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Full Length Research Paper

A model to create high-tech start-ups from the academic environment: The case of Peking University (PKU) and Tsinghua University (THU)

De-Jin Su, Murad Ali and Dong-Won Sohn

Graduate School of Business Administration Inha University, Incheon, 253 Yonghyeon-Dong, Nam-Gu, 402-751, South Korea.

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The aim of this paper is to propose a feasible high-technology start-up model for Chinese universities through "university-industry linkages" by conducting analysis of Peking University (PKU) and Tsinghua University (THU). PKU and THU have created numerous high-tech start-ups based on knowledge transfer and intellectual patents' application, thereby researching viable ways to drive the links between universities (academic results) and high-tech market (commercialization). At the micro-level, studying high-tech start-ups from academic environments, which expedite industrial application of newly developed knowledge, and at the regional level, high-tech start-ups from academic environments, which boost economic vitality, and establish regional innovation systems. And at the national level learning about high-tech start-ups from academic environments which improve technical contents thereby upgrading industrial structure.

Key words: Peking University (PKU), Tsinghua University (THU), high-tech start-ups, China.

INTRODUCTION

In today's knowledge society, an important issue at the national level is a country's capability to absorb existence knowledge, to adapt it to suit their particular needs, and to create new knowledge for its continuous innovation (Alam, 2009). High-technology (or high-tech) management is considered to be a key driving force in the development of an economy (Wang, 2011). It is highly recognized that universities play a pivotal role in promoting advance technological knowledge. This role is not limited to the advancement of knowledge and education of skilled people, but also in commercialization activities (Hashim et al., 2010). Wide attention has been paid to university-industry linkages because strong coordination and linkages facilitate the transfer of technology from research laboratories (labs) to commercial markets (Gu and Whewell, 1999; Sohn and Kenney, 2007). The literature on high-tech as a sector lacks comprehensive universally accepted definition (Oakey et al., 1998). Madcof (1999) defines this area as, "one whose business activities are highly dependent upon innovation in science and technology."

As the main economic driver, high-tech industry is classified into five sectors by the National Bureau of Statistics (NBS)[1], that is, 1) pharmaceuticals (Ps), 2) aircraft and spacecraft (AS), 3) electronic and telecommunication equipments (ETE), 4) computers and office equipment (COE), and 5) medical equipment and meters (MEM). Compared with labor-intensive industries, high-tech industry should contribute to R&D activities of new technologies, technology transfer, mutual cooperation and patents' protection. In a knowledge-based economy, R&D affairs are mainly implemented by specialist agencies, including universities, research institutes, individual innovator, and firms with labs. As main R&D performers, universities which undertake the tasks of knowledge

*Corresponding author. E-mail: muradjee81@hotmail.com.

[1]China High-tech Industrial data. (2011). High-tech Industries. Retrieved March 12, 2010 from http://www.sts.org.cn/sjkl/gjscy/data2010/data10.htm

generation transfer, and reproduction, can not only supply a sustainable developing source for national economy, but can also facilitate knowledge-based start-ups as the effective incubators (Gu and Whewell, 1999; Di Gregorio and Shane, 2003; Sohn and Kenney, 2007; Sohn et al., 2009). Meanwhile, by using specific resources (professional talents and labs with advanced equipments), universities help nations to increase high-skilled workers as well as high-tech companies or training institutions. In recent years, during the processes of technology transfer and commercialization, universities are playing a critical role as partnerships with high-tech sectors (Nerkar and Shane, 2002; Poyago-Theotoky et al., 2002). In the past several decades, based on knowledge and academy support during innovation processes, many universities' spin-offs and high-tech clusters have evolved, such as *Silicon Valley* in USA, *Zhong Guan Cun* in mainland China[2] (hereinafter China), *Daedeok Innopolis* in South Korea, *Friuli* in Italy, and *Wallonia* in Belgium, which rapidly grew mostly depending on abundant new technologies and original ideas through governmental actions. The most obvious feature of emerging high-tech clusters is the location of universities, firms and research institutes (Phambuka-Nsimbi, 2008), which play a key role in developing of High-tech economy and knowledge economy especially concentrating on biotechnology (such as DNA, clone and tissue culture) and information technology (such as software, hardware and internet search engine) which have led to create many high-tech firms. In these regions, when talents (researchers, students or professors) have original intellectual properties or original ideas, they are more likely to start new-businesses, such as HP's *William Hewlett* and *David Packard* from Stanford University, Microsoft's *Bill Gates* from Harvard University, Google's *Larry Page* and *Sergey Brin* from Stanford University, Yahoo's *David Filo* and *Jerry Yang* from Stanford University, Cisco's *Leonard Bosack* and *Sandy Lerner* from Stanford University, Lenovo's *Liu Chuanzhi* from Chinese Academy of Sciences. In the knowledge economy, universities are the distinctive places in which students are trained by professors. Universities supply well-educated R&D labor and the well-trained gain knowledge or skills for regional industries. Based on these circumstances, most countries have concentrated on cooperation with academic organizations, thereby establishing a regional innovation system (RIS) and improving economic technical contents. As the world becomes composed of closely interrelated networks, knowledge becomes more important, as oxygen. From the first industrial revolution in the middle of the 19th century (based in England) to the recent information and communication technologies (ICT) revolution (based in USA), the technology innovation center has continuously been moving from the west, which pays more attention to the importance of entrepreneurs, venture capital, R&D investments, and knowledge spillovers (Popkin and Iyengar, 2007). Despite the center of high-tech world still staying in the west and USA particularly, the development trend of science and technologies centers of Chindia[3] has challenged their dominant positions in high-tech industry. As the result of continual emphasis of new technology development, a large number of high-tech start-ups are emerging in Chindia. Chindia firms are moving on to high-tech technological innovation. Companies such as Lenovo *(in China)* and National Institute of Information Technology (NIIT; *in India*) are now generating their own high-tech technological capabilities to challenge firms from advanced countries. Start-ups are the important sources of innovation (Schumpeter, 1934; Igarashi and Taji, 2006). Although, Taiwan has established a series of science parks and recently, a tremendous growth can be seen in Taiwan's high-tech industry (Lu et al., 2010) but China is still in transition stage. Much literature has argued that universities and research institutes help local government to establish regional innovation systems (RIS) which is the basis to stimulate information communication and knowledge spillover, support technologies' transfer and commercialization. As a result, this RIS forms high-tech clusters and improves regional competiveness (Cooke, 2001; Lim, 2006; Chen and Kenney, 2007). Such situation raises several research questions like 1) in the past several decades, Peking University (PKU) and Tsinghua University (THU) have created many high-tech start-ups, what are the main factors that led to their success? 2) What roles can PKU and THU play in the emerging high-tech industry? 3) As the two top universities, whether PKU and THU should pay the same attention to the knowledge development and spin-offs? and finally, 4) can other Chinese universities follow PKU and THU steps to create start-ups? This study opts both descriptive and exploratory research design which leads the study to a conclusive research design. This study utilizes a case-based analysis and literature related to high-tech start-ups in China. Most frequently, the case study is used as methodology in research related organization. The suitability of this methodology is properly documented (Eisenhardt, 1989; Pettigrew, 1990). The descriptive and empirical data is collected from different sources and databases such as empirical studies, reports, cases, archives and statistics to obtain measures on a number of high-tech start-ups. Due to the extent of the control the authors have over the actual behavioral events, the focus of contemporary events and the nature of research questions, case study is considered to be the most appropriate methodology for this study (Yin, 2009). While empirical analysis is carried out to facilitate the

[2] Excluding Taiwan, Hong Kong and Macau.

[3] *Chindia* is a portmanteau word referring to China and India. Together, they contain about one-third of the world's population, both are regarded as growing countries and are among the fastest growing major economies in the world. They have been named as countries with the highest potential for growth in the next 50 years in a BRIC *(Brazil, Russia, India, and China)* report (Wikipedia).

methodology. Since current literature is progressing; therefore, it is believed that this study would also make a timely contribution to the existing literature on high-tech start-ups in China.

LITERATURE REVIEW

No university can successfully develop new businesses without any support from policy, venture capital, users or other essential factors. In order to find out the main factors which determine whether universities and research institutes can successfully create high-tech start-ups, a review literature documents is necessary (Alam, 2009b).

Tim (2003) summarizes that there are many channels (including the movement of graduates into the workforce, employees' training on contract, papers or books' publication, academics consultation, technologies transfer, industry-university-institute collaboration, licensing of intellectual property, and independently start-ups based on R&D achievements) that can make knowledge effectively transfer from academic environment to industrial application. Based on empirical analysis, Di Gregorio and Shane (2003) conclude that four macro-level factors affect successes of high-tech start-ups from universities. First, the closer to locations rich in venture capital, the more likely they will successfully create start-ups. Entrepreneurs should get funds' support which would be used for employment, material purchase and rent payment during the commercialization of intellectual property rights. As start-ups from universities, entrepreneurs usually lack venture funding and ask venture capitalists to provide financial support. Second, universities that lay emphasis on industry-application research could make it possible to create start-ups because they can connect market demand to R&D activities, thereby improving the success of new businesses. Third, universities' academic competences would help themselves to generate start-ups because the excellence of education would supply well-trained graduates and intellectual patents which supply human resources and commercialized objects for start-ups. Fourth, the suited polices (proper assignment of universities' budget, equipments, and investment) of universities would reduce constraints during creation of start-ups. Through an empirical research of 128 new technology firms established by MIT-assigned intellectual properties, Nerkar and Shane (2003) suggest that radical technology and patent protection would help new firms to survive in special industries. In terms of empirical analysis of Canadian universities, Hoye and Roe (2003) argue that university size, type and reputation would influence successes of intellectual property transfer, university- industry collaboration. Mustar et al. (2007) suggest that entrepreneurial teams, various policy mechanisms, policy actions, academic resources, the way of technology transfer, finance provision, university strategies, universities' IP and patent strategies, funding gaps, star and middle-ranking researchers and boundary spanners (language) would drive the creation of universities' spin-offs. And they consider entrepreneurial teams who are asked to have the capability to combine scientific knowledge with an understanding of the market, are the most critical resources during the development of spin-offs. Kondo (2003) advance one model and classified four factors: 1) supply, 2) driving, 3) enabling, and 4) demand/market as shown in Figure 1 which are considered as the main causes to create high-tech start-ups for Chinese universities and research institutes.

Through analyzing the factors why Portland, Kansas City and Boise have informed high-tech clusters, Mayer (2009) consider that the history of high-tech development, current status of high-tech industry clusters, and the role of public policy and higher education would facilitate high-tech start-ups.

The Silicon Valley model

As the world's dominant high-tech innovation center, Silicon Valley in the US is the hub of more than a hundred leading companies, more than twenty four worldwide famous universities and colleges and many government facilities (Wikipedia, 2011). These companies, universities and institutes help the US to conduct the development of trends of high-tech industries (Florida and Kenney, 1988; Mann and Luo, 2010). At the beginning, Silicon Valley was a place for research and production of semi-conductors based on silicon. In recent years, the semi-conductor industry is still an important business but many high-tech start-ups (particularly related to software and Internet) have successfully entered into the global market and influenced computer operating systems, software, and user interfaces. Therefore, this successful high-tech start-ups model is called, the "Silicon Valley Model", which is more likely to help and generate high growth technological start-ups from its regional universities and research institutes. Considered the world's most successful high-tech start-ups model, the Silicon Valley Model has attracted global attention. There are many high-tech businesses which were rooted in Silicon Valley and which influence the industrial structure. The Silicon Valley Model has stimulated American economical development and improved nation competitiveness (Kenney and Von Burg, 1999; Davis, 2010). The USA model of high-tech is influencing other economies such as Korea as emerging country followed their model while China is now catching-up their model as shown in Table 1.

The Chinese context

Many multinational and global high-tech companies such as IBM, Intel, Microsoft, Dell, Apple, Lenovo, Toshiba, Samsung and LG have established their R&D labs and branches in China (Chung, 2006). The rationales for

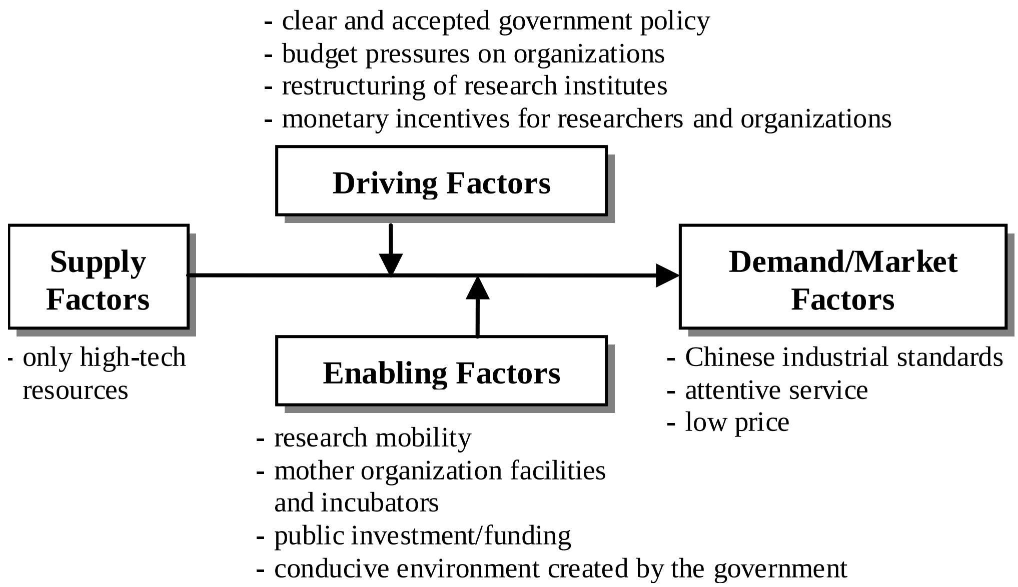

Figure 1. China model to create high-tech start-ups from universities and research institutes.

Table 1. Comparison of high-tech industry.

Country	Country style	High-tech start-ups model	Representative area	Key point
USA	Developed	Silicon valley model	Silicon valley	High-tech industry leader
Korea	Emerging	Korean model	Daedeok innopolis	High-tech follower
China	Developing	Zhong Guan Cun model	Zhong Guan Cun	High-tech catch-up

establishing so many R&D institutions in China are the world's pool of low-cost, well-skilled knowledge workers and the Chinese's government positively contribution to the establishment of national innovation mechanisms (Ernst, 2008). Comparatively with the USA, Japan and Korea are high-tech catch-ups, despite which China has no mature national innovation system, but it has paid more attention to the importance of high-tech start-ups from academic environment for facilitating regional and national economic development.

As compared with US universities, Chinese universities laid emphasis on students' education rather than research and spin-offs in the past (Chen and Kenney, 2007). Since the Chinese government started implementing economic reform policy in 1978, there have been some spin-offs established by universities and research institutes. These spin-offs have also generated their own systemic competency of knowledge development and technologies innovation. For instance, as China's academic authority, the Chinese Academy of Sciences (CAS) has created many high-tech start-ups, including Lenovo. Meanwhile, China's top two universities, PKU and THU have also created many high-tech start-ups, such as the Founder Group and Tinghua Tongfang Group respectively as shown in Table 2. Through analyzing the factors that facilitate high-tech start-ups from universities and research institutions, one model will be advanced to help stimulate new spin-offs based on knowledge and R&D competency.

Tables 3 and 4 show that the income of PKU enterprises is up to 53.09 billion RMB with 2.66 billion RMB at the top ranking while the income of THU enterprises is 30.86 billion RMB with 0.91 billion RMB following PKU (NBS, 2010). In addition, according the Ministry of Science and Technology's report (MOST, 2010) the size of Chinese R&D persons was 2.291 million in 2009, which was 2.5 times larger than in 2000. In 2009, there were 45, 000 research institutes. These institutes hired 1.426 million R&D persons (23% including master degree and Ph.D.). This number was 2.3 times larger than in 2000. By 2009, there were 2,305 universities and colleges (including three-year and four-year degree program). Out of total, 1,345 (58.7%) universities carried out science research activities which hired 509,000 R&D persons.

In 2009, the R&D expenditure of Chinese universities was up to 46.82 billion RMB, which was 6.1 times bigger than that of 2000. The Compound Average Growth Rate was 22.3%. Chinese universities implemented 476,000 R&D projects from government and industries, which

Table 2. Chinese IT start-ups from universities and research institutions.

Year	Firms	Universities or research institutions	Main business	Initial capital
1984	Lenovo	Institute of Computing Technology, Chinese Academy of Sciences	Computer Systems, IT Peripherals, IT Software	200 thousands RMB (0.2 million)
1986	Founder Group	PKU	IT, pharmaceuticals	4.4 million RMB
1997	Tsinghua Tonfang	THU	IT, Energy, environment	N/A

Table 3. Chinese universities-run enterprises gross income ranking (ten thousand RMB).

Rank	University	Income
1	PKU	5,309,544.73
2	THU	3,086,309.07
3	Chinese University of Petroleum (Shan Dong Province)	576,876.41
4	Northeastern University	532,028.67
5	Tong Ji University	353,936.66
6	Huazhong University of Science and Technology	303,010.01
7	Sun Yat-Sen University	233,440.00
8	Wu Han university	210,925.61
9	Shanghai Jiao Tong University	144,802.49
10	ShanDong University	127,479.72
Total		10,878,353.37

Source: MOE, 2009.

Table 4. Chinese universities-run enterprises profit ranking (ten thousand RMB).

Rank	University	Income
1	PKU	266,106.72
2	THU	91,496.58
3	Northeastern University	80,634.96
4	Huazhong University of Science and Technology	55,851.19
5	Tong Ji University	34,031.30
6	Chinese University of Petroleum (Shan Dong Province)	30,210.69
7	Beijing Foreign Studies University	27,677.51
8	ShanDong University	20,438.22
9	Wu Han university	16,863.04
10	Shanghai Jiao Tong University	15,729.16
Total		639,039.37

Source: MOE, 2009.

involved 272,000 researchers and the funding was up to 34.39 billion RMB. By 2009, in Chinese universities and colleges, there were 6,802 research centers which hired 91 thousand R&D workers (63,000 master and doctor degree holders). In 2009, 1,106 papers and 41,000 literature articles were published. An exponential positive increase can be seen in all these facts and figures.

Table 5 shows the comparison between 2009 and 2000 of R&D main indexes of Chinese universities and colleges. It is obvious that China's universities have enormous R&D resources which help them to enhance knowledge exchange with industries and facilitate high-tech start-ups.

Proposed model: To create high-tech start-ups from Chinese universities

Here, a model is proposed which consists of four factors

Table 5. Comparison of R&D main indexes of Chinese universities and colleges.

Index	2000	2009	Growth rate (%)
R&D workers	159 thousands	275 thousands	72.8
Research funding	7.68 billion RMB	46.82 billion RMB	610
R&D centers	5430	6082	12.0
R&D projects	n/a	476 thousands	n/a
Science papers	464 thousands	1.016 million	250
Literatures	25.63 thousands	41 thousands	160
Patents application	3608 (Patent inventions: 2083)	56641 (Patent inventions: 36241)	1570 (1740)
Patent approved	n/a	25570 (14408)	n/a

Source: Retrieved March 12, 2010 from http://www.most.gov.cn/tztg/201011/P020101122400627696682.pdf (in Chinese). n/a = not available.

which drive Chinese universities to facilitate high-tech start-ups as shown in Figure 2. The model shows how to successfully create high-tech start-ups from universities and these start-ups can be advanced. Recently, while they stick to emphasizing undergraduate education and developing new knowledge, many universities are gradually paying attention to promotion of technology transfer and commercialization. Based on a study conducted in China and France, Matt and Tang (2010) conclude that university incubators help to promote the creation of start-ups in academic environments and produce lots of well-trained graduates, patents and new knowledge. The circle dotted-lines as shown in Figure 2, means that inside the academic environment, universities carry out education programs of knowledge, skill as well as creation of high-tech start-ups. In order to expatiate how university can create high-tech start-ups, the four driving factors (that is, universities' internal level, political level, industrial level and market level) have been discussed in this section. Also considered are universities' internal factors including R&D competency, locations, faculty, size, and reputation and political factors include government role, funding support, policy's support and institutional relationships. Additionally taken into account are industrial factors such as industrial standards, industrial collaboration and competitors while market factors includes brand cognitive, market scale and market potential.

University internal factors

Universities are places which produce a large number of well-trained graduates and hire excellent R&D personnel to implement knowledge development (Shambare, 2011). While focusing on teaching and education activities, PKU and THU have heavily invested in a large number of funding projects, human resources and equipments into high-tech development. As China's top two universities, they commonly emphasize the links of research results and industrial applications. Such emphasis has led them to establish mature industry-university-research institute systems including venture capital firms of university, science parks of university, successful high-tech spin-offs and a large number of technology transfers as shown in Table 6.

Table 6 shows that main high-tech start-ups of PKU and THU were established after 1980s. The reason behind very few high-tech spin-offs being evolved from Chinese universities before 1980s is due to the College Entrance Examination which was abolished by The Gang of Four[4] from 1966 to 1977. In 1977, government gave up the universities' model of Soviet Union which was imitated before the Great Proletarian Cultural Revolution and started patterning American universities to form comprehensive or specialized universities (Chen and Kenney, 2007; Pepper, 1996; Wang, 2000). Based on traditional faculty basis and advantaged location to political center, PKU and THU have created more high-tech start-ups than other Chinese universities from the academic environment.

According to the QS World University Rankings 2010[5], PKU was at 47th and THU was at 54th position in the global top 500 universities. Table 7 shows that as compared with other Chinese universities, PKU and THU have competitive advantages in three fields that is., Academic Reputation, Employer Reputation, and Faculty-Student. It means that the competence of knowledge development, the practical ability of graduates, and the linkages of university-industry have been acknowledged in public.

In order to create high-tech start-ups from academic environment, one prerequisite is that universities need to hold a certain number of professors and researchers who mainly undertake the tasks of developing new knowledge and technologies. Until the end of 2010, in THU, there were 35 academicians (4.92%) of Chinese CAS and 34 academicians (4.55%) of Chinese Academy of Engineering

[4] This Group consisted of Jiang Qing, Zhang Chunqiao, Yao Wenyuan, Wang Hongwen who controlled the Communist Party of China between 1966-1976.

[5] www.qs.com

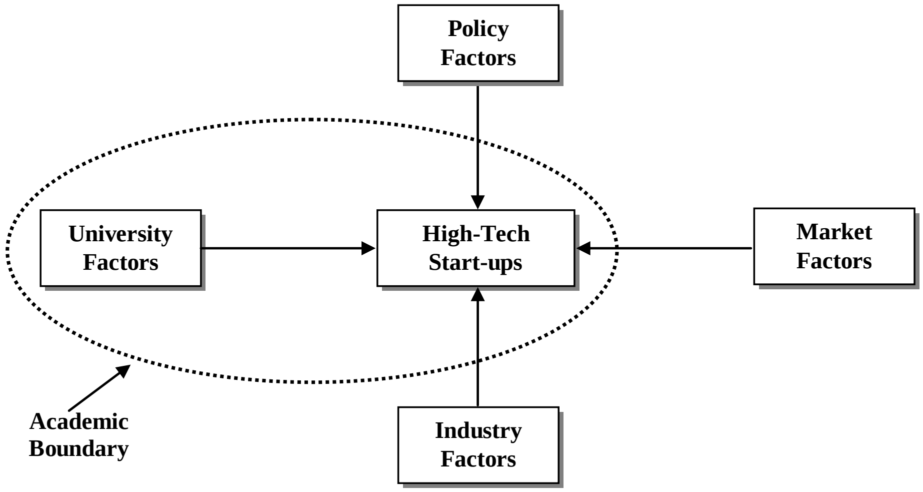

Figure 2. A model to create high-tech start-ups from Chinese universities.

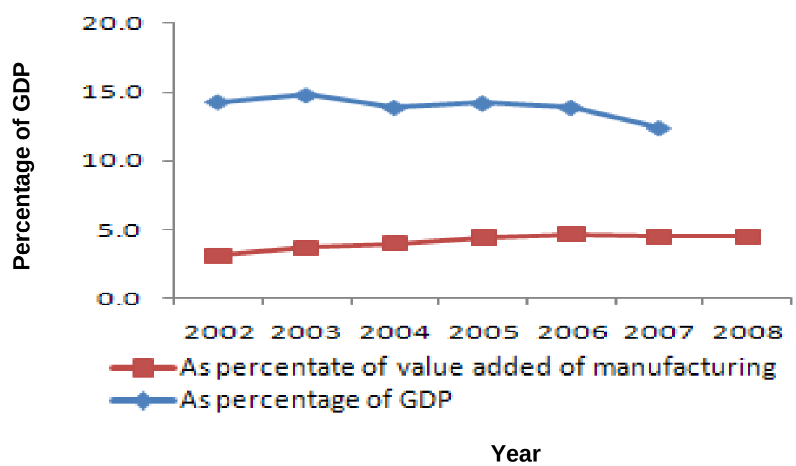

Figure 3. Value added of high-tech industries as a percentage of value added of manufacturing and GDP.

(CAE)[6]. While in PKU, there were 58 academicians (8.12%) of CAS, 8 academicians (1.07%) of CAE and 16 academicians (1.6%) of The Academy of Sciences for the Developing World. Table 8 shows that these two universities own a certain number of Chinese highest and most important academic talents who help these universities to develop high-tech knowledge and patents which will be applied into commercialization at the earliest.

In view of location to "Chinese Silicon Valley" Zhong Guan Cun, Beijing universities are more likely to engage into university-industry collaborations through employees' training, intellectual patents' transfer, professional consulting, and joint projects. For instance in 2000, 8,278 research projects were implemented in Beijing universities, 1,540 of them were conducted by joint collaboration of universities and firms while another 795 were technology service contracts (Chen and Kenney, 2003). From 2001 to 2005, PKU carried out more than 4,000 projects with the Chinese central government, including 320 projects with firms. More than 8,000 *Science Citation Index* (SCI) papers were published, including 2 in *Science*, 3 in *Nature*, 7 in *the Proceedings of the National Academy of Sciences USA* (PNAS), 26 in *Journal of the American Chemical Society* (JACS), 11 in *Physical Review Letters* (PRL) and 1 in *Lancet*. In 2008, THU applied for 1,450 patents in domestic (authorized 856 patents) and 515 patents in other countries (authorized 132 patents). THU published 2,589 SCI papers which gave it as first position in Chinese domestic universities.

To facilitate the speed of intellectual properties

[6] In total, there are 712 academicians in CAS, 747 academicians in CAE and 999 academicians in The Academy of Sciences for the Developing World. The aim of The Academy of Sciences is to promote scientific capacity and excellence for sustainable development in the developing countries.

Table 6. High-tech spin-offs of PKU and THU.

No.	PKU			THU		
	Firm	**Industry**	**Year**	**Firm**	**Industry**	**Year**
1	Founder Group	IT	1986	Unigroup Ltd.	IT and Pharmacy	1988
2	SINOBIOWAY	Biotech	1992	Qinghua TONGFANG	IT, Engineering	1997
3	PKU Resource Group	Construction	1992	Unisplendour Co., Ltd	IT	1999
4	BEDA JADE BIRD Group	IT and Education	1994	Chengzhi Co., Ltd.	Biotech and Pharmacy	1998
5	WBL Biotech Co., Ltd	Pharmacy	1994	THSP	High-tech Incubator	2000
6	Pulead Technology	Chemical	1999	CapitalBio	Life Science and Biotech	2000
7	IER	R&D institution	1999	Tsinghua YUANXING	Pharmacy	2002
8	PKU International Healthcare	Healthcare	2003	CHINERGY Co., Ltd.	Engineering	2003

industrialization, THU established a professional incubator company-Tsinghua Holdings Co., Ltd. (registered on September, 2003 with capital of 2 billion RMB) that aims to carry out commercialization of high-tech results, high-tech start-ups' incubation, technical consulting, venture capitals' supports for university inside. In 2003, operating revenue of Tsinghua Holdings Co., Ltd. was 12.648 billion RMB, which had been up to 26.038 billion RMB in 2008.

Policy factors

The second level is policy factors. During the commercialization of R&D achievements, government play a very important role including building university environment, constituting university intellectual property policies, changing public education mechanisms, and political strategy on enhancing universities' R&D capability (Hairston et al., 1998; Stevens and Bagby, 1999).

As known, most of the Chinese universities belong to the state and are administrated by government sectors[7]. Of course, as the two top universities, PKU and THU are running under the jurisdiction of the Ministry of Education. On the other hand, as the purpose of establishing global top universities and research-oriented universities, Chinese government formulated Project 985 and Project 211[8] to supply innovation platforms for knowledge development, academic communications and industrial applications through political and financial supports. In order to facilitate R&D activities of academic environment, Chinese government positively authorized to build some science parks[9] in the vicinity of universities, thereby enhancing the shift and spillover of high-tech research results for commercial application.

In 1986, to meet the global challenges of new technology development and improve Chinese industrial competitiveness, four Chinese scientists - Da-Heng Wang, Gan-Chang Wang, Jia-Chi Yang, and Fang-Yun Chen - jointly proposed to accelerate China's high-tech development. The second Chinese leader Xiao-Ping Deng argued that "science and technology are the chief productive forces" and approved the national high-tech R&D program, namely the 863 Program, which aims to improve Chinese self-reliant innovation competency and frontier technology R&D dynamics. From 1986 to 2005, 33 billion RMB of funding was invested into the 863 Program. This fund was also included to support 150 thousand researchers and scientists, more than 300 universities and research institutes and more than a thousand enterprises. It is greatly facilitating Chinese technical competitiveness and establishing solid basis for high-tech industry. As a result of the 863 program, 120 thousand papers including books have been published, about 8,000 thousand patents have been certificated and more than 1,800 national or industrial standards have been established in the last 20 years[10]. As China's top academic organizations, PKU and THU positively affect these kinds of high-tech R&D activities, technology transfer and

[7] These sectors mainly refer to the Ministry of Education of the People's Republic of China, other ministries and commissions of the state council, provincial governments, and city governments.

[8] The aim of Project 985 is to promote the development of Chinese higher education system, including 39 universities, while the aim of Project 211 is to train high-level talents for national economic and social development strategies, including 116 universities by Dec, 2010. (Some universities belong to Project 985 as well as 211 universities, such as Peking University and Tsinghua University).

[9] By Dec.2010, there are 87 Science Parks in Chinese universities, such as Science Park of Peking University, Science Park of Tsing University (source: http://baike.baidu.com/view/1251754.htm).

[10] http://www.most.gov.cn/eng/programmes1/index.htm (Ministry of Science and Technology of The People's Republic of China)

Table 7. Universities from China in the QS world university rankings top 100.

University	Territory	Academic reputation	Employer reputation	Faculty student	Citations per faculty	International faculty	International students	Overall	2010 rankings	2009 rankings	2008 rankings
HKU	HK	96	74	94	55	100	98	87.28	23	24	26
HKUST	HK	86	71	82	48	100	98	78.67	40	35	39
CUHK	HK	88	64	74	55	97	86	77.94	42	46	42
PKU	CN	100	90	95	23	18	34	76.35	47	52	50
THU	CN	98	78	88	24	42	28	74.18	54	49	56
NTU	TW	94	68	37	57	17	17	66.03	94	95	124

industrial application under such national policy support.

In addition, the Chinese government has established a 15 year-S&T (Science and Technology) Plan which has declared R&D spending would rise from US$ 24.6 billion in 2004 to US$ 113 billion in 2020 as shown in Table 9

Moreover, to encourage high-tech R&D activities and technological transfer, the Chinese State Administration of Taxation and the Ministry of Finance commonly published "Notice about tax policy of Non-profit R&D institutes"[11] which stated that non-profit R&D institutes which undertake the technology R&D activities, technology transfer, technology consulting or technology service do not need to pay sales tax and business income taxes. Most Chinese universities and public research institutes are owned by the state which means they belong to non-profit R&D institutes. On 20th August 2007, these two government sectors published another important policy "Notice about tax policy of Nation's university Science Parks"[12], which stated that incubators of Science Parks are blessed with business income taxes' concessions. Therefore, such preferential measures would encourage Chinese universities to positively carry out high-tech research and transfer, thereby accumulating more funding to reinvest R&D research, which can offer initial funding for Chinese universities when intend to commercialize R&D achievements by themselves.

In the individual dimension, there are many policies and regulations to reward professors and researchers including material and psychical incentives.

For instance, one important incentive measure is "Chang Jiang Scholar's Program" which aims to encourage scholars' research and academic innovation of universities and CAS, thereby improving the industrial application of research results and improving Chinese academic influence worldwide.

In 1996, the Chinese government enacted a law stated that researchers and team who develop high-technologies could receive up to 20% of profits if start-ups from university and R&D institutes are established based on such technologies (Kondo, 2003). A substantial inventive program would stimulate universities' professors and professional researchers to implement R&D activities for commercialization.

Industrial factors

The industrial factors include Chinese high-tech industrial standard and industrial collaborations. There have been various issues that suggested that high-tech firms should adopt original open innovation strategy rather than traditional closed innovation strategy (Chesbrough, 2006). Comparatively with textile products, advanced high-tech products (especially software and semiconductor sector, such as smart-phones, notebooks and ipad) cannot be developed and produced by a single firm. It raises a concern that high-tech companies should enhance collaborations with each other during the processes of research and development of new technologies (Fossas-Olalla et al., 2010).

Secondly, regional industrial zones (including special economic zones and science parks) would be helping universities to engage into industrialization. This support is facilitating the speed of knowledge diffusion, technology transfer and industrial applications. In the late 1980s, Chinese high-tech industry and local policy makers positively constructed science parks and industrial parks to inform innovation platforms and enhance knowledge-based technology transfers (Alam et al., 2010). Until 2010, there have been 54 national high-tech parks which contribute toward technology commercialization, industrial structural adjustment and RIS.

Science and Technology Parks (S and TP) which can be useful for strengthening the

[11] Source: http://www.chinatax.gov.cn/n480462/n480513/n480949/n644721/1014126.html (Chinese State Administration site).
[12]Source:http://www.chinatax.gov.cn/n480462/n480513/n480902/6632088.html (Chinese State Administration site).

Table 8. The context of THU and PKU.

Rank	Category	Sub- category	PKU	THU
1	Faculties	Full Professors	5,000	1,211
		Associate Professors	n/a	1,186
		Postdoctoral Researchers	n/a	1,266
2	Student numbers	Undergraduates	14,465	13,954
		Graduates	10,031	17,035
		Master's Students	5,088	9,783
		Ph.D. Candidates	n/a	7,252
3	Laboratories	National Labs	1	2
		The State Key Labs	12	15
		Key Labs of the Ministry of Education	13	18
		Post-Doctoral Research Stations	39	23
4	Library	Books collections	10.46 million	2.6 million

Table 9. R&D costs of S&T plan.

Period	R&D spending ($ billions)	Percent of GDP (in %)	Central government R&D	Appropriation (% of overall)
2004	24.60	1.23	8.70	35
2010	45.00	2.00	18.00	40
2020	113.00	2.50	n/a	n/a

Source: http://www.sciencemag.org/.

collaboration among universities, research institutes and high-tech firms would offer a platform to stimulate knowledge production and transfer to the economy in the form of spin-offs and simple knowledge spillovers (Almeida et al., 2008). Establishing high-tech science parks among universities and research institutions will enhance the linkage of academic results, high-tech markets, governmental special preference, venture capital and partnership collaboration.

In order to enhance the links between high-tech research results and market commercialization, CAS and the Haidian District government jointly established the “Science and Technology Development Center” (Kondo, 2003). In May 1988, the first national high-tech industry zone “Zhong Guan Cun” was regarded as *Chinese Silicon Valley*.

It was established comprising seven science parks, which cover thirty nine universities (including THU, PKU, University of Science and Technology, Beijing).

The parks employ around 400 thousand graduates who work at 213 research institutions (such as CAS), 41 national engineering centers, 42 critical laboratories, more than 10 national level enterprises' technological centers, more than 3,000 Chinese high-tech firms developed from universities and research institutes (such as Lenovo, Founder, Tsinghua Tonfang), and more than 1,600 foreign high-tech enterprises and research institutes (such as Nokia, IBM, HP, Microsoft, Intel) by October 2010. In the presence of many major universities and research institutes, this region has become high-tech paradise. Recently, many high-tech companies choose universities as their partners in the development of high-tech knowledge and patents which would lead them to concentrate on the current market (Xue, 1997; Chang and Shih, 2004). For instance, Siemens and China University of Mining and Technology have jointly established the Automation Technology Common Laboratory which aims to enhance the commercialization of automatic technology developed by university. Based on such collaborative strategies, joint ventures realize win-win outcomes. In the case of PKU, many global high-tech firms (such as IBM, Lucent, and Fujitsu) with PKU positively entered into cooperation in information technology, life sciences, environmental sciences and other high-tech fields. To capitalize on first-class R&D competencies, Fujitsu has invested 3 million RMB in PKU to develop information communication technologies in total. Meanwhile, THU and GE usually hold interchange activities of scientific research which aim to strengthen R&D collaboration.

Table 10. Gross industrial output value of high-tech industries (2002 to 2008).

Sector	2002	2003	2004	2005	2006	2007	2008
Pharmaceuticals (Ps)	2378	2890	3241	4250	5019	6362	7875
Aircraft and spacecraft (AS)	535	551	502	797	828	1024	1198
Electronic and telecom equipments (ETE)	7948	10217	14007	16867	21218	25088	28151
Computers and office equipments (COE)	3479	5987	8692	10667	12511	14859	16493
Medical equipments and meters (MEM)	759	911	1327	1785	2421	3128	3369
Total	15099	20556	27769	34367	41996	50461	57087

Market factors

The market factors include: brand cognitive, Chinese high-tech market scale, users' characteristics, and price level. In the current Chinese high-tech market, some main domestic IT products are developed and produced by high-tech firms from academic organizations, such as Lenovo (CAS), Founder (PKU), and Tongfang (THU) (Kleczyk, 2008). As compared with other brands, Founder group and Tongfang group adopt high quality-low cost strategy to seize high-tech markets in China.

Table 10 shows gross industrial output value of Chinese high-tech industries from 2002 to 2008. Total output of Chinese high-tech sectors in 2008 was 3.78 times greater than that of in 2002 while considering with the velocity increase of each sector, the rank is COE (4.74), MEM (4.43), ETE (3.54), Ps (3.31) and AS (2.24).

In addition, it is necessary to maintain relationships with customers for high-tech start-ups and understand what they need. Meanwhile, customers would give feedback which help firms to ameliorate products' quality or service quality. However, most start-ups prefer to save capital so that they usually neglect the importance of markets' survey (Chorev and Anderson, 2006). PKU and THU have the best business schools[13] to take on some research and consultation about behaviors and psychologies of high-tech product customers.

DISCUSSION

As compared with developed countries, China does not pay enough attention to the transition process potential of the high-tech economy. Chinese high-tech industrial infrastructure very much lags the US, EU and Asia (Japan and South Korea). China contributes to developing an emerging technical base. In these circumstances, as a subject of high-tech development in China, universities should adequately connect internal competencies with political factors and industrial factors. It will enhance cooperation of industry-university-research institutes that aims to efficiently use respective strengths of universities, firms, research institutes which then combines knowledge with practical experience and capacities to prevent discrepancies of academic education and social needs and improves students' competiveness. High-tech start-ups from universities can provide internships to students, who are more likely to get practical opportunities or be hired after graduation. Similar to the Silicon Valley Model in America, there have been many high-tech firms developed from academic environment in China, particularly in Zhong Guan Cun of Beijing city.

To compete with established companies, high-tech start-ups from universities are more likely to exploit advanced emerging technologies with broad scopes toward patents (Nerkar and Shane, 2002). In the future, not only PKU or THU but also other Chinese universities and research institutes will be more likely to adopt commercially-oriented research in high-tech fields so that newly-developed knowledge or intellectual property can serve as regional economic development. To survive, high-tech start-ups from universities need to pay more attention on improvement of technology contents, because they lack cost, network or market advantages compared with established firms.

The establishment of new companies, business and start-ups would help to create more job opportunities, stimulate related businesses, and gather industrial competitive advantages. In the emerging knowledge economy age, these startups have become an important innovation tool to stimulate technology development and job creation. In the knowledge information age, for the commencement of new high-tech start-ups, the establishment of a feasible business network is very critical. The cause of which stems from internal competencies, users' roles, industrial situations, government policies, and other factors would affect business successes at the beginning of new start-ups.

This study used descriptive and exploratory research design in order to lead the study to a conclusive research design. In conclusion, the model presented in this study explains the process of creating high-tech start-ups from the academic environment by analyzing the vibrant history of high-tech start-ups at PKU and THU as a case in point. If the model becomes generalizable through empirical research, it will provide useful implications for other the universities and policy makers. Similarly, it will also provide useful implications for other developing

[13] According to Chinese Business Schools' Rankings published by Forbes China (http://www.forbeschina.com). PKU has two business schools 1) Beijing International, MBA (2nd) and 2) Guanghua School of Management (4th). THU has one business school-School of Management and Technology (3rd)

countries who attempt to develop high-tech start-ups. These are the concerns for further research. This study used descriptive and exploratory research design in order to lead the study to a conclusive research design. In conclusion, the model presented in this study explains the process of creating high-tech start-ups from the academic environment by analyzing the vibrant history of high-tech start-ups at PKU and THU as a case in point. If the model becomes generalizable through empirical research, it will provide useful implications for other the universities and policy makers. It will also provide useful implications for other developing countries who attempt to develop high-tech start-ups. These are the concerns for further research.

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