs made significant contributions to China's technological progress and economic growth in the past several decades.

2. TECHNOLOGICAL PROGRESS IN CHINA

2.1. China's National Innovation System

China is a superpower in terms of size (9.6 million km^2), population (more than 1.3 billion), and GDP (10.42 trillion US$ in 2015). China joined APEC in 1991 and the WTO in 2001, and plays an increasingly important role in the context of globalization. Since the 2000s, China has maintained a higher economic growth rate among newly industrializing economy entities (such as Brazil, India, Russia and South Africa), with a GDP growth rate over 8% during 2000-2011.[4]

Scholars argue that China's rapid economic growth partially benefits from the development of its national innovation system (Gross, 2013; Huang, Swamidass, & Raju, 2016). The Chinese government puts considerable effort into developing its national innovation system. This is illustrated by the fact that public R&D expenditure in terms of GDP (Table 1) increased consistently since 1990. Public R&D expenditure is an important indicator for measuring national technological progress as it reflects the intensity of innovation activities toward developing cutting-edge technologies (Wakelin, 2001). In addition, public R&D expenditure also influences firms' strategic decisions with respect to their geographical locations (Hammadou, Paty, & Savona, 2014). More specially, higher public R&D expenditure indicates that a certain area may feature an excellent technological envi-

[3] Daedeok Innopolis is affiliated with KAIST, Chungnam National University, and a group of public and private research institutes. It promotes technology transfer for the development of high-tech industries in Korea. This area is currently the core R&D and business region for semiconductors, computers, biotechnology, medicine and other cutting-edge technologies in Korea.

[4] However, China's GDP growth rate was down to 8% since 2012, making some believe that China is confronting certain economic difficulties.

ronment for enterprises to develop competitive advantages. In this respect, the Chinese national innovation system benefits from the growing public R&D expenditure and as its sub-sectors become more closely linked and interactive.

TABLE 1. R&D Expenditure from 1990 to 2014 (Unit: Trillion RMB)

Year	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014
GDP	1.87	6.08	9.92	18.50	31.40	34.09	40.15	47.31	51.89	58.80	63.59
Proportion of GDP (%)	0.71	0.50	1.0	1.34	1.47	1.70	1.76	1.84	1.98	2.02	2.05
R&D expenditure	0.013	0.030	0.099	0.25	0.462	0.580	0.707	0.871	1.027	1.185	1.302

Source: China Statistical Yearbook (1991, 1996, 2001, 2006, 2009–2015)

The history of the Chinese national innovation system can be categorized into two major periods. In the planned-economy period (1949-1978), public research institutes were the primary innovators that got relatively abundant financial and political support from the government as it implemented national S&T projects. Universities, however, were required to concentrate purely on education and did not have a significant research mission during this period (Chen & Kenney, 2007). As a result, this national innovation system led to a lot of problems: Low market adaptability, low effectiveness, weak research-industry linkages, and rigid technology-based commercialization, because most innovation results were used for national key areas rather than civil industries (Chang & Shih, 2004). In 1978, the Chinese government launched its Open and Reform Policy which aimed at shifting from a plan-oriented economy to a market-oriented one (Gao, Guo, Sylvan, & Guan, 2010). Therefore, not only research institutes but also universities were encouraged to participate in innovation activities and enhance UILs in response to the demands of Chinese high-tech market.[5] Meanwhile, experiences from developed countries also indicate that the university as a creator and disseminator of new knowledge should be an important part of the national innovation system. With this background, universities became important driving forces for the development of indigenous technologies (Huang, Audretsch, & Hewitt, 2013).

2.2. University and Technological Progress in China

Since the 1980s, the Chinese universities have become an essential part of the national innovation system through implementing talent education, new knowledge creation, and cutting-edge technology development (Chang & Shih, 2004; Gao, et al., 2010; Su, Sohn, & Sohn, 2013). In turn, a growing number of technology-based firms work with universities for coping with the strategic

[5] China made dramatic technological progress since the start of its Open and Reform Policy in 1978. In order to promote structural reform and create knowledge-based industries, the central government enacted a series of S&T policies encouraging innovation actors to carry out research activity towards cutting-edge technologies and facilitate the commercialization of research results. However, public research institutes were the primary R&D actors taking the lion's share of S&T projects while universities played a supplementary role in technological progress before the end of the 1980s.

conundrum of how to enrich their source portfolio and develop competitive advantages in a rapidly changing business environment (Huang, et al., 2013; Zou & Zhao, 2014).

TABLE 2. University-affiliated Enterprises in High-tech Industries (Unit: Million RMB)

Year	Firms	Parent-university	Core Business	Initial Capital	Sales in 2012	Net Profit in 2012
1986	Founder	Peking University	Computer systems, IT peripherals, IT software	4.4	62376.7	1487.2
1991	Neusoft	Northeastern University	Energy, IT, Biotech, Logistics, Health	0.03	7211.9	542.7
1997	Tsinghua Tongfang	Tsinghua University	IT, Nuclear technology, Energy, Environment,	N/A	23546.2	1027.8

Source: A Statistical Report on China's university-affiliated enterprises in 2012.

As of 2015, China had established a large higher education network of 2429 universities and colleges, some of which have had dramatic success in UILs. Significantly, a growing number of research universities have directly commercialized their technologies or invested various resources to create university-affiliated enterprises (Eun, Lee, & Wu, 2006; Wu & Zhou, 2012). For instance, Peking University (PKU) successfully established the Founder Group, Weiming Group, Beida Jade Bird Group, Pulead Technology Industry Co., Ltd., Virtus Group and other enterprises by utilizing new research results, entrepreneurial funding, or well-educated talents (Su, Ali, & Sohn, 2011). The Founder Group was launched based on a new information technology called "Chinese Characters of Laser Phototypesetting Technology (1986)." Since its founding, the Founder Group consistently contributed to commercializing new research results developed by PKU researchers as well as bringing abundant financial benefits for PKU (Table 2).

2.3. University Science Parks (USPs) in China

In the light of the importance of universities in technological progress and economic development, an effective stimulation of UILs is now a critical issue for China's policymakers and practitioners. Examples from developed economies such as Stanford Research Park, Cornell Business and Technology Park in the US prove that well-running USPs facilitate UILs and promote the development of high-tech clusters (Kenney & Patton, 2009; McAdam & McAdam, 2008). This is because USPs effectively link university scientific research to industrial systems and incubate technology-based spin-offs or transfer cutting-edge research results to outsider organizations. Many firms incubated through USPs grew into famous transnational enterprises such as Yahoo! and Google. Motivated by the experiences of developed countries, the Chinese government also encourages and guides universities to establish USPs for the direct or indirect commercialization of university research results, as well as to enhance the interactions between the academic environment and industrial sectors (Zou & Zhao, 2014). In the past 27 years, USPs in China have been important means for research universities to directly participate in economic activities in the form of technology licensing, joint research with industrial sectors, and even new spin-offs. Similar to developed countries, China also features a growing number of high-tech clusters around USPs, such as Zhongguancun in Beijing and Guanggu in Wuhan, both regarded as successful cases of UILs.

3. THE TRAJECTORY OF USPS IN CHINA

Since the "Reform and Open Policy" started in 1978, the Chinese central government enacted a range of S&T policies promoting technological progress and the development of a knowledge-based economy (Gross, 2013; Su, et al., 2013). The policy implies that all actors of the national innovation system—such as technology-based firms, research institutes, R&D laboratories, and universities—are expected to engage in technological innovation and knowledge-based economic development. More specially, universities were encouraged to transfer their innovation results to the market through technology licensing, university-industrial collaboration, and spin-offs (Wu & Zhou, 2012; Zou & Zhao, 2014). Under this directive, certain Chinese research universities followed American precedents to establish USPs to enhance the commercialization of research results and promote linkage with industries. For a deeper understanding of how USPs contributed to technological progress in China, this section investigates the trajectories of USPs from a historical perspective.

3.1. The Emergence of USPs

The history of USPs in China began in 1989 when UILs gradually strengthened with economic growth (Chen & Kenney, 2007). In 1989, Northeastern University (NEU) founded China's first USP as a platform to provide software, industrial solutions, product engineering solutions and other information services for emerging high-tech enterprises. NEU had acknowledged that information technology would become a critical driving force for technological progress and social development in the coming decades (Zhang, 2014). Since its founding, NEU's science park and affiliated enterprises implemented numerous state-level S&T projects such as Plan 863,[6] Plan 973,[7] and the Torch Program.[8] Aside from significantly contributing to technological progress and industrial applications, the park also generated strong financial revenue for the NEU parent institution. Motivated by the dramatic success of the NEU's science park, an increasing number of universities (such as PKU and Tsinghua University) individually or jointly founded USPs to commercialize their owned technologies or external inventions for economic profit.

In 1992, PKU established its USP to industrialize its proprietary research results in response to the national strategy of "develop the country through science and education (*kejiao xingguo*)." As one of the nation's top two universities for science and engineering (the other being Tsinghua Univer-

[6] Proposed by MOST in March, 1986. This plan mainly focuses on the R&D activities of biotech, aerospace, IT, laser technology, automatic technology, energy, new material, marine technology and other cutting-edge technologies.

[7] Also named the State Key Basic R&D Plan, proposed by MOST (March, 1997). This plan mainly supports the basic R&D activities of agriculture, energy, IT, resource, material and human health.

[8] In 1988, MOST and MOE proposed an S&T policy aimed at stimulating the development of high-tech industries.

sity), PKU possesses a wealth of knowledge assets in terms of innovation talent, R&D facilities, and soft infrastructure that would be useful for the creation of numerous innovation results. The new park provides an effective platform for technology transfer, the incubation of high-tech firms, the education of entrepreneurs, and technology industrialization. PKU currently has science parks in several locations throughout China including Beijing, Nanchang, Baotou, Nanjing, Hangzhou, and Jinhua, including one in California's Silicon Valley. PKU believes that the dramatic successes of the US's UILs in Silicon Valley will provide crucial experience and opportunities for PKU in commercializing new research results (Zhang, 2014). Meanwhile, this science park is considered an important front line for Chinese entrepreneurs carrying out outward foreign direct investment (FDI) into the US. Since their founding, the science parks founded by PKU have launched numerous high-tech firms, such as the Founder Group, SinoBioway Group, Beida Jade Bird Group, and Virtus Group, which are not only playing important roles in the transfer of research results developed by PKU, but are also crucial leaders of the high-tech industries in China. To summarize, PKU states that the dramatic successes of UILs are attributed to its science parks' advanced industrial operation service system called "3M+T": (1) Providing monetary/financial (M) support, (2) providing entrepreneurial mentors (M), (3) providing market (M) expansion support, and (4) providing technology (T) licensing support for entrepreneurs or innovators. Two other famous engineering technology-based universities (Harbin Institute of Technology and Shanghai University) also founded USPs in 1992, putting considerable effort into driving technological progress and regional economic growth over the past two decades. For instance, the Harbin Institute of Technology USP industrialized over 200 research results in 2012 alone.

In 1994, Tsinghua University (THU) also founded a science park ("TusPark" or "Tsinghua Kejiyuan") to facilitate linkage between university and industry (Zou & Zhao, 2014).[9] Considering that geographical location is crucial for UILs, TusPark chose to locate in Zhongguancun, a technology hub containing 5000 state-level high-tech enterprises and 331 listed companies with an of high-tech enterprises of up to 1.2 trillion RMB (Li & Chen, 2014). The goal of TusPark is to provide a series of provisions for new ventures, venture capitalists, innovators, technology licensing agencies, and other actors (Shou, Chen, & Feng, 2013). So far, various new ventures (such as university spin-offs, research institutes spin-offs, corporate spin-offs, returnee start-ups, independent start-ups, and university-industry joint ventures) are eligible for moving into TusPark and utilizing the entrepreneurial resources provided. To absorb and exploit China's significant intellectual resources, transnational enterprises such as P&G, Sun, and Google also established R&D centers in TusPark. Owing to the strong research capacity of the parent university and close linkage with industry, TusPark features companies engaging in a diverse array of global technologies, such as digital imaging, 3D-printing, analysis testing, and integrated circuit (Li & Chen, 2014). In addition, by 2013 TusPark incubated more than 1500 enterprises, some of which play significant roles in China's high-tech sector.

[9] That is, although THU had developed a lot of new technologies or processes based on its excellent R&D capabilities, those innovation results were often locked in labs and could not be brought to market for industrialization in the planned-economy era. More specially, rigid linkage with industry led to waste in university technology resources.

Unfortunately, the Chinese government did not propose any state-level S&T policies with respect to USPs up to the late 1990s despite the rapid increase in the number of USPs and how USPs have become effective platforms for technology transfer. In centralized economies such as China, however, institutions are more likely to have a critical influence on national innovation activities (Gross, 2013; Su, et al., 2013). The Chinese government did propose “Project 211” in 1995 and “Project 985” in 1998, both of which aimed to improve the academic capacity and research level of selected universities. However, such S&T policies did not refer to USPs. This lack of political support for USPs led to uneven development as weaker universities with few comparative advantages in terms of R&D and industry linkage also blindly established USPs. Another urgent point is the need to narrow the gap between the status of the USPs and their institutional design.

In the light of the importance of USPs in job and wealth creation, the central government began to enact specialized S&T policies for USPs since 1999, proposing its Decision on Strengthening Technology Innovation, Developing High-technology, and Realizing Industrialization (1999) requiring universities to utilize their advantages in terms of talent, technologies, and platforms. This decision officially encouraged research universities to establish science parks for more effective and successful UILs, such as new results’ commercialization, university-industry joint collaborations, and high-tech spin-offs’ incubation.

3.2. The New Stage into State-level USPs

In November 2000, the Ministry of Science and Technology (MOST) and the Ministry of Education (MOE) jointly proposed a special policy for USPs titled the Proposed Regulation of State-level USPs Management. Notably, this was the first time application conditions, procedures, and performance evaluation methods with respect to state-level USPs were formally set. In May of 2001, twenty-two USPs covering thirty-three research-intensive universities were selected for state-level support. According to the statistics report, 17.065 billion RMB was invested into these twenty-two state-level USPs, which hired 68,400 employees and applied 9,184 patents in 2001 (Zhang, 2014). Two years later, another fourteen USPs covering sixteen universities entered the second batch of state-level USPs lists. Until 2004, the total number of state-level USPs was forty-two (covering fifty-six prestigious Chinese universities).

In order to utilize and manage state-level USPs more effectively, MOST and MOE jointly enacted a critical S&T policy called the Recognition and Management regulation on State-level University Science Parks (USPs) in 2005. Furthermore, this regulation confirmed more rigorous application conditions with respect to state-level USPs including: (1) The park construction area should be up to 15000 square meters, and the incubator area should be up to 10000 square meters; (2) more than 50% enterprises incubated in USPs need to have linkage with parent-university in terms of technologies and talent; (3) the number of enterprises incubated in state-level USPs needs to be more than fifty; (4) each state-level USP needs to provide more than 1,000 jobs, and; (5) each state-level USP needs to establish cooperative links with venture capital, guarantee institutions and other financial agencies. In addition, this policy also set several conditions for enterprises under incubation in State-level USPs including: (1) The incubating time in state-level USPs cannot exceed three years; (2) registered capital of incubating enterprises cannot exceed 5 million yuan; (3) the rent area cannot exceed 1000 square meters per incubating enterprise, and; (4) top managers of incubating enterprises need to be familiar with R&D activities. Based on these strict regulations, Chinese policymakers expect state-level USPs to play a more powerful role in the connections between university resources (such as intellectual assets, R&D equipment, well-educated talent and academic reputation) and social resources (such as venture capital, business information, market network, and social capital). In other words, state-level USPs are believed to become critical bridges for technology transfer, high-tech spin-offs incubation, innovators and entrepreneurs' education, and other forms of UILs.

In 2010, MOST and MOE jointly proposed its Guidance on the Performance Evaluation of State-level University Science Parks (Table 3) aiming to regulate state-level USPs' management processes and improving their self-innovation capacity. This guidance classifies state-level USPs into four levels (A: excellent; B: good; C: correction; D: delist). The primary goal of this policy is that state-level USPs enhance their competition senses and crisis consciousness, therefore contributing to technology transfer and high-tech industrial development.

TABLE 3. Index System of State-level USPs' Performance Evaluation

Indexes	Weight	Items	Values
Science service and operation	20	Public entrepreneurial service system	6
		Technology service and transfer system	4
		Ownership structure and operation management	5
		Service expenditure	5
Innovation performance	18	Number of new added intellectual property from high-tech in USPs	6
		Ratio of high-tech enterprises in USPs	6
		Ratio of R&D expenditure in total investment in USPs	6
Ability of technology transfer	17	The number of university technology transfer	5
		The number of university-based spin-offs in science	6
		The linkages between university R&D department and science	6
Incubation performance	15	The number of enterprises under incubation	5
		The number of enterprises graduation	5
		Average financing amount of incubating enterprises	5
Talents education and collection	16	The number of interns from universities and days of internship in USPs	4
		The number of spin-offs founded by students in science	4
		The number of jobs for university graduates	5
		The number of high-level overseas talents	3
Social contributions	14	The contributions to parent-university	7
		The contributions to regional economy	7

As of 2010, the number of state-level USPs was eighty-six, which successfully transferred 4,606 technology results, applied 5,603 patents (2,333 inventions), and hired 128,000 employees (Zhang, 2014).

TABLE 4. Main Economic Indicators of State-level USPs

Year	Number of State-level USPs	Space Area (1000 m2)	Number of Tenants	Total Income of Tenants (Billion RMB)	Accumulated Number of Graduated Tenants	Number of Employees of Tenants (1000 person)	New Tenants of the Year
2001	22	/	/	/	/	/	/
2003	36	/	/	/	/	/	/
2004	42	478.4	4798	22.62	1137	65	1120
2005	49	500.5	6075	27.19	1320	110	1213
2006	62	517.0	6720	29.50	1794	136	1348
2007	62	528.3	6574	29.51	1958	129	1359
2008	68	698.2	6173	24.72	2979	125	1294
2009	76	814.3	6541	49.89	3673	139	1396
2010	86	814.5	6617	22.16	4363	128	1858
2011	85	766.7	6923	17.05	5137	131	1673
2012	94	919.4	7369	20.67	5715	132	1787

Source: Torch High Technology Industry Development Center, MOST.
Note: The number of state-level USPs in each year is cumulative.

Table 4 shows that state-level USPs play an increasingly important role in technological progress and regional economic growth, such as patents protection, technology transfer, new job creation, and new spin-offs incubation. In other words, state-level USPs are believed to provide an effective vehicle for university, industry and other actors to interact (Ratinho & Henriques, 2010).

In 2013, the Ministry of Finance (MOF) and State Administration of Taxation (SAOT) jointly enacted two important policies: the Taxation Policy on Technology-based Enterprise Incubators and the Taxation Policy on State-level University Science Parks (USPs). The latter policy stated that from January 1st, 2013 to December 31st, 2015, state-level USPs are not required to pay certain taxes including the house property tax, land tax, and business tax of the firms they incubate. As start-ups launching from USPs often face shortages in entrepreneurial funding, these policies were instigated to more effectively stimulate academic entrepreneurship by reducing the taxation burden and providing financial preferences.

Generally speaking, USPs in China went through two developmental waves since the first USP was founded by NEU in 1989. The first wave started from the late 1980s to the late 1990s when the central government did not propose any special policy for USPs. In this period, although a number of universities established USPs to enhance technology transfer and to engage in economic development, the USPs suffered from uneven development. The second wave begun in 2000 when MOST and MOE jointly enacted the Proposed Regulation of State-level USPs Management where state-level USPs were expected to meet the needs of UILs in the knowledge-based economy era.

4. MAJOR DRIVING FORCES WITH RESPECT TO UPS

Historically, knowledge-based assets and institutional support are crucial elements that drive modern technological progress and economic growth (Intarakumnerd, Chairatana, & Tangchitpiboon, 2002). Similarly, as discussed in Section 3, the development of USPs in China can be primarily attributed to two major driving forces: University-level factors and government-level factors.

4.1. University-level Factors

Previous literature focusing on Western cases suggested that the university is the primary internal driving force that stimulates the establishment and development of USPs (Guerrero & Urbano, 2012). In the case of China, the USP as a part of its parent institution requires a wealth of university-level resources.

First, USPs need various human resources, such as managers, full-time staff, and even academic researchers. As known, professional managers with high-level leadership are critical of a new organization's operation and outcome creation. In China, USPs' managers are appointed by its parent-university because the universities believe that they can fulfill the USP's mission and effectively maintain mutual relationships. For instance, THU founded Tsinghua Holdings to manage TusPark, and top managers of Tsinghua Holdings are also THU professors or staff. Meanwhile, academic researchers willing to transfer or directly commercialize their research results may help USPs enrich their knowledge-based assets and develop competitive advantages (Zou & Zhao, 2014).

Second, a USP is closely related to its affiliated university's financial resources despite the fact that some financial support can be obtained from the government. The Chinese experience indicates that in the early stages, the university can provide critical funding for its USP because of its affiliation to its parent university.

Third, the university can provide various physical resources for its USP. At the early stages of founding a USP, the university can provide offices, computers, incubation conditions and similar hardware. For example, THU built a 0.77 million square-meter building for TusPark, aiming to attract technology incubation projects with high market potential.

Fourth, technological resources are also crucial for USPs. While universities are the primary source of new knowledge, cutting-edge technologies, and even innovative capabilities, they are also non-profit organizations that need professional departments that will enable profiting from new research results. In this regard, USPs are a strategic option. According to the homepage of TusPark, it states that one of its important missions is to incubate or directly commercialize new research results and have them implemented by THU researchers.

In addition, the universities' reputational resources such its public reputation also play important role in the development of USPs. In China, well-running science parks such as THU's Tuspark are often those affiliated to well-known universities (Zou & Zhao, 2014).

Generally speaking, the university is the heart of the establishment and development of science parks. USPs can benefit from their parent universities and the university also can realize its goals (regarding income or social reputation) through founding a science park. In this respect, the relationship between parent-universities and USPs is cooperative rather than competitive.

4.2. Government-level Factor

Current research finds that political force have an important effect on technology transfer and progress (Atherton, 2006; Giaretta, 2014; Huang, et al., 2013; Kenney & Patton, 2009; Wu & Zhou, 2012). In this respect, both developed countries (such as USA, UK, and Japan) and emerging countries (such as China, Brazil, and India) actively propose S&T policies to provide monetary or political support to enhance the interactions of various innovation actors such as universities, research institutes, and industries.

The Chinese government developed a range of S&T policies (such as "Program 863," "Torch Program," and "Program 973") to stimulate technological progress since the early 1980s. More specially, most of these S&T policies are general guidelines that guide all innovation actors towards becoming involved in technological progress. Although more and more universities began to establish science parks in order to provide effective platform for UILs, there was still no specialized S&T policy regarding USPs before 1999. In other words, USPs were less likely to get monetary or political support from the government. In 1999, the Chinese government started to propose some special S&T policies with respect to USPs. Table 5 summarizes the major special S&T policies and analyzes their main effects on technological progress.

TABLE 5. Special S&T Policies for USPs and their Main Effects on Technological Progress

Year	Typologies	Agencies	Key Focus
1999	Decision on Strengthening Technology Innovation, Developing High-technology, and Realizing Industrialization	The central government	(1) Require the university to utilize its advantages in terms of talents, R&D and platforms for UILs. (2) Encourage the university to found USP for high-tech spin-offs incubation. (3) Encourage university researchers to collaborate with high-tech clusters.
2000	Proposed Regulation of State-level USPs Management	MOST and MOE	(1) Set out application conditions and procedures of State-level USPs. (2) Require local government to propose S&T policies for the establishment of state-level USPs. (3) Found performance evaluation system for State-level USPs, etc.

2001	State-level University Technology Transfer Centers	MOST/MOE	Establishing state-level university technology transfer centers to develop R&D capabilities, drive entrepreneurial behavior and provide benchmarking for other universities.
2005	Recognition and Management Regulation on State-level University Science Park (USP)	MOST/MOE	Making rigorous application conditions for state-level USPs: (1) park construction area up to 15,000 square meters, and incubator area up to 10,000 square meters; (2) more than 50% incubating enterprises need to have linkages with parent-university in terms of technologies, talent; (3) the number of incubating enterprises located in state-level USPs needs to be more than 50; (4) providing more than 1000 jobs for society; (5) state-level USPs need to establish cooperative links with venture capital, guarantee institutions and other financial agencies.
2010	Guidance on the Performance Evaluation of State-level University Science Park (USP)	MOST and MOE	Set six indexes to evaluate performance of state-level USPs: science service and operation; innovation performance; ability of technology transfer; incubation performance; education and collection; and social contributions.
2013	Taxation Policy about State-level University Science Park (USP)	MOF and SAOT	State-level USPs do not need to pay some special taxes, including house property tax and land tax of incubating firms; business tax of incubating firms.

5. PROBLEMS WITH USPS IN CHINA

Similar to the success cases of developed countries, Chinese USPs made important contributions to technological progress and economic development by providing effective platforms for stimulating UILs over the past several decades. Furthermore, an increasing number of high-tech clusters emerged around these USPs. For instance, the establishment and development of the East Lake High-tech Cluster benefits from USPs attached to Wuhan University, the Huazhong University of Science and Technology, the Wuhan University of Technology and other similar famous universities located in Central China (Huang, et al., 2013). However, it is not easy to create a Chinese "Silicon Valley," which remains a long-standing dream of Chinese policymakers (Colyvas, Crow, Gelijns, Mazzoleni, Nelson, Rosengerg, & Sampat, 2002; Liu, Lu, Filatotchev, Buck, & Wright, 2010). The success of Silicon Valley can be attributed to high-level talent (both R&D personnel and excellent managers), active technology transfer, a wealth of venture capital, and a near-perfect market system, but these are precisely the deficiencies of Chinese USPs (Chen & Kenney, 2007; Kenney & Patton, 2009; Wang, Zweig, & Lin, 2011). In addition, USPs in China face several particular conundrums that may influence the processes and outcomes of UILs and that require policymakers to seek out specific measures or solutions.

5.1. Bureaucratism of USPs

S&T policies enacted by China's policy-makers over the past several decades proved that the government should guide the directions of UILs by providing monetary or political support (Gross, 2013; Huang, et al., 2013). Furthermore, a notable symbol of UILs is that an increasing number of universities established science parks over the past several decades. However, most USPs have hierarchical administrative systems with top managers appointed by parent universities or local governments, mostly whom tend to emphasize short-term performance (administrative achievements) rather than long-term performance. In this respect, USPs that often maintain certain political organizational characteristics are more likely to suffer severe bureaucratism, which influences the USPs' operations and performance (Zhang, 2014). In other words, the performance of USPs is low when the government excessively intervenes in the USPs' operations.

5.2. Weak Marketing Capability of USPs

Parent universities may provide a wealth of knowledge-based assets for USPs to increase their technological capability. However, technological capability is not the only attribute of successful USPs. The actors also need to focus on narrowing the gap between academics (technologies) and practice (markets). In the context of China, Wu and Zhou (2012) pointed out that USPs often present weak marketing capability, regarded as a critical reason for failure in Chinese UIL. Furthermore, despite how Chinese USPs incubate numerous technological projects, most of these projects break down in the early stages and only very small number go to market. Therefore, the second problem that USPs have to deal with is weak marketing capabilities.

5.3. Disparities in USPs

The third challenge is the disparities in USP distribution. Although China has founded many USPs nationwide, they are mostly located in the eastern regions with only a few in the central and western regions of China. The disparities in USP distribution can be attributed to two major reasons. First, eastern China comprises thirteen provinces with a GDP of 34.64 trillion (67.09%) and a total population of 624 million in 2012; whereas central and western China includes eighteen provinces with a GDP of 16.99 trillion (32.91%), and a total population of 729 million. Second, many research universities are also located in eastern China,[10] such as the top three leading cities in terms of university quality and quantity (Beijing, Shanghai, and Nanjing) in which UILs are more active than in other regions.

6. DISCUSSION

Our research suggests that the Chinese case is particular because of its unique mechanism as an emerging economy, where the pressure for changing growth patterns and the pace of shifting towards a knowledge-based economy to increase innovative capability is a significant trend in recent years (Su, Liu, & Sohn, 2016). Accordingly, Chinese policymakers have proposed state-level strategic objective that shifts from "Made in China" to "Innovated in China" (*cong "zhongguo zhizao" dao "zhongguo chuangzao"*). In this regard, universities as a critical and innovative part of the national innovation system are expected to play a more important role in education, R&D activities,

[10] As of 2012, there were 2442 universities in China: 1202 (49.22%) in Eastern China and 1240 (50.78%) in Central and Western China.

and technology transfer. However, it is very difficult for a university to directly create new markets for research results that are created by university researchers (Comacchio, Bonesso, & Pizzi, 2012). Therefore, universities have to establish professional offices that specialize in managing linkages with industries. Encouraged by American experiences such as Silicon Valley and Route 128, establishing USPs seems to be an optimum choice for universities to effectively stimulate UILs (Rothaermel, Agung, & Jiang, 2007). That is because an USP may provide six common functions, namely: Locating a business opportunity, accumulating resources, marketing products and services, producing the product, building an organization, and responding to government and society (Stevenson & Jarillo, 1990).

6.1. Managerial Implications

This study has some practical implications for parent-universities, USPs, and policymakers. The heart of a USP is the parent university. To enhance linkages with industries, parent universities should build a smooth mechanism that more effectively transfers new research results to USPs for commercialization, which might in turn generate a wealth of economic profit to support R&D activities. In recent years, Chinese universities also proposed numerous S&T policies that encourages faculty and staff to commercialize their research results through USPs (Li & Chen, 2014), university-affiliated enterprises (Zou & Zhao, 2014), and technology licensing (Huang, et al., 2013). In some universities (such as Jiangsu University of Science and Technology), the commercialization activity of university-based technology is also regarded as an important part of the research performance evaluation of university staff (Su, et al., 2013).

Second, USPs have emerged as incorporating and promoting platforms that link universities, government, and other organizations, therefore facilitating technology transfer and commercialization in the knowledge-based economy (McAdam & McAdam, 2008). Compared to the role of USPs in developed economies (such as USA and UK), Chinese USPs need to be more productive and more innovative in terms of technology transfer and high-tech firm creation (Su, Zhou, Liu, & Kong, 2015; Tan, 2006). More importantly, USPs such as those located in PKU and THU might pay attention to the technological needs of customers (such as government, firms or individuals), thus serving China's technological progress. That is because effective and successful UILs (high-quality education, university technology transfer, and start-ups launch) are critical for the development of USPs (Ratinho & Henriques, 2010).

Third, policymakers should promote the positive effects of USPs on the development of high-tech industries. Fortunately, in order to facilitate indigenous innovation, the Chinese government continues to be interested in establishing science parks with universities by providing monetary or political support (Zou & Zhao, 2014). To a certain extent, the development of USPs benefits from such S&T policies. The Chinese experience indicates that government policies are important factors that sustain USPs and enable them to grow over time. This suggests that policymakers need to enact more effective and targeted S&T policies for USPs to enhance UILs.

6.2. Directions for Future Research

In the fields of academic entrepreneurship, scholars need to examine why some USPs are more effective than others. Existing research found some primary reasons: USPs vary considerably in terms of sophistication of the commercialization mechanism, the quantity and quality of new technologies provided by parent universities, and loyalty among stakeholders (researchers, entrepreneurs, USPs). Future research can examine some of China's particular contexts, such as bureaucratism, academic entrepreneurial culture, and S&T policies regarding USPs.

Our research results argue that university-level factors and government-level factors are the two major driving forces stimulating the establishment and development of USPs. Future research can investigate the interaction of these two influencing factors. Are they complementary or supplementary? Furthermore, it would enhance our understanding of how to establish USPs and how to operate them effectively.

Future research also needs to investigate whether USPs have made contributions to improving innovative capacity and economic performance of the spin-offs located within them. Researchers can compare several different types, such as independent spin-offs, corporate spin-offs, and university spin-offs. Such research may provide a better insight into how USPs can more effectively and successfully launch spin-offs in the rapidly changing business environment.

7. CONCLUSION

This study has examined the trajectory of Chinese USPs by providing a brief historical overview, and then discussed the role of government-driven S&T policies in the development of USPs. Meanwhile, it also summarized the major problems with USPs and provided several managerial implications for parent universities, USPs and policymakers. Encouraged by the successful cases of developed countries, China has intensively proposed a range of S&T policies that promote the importance of USPs in knowledge spillover. Over the past decades, it proved that USPs in China are becoming more and more important in narrowing the gap between academic research and industrial growth. The Chinese experience in the past two decades might provide useful insights for other emerging countries such as Brazil and India, which have also founded USPs to stimulate UILs for driving technological progress and economic growth.

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