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The entrepreneurial university in China: nonlinear paths

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Is the entrepreneurial university mode that originally appeared in the US possible in China? Thirty-four universities in the '985 Project' were studied in order to address this question. It is hypothesized that the necessary internal factors for a university to be entrepreneurial are: its research, technology transfer and entrepreneurship capabilities. External factors include: government support through policies and funding, venture capital and collaborations with firms. We concluded that it is possible to achieve an entrepreneurial mode in China, though different from that in the US. As a developing country, China starts from a university-run enterprise model, forming firms within the university. These generally operate in nonhigh-tech mode to gain experience and raise capital, as well as develop research capacity, and then upgrade to a high-tech entrepreneurship mode. A few elite universities will become entrepreneurial universities within 10–20 years.

A 'DOMESTIC INNOVATION GAP' has been identified as a national issue in China. Although it is a major manufacturing base and becoming one of the largest consumer markets in the world, lack of products with intellectual property rights (IPR) has seriously decreased the long-term profitability potential of technical enterprises. According to the Chinese patent statistical analysis of January 2007, of 19,950 patent applications 7527 (29%) are at an international level and 17,996 (71%) at a national level. However, most of the applications emanate from transnational corporations.[1] From the 1950s to the 1970s, manufacturing industry fell into a declining technological spiral due to lack of technology imports on the one hand and the low level of indigenous development, on the other. From the 1980s, as China opened to the world, imported technologies played a predominant role in industry.

Nevertheless, it was recognized that for long-term success, it was necessary to pursue 'indigenous innovation', building upon the technological innovation capital accumulated in the manufacturing base. Government formally emphasized the significance of indigenous innovation at the National Science and Technology Conference held in Beijing in January 2006. It was simultaneously decided to enhance the role of universities in innovation, not only knowledge innovation, but also technological and institutional innovation. Projects and programs such as '985' and '211' were started to promote university research and technology transfer capacity. As a result, some Chinese universities began a transition to the entrepreneurial mode.

The development of high-tech entrepreneurship is strongly dependent upon research and development (R&D) capabilities. Thus, China seeks to simultaneously enhance its research capabilities while pursuing entrepreneurship based on existing knowledge and technology. The Chinese case is especially interesting in that it suggests that nonlinear paths are possible to at least some extent with entrepreneurial activity preceding research. Some universities are evolving from a university-run enterprise (URE) model based on imported new-techs[2] to the high-tech entrepreneurship model. In this paper we analyze the development of research, technology transfer and entrepreneurial capabilities in Chinese universities in order to address the possibility and potential for the entrepreneurial mode.

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Entrepreneurial university: definition and characteristics

The entrepreneurial university, combining teaching, research and contributions to economic and social development, has been identified as the next stage in the evolution of the university (Etzkowitz, 2002). In the US, the path of university development has proceeded from teaching to research to entrepreneurial in an apparently linear sequence. However, it must be asked, especially for developing countries eager to speed the pace of both academic and economic development: is there a necessary sequence to achieving an entrepreneurial format? Must development of research capabilities precede entrepreneurial activities or can academic development proceed nonlinearly with entrepreneurship occurring simultaneously with the development of research or even prior to it?

What is an entrepreneurial university and how can it be realized? Massachusetts Institute of Technology (MIT) and Stanford University exemplified that it must: (1) be extrusive (very good) at high-tech entrepreneurship; (2) have a critical (quite strong) influence on the regional industry and economy. The entrepreneurial university is rooted in the evolution of university missions. The first academic revolution gave birth to the university research function and the 'research university'. The emergence of a social service function and 'entrepreneurial university' is the second academic revolution. The universities not only produce and diffuse knowledge but also apply it to industrial practice, thus creating new high-tech industries. These knowledge applications also impel the formation of an entrepreneurial university. Such a university can spill its new technologies over into industry through connections with industries, such as consultancy, patent licensing and the formation of firms. In addition, some external environmental factors are needed to create an entrepreneurial university such as government support and collaborations with industry.

From the origins of modern science in the 17th century through the development of academic science in the early 19th century, scientists have interwoven research and practice, fundamental investigation and consultancy (Brown, 1989). Commercial benefit from research greatly inspired the emergence of the land-grant universities[3] in the US. Science-based technological innovation has been demonstrated to be an effective approach to promoting the application of new knowledge (Stokes, 1997). In the US, most important innovations in recent decades have been indigenous. They are born and applied in the country and protected by IPR. Indigenous innovation has become one of the US's advantages in state defense, cutting edge technology and maintaining economic growth. The electronic industry in Japan and the software industry in India also benefit from indigenous innovation.

A triple helix of university–industry–government interactions is hypothesized to provide the optimum conditions for innovation. Science parks, spinoffs, UREs and incubators, are innovative organizations which are highly conducive to regional development, that arise from 'triple helix' interactions emphasizing the university's role in knowledge-based economies (Etzkowitz and Leydesdorff, 2000). In addition to industrial R&D, university research plays a very important role in generating 'indigenous innovation'; thus the importance of developing the research university is increasingly recognized. The entrepreneurial university, however, is the best tool to achieve indigenous innovation, as it has a stronger service function to the economy and greater influence on society than the research university.

An entrepreneurial university thus could be defined as: *the university that strongly influences the regional development of industries as well as economic growth through high-tech entrepreneurship based on strong research, technology transfer and entrepreneurship capability.* The entrepreneurial university has four primary characteristics, which can be used as criteria to identify the entrepreneurial mode:

- It undertakes technology transfer and entrepreneurship based on high-tech R&D.
- It has sufficient resources of science and technology (S&T) research and knowledge spillover through innovation, and has a strong influence on its regional industries and economy.
- Entrepreneurship is widely accepted in ideology and supported systematically by government and the administration of the university. Considerable numbers of staff engage in firm formation or 'high-tech entrepreneurship'. Moreover, the spinoffs or UREs very strongly influence the regional industries.

- There are organizational mechanisms at the university–industry interface, e.g. technology transfer offices and industry–university collaboration committees.

In a knowledge-based economy, knowledge has replaced material, labor and capital, becoming the most important factor of production. The premise of a university's cooperation with industry is needs and consensus. MIT's loss of state funding in the early 20th century led it to develop an industrial relationship to resolve its financial crisis. Industry needs a university that applies knowledge to resolve its practical problems but the role of the entrepreneurial university transcends this industrial service function. The entrepreneurial university mode is the most highly developed and complex university mode so far as it encompasses and transcends previous academic formats.

University–industry linkage is an important condition for an entrepreneurial university. Not surprisingly, the university, as the producer of knowledge and industry as the user need each other. In countries such as the US, the private universities struggle for their sustainability; they try their best to obtain money from both government and industry. In fact, the effort to develop prompts them to apply the knowledge created by the faculty. However, in China, most universities, especially those in the top rank, are public. There is a native university–government affinity. The key to an entrepreneurial model is to make the university–industry linkage. The basic reason why the linkage can occur is the presence of reciprocity.

A relationship to industry is only a necessary condition, but not a sufficient one. *An entrepreneurial university that has the potential to engage with the development of industry also has to embody three abilities: research, technology transfer and entrepreneurship.* Therefore, an entrepreneurial university must embody the research and teaching university, although different universities have different educational goals. Actually, only the entrepreneurial university has sufficient outreach to participate in the whole society's innovation, thus improving the triple helix interaction. Promoting research ability, stimulating technology transfer and fostering high-tech entrepreneurial capability are three important internal factors for developing an entrepreneurial university.

In summary, the conditions that are necessary to achieve an entrepreneurial university include: (1) an excellent undergraduate and graduate education system; (2) strong research; (3) a highly developed technology transfer ability; (4) academic capabilities and initiatives that put new knowledge to a use for which there was no pre-existing demand; and (5) a considerable amount of funding investment from industry and government, or favorable university–industry–government affinities (Etzkowitz *et al*., 2006).

University entrepreneurship and the entrepreneurial university

The entrepreneurial university is a different conception from university entrepreneurship. Any university can actualize entrepreneurship, for example, committing itself to entrepreneurial education, or initiating enterprises (i.e. UREs) at low-tech level. As we know, an entrepreneurial university is rich in entrepreneurship activities based on high-techs. This narrows its definition and characteristics. In other words, a teaching university may have multiple entrepreneurship activities, e.g. running a university hotel or inn, an autorepair shop, or a food-processing factory, but it is not in the 'entrepreneurial mode'. Therefore it is almost impossible that a professional college can evolve into an entrepreneurial university without developing research strengths and high-tech entrepreneurship.

An entrepreneurial university has the strongest regional influence and high-tech entrepreneurship activities. It is a specific university mode based on a variety of entrepreneurship activities. Any university can develop entrepreneurship activities, but only those strong in research, technology transfer and entrepreneurship will significantly influence the regional economy. Typically, universities that have strong science and engineering schools are easier to develop into an entrepreneurial mode than those that are strong in arts and liberal studies. The latter's direct contribution to the economy is far less than the former although this balance is shifting with the rise of 'creative industries' linked to art and fashion design schools.

Impetus to change

The process of achieving an entrepreneurial university through promoting research, technology transfer and high-tech entrepreneurship is multilinear. Chinese universities have typically promoted their entrepreneurial capacity through developing UREs,[4] utilizing the internal resources of the university to create new firms. In contrast to the US spinoff model in which protofirms rapidly move out of the university, UREs have persisted within the administrative framework of the university, until the quite recent institution of policies to encourage separation of operations. Nevertheless, in an earlier era when resources were scarce in China, as in the early years of US academic entrepreneurship, utilizing academic resources to promote firm formation was a common cost-saving approach.

In China, a 'horse race' to the research university is proceeding with government support. Technology transfer is just beginning and high-tech entrepreneurship is still being incubated. To acknowledge the stage of development of these capabilities, it is helpful to understand how far China is from the entrepreneurial mode.

China is in a 'government-pulled triple helix' mode in which the government controls academia and industry (Etzkowitz *et al*., 2007). Most Chinese universities are in a transition from teaching to research, assisted by government policies and programmes. The lack of capabilities in existing industry for technological innovation and deficits in university knowledge production affected the early stages of the transition, leading to poor technology transfer (industry–university collaboration acting to centralize industrial needs) and university high-tech entrepreneurship. It is expected, however, that the universities will play an increasingly important role in the indigenous innovation strategy. Nevertheless, until fairly recently only a relatively few universities had developed significant research capabilities. The Chinese government is trying to build world-class universities through the '985 Project' and 34 universities have entered the project so far.

From industry–university collaboration to university–industry collaboration

Universities in China have maintained a tradition of industry–university collaboration since the 1950s when the People's Republic of China was established. Institutions in industry and university as state affiliated parts generally collaborate with each other to improve their techniques. Usually, factories or other industrial sectors have sought university help to resolve technological difficulties. Although universities have an obligation to aid industries, they are in a passive mode waiting for requests and funding offers. The objective of industry–university collaboration is to meet needs from industry. So this can be called 'industry-based collaboration'.

Most Chinese universities were built in the 1950s when the needs of industrial production were paramount, as the newborn People's Republic of China faced the issue of recovering her economy. Universities were oriented to application purposes. During the 1950s to the 1970s, universities mainly worked for industries through their consultancy and paid most attention to improving techniques. University development evolved with the local industries. For example, the Northeastern University located at Shenyang City in Northeast China was good at mining and steel smelting, since there were many related factories in or around that region.

Another kind of collaboration is university-based collaboration or university–industry collaboration, attaching most importance to the needs of the universities for research funding and practical education. US research universities always try to search for such collaborations, rather than only industry–university collaborations. The proportion of university–industry collaborations is increasing, as the role of the university evolves. However, in past decades, universities in China almost only engaged in industry–university collaboration. Recently, the university–industry relationship has been undergoing a transition from industry–university to university–industry collaboration.

As university research recovered in the 1980s, its regional role changed into importing or producing more new inventions to market to firms as users. At the first stage of the process, since the state strategy was to import techniques from other countries, faculty members were encouraged to be consultants for existing firms to help them understand the new technologies.

Government promotion of academic research ability

In recent decades, Chinese university research has increased as the government has taken a lead in providing resources. The development of research universities has been looked upon as a measure to fulfill effective indigenous technological innovation. There have been some 'university-based collaborations' with industry supported by China National Science Foundation (CNSF), Ministry of Education (MoE) and the S&T Ministry. For example, CNSF prescribes that projects with industrial potential will be given priority during the application process.

Nevertheless, the research ability of Chinese universities is not strong enough to contribute significantly to indigenous innovation. On average, top-ranking private universities in the US have around 900 postdoctoral fellows; whereas top-ranking public universities have 700 postdoctoral fellows. The universities in China have far fewer. Tsinghua University has less than 1000 whereas Harvard University has over 3000 postdoctoral fellows. In recent years the research funds of the top universities have ranged from US$100 million to over billions in the US (Liu *et al*., 2002) whereas universities in China range from US$5.36 million (Northeastern University) to US$180 million (Tsinghua University) (see Table 1).

In recent years, some Chinese universities have been assisted by additional government funding through national research programmes, including the Climb Programme (1991) and 973 Programme (1998), Knowledge Innovation Engineering implemented by China Academy (1998), as well as various local programmes. Overall, the central government continues to enhance its investment in university research (see Table 2). It is a relatively stable rate of increase in university funding. This policy has greatly improved the research ability of the universities.

In addition, '985 Project' and '211 Project' play important roles in developing the research abilities of the universities. In the period 2001–2005, R&D workers in higher education increased from 171k to 227k. R&D expenditure increased from CNY10.24 billion to CNY24.23 billion. Moreover various S&T programs provide R&D expenditure to universities, especially research universities.[5]

Table 1 shows that only four universities have over one billion ren min bi (RBM) in total research funding. Some universities, such as Beijing

Table 1. Research capabilities of 21 universities in '985 Project' in 2005

No.	University	Advantage (A++: best at; A+: better at; A: good at)			Research ability							
		Science	Engineering	Liberal arts	Total research funds (kRMB)	Funds from government (kRMB)	No. of research projects	No. of national key labs and engineering research centers	No. of papers collected by EI	Cited frequencies of papers collected by SCI	No. of appraised S&T achievements	No. of patents won
1	Tsinghua University	A++	A++	A+	1381048	521301	3280	27	3242	7200	68	547
2	Beijing University	A++	A	A++	656457	618197	2896	22	847	7355	37	72
3	Zhejiang University	A++	A++	A++	1208306	476746	8070	12	2871	4739	146	659
4	Nanjing University	A+	A	A++	285619	122531	1161	9	759	5865	20	119
5	Fudan University	A++		A++	493103	350469	1839	12	796	4413	56	136
6	Beijing Normal University			A+	152900	149381	589	7	441	1305	4	12
7	Tianjin University	A	A++		463326	185513	1672	6	1630	1084	39	152
8	Dalian University of Technology	A	A+		409681	106517	2371	4	1023	1251	11	81
9	Zhongshan University			A	364549	208189	2208	4	472	2665	12	92
10	Nankai University	A		A+	239406	170627	776	5	435	2524	27	41
11	Huazhong University of S&T	A++	A+	A	637770	326490	2365	13	2055	1447	16	182
12	Wuhan University	A+	A+	A++	522990	530325	2466	9	618	2387	332	141
13	Shandong University	A	A	A	260165	128193	1465	5	776	2376	68	67
14	Sichuan University	A+	A	A+	623082	151309	2535	7	779	1405	48	114
15	Xiamen University	A		A+	122151	51432	694	5	357	1253	0	41
16	Dongnan University	A		A	555513	93904	1600	7	822	789	70	178
17	Jilin University	A+	A	A	451820	116899	1551	10	801	2990	210	100
18	Tongji University	A	A		966042	230941	3061	6	910	286	57	78
19	Central South University				588457	209617	1303	4	627	717	24	46
20	Northeastern University	A	A		166735	40194	1039	3	829	318	10	42
21	Hunan University				242562	116412	858	2	473	635	36	69
	Total				10791682	4383886	43799	179	21563	53004	1291	2422

Sources: S&T Development Centre of Ministry of Education in China <http://www.cutech.edu.cn/cn/dxph/qt/ 2007/ 11/ 1194500769155527.htm>. The advantages are taken from Top 100 of Social Science Education of Chinese Universities in 2005 <http://edu.sina.com.cn/1/2005-03-29/108716.html>; data on research ability is from S&T Statistics Compilation of Universities in 2006 <http://www.mmdy26.cn/zonghexinxi/682.html> and Chinese Science and Technology Papers Statistics and Analysis 2005

University, University of S&T of China and Beijing Normal University, are funded almost entirely by the government. Most universities won less than 150 patents. Obviously, there is still a huge gap between China and the US. But, going back to the end of 2000, we can find a big improvement. Table 3 reflects the research situation of Tsinghua University, Nanjing University and Dalian University of Technology in 2000 and 2005, respectively.

University–industry interface: technology transfer

According to Stanford's Office of Technology Licensing (OTL), in 2003, Stanford earned US$43.2 million from licensing patents. Up to 2004, its alumni and faculty built 1200 firms. A survey by the US Association of University Technology Managers showed that, overall, 196 US academic and nonprofit institutions reported nearly US$1.4 billion in net licensing income from various innovations in 2004; an average of US$7.14 million per institute (US$218 million in 1991, the average was US$1.11 million).[6] However, according to the website of the S&T Development Center of the MoE,[7] in 2005, among selected 63 universities affiliated by the MoE, 31 have received income from their patent marketing. Their average income in 2005 was RMB5.4342 million (around US$0.68 million). The top university, Tsinghua University, received RMB35 million (around US$4.375 million) from its patent marketing in 2005, which is far from the US$43.2 million at Stanford in 2003. Table 4 lists 11 universities whose contracts for technology transfer are valued at over RMB10 million (US$1.33 million). The total value of the contracts for technology transfer at Tsinghua University is only RMB213.6 million (US$28.48 million). Obviously, leading Chinese universities have rather less technology licensing and transfer than their peers in the US.

Table 2. Change in total research funding and funding from Chinese government in 2000 and 2005

No.	University	Total research funding (kRMB)		Funding from government (kRMB)	
		2000	2005	2000	2005
1	Tsinghua University	755654	1381048	512930	521301
2	Beijing University	333168	656457	249679	618197
3	Zhejiang University	610031	1208306	145018	476746
4	Nanjing University	128770	285619	88030	122531
5	Fudan University	213458	493103	145607	350469
6	Beijing Normal University	73944	149381	56148	152900
7	Tianjin University	314510	463326	143866	185513
8	Dalian University of Technology	158116	409681	45513	106517
9	Zhongshan University	88785	364549	59079	208189
10	Nankai University	86451	239406	53063	170627
11	Huazhong University of S&T	257964	637770	110215	326490
12	Wuhan University	157982	522990	85986	530325
13	Shandong University	71973	260165	64864	128193
14	Sichuan University	120001	623082	44270	151309
15	Xiamen University	43194	122151	19569	51432
16	Dongnan University	196977	555513	65617	93904
17	Jilin University	149668	451820	73050	116899
18	Tongji University	284280	966042	75684	230941
19	Central South University	217060	588457	115286	209617
20	Hunan University	81185	242562	28045	116412
	Total	4343171	10621428	2181519	4868512
	Percentage from government			50.0%	45.84%

Sources: S&T Development Centre of MoE in China <http://www.cutech.edu.cn/cn/dxph/qt/2007/ 11/1194500769155527. htm>; Basic Situation Compilation of Universities Belonging to MoE in 2000 and S&T Statistics Compilation of Universities in 2006

MIT outsourced technology transfer in the 1930s out of concern that too close an association with business might taint the school. However, it was re-integrated in the 1960s to allow the university to balance its financial interest in technology transfer with maintaining the good will of firms that support the university in various ways (Etzkowitz, 2002). MIT exemplifies an entrepreneurial mode: a seamless pursuit of education, research, translational R&D and firm formation (Hatakenaka, 2004).

Stanford followed MIT in creating a tradition of firm formation from academic research in the early 20th century. OTL was founded in 1969, based on the criterion of realizing the full financial worth of university technologies by actively seeking customers rather than merely obtaining patent protection and waiting for users to appear. Since university-originated technologies are often at a very early stage there may not be an existing firm to market an invention. Thus, university technology transfer increasingly turned to assisting the formation of new technology-based firms. Google Inc. exemplifies the shift from transfer to existing firms to firm-formation due to the vastly greater amount of funds that can be earned from a successful startup.

The Chinese university is undergoing a shift from providing consultancy services for existing firms to starting new firms and creating new industries. Technology transfer departments have been set up in most universities. University entrepreneurship ability

Table 3. Research capabilities at Tsinghua University, Nanjing University and Dalian Institute of Technology in 2000 and 2005

Indicators	Tsinghua University		Nanjing University		Dalian University of Technology	
	2000	2005	2000	2005	2000	2005
No. of Science Citation Index papers	1275	2874	616	1436	132	760
No. of Engineering Index papers	1418	3242	187	759	160	1023
No. of national key labs	10	13	7	7	4	4
No. of MoE key labs	8	11	2	2	0	0
No. of national engineering and technology centres	2	2	0	0	0	0
Total funding (kRMB)	755654	1381048	128770	285619	158116	409681
Funding from government grants (kRMB)	512930	521301	88030	122531	45513	106517

Sources: S&T Development Centre of MoE in China <http://www.cutech.edu.cn/>. Basic situation compilation of universities belonging to MoE in 2000; S&T Statistics Compilation of Universities in 2006; <http://www.mmdy26.cn/zonghexinxi/ 682.html>; Chinese S&T Papers Statistics and Analysis 2005

Table 4 University technology transfer ability in 2005

No.	University	Advantage (A++: best at; A+: better at; A: good at) Science	Engineering	Liberal arts	Technology transfer ability: Does it have a national technology transfer center?	Total amount of contracts for technology transfer (kRMB)	No. of marketed patents	Income from marketing patents (kRMB)	Funds from firms (kRMB)
1	Tsinghua University	A++	A++	A+	Y	213600	70	28000	36838
2	Beijing University	A++	A	A++	N	10616	3	2685	8592
3	Zhejiang University	A++	A++	A++	N	41076	59	11862	46075
4	Shanghai Jiaotong University	A++m	A++		Y	91360	10	6276	71827
5	Dalian Universityof Technology	A	A+		Y	87772	8	1250	8763
6	Xi'an Jiaotong University	A	A+	A	Y	32931	9	912	11670
7	Huazhong University of S&T	A++	A+	A	Y	32422	12	2630	68517
8	Shandong University	A	A	A	N	327862	11	1400	13979
9	Dongnan University	A		A	N	15433	2	5056	50584
10	South China University of Technology	A	A+		N	12582	4	2800	6780
11	Chongqing University		A		N	18118	41	31	5410

Sources: S&T Development Centre of MoE <http://www.cutech.edu.cn/cn/dxph/qt/2007/11/ 1194500769155527.htm>; data on advantages are from Top 100 of Social Science Education of Chinese Universities in 2005 <http://edu.sina.com.cn/1/2005-03-29/108716.html>; data on technology transfer ability is taken from <http://www.ebiotrade.com> and S&T Statistics Compilation of Universities in 2006

is increasing and the technological level of firms founded may be expected to increase concomitantly with the expansion of high quality research. Moreover, as low- or new-tech firms succeed, they expand their research capabilities and contribute to developing the research strength of their sponsor. Since these companies typically operate as UREs, under the umbrella of the university, the distance between 'firm' and academic lab is virtually non-existent, with the same personnel often occupying key roles in both venues.

The evolution of university entrepreneurship ability: UREs, capital and high-tech entrepreneurship

The First Chinese National Science Conference held in 1978 concluded that S&T is the leading source of productivity. Since then, the university has been expected to systematically play a role in regional innovation. The 2006 National Conference of Science and Technology embodied the idea of constructing a Chinese national innovation system, with the university contributing to achieving 'indigenous innovation' in the regions. More recently, a policy document 'Solution on Implementing the Outline of Science and Technology Program' (in 2006), proposed encouraging enterprises to take the lead in technological innovation. These policies are expected to influence university–industry relationships for the next 30–50 years.

The tradition of serving economy and state needs makes UREs feasible. UREs in China started in 1980 and developed with surprising speed during the 1990s, encouraged by national policies. A few universities have created some of the largest and most successful high-tech enterprises in the country. Tsinghua Tongfang, Beida Fangzheng, Beijing Zhongnong Tiannuo Science Developing Co. Ltd. and Beijing Futong Environmental Engineering Co. Ltd. are among the UREs that have earned significant monies for their university. As a whole, UREs have three characteristics: (1) the university takes all or part of the equity in its UREs; (2) those who operate UREs basically come from the university staff or are students, especially at the very outset; (3) R&D of UREs mainly relies on their parent university. Table 5 reflects the entrepreneurship ability of universities in the '985 Project'.

Obviously, some universities maintain stable growth, while a few show varied trends. For example, Nankai University experienced failure in running UREs in 2005. The data for Nanjing University (see Table 5) seems terrible in 2005. However, some are on the way to becoming good research universities. They have had the necessary research bases for commercialization of knowledge, but the research results do not spill over enough to develop high-tech entrepreneurship, which impacts the regional economy. External factors which are propitious for this development include: strong support to universities from the government, natural collaboration between university and industry, and service consciousness to contribute to the economy as well as university growth in recent decades.

Table 5. Entrepreneurship ability of 15 universities in '985 Project' in 2005

No.	University	Advantage (A++: best at; A+: better at; A: good at; B:; C:; C+:)			Entrepreneurship ability							
		Science	Engineering	Liberal arts	Total amount of UREs net profit (kRMB)	Total amount of sci-tech UREs' net profit (kRMB)	Net profit of university marketing companies (kRMB)	No. of incubating enterprises in national university science park	Total No. of enterprises graduated from national university science park	Total income of incubating enterprises in national university science park (kRMB)	Is there an experimental unit for entrepreneurial education?	No. of entrepreneurial practice bases
1	Tsinghua University	A++	A++	A+	425813.1	343308.0	236211.6	170	70	403140	Y	4
2	Beijing University	A++	A	A++	670086.6	716382.2	-266038	79	9	11642	N	2
3	Zhejiang University	A++	A++	A++	81197.4	83671.4	90662.4	287	50	580000	N	4
4	Nanjing University	A+	A	A++	-2386.4	-8113.4	2715.8	457	N/A	1691030	N	2
5	Fudan University	A++		A++	218821.7	172217.0	19518.7	389	61	763990	N	2
6	Beijing Normal University			A+	39088.1	1403.3	N/A	61	3	123410	N	2
7	Tianjin University	A	A++		18503.4	18548.2	N/A	37	N/A	288671	N	1
8	Dalian University of Technology	A	A+		6192.1	7559.9	N/A	112	12	774059	N	2
9	Nankai University	A		C+	-1412.2	1722.6	20638.6	76	17	139240	N	1
10	Shandong University	A	B	C	25643.7	25735.2	6154.4	230	75	1020000	N	2
11	Sichuan University	A+	B	C+	27875	31388.7	N/A	86	30	65432	N	2
12	Dongnan University	A		A	15297.3	10049.1	N/A	37	2	331545	N	1
13	Jilin University	A+	A	A	1783.8	2912.7	N/A	74	6	219558	N	2
14	Tongji University	A	A		81504.8	72301.9	28379	191	20	N/A	N	2
15	Northeastern University	A	A		172542.3	170741.8	58249	102	28	246000	N	4

Note: According to Shulian Wu, a famous Chinese professor in higher education study, universities in China were divided into 11 rankings: A++, A+, A, B+, B, C+, C, D+, D, E+ and E, from higher to lower level. Disciplines were classified as science, engineering, medical, philosophy, economics, law, education, literature, history and management. First, the universities were ranked on different disciplines. A university could obtain an A+ in engineering, but maybe a B in economics. As regards the ranking method, first obtain marks for all of the universities in China, then add them from large to small score until the sum is 61.8% over the whole score, then A level universities can be obtained. If we sum the scores of A level universities in an order from high to low until it reaches 61.8% over the sum of all A level universities, then can have A+ level universities. In the same way, all levels of universities can be identified. See <http://edu.sina.com.cn/l/2004-01-14/59603.html>, last accessed on 10 April 2005, for details of the methodology

Sources: The advantages are taken from Top 100 of Social Science Education of Chinese Universities in 2005. <http://edu.sina.com.cn/l/2005-03-29/108716.html>; the data on entrepreneurship ability is taken from Statistics Report on UREs of Chinese Universities in 2005; 2005 Report on the Development of National University Science Parks; as well as the website <http://t5105.crcoo.com/sdgaoxiao.htm>; section on entrepreneurial practice includes: the courses of entrepreneurial education, entrepreneurship research centre, entrepreneurship design games and the development of a practice base. Scores for entrepreneurial practice are mainly taken from the campus websites of the relevany universities and <http://www.kab. org.cn/NEWS.ASP?ID=26; http://chuangye.cyol.com/content/2006-06/23/content_1425726.htm>

The environment for developing an entrepreneurial university

Three aspects (research, technology transfer and entrepreneurship ability) are the internal factors but the environment also shows the importance of additional factors, especially policy and funding support from government as well as venture capital from industrial firms. Government-pulled + industry–university collaboration is a starting stage for the evolution to a triple helix. The evolution points to a co-existence of industry–university and university–industry collaboration, as well as a triple helix with a mixture of government-pulled, corporate-led and university-pushed models (Etzkowitz and Zhou, 2007).

Government promotes the formation of an entrepreneurial university through policy stimulation. The support of the relevant officials is essential. Firms in industries provide the venture capital, market and users for the technologies from university campuses. Undoubtedly, China's government is powerful enough to make strong policies to support creating an entrepreneurial university mode. Under its leadership, some organizations such as 'Northeastern University–Enterprise Cooperation Committee of Northeastern University' (established in 2001) have appeared, so that many firms are given access to university resources. Chinese universities thus have an excellent external environment in which to develop an entrepreneurial mode.

However, some negative factors have to be considered. The strong intervention from the government results in a university that does not have an explicit orientation towards an entrepreneurial mode. For example, when UREs developed too much, some people worried whether or not the university had changed its nature, becoming an industry. The ambiguous attitude of the government resulted in some universities hesitating to move towards an entrepreneurial mode. However, university autonomy is a necessary condition for the formation of a triple helix, but not for an entrepreneurial university. In other words, a nonautonomous university can develop into an entrepreneurial mode, as long as it has enough external support and internal development.

The ambiguous attitude is rooted in a lack of clear understanding of the differences between university entrepreneurship and an entrepreneurial university. If a university paid more attention to entrepreneurship, the time and energy of its academics would be diverted from normal teaching and research activities. In addition, a university will initially be less effective at business than industry. Low-tech entrepreneurship is not an effective option in the long term although it may help to develop university resources and capabilities in the short term. However, university high-tech entrepreneurship is another matter. It is in accordance with university goals in knowledge production and application. Universities should pay more attention to high-tech entrepreneurship (see Figure 1). Thus, implicit university–industry relationships can be formed.

University technology transfer is attracting greater attention from industrial firms. To date, national centres of university technology transfer have been set up in seven universities by the government. Some universities have even established international centres for technology transfer. Nevertheless, the problem is how to generate technologies, rather than importing them from outside, how to transfer research results out of the campus for commercialization and how to encourage university high-tech entrepreneurship.

Conclusions

The Chinese government has taken a concerted set of actions to achieve an entrepreneurial academic mode. For example, the MoE issued 'Several Opinions on Promoting Research University Development to Enhance University's Indigenous Innovation Ability' on 10 July 2007. Seven national university technology transfer centres have been established and 61 national university science parks developed for innovation, since the first science park was established near Northeastern University in Shenyang in 1989. The 'hardware' to achieve indigenous innovation seems sufficient. Obviously, the next step is to develop the capabilities, including university research, technology transfer and entrepreneurship capability, so that a few entrepreneurial universities can appear as soon as possible.

University		Industry
★★★★★	High-tech entrepreneurship	★
★★★	Mid-tech entrepreneurship	★★★
★	Low-tech entrepreneurship	★★★★★

Figure 1. University and industry entrepreneurship

Some elite Chinese universities have developed an entrepreneurial and technology transfer atmosphere. As their research ability increases, the other two abilities will undoubtedly be strengthened. The critical point is a breakthrough in understanding the necessity of university high-tech entrepreneurship. It means a zero distance (no gap) to recognizing the entrepreneurial mode in social ideology. In a China that can continuously create miracles by its centralized leadership, once the ideological obstacle has been surmounted, there would be a surprising improvement. On the other hand, even Tsinghua University, Beijing University and Zhejiang University, do not yet have enough spillover research for high-tech indigenous innovation.

Northeastern University, with an industry–university collaboration tradition, took a lead in establishing a science park and formed the Chinese Microsoft (Neusoft). In spite of working hard to achieve an entrepreneurial mode, its research and technology transfer ability are still not strong enough to lead indigenous innovation. A few UREs born from making money for the university have been put into the marketplace, becoming 'listed companies'. They are changing into real spinoffs.

UREs as an alternative path suggest that university entrepreneurship is not necessarily based on a high level of university research; business development precedes research capability in the Chinese university. Although there are successful 'high-tech enterprises', many UREs in China started from low-tech, even no tech (e.g. a university-run press or hotel), and then grew into a higher-tech industry. The route for university entrepreneurship is from low-tech entrepreneurship to capital accumulation and then to high-tech innovation or startups, rather than direct to startups as in the US. In addition to technological level evolution, there is an owner difference here. If we look at university-related enterprises as a spectrum, following an order of university control degree from left (strong) to right (weak), UREs should be on the left whereas spinoffs like Hewlett-Packard should be on the right.

The approaches to an entrepreneurial mode are nonlinear. The entrepreneurial university may be created by government rather than evolve as an independent university institution. Here the political system factor seems critical, rather than the change of any social sphere such as university, industry or government. Hitherto all 'Chinese research universities'[8] have been public and directly managed by the government. Most large-scale enterprises are still state-run. With its special political system, China could retain a main government-financed university system. However, to reach a triple helix with independent spheres is a much longer, if not impossible, goal, even though the entrepreneurial university can be achieved in a government-pulled triple helix in 10–20 years.

Can Chinese universities achieve relative independence to form a triple helix for innovation as in the US? Put differently, is it possible that the universities can become relatively independent of government or completely autonomous in China? Some predict that it will take 10–20 years to build several world-class universities in China. For example, Tsinghua University has tried to schedule the process. It hopes that it will develop into a world-class university in 2020.[9] We believe that a few Chinese universities can generate a strong influence on their regional economy through their high-tech entrepreneurship in 10–20 years, even without adjustment in triple helix relations to a condition of relative autonomy, as the goal of building world-class universities in China is achieved.

Notes

1. Data obtained from the State Intellectual Property Office of the People's Republic of China, Bejing. Available at <http://www.cnipr.com/ztxx/zltj/php/t20070416_85013.html>, last accessed on 10 March 2008.
2. 'New-techs' are those technologies that are imported as high technologies but are not at the leading edge. However, they are relatively novel in the regions where they are utilized.
3. The so-called US land-grant universities, established by the Morrill Act of 1862, focused on improving the agriculture and industrial production in their regions, in addition to traditional academic activities.
4. University-run enterprises: firms which belong to a university and are run by the university's administration department, i.e. university firms.
5. Available at <http://www.chinainfo.gov.cn/data/200512/1_20051220_124759.html>, last accessed on 15 December 2007.
6. Available at <http://stevens.usc.edu/read_release.php?press_id=12>, last accessed 4 February 2008.
7. Available at <http://www.cutech.edu.cn/cn/dxph/qt/2007/11/1194500769140304.htm>, last accessed on 4 February 2008.
8. According to the group led by Prof. Shulian Wu, there are 36 research universities in 2008. Available at <http://edu.qq.com/a/20060109/000102.htm>, last accessed on 11 November 2007.
9. Jianping Wu, Shuxia Gu 2003. The president of Tsinghua University announced the schedule to become a 'world-class' university. *Beijing Evening*, 7 April 2003 (in Chinese). Available at <http://www.people.com.cn/GB/kejiao/39/20030407/964686.html>, last accessed on 18 November 2008.

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