Barriers to entrepreneurial growth: an empirical study on university spin-offs in China

Yuan Zhou, Guannan Xu and Jun Su
School of Public Policy and Management, Tsinghua University, Beijing, China, and
Tim Minshall
Centre for Technology Management, Institute for Manufacturing, University of Cambridge, Cambridge, UK

Abstract

Purpose – Literature shows that university spin-offs (USOs) have idiosyncratic strengths in comparison to other new firms; however, evidence also shows that Chinese USOs have a low survival rate, and only a small percent of them can grow into sustainable businesses. The purpose of this paper is to conduct an empirical study to inquire about the variable growth barriers to Chinese USOs, in order to address two major research questions of this paper: what are the major growth barriers, and how significant they are; and what supports should university and government provide to eliminate those barriers?

Design/methodology/approach – In the first place, this paper attempts to explore the research questions through literature review and pilot interviews, based on which, a questionnaire for a survey was developed. Then, this study then attempts to address the research questions through a nation-wide survey in 2009 across 69 national university science parks.

Findings – This paper finds that corporate governance issues, managerial concerns, and lack of infrastructure support are three major categories of barriers that thwart the growth of USOs in China. In addition, this paper also identified the support that is expected from universities and government agencies in order to cope with the barriers.

Originality/value – This paper contributes to theory in three ways. First, it tests and validates some existing conceptual frameworks concerned with the growth barriers to USOs. Second, it sheds light on the specific growth concerns of Chinese USOs and identifies three kinds of barriers. Further, this study provides evidence for future policy making regarding USOs and university technology transfer activities in China. This research will be of interest to policy makers, academic entrepreneurs, and university administrators.

Keywords China, Universities, Government policy, Business development, Growth barriers, University spin-offs

Paper type Research paper

1. Introduction

China is facing the great challenge of building up its innovation capacity (Watkins-Mathys and Foster, 2006). For example, China has been endeavouring to increase its R&D capacity, and is catching up very quickly in terms of patent filing – China was ranked No. 6 worldwide in terms of the number of Patent Cooperation Treaty filings in 2008, with an annual growth rate of 56.1 per cent (WIPO, 2009).

This research is supported by Tsinghua University Initiative Scientific Research Program (Grant 20101081967) and Ministry of Education Soft Science Research Program (Grant 909001).

Journal of Science and Technology Policy in China
Vol. 2 No. 3, 2011
pp. 277-294

1758-552X
DOI 10.1108/17585521111167289

However, China still has an innovation gap in terms of technology transfer and commercialisation from original research, as only about 10 per cent of the filed patents have been actually commercialised in China (Von Krogh and Haefliger, 2007). University entrepreneurship has been viewed as a major component which may help to overcome this innovation gap, involving technology licensing, contract research, and especially university spin-offs (USOs)[1].

The extant research on USOs differs in terms of its themes. Besides the potential to translate research into technological innovation (Di Gregorio and Shane, 2003; Shane, 2004; Wright *et al.*, 2004), USOs should be examined as new firms which can generate wealth from research (Mustar *et al.*, 2006). However, few USOs studies have paid attention to the firm-level management issues (Rothaermel *et al.*, 2007). For example, much extant research views USOs as individual black boxes for university technology transfer activities, concerned with their institutional environment, infrastructure support and public policies, that encourage and shape the emergence of USOs from the knowledge base (such as universities and research institutes) (Di Gregorio and Shane, 2003; Minshall *et al.*, 2008; Mustar *et al.*, 2006), thus overlooking the micro-level dynamics of USOs (Siegel *et al.*, 2003).

From a firm-growth perspective, some attempts (although limited) have analysed the factors that impede or facilitate the creation and development of USOs (Clarysse *et al.*, 2005; Lockett and Wright, 2005; Mustar *et al.*, 2006). However, there is limited research that has examined the growth barriers to USOs in China, specifically concerned with Chinese specifics. Further, even less research has conducted empirical validation of the "potential" barriers with large sample size, rather than examining unique but limited cases (Su *et al.*, 2009; Zhou *et al.*, 2010). This reflects a research gap which requires further inquiry.

This study, therefore, will conduct an empirical study through a nation-wide survey (in China) to inquire about the variable growth barriers to Chinese USOs, in order to address two major research questions of this paper:

RQ1. What are the major growth barriers, and how significant they are?

RQ2. What supports university and government should provide to remove the barriers?

This paper attempts to explore these questions by examining Chinese USOs through pilot interviews and a nation-wide survey in 2009 across 69 national university science parks.

The remainder of this paper is structured as follows. First, we provide a brief literature review, followed by a description of the research method. Empirical evidence has then been analysed in two parts (sections):

(1) Variable barriers to growth. In turn, the major growth barriers have been validated through econometric factor analysis.

(2) Required supports from university and government.

Finally, this paper concludes with a short summary that depicts the research output, theoretical contributions, and relevant implications.

2. Practical context and theoretical review

This study attempts to conduct an empirical study to analysis the key barriers that thwart the growth of Chinese USOs. This section will, therefore, investigate the existing USOs studies – in order to confirm the research gap, and contribute to hypotheses regarding the key impact factors. The authors attempt to review two major categories of literature:

(1) The overview of USOs in China.

(2) Existing studies concerned with variable barriers to USOs' growth.

These literature will help to identify the key factors when developing questionnaire, and the associations between them through data analysis of the survey.

2.1 USOs in China: context, transformation and gap

(1) Context – the value of USOs in China. In an effort to improve the technology transfer rate, the government agencies introduced policies similar to the US Bayh-Dole Act of 1980 in around 2000. In addition, by 2001, China had established more than 30 university affiliated science parks in order to promote university entrepreneurship[2]. Specifically, USOs have played a significant role among those entrepreneurial activities (Liu and Jiang, 2001; Watkins-Mathys and Foster, 2006). The overview of university startups is illustrated in Table I.

However, there is an intensive, on-going debate regarding the value of USOs in China. Some research showed that these firms perform less well than other commercial entities, due to the lack of business agenda, unwilling to take risks, and limited business and management skills (Zhou and Feng, 2004). On the contrary, some argued that USOs have indeed proved to be an appropriate solution for technology transfer at Chinese universities. In addition, by lifting or easing the restrictive regulations, the Chinese spin-off formation has been complemented by a surge of entrepreneurial transformation (Kroll and Liefner, 2008).

(2) Transformation: university-owned enterprises to USOs. A significant transformation of Chinese university startups have been identified by some researchers. They argued that more and more Chinese university startups are no longer owned by universities, but appear to be more entrepreneurial oriented when affiliated to parent organisations (Kroll and Liefner, 2008; Xue, 2007). For example, Xue argued that the transformation can be classified into three stages (Table II).

(3) Definitions of USOs and the research gap. Xue's view was echoed in some other literature. However, Kroll and Liefner (2008) argued that UAEs had differences

Enterprise characteristics		Number of spin-offs	Total income	Total profit
Business orientation	Production	1,995	28.61	2.66
	Trade	849	4.35	0.24
	Others	2,607	15.50	1.66
Ownership structure	University	4,793	32.18	2.51
	JV with partners	658	16.27	2.05
Level of management control	University	4,217	45.53	4.38
	School, Department	1,234	2.93	0.18

Source: Sorted from data at: www.sts.org.cn/kjnew/maintitle/MainTitle.htm

Table I.
University startup companies in China (2006)

between themselves, and some UAEs could be classified as entrepreneurial "spin-offs" because UAE is a temporary term to describe the university startups during the transformational contextual settings. In this case, the authors attempted to focus on the USOs, which differ from the conventional concept of university-run enterprises (UREs) in China (e.g. Unilever Group, etc.), and some of the university wholly-owned UAEs. In recent years, given the change of policy and other external factors, entrepreneurial USOs appeared to take the place of old UREs or UAEs as a significant component of university technology commercialisation activities.

In summary, USOs and university technology transfer have been duly emphasized in the USA and the UK. By contrast, there is still limited research on the USOs in China (Bing and Jun, 2007), where universities (and research institutes) accounted for 27 per cent of total inventions in China in 2006[3]. Consequently, this research will address an important research gap (USOs in China in a dynamic environment) that will contribute to the existing literature by adding sound evidence, helping to enrich the robustness of the existing models in order to extend the boundaries of knowledge.

2.2 Growth barriers: general problems, and the specifics of Chinese USOs

(1) General growth barriers to USOs. Basically, spin-outs emerge when:

- scale economies, first mover advantage and learning curves do not provide competitive edge to incumbents;
- there are low barriers to entrepreneurs;
- there is intellectual protection;
- there is more uncertainty;
- when complementary assets are not required; and
- when opportunities destroy competence (Casson, 2005; Tushman and Anderson, 1986; Teece, 1986).

BVCA attempted to incorporate the technology aspect into the growth barriers for USOs (Table III) in more detail. However, the problems that they summarized were investor-orientated and not comprehensive, which miss some entrepreneurship-orientated problems such as funding gaps or industrial knowledge; in addition, this summary failed to consider the heterogeneity of USOs.

Some specific innovation problems to USOs have also been summarized in Table IV. However, the author argues that this list is not comprehensive and too technology-skewed, and it misses some key concepts including organisational concerns. In addition, these models failed to consider the specifics of Chinese USOs.

Table II.
The evolution of university startup companies – three phases

Duration	Stage	Character
1980s-1990	UREs: university-run enterprises	A unit in a university
1991-2000	UAEs: university-affiliated enterprises	A transformation, more business-oriented and partially owned by university
2001-now	Spin-offs	Business-orientated

Source: Summarized from Xue (2007)

Perspectives	Specification	Marks
Entrepreneurial management	1. Recruiting exceptional management to execute the business plan	3.9
	2. Identifying management with the required skills and level of experience	3.4
	3. Recruiting management having successfully created wealth for investors	3.8
	4. Assessing expected exit	3.5
	5. Assessing the likelihood of achieving an exit	3.3
	6. Demonstrating a path to exist for investors	3.4
Technology commercialisation and R&D management	1. Developing intimacy with customers in order to understand their needs	3.5
	2. Producing evidence to demonstrate proof of concept or principle	3.2
	3. Identifying and assembling customer evidence and market data	3.4
	4. Validating an unmet customer need for applications of the technology	3.5
	5. Developing intimacy with customers to convert technology into solutions	3.5
	6. Assessing the commercial value of the innovation or technology	3.5
	7. Demonstrating the ability to generate profits and positive cash flows	3.5
	8. Establishing a clear route to market/availability of channels to market	3.5
	9. Determining market readiness for applications of the technology	3.4

Source: Adapted from BVCA (2004)

Table III.
Factors that USOs find difficult to deliver

Following section will review the relevant literature which takes into account the Chinese context for USOs.

(2) Chinese USOs: any specific barriers to growth? There is limited research that has probed the required capabilities for Chinese USOs. Some research has attempted to address the Chinese specifics in terms of resources and growth barriers, as depicted in Table V.

As shown in Table V, China's institutional weakness is not the only barrier for USOs to innovate. The lack of managerial competence within Chinese USOs also significantly hampers the entrepreneurial process. These summarized concepts of growth barriers will be brought into the design of questionnaire and variables in the next section.

3. Research design

In order to examine how USOs operate in China and identify the barriers to their development, we conduct a survey among Chinese USOs.

3.1 Questionnaire design

On the basis of literature review, we did pilot studies in eight typical university science parks, including Tsinghua University, Zhejiang University, Nanjing University, Fudan University, Shanghai Jiaotong University, Tongji University, East China University

Perspectives	Stages or perspectives	Problems (including barriers, junctures and dynamic retardants)	Comments
Vohora *et al.* (2004)	R&D	Opportunity recognition	Problems are not necessarily consecutive in reality
	Incubation	Entrepreneurial commitment	
	Commercialisation	Threshold of credibility	
	Growth	Threshold of sustainability	
Clarysse and Moray (2004)	Concept	Project leader: planning and proposal writing	Missing the technology perspective
	Development	Entrepreneurial team: forming entrepreneurial team, motivation, technology gatekeeper	
	Product launch	Business manager: strategic inertia, management model, technology gatekeeper	
	Spin-off	Business developer: team structuring	
Colombo and Piva (2008), Van Geenhuizen and Soetanto (2009)	Technology commercialisation	1. Proof of concept or principle of technology	1. Problems are skewed to technology commercialisation aspect, failing to cover more organisational concerns
		2. Customer and market data for applications of the technology	2. Problems are too static and fail to consider the dynamic influences
		3. Assessing the potential (commercial value) of the technology or innovation	
	Finance and funding gap	1. Ability to generate profits and positive cash flows	
		2. Investment capital (problem of exit, managerial conflict, corporate governance problem, appropriability hazards)	
		3. R&D investment (for development)	
	Entrepreneurial management	1. Dealing with uncertainties	
		2. Dealing with knowledge gap (industrial knowledge, market knowledge, cross-disciplinary knowledge, etc.)	
		3. Forming the management team (with required skills, experience, and entrepreneurial commitment)	

Table IV.
Possible problems from USOs' perspective

(*continued*)

Perspectives	Stages or perspectives	Problems (including barriers, junctures and dynamic retardants)	Comments
	Market-related	1. Market knowledge and channel to markets	
		2. Build customer (commercial) bases	
	Physical resources	1. Infrastructure and proximity to market	
	Government	1. Regulations, bureaucracy	

Source: The authors

Table IV.

of Science and Technology, and China University of Mining. Based on interviews with experts in pilot studies, we put forward a question list to describe the key issues of Chinese USOs and organised 17 seminars to design a preliminary questionnaire. Then we did a pilot questionnaire survey in USOs in Beijing and polished the questionnaire.

The questionnaire consists of three parts: the first part is about the basic information of USO, such as size and age; the second part is about the influence of university and government; and the third part is about the barriers to USO's growth.

3.2 Sampling and data collection

We carried out the questionnaire survey in USOs affiliated to 108 universities in 69 university science parks that had been certificated by Ministry of Science and Technology or Ministry of Education in China. With the support from the Committee of Science and Technology, Ministry of Education of China, we sent questionnaires to 138 randomly selected USOs from the recommended list by ministries (so the selected USOs are quite representative) and received 78 feedbacks, including 64 valid questionnaires. The respond rate is 46.4 per cent, which means the samples cover almost half of the selected USOs. A comparison of responding and nonresponding USOs indicates no significant differences in terms of the key firm characteristics (e.g. firm size, location, age), so nonresponse bias is not a concern. Therefore, we can regard the data a representative reflection of the current status of Chinese USOs.

3.3 Measures

According to literature review and pilot interviews, we identified 12 items representing the key growth barriers to USOs in China, including insufficient policy support, insufficient financial support, lack of facilities, lack of venture capital, ambiguous governance structure, vague beneficial interest, lack of economy of scale, laggard management style, laggard operation philosophy, unreasonable management structure, laggard human resource management, lack of market-oriented research institutions, etc. Moreover, we also investigated what supports university and government should provide to USOs. Supports from university include fund support, brand support, technology support, R&D orientation, R&D cooperation with Parent University, talent training, and human resource management. Supports from government include preferential policies, government investment, human resource support, technology resource support, and information services. To measure these items, we used a five-point

Table V.
Review on Chinese specifics of USOs: barriers/capabilities

Research	Barriers to growth/required resources or capabilities
Su *et al.* (2009), Xue (2007)	1. Lack of systematic policy support 2. Lack of ecosystem support: (i) venture financial sources (ii) infrastructures (iii) credit support – collaterals, and (iv) relationship with parent universities 3. Lack of corporate governance and benefit sharing system 4. Old strategy on low price products → low profitability 5. Lack of focus on business
Eun *et al.* (2006)	1. A strong international resources: (i) application-oriented culture; (ii) property rights and social capital nourished in the universities 2. Barriers (barren external environment), lack of: (i) "absorptive capacity" of industrial firms, and (ii) the "intermediary institutions" that facilitate knowledge flows between universities and industrial firms; → this situation makes the "open innovation models" difficult to implement
Kroll and Liefner (2008): due to lack of IPR and absorptive capacity, USO is the only option to commercialise technologies	1. Restrictive regulations: being easing gradually 2. Unskilled workers/lack of absorptive capacity 3. Traditional labour-intensive strategy to compete through low product prices; in contrast, investment on new product/technology usually generate little return (Liefner *et al.*, 2006) 4. Technology demand tends to be non-generic/application-oriented 5. Policy results in the government urging universities to implement technology transfer to the industrial sector, USOs are government-driven
Watkins-Mathys and Foster (2006), Wright *et al.* (2008)	1. Weak R&D capacity (industry) and low technology transfer rate → weak complementary assets sources 2. Lack of entrepreneurial culture and ecosystem: human and social capitals 3. Key factors: networking, opportunities, entrepreneurial skills, including international business experience and access to, more financial sources

Source: The authors

Likert scale and asked respondents to rate them: 1 for least important, 2 for less important, 3 for important, 4 for very important, and 5 for most important.

3.4 Analytical approach

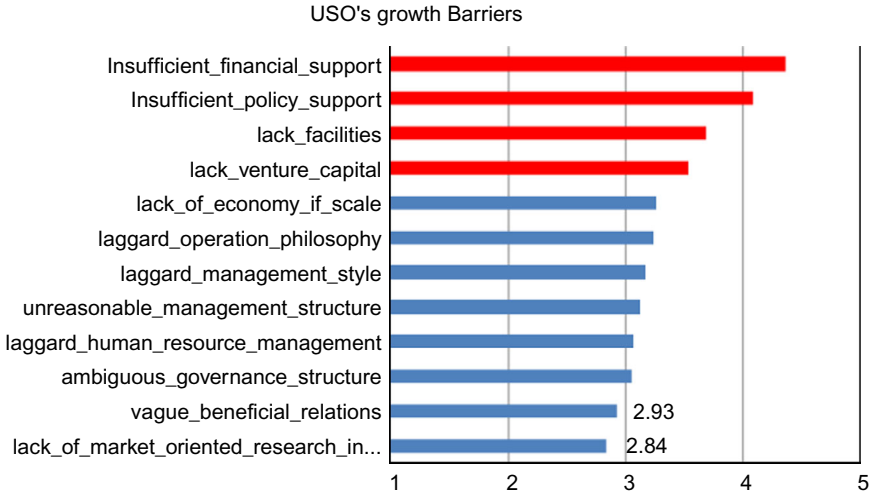
We analyse the data using SPSS. First, factor analysis is applied in empirical analysis Part I to analyse the main barriers of USO's growth. Among many variables (growth barriers), the main applications of factor analytic techniques are:

- to reduce the number of variables; and
- to classify variables.

Therefore, factor analysis is applied as a data reduction or principle components detection method in this paper. We use principal components for factor extraction and Varimax for rotation. Second, analysis that measures variability is used to examine the expectation of policy supports from universities and government agencies, which aggregate the questionnaire responses to create average scores such as means, standard deviations (SD), and variances for the descriptive analysis in empirical analysis Part II.

4. Empirical analysis I: various barriers to growth

Through literature review and interviews, we find there are mainly 12 barriers (Figure 1) immerging in the growth of USOs, including insufficient policy support, insufficient financial support, lack of facilities, lack of venture capital, ambiguous governance structure, vague beneficial interest, lack of economy of scale, laggard management style, laggard operation philosophy, unreasonable management structure, laggard human resource management, lack of market-oriented research institutions, etc. Compared with spins from other countries, some of the barriers are branded by China's actual conditions, such as explicit property relations and explicit beneficial relations.



Source: The authors

Figure 1.
Evaluation of USO's growth barriers

According to our questionnaire survey, there are ten barriers that are rated more than 3 (important), and only two of them are less than 3 (but quite close, 2.93 and 2.84, respectively). This suggests that at least ten items are viewed as important barriers to entrepreneurs in statistics. However, the two least-scored barriers are also receiving great attentions through pilot interviews, and their score differences to 3 are quite small, so we also consider them as important barriers.

Meanwhile, among all the barriers, insufficient financial support, insufficient policy support and lack of facilities and lack of venture capital rank top four, which means these problems are the most crucial barriers for USOs in China.

We conducted Ksiser-Meyer-Olkin (KMO) measure and Bartlett's test, and both passed verification (the KMO score is 0.743 and significance of Bartlett's test is 0.000). Then by factor analysis, three factors are extracted from these items, which explain 71.74 per cent of all the variance. This result explains three major factors though not statistically perfect; supportively, these factors have been duly emphasized by a series of conceptual studies in Section 2.2. Therefore, we argue that these factors can be viewed as three major categories of barriers.

As seen in Table VI, all the items can be expressed by the three factors as follows.

Through analysing the data, it shows that ambiguous corporate governance, managerial concerns, and lack of infrastructure support are the three major categories of barriers that thwart the growth of USOs in China. The results are robust both to those USOs that are affiliated to universities science parks and to those USOs which still have close links with their parent universities. The data do not support the important alternative explanations: USOs are of no value to university technology transfer due to inherent limit in growth. Rather, this research shows that researchers

Barriers	Factors Ambiguous corporate governance	Business-oriented managerial concerns	Lack of infrastructure support
vague_beneficial_relations	0.870	0.175	0.040
ambiguous_governance_structure	0.850	0.132	0.155
unreasonable_management_structure	0.799	0.417	−0.076
lack_of_market_oriented_research_institutes	0.686	0.208	0.091
laggard_operation_philosophy	0.039	0.854	0.280
laggard_management_style	0.391	0.800	0.100
lack_of_economy_of_scale	0.352	0.773	0.213
laggard_human_resource_management	0.516	0.599	0.091
insufficient_financial_support	−0.217	0.238	0.812
lack_venture_capital	0.386	−0.123	0.792
lack_facilities	0.391	0.200	0.672
insufficient_policy_support	−0.051	0.261	0.659

Source: The authors

Table VI.
Rotated component matrix

on Chinese USOs should pay more attention on coping with the institutional and managerial barriers, other than to negate USOs' value in haste.

4.1 Ambiguous corporate governance

Ambiguous corporate governance mainly means vague beneficial relations, ambiguous governance structure, unreasonable management structure, lack of market-oriented research institutes.

Through the growth process, many Chinese USOs have received both intellectual property and direct investment from parent universities. In addition, most of the shareholding structures failed to be arranged in a clear-cut and appropriate way. Therefore, stock-right ownership becomes a concern and may stimulate some conflicts of interests. This vagueness may result in mismatches of rights and responsibilities, and even the ambiguity of corporate governance structure. In fact, USOs are often treated as school subordinate agencies or departments' affiliates.

Echoing this result, literature shows that there are still more than 66 per cent USOs owned by universities (wholly or partially). Many of these spin-offs are trapped in property and intellectual property rights (IPR) ownership issues. That brings economic and legal troubles in long term for all these spin-offs. The vagueness of cooperate governance may also undermines the construction of business-oriented management for USOs, which may significantly hamper the growth.

4.2 Business-oriented managerial concerns

Business-oriented managerial concerns are characterized by laggard operation philosophy, laggard management style, lack of economy of scale, and laggard human resource management.

Many of our samples are affiliated to universities and thus they suffer from the non-business culture. For example, USOs' senior management sometimes are appointed by university administration apartment or officials, rather than being recruited in the job market. Thus, enterprise officials appointed do not have adequate capability to manage growth.

In addition, incentive mechanism is insufficient. The relationship between university and USOs is administrative and subordinate in many of our cases. The incentives to manager of these enterprises consist of mainly political gains and personal economic benefits, relatively of equalitarian. This incentive mechanism is easy to bring distortions in ethics and values, for example, some executives are shown to be passive in risk-taking innovation and tend to control rent-seeking. Insufficient incentive to key positions also deteriorates the aggressiveness of senior executives. This distorted incentive mechanism is actually award lazy but punish attendance. Consequently, many USOs miss their efficiency and competitiveness.

4.3 Lack of infrastructure support

Lack of fundamental support mainly explains barriers such as insufficient financial support, insufficient risk capital, lack facilities, insufficient policy support. USOs are often capital intensive, risky and of high yield. Fundamental environment, such as capital support, policy support and infrastructure are crucial for their growth and development. However, in China, many of these supports are insufficient.

Take capital support as an instance. It is recognized that capital support from public sector are limited for technology transfer and university entrepreneurship. However, things are worse in China – there is no money for USOs in private sector. China's venture capital and equity investment market are still in its infancy, and bank loans are reserved for large state-owned business. Limited venture investors are thwarted by the lack of exist mechanism, and the lack of understanding of technology-oriented USOs. In addition, it is also difficult for Chinese USOs to find loan accruals as many of them do not have enough fixed assets in the balance sheets as collateral. Furthermore, the capital market is still weak and flawed in China, only few USOs may benefit from Shanghai and Shenzhen Stock Exchanges markets.

4.4 Summary of analysis I

Using factor analysis, this section identified three components (ambiguous corporate governance, business-oriented managerial concerns, and lack of infrastructure support) as principle problems among the 12 observed specific barriers. In order words, the variations in these 12 specific barriers mainly reflect the variations in these three principle problems as a reduced number of variables.

Compared to prior findings from conceptual studies (Section 2.2), these findings are generated from empirical data and analysis, which provide a solid base to validate some of the conceptual argument, i.e. institutional problem and managerial issue are two of three major concerns. Adding to that, this empirical study successfully highlights the significance of infrastructure support to Chinese USOs.

These findings may help to strategize the policy solutions to cope with the barriers. Specifically, these findings imply that who (in what level) might be mainly responsible to solve these barriers. These entities, in specific the supports from them, will be particularly attended in the following section.

5. Empirical analysis II: supports needed from university and government

The existing three categories of barriers, including ambiguous corporate governance, business-oriented managerial concerns, and lack of infrastructure support, need different levels of solutions. The first two kinds of barriers are institutional and managerial problems which require attentions from academic entrepreneurs and parent organisations, while the lack of infrastructure supports needs more efforts from universities and government agencies. Institutional and managerial problems need more than policy solutions and will be further studied in future research. In this study, we focus on the expectation for the supports from parent universities and government agencies, and we found infrastructure support is critical for resolving the growth barriers for USOs. These expectations mainly imply the policy solutions for the third barrier, and they also will bring inspirations to cope with the first two problems, e.g. training to enhance managerial skills.

5.1 Supports needed from parent universities

We could find in Table VII that USOs need to gain supports from their parent universities through three main ways: technology resources, high brand effect, and affluent human resources. In addition, the influence of fund support has big variance in different universities.

	n Statistic	Mean Statistic	SE	SD Statistic	Variance Statistic
Technology support	64	4.42	0.073	0.586	0.343
R&D orientation	64	4.08	0.114	0.914	0.835
R&D cooperation with Parent University	64	4.08	0.110	0.878	0.772
Brand support	64	4.20	0.118	0.946	0.895
Talent training	64	4.00	0.114	0.909	0.825
Human resource management	64	3.61	0.140	1.121	1.258
Fund support	64	3.37	0.180	1.442	2.079
Valid *n* (listwise)	64				

Source: The authors

Table VII.
Supports expected from Parent University

Technology resources are the most significant supports that can be provided by parent universities. The importance of technology support, R&D orientation and R&D cooperation are 4.42, 4.08 and 4.08, which are all more than 4. Their SDs are all lower than other items. Specifically, the technology support which means the USOs could get the technology achievement from their parent universities is the most important resource for the USOs (its mean is 4.42, which is the highest; and the SD is 0.586, which is the lowest). This is because that the R&D costs and risks of new product are very high for a high-technology enterprise for its large uncertainties, which bring both risk and profit to innovation. The USOs need to use the affluent science and technology R&D achievements resources such as inventions, new technology applications and new product prototype which are possessed by the universities. The enterprises could also reduce their R&D costs and risks on choosing the technology direction if they could get the support of parent universities. They could get the information via close cooperation with their parent universities. For this reason, universities play a role of technology source which could reduce the R&D costs and risks for the USOs.

The second important resource that USOs need to gain from their parent universities is brand support. The brand of parent universities could bring a good reputation and extensive social acceptance in the market to the USOs' products. Meanwhile, the SD of brand support is higher than 0.9. This means the different USOs expecting different brand effect from their parent universities. For instance, the expecting for brand support of USOs affiliated to Tsinghua University and Peking University (their score is 5) is much higher than the Beijing Agricultural University's and Beijing University of Posts and Telecommunications'.

The third kind of support from university expected by USOs is the human resources. With close relationship to Parent University, USOs could easily get information and engage high quality talents to their business. USOs could also make use of their Parent University's education resources to train their talents.

In Table VII, we could find the score of fund support which is 3.37 is the lowest, while the SD (1.442) is the highest. This means capital is not a critical resource that is expected from university, and its importance varies according to the age and scale, etc. of the USO.

5.2 Supports needed from government

The data in Table VIII shows the expected supports from government. The government has powers of macroscopic guide, policy orientation, technology support, and information service in the development of USOs. Most USOs agree that the special market policy (the mean 4.66 is the highest, and the SD is 0.695, the lowest) which means preferential policy such as tax incentive is the most expected support from government. It could set up a good environment for USOs' development. The second expectation of USOs is the investment from government (the mean is 4.14). Most USOs have collaboration R&D programs with their parent universities that sponsored by the government fund. These funds sustained a big part of their R&D. The technology resource support (mean 3.14) and human resource (mean 3.17) support from government is relatively low, which means that government cannot do much to enhance the USOs' micro abilities such as human resources and technology achievements. These results mainly lie in the following aspects: first, government has the power integrating of resources, improving the country's overall innovation capability and creating a good environment for USOs. Chinese Government has emphasized the indigenous innovation and encouraged knowledge transfer from university to market. For this goal, the government could integrate the dispersed human, financial, and material resources, etc. effectively to enhance the cooperation of USOs and universities. Second, the government has concentrated on the superiorities to promote the development of the USOs as a part of regional economic development. The government can acquire excellent innovative talents, enhance the regional overall level of innovation, adjust the industrial structure, and promote regional characteristic economy development purposefully through the USOs. USOs all care much about the opportunity to get this resource. Third, government has established policy mechanism to improve the R&D input-output ratio. Government always faces to the question about how to pick up winners to achieve the funds' maximum efficiency. USO is a good option. It cannot only be fully exerting the universities' superiority in the advanced technology knowledge, but also enhance the combination between enterprise and market on the government-oriented aspects. Therefore, the government could increase the efficiency of its funds and the transformation from technology to economy.

5.3 Summary of analysis II

Echoing existing literature, this empirical result shows there are various supports from universities and governments that are expected by USOs. In addition, this result also finds that technology, brand, and human resource are the top three supports that USOs want, while USOs expect government supports on favourable market policy and

	n	Mean		SD	Variance
	Statistic	Statistic	SE	Statistic	Statistic
Special market policy for USOs	64	4.66	0.087	0.695	0.483
Government investment	64	4.14	0.132	1.052	1.107
Human resource support	64	3.17	0.173	1.386	1.922
Technology resource support	64	3.14	0.189	1.510	2.281
Information service to USOs	64	3.94	0.144	1.153	1.329
Valid N (listwise)	64				

Table VIII.
Supports needed from government

Source: The authors

government investment (e.g. grant). These findings successfully validate some conceptual work in Section 2.2, and also find some phenomenon like "fund supports from parent universities are less expected".

These findings may help Chinese USOs to strategize the policy solutions to cope with the third growth barrier. In addition, the findings also shed some light on how can universities and government help to deal with institutional and managerial obstacles, including talent training, information service to USOs, etc.

6. Conclusions

USOs have received great attention from researchers and policy makers, and there is a strong need to investigate empirically the barriers to the growth of Chinese USOs. In this empirical study, we studied some specifics of the USOs in the context of China. Some growth barriers have been identified through literature review and pilot interviews, and have been tested through a nation-wide survey. The data analysis showed that obstacles to the USOs' growth can be grouped into three major factors: ambiguous corporate governance, business-oriented concerns in management, and lack of infrastructure support. Furthermore, we analysed the supports that are expected from parent universities and government agencies, and find that USOs have different expectations in priority on two parties: technology, brand, and human resource from universities, favourable market policies and investment from governments.

The results have several important implications for USO's development in China. First, the results suggest that USOs' growth barriers do exist in many ways, but those highlighted barriers – three major factors – are not as broad as other prior research argued, and many barriers appear to be solvable. Second, the results suggest that the institutional and managerial barriers require more attention from academic entrepreneurs themselves, while the lack of infrastructure supports needs more efforts from university and government to cultivate USOs. Third, the results provide evidence for future policy changes, suggesting that policy makers in China should think carefully about the USOs before adopting policies similar to those undertaken in developed countries.

This paper also contributes to theory. First, it tests and validates some existing concepts about the growth barriers to USOs. Second, it sheds light on the specifics of Chinese USOs when concerned with firm growth. This paper also provides evidence for future policy making to provide with supports to USOs when concerned with university technology transfer activities in China.

Limitations do exist. First, this paper used a limited sample size due to the difficulties to assess to Chinese USOs' data. Second, the insufficiency of pilot case studies undermines the construct validity of the survey design. In the future research, the authors will attempt to improve the validity and reliability of questionnaires through more qualitative and quantitative tests. In addition, the authors will further conduct in-depth case studies to analyse the 12 growth barriers in detail.

This paper will be the basis for further work to convert analysis into guidance for practitioners to address "growth barriers" and to support the management of Chinese USOs' growth.

Notes

1. There are a variety of definitions pertaining to USOs: (i) USO was defined as "the unit of analysis in this study as a venture founded by employees of the university around a core

technological innovation which had initially been developed at the university" (Birley, 2002) (ii) USO was defined as "businesses that are dependent upon licensing or assignment of the institution's technology for initiation." (Lockett and Wright, 2005), and (iii) USO was also defined as new firms created to exploit commercially some knowledge, technology or research results developed within a university (Pirnay *et al.*, 2003). This study will adopt the third definition.

2. Refer to the Ministry of Science and Technology's (MOST, China) data for 2006.
3. See the State Intellectual Property Office (SIPO) Annual Report (2006) www.sipo.gov.cn/sipo/

References

Bing, W. and Jun, M. (2007), "Collaborative R&D: intellectual property rights between Tsinghua University and multinational companies", *Journal of Technology Transfer*, Vol. 32 No. 4, p. 457.

Birley, S. (2002), "Universities, academics, and spinout companies: lessons from imperial", *International Journal of Entrepreneurship Education*, Vol. 1 No. 1, pp. 133-53.

BVCA (2004), *Report on Investment Activity*, British Venture Capital Association, London.

Casson, M. (2005), "Entrepreneurship and the theory of the firm", *Journal of Economic Behavior & Organization*, Vol. 58 No. 2, pp. 327-48.

Clarysse, B. and Moray, N. (2004), "A process study of entrepreneurial team formation: the case of a research-based spin-off", *Journal of Business Venturing*, Vol. 19 No. 1, pp. 55-79.

Clarysse, B., Wright, M., Lockett, A., Van de Velde, E. and Vohora, A. (2005), "Spinning out new ventures: a typology of incubation strategies from European research institutions", *Journal of Business Venturing*, Vol. 20 No. 2, pp. 183-216.

Colombo, M.G. and Piva, E. (2008), "Strengths and weaknesses of academic startups: a conceptual model", *IEEE Transactions on Engineering Management*, Vol. 55 No. 1, pp. 37-49.

Di Gregorio, D. and Shane, S. (2003), "Why do some universities generate more start-ups than others", *Research Policy*, Vol. 32 No. 2, pp. 209-27.

Eun, J.-H., Lee, K. and Wu, G. (2006), "Explaining the 'university-run enterprises' in China: a theoretical framework for university-industry relationship in developing countries and its application to China", *Research Policy*, Vol. 35 No. 9, pp. 1329-46.

Kroll, H. and Liefner, I. (2008), "Spin-off enterprises as a means of technology commercialisation in a transforming economy – evidence from three universities in China", *Technovation*, Vol. 28 No. 5, pp. 298-313.

Liefner, I., Hennemann, S. and Xin, L. (2006), "Cooperation in the innovation process in developing countries: empirical evidence from Zhongguancun, Beijing", *Environment and Planning*, Vol. 38 No. 1, pp. 111-30.

Liu, H. and Jiang, Y. (2001), "Technology transfer from higher education institutions to industry in China: nature and implications", *Technovation*, Vol. 21 No. 3, pp. 175-88.

Lockett, A. and Wright, M. (2005), "Resources, capabilities, risk capital and the creation of university spin-out companies", *Research Policy*, Vol. 34 No. 7, pp. 1043-57.

Minshall, T.H.W., Wicksteed, W., Druilhe, C., Kells, A., Lynskey, M. and Širaliova, J. (2008), "The role of spin-outs within university research commercialisation activities: case studies from 10 UK universities", in Groen, A., Oakey, R., Van der Sijde, P.C. and Cook, G. (Eds), *New Technology-based Firms in the New Millennium*, Emerald, Oxford, pp. 185-201.

Mustar, P., Renault, M., Colombo, M.G., Piva, E., Fontes, M., Lockett, A., Wright, M., Clarysse, B. and Moray, N. (2006), "Conceptualising the heterogeneity of research-based spin-offs: a multi-dimensional taxonomy", *Research Policy*, Vol. 35 No. 2, pp. 289-308.

Pirnay, F., Surlemont, B. and Nlemvo, F. (2003), "Toward a typology of university spin-offs", *Small Business Economics*, Vol. 21 No. 4, pp. 355-69.

Rothaermel, F.T., Agung, S.D. and Jiang, L. (2007), "University entrepreneurship: a taxonomy of the literature", *Industrial and Corporate Change*, Vol. 16 No. 4, pp. 691-791.

Shane, S. (2004), "Encouraging university entrepreneurship? The effect of the Bayh-Dole Act on university patenting in the United States", *Journal of Business Venturing*, Vol. 19 No. 1, p. 127.

Siegel, D.S., Waldman, D. and Link, A. (2003), "Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study", *Research Policy*, Vol. 32 No. 1, pp. 27-48.

Su, J., He, J.Q., Xue, E.Y., Xiao, Y.D., Li, S.C., Sui, J.G., Xie, X. and Zhou, Y. (2009), *A Study of Knowledge-based Innovation and Technology Spin-offs in Chinese University*, Tsinghua University Press, Beijing.

Teece, D.J. (1986), "Profiting from technological innovation: implications for integration, collaboration, licensing and public policy", *Research Policy*, Vol. 15 No. 6, pp. 285-305.

Tushman, M.L. and Anderson, P. (1986), "Technological discontinuities and organizational environments", *Administrative Science Quarterly*, Vol. 31 No. 3, pp. 439-65.

Van Geenhuizen, M. and Soetanto, D.P. (2009), "Academic spin-offs at different ages: a case study in search of key obstacles to growth", *Technovation*, Vol. 29 No. 10, pp. 671-81.

Vohora, A., Wright, M. and Lockett, A. (2004), "Critical junctures in the development of university high-tech spinout companies", *Research Policy*, Vol. 33 No. 1, p. 147.

Von Krogh, G. and Haefliger, S. (2007), "Nurturing respect for IP in China", *Harvard Business Review*, Vol. 85 No. 4, pp. 23-4.

Watkins-Mathys, L. and Foster, M.J. (2006), "Entrepreneurship: the missing ingredient in China's STIPs?", *Entrepreneurship & Regional Development*, Vol. 18 No. 3, pp. 249-74.

WIPO (2009), *PCT Yearly Review: The International Patent System in 2009*, Economics and Statistics Division, WIPO, available at: www.wipo.int/pct/en/activity/pct_2008.html

Wright, M., Birley, S. and Mosey, S. (2004), "Entrepreneurship and university technology transfer", *The Journal of Technology Transfer*, Vol. 29 No. 3, pp. 235-46.

Wright, M., Filatotchev, I., Liu, X., Buck, T. and Campus, J. (2008), "Returnee entrepreneurs, science park location choice and performance: an analysis of high-technology SMEs in China", *Entrepreneurship Theory & Practice*, Vol. 32 No. 1, pp. 131-55.

Xue, L. (2007), "The changing roles of universities in China's national innovation system", paper presented at Biennial International Conference on University, Industry and Government Linkages, Paris.

Zhou, L.A. and Feng, H. (2004), *A Research Report on the Performance and the Problems of University-owned Firms in the Zhongguancun Science Park*, Administrative Committee of Zhongguancun Science Park, e-Business Centre, Peking Univeristy, Beijing.

Zhou, Y., Minshall, T. and Hampden-Turner, C. (2010), "Building innovation capabilities: an inquiry into the dynamic growth process of university spin-outs in China", *International Journal of Innovation and Technology Management*, Vol. 7 No. 3, pp. 273-302.

About the authors

Yuan Zhou is an Assistant Professor at the School of Public Policy and Management, Tsinghua University (China). He received his PhD degree (Technology Management) from the University of Cambridge (UK) in 2010. Joseph holds a BEng (Mechanical Engineering) and MSc (Robotics Design) from Nanyang Technological University (Singapore). His recent research interests include public policy, innovation policy and technology innovation management. Yuan Zhou is the corresponding author and can be contacted at: zhou_yuan@mail.tsinghua.edu.cn

Guannan Xu is a Postdoctoral Researcher at the School of Public Policy and Management, Tsinghua University (China). She received her PhD degree in Management from Zhejiang University (China). Her recent research interests include innovation management, international manufacturing management and public policy.

Jun Su is a Professor and Doctoral Tutor at the School of Public Policy and Management, Tsinghua University (China). He is currently Director of the Social Science Development Office and Centre for Science, Technology and Education Policy at Tsinghua University, and he is also the Deputy Director of Chinese Institute of Engineering Development Strategies. His research interests include public policy, innovation policy and technology management.

Tim Minshall is a Senior Lecturer at the Centre for Technology Management, University of Cambridge (UK). He is a member of the Board of St John's Innovation Centre. He has a PhD from Cambridge University Engineering Department. His research interest focuses on technology management, specifically on open innovation and industry-university linkages.

This article has been cited by:

1. Hao Hu, Chao-Chen Chung. 2015. Biopharmaceutical Innovation System in China: System Evolution and Policy Transitions (Pre-1990s-2010s). *International Journal of Health Policy and Management* **4**:12, 823-829. [CrossRef]