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A Comparative Study on Tenant Firms in Beijing Tsinghua University Science Park and Shenzhen Research Institute of Tsinghua University

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Abstract This paper aims to explore the institutional difference between Tsinghua University Science Park (TusPark) in Beijing, and business incubator of Research Institute of Tsinghua University in Shenzhen (RITS), and to examine how the difference leads to different new product performance for tenants. In doing so, we use survey methodology to investigate the innovation sources, university linkages, and innovation outputs of tenants in TusPark and RITS. We found that tenants in RITS reply more on "market-driven" knowledge sources for innovation: including knowledge from customers, suppliers, and competitors. The empirical findings suggest that the technology support provided by RITS and the high dependency on "market-driven" knowledge sources jointly contribute to the better new product performance for tenants in RITS.

Keywords University science park, business incubator, regional innovation system, innovative cluster, startup

I. Introduction

This paper examines the role of university science park and business incubator on the innovation performance and business performance of tenants. We use survey data from two institutions affiliated to China's top university – Tsinghua University. One is Tsinghua University Science Park (TusPark), the other one is the business incubator of Research Institute of Tsinghua University in Shenzhen (RITS). This paper explores the following research questions: (1) what are the institutional difference between TusPark and RITS? (2) How this difference leads to different new product market performance for tenant firms in TusPark and RITS?

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University science park and business incubator were created with the objective of transferring university knowledge to nearby firms in the mechanisms of formal and informal collaborations, interfirm human mobility, and spin-off of universities. Such exchange of tacit and explicit knowledge between firms and universities may contribute to firms' innovation in the form of new products, new services, or new processes (Díez-Vial and Montoro-Sánchez, 2016; Löfsten and Lindelöf, 2005). Recent literatures suggested that roles of universities / research institutes (URIs) in regional innovation systems (RIS) might be different across regions (Chen and Kenney, 2007). Therefore, it is imperative to take the institutional differences of RIS into account when analyzing the roles of university science park and business incubator across regions.

Previous studies explored the mechanisms of TusPark and RITS respectively. Studies on TusPark found that firms having internal innovations grounded in their own competitive advantages showed better innovation performance, and formal research and development collaboration with Tsinghua University only played a marginal role (Motohashi, 2013). Some Chinese scholars studied the innovation system of RITS by using case study method. They found that the joint collaborations between RITS's laboratories and tenants are more market-oriented: RITS provides more upper stream applied research, and partner tenants are responsible for development and manufacture process; RITS also provide pilot experiment platform to encourage firms to conduct intermediary test for their products with their customers (He, Wang, and Zeng, 2013; Sun, Gao, Zhang, Wang, and Feng, 2009). However, there is little empirical research on comparing the institutional differences between TusPark and RITS, and on how such institutional differences lead to different new product market performance for tenant firms.

In this paper, we close this gap by conducting a comparison study on tenants in TusPark and RITS. We found that firms in RITS have better new product market performance than firms in TusPark. We demonstrated that the main institutional difference between TusPark and RITS lies in that tenants in RITS rely more on "market-driven" knowledge sources for innovation, such as knowledge from customers, suppliers, and competitors. We found that the technology support provided by RITS and the high dependency on "market-driven" knowledge sources jointly contribute to the better new product performance for tenants in RITS.

II. Literature Review

1. Science Parks and Business Incubators

There is no informal definition of Science Park or Business Incubator. There are several similar terms that describe these institutions, such as Technology Park, High-tech Park, Research Park, Innovation Center and so on (Löfsten and Lindelöf, 2002). Previous studies defined these institutions as property-based organizations with identifiable administrative centers focused on the mission of business incubating through incubation services, resources sharing, and knowledge agglomeration (Chan and Lau, 2005; Löfsten and Lindelöf, 2005; Phan, Siegel, and Wright, 2005). Many universities established science parks to foster the creation of university spin-offs (Link and Scott, 2003, 2005). Previous studies on science parks and business incubators demonstrated that university linkages may foster tenant firms' innovation (Löfsten and Lindelöf, 2002; Quintas, Wield, and Massey, 1992; Rothaermel and Thursby, 2005). Scholars also explored the role of science parks by comparing the performance of firms locating inside and outside parks, and found that firms located on parks tend to be more innovative. Scholars attributed the reasons to the fact that science parks offer a clustering effect and establish links among firms and universities (Lindelöf and Löfsten, 2003; Yang, Motohashi, and Chen, 2009).

The first national high-tech parks in China appeared in 1988, when the Chinese government launched the Torch Program, an initiative aiming at promoting university-industry collaboration and stimulating regional economic growth. The Tsinghua University Science Park (TusPark) in Beijing was among the first national level university science parks in China. In 1998, Tsinghua University and Shenzhen municipal government jointly established the Research Institute of Tsinghua University in Shenzhen (RITS). Previous studies explored the university linkages and innovation in TusPark (Motohashi, 2013), and the mechanisms of RITS (Wang Luhao, 2013). However, there is a lack of comparative studies on university linkages and firms' innovation in TusPark and RITS. There are also few studies exploring how the institutional differences between TusPark and RITS contribute to the differences of firms' performance.

2. Innovative Clusters and Regional Innovation Systems

An innovative cluster can be defined as a geographically proximate group of interconnected companies and associated institutions linked by commonalities and complementarities (Porter, 2000). Previous studies suggested that learning through networking and interacting, such as formal and informal collaborations, interfirm human mobility, and spin-off of new firms from existing firms, universities and research institutes, are crucial forces pulling new firms into clusters and the essentials for the on-going success of an innovative cluster (Breschi and Malerba, 2001). Previous studies demonstrated the success of Silicon Valley as an innovative cluster (Angel, 1991; Bresnahan, Gambardella, and Saxenian, 2001; Saxenian, 1990). Recent studies also examined innovative clusters in China, such as the Beijing Zhongguancun Science Park, which is called the "Chinese Silicon Valley" (Tan, 2006; Zhou, 2005).

On the other hand, the concept of regional innovation system (RIS) focuses on wider geographical regions at the sub-national level. Scholars suggested that RIS plays critical role in creating the appropriate context for knowledge creation and transfer within innovative clusters (Cooke, 2001; Cooke, Uranga and Etxebarria, 1997). Although embedded in the same national innovation system, the RIS in China may have completely different evolutionary trajectories. Recent studies explored the differences of RIS in China, and found that China's competitiveness depends upon institutional differences among regions (Zhao, Cacciolatti, Lee and Song, 2015).

3. The Role of Universities / Research Institutes in Innovative Clusters and Regional Innovation Systems

Academic literatures suggested that universities / research institutes (URIs) are critical knowledge sources in innovative clusters and regional innovation systems (RIS). Beyond generating commercializable knowledge, they produce other means of knowledge transfers, such as generating and attracting high quality talents to the RIS, and collaborating with local industries through formal and informal technology support (Bramwell and Wolfe, 2008; Sohn and Kenney, 2007). Recent literatures on the comparison between RIS suggested that the university-based innovation support in the RIS can either be science-based or applied research oriented (Coenen, 2007), and demonstrated that the overall institutional context of the regional innovation system is also imperative for the varying role of URIs institutes across regions (Trippl, Sinozic, and Lawton Smith, 2015). Previous study explored the different roles of URIs in China's RIS through a comparison of the development of the Beijing and Shenzhen technology clusters, and found that URIs in Beijing play extremely important role in the formation of local high-technology clusters, whereas URIs in Shenzhen are more important in providing for technology support and industrial upgrading (Chen and Kenney, 2007).

III. Comparative Study Framework

1. Differences of Innovation Systems in Beijing and Shenzhen

Beijing is the capital city which has the most intensive concentration of universities and research institutes in China. The Haidian district, where TusPark is located, is the heart of the innovative cluster Zhongguancun Science Park. The District is concentrated with long-standing universities and research institutes, including Tsinghua University, which was established in 1911; and Chinese Academy of Sciences (CAS), which was founded in 1949. On the contrary, Shenzhen was a fishing village which is located closely to Hong Kong. In 1980, Shenzhen was designated as a “special economic zone” to experiment China’s market reform. Shenzhen successfully transferred from a fishing village to the center of manufacturing exports in China, and further turned into a high-tech center, when telecommunication technology firms such as Huawei and ZTE had appeared in the early 1990s. However, the municipal government realized that the lack of famous institutions of higher education and research would be an obstacle for industrial upgrading. In 1998, the municipal government and Tsinghua University in Beijing jointly established the Research Institute of Tsinghua University in Shenzhen (RITS). In 2000, the municipal government constructed the “University Virtual Campus” (UVC) to attract URIs in other regions to establish branches.

Figure 1 shows the differences of RIS between Beijing and Shenzhen by China patent statistics. In Beijing, the ratio of number of URI patents to number of firm patents decreased to 0.5 from 2000 to 2015. However, in Shenzhen, the ratio remained close to 0 during the same period. It demonstrated that the RIS in Beijing and Shenzhen followed very different evolutionary trajectories: while in Beijing the URIs could be a primary force for industrial growth; in Shenzhen the emergence of URIs happened after the industrial growth, and played a role in providing technology and educational support for industrial upgrading.

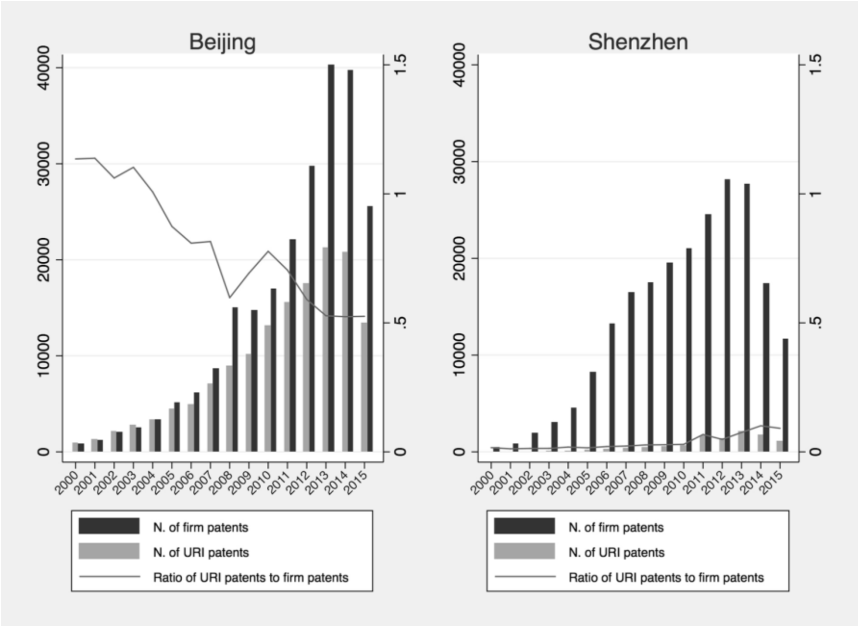

Figure 1 RIS differences between Beijing and Shenzhen by patent statistics

2. Tsinghua University Science Park (TusPark): An Overview

In 1994, Tsinghua University proposed the concept of establishing Tsinghua University Science Park, and obtained substantial support from Beijing government. The initial goals of constructing Tsinghua University Science Park were: (1) Promoting Tsinghua University technology commercialization; (2) Establishing an area to manage Tsinghua University spin-off companies (Li and Chen, 2014). In 1998, the construction of TusPark was completed. In 1999, the Entrepreneurship Park, which is especially for young venture start-ups, was established within the TusPark. In 2000, the Development Center of TusPark, Beijing Zhongguancun technology and development Co., Ltd, Beijing national asset management Co., Ltd, and other two famous Tsinghua spin-off companies: Tsinghua Tong Fang Co., Ltd and Tsinghua Unisplendour Co., Ltd, jointly established the Tsinghua University Science Park Construction Co., Ltd (the name was later changed to "TusPark Holding Co., Ltd in 2004). This company is responsible for the management, construction and development of TusPark.

3. Tsinghua University in Shenzhen (RITS): An Overview

In 1998, the Research Institute of Tsinghua University in Shenzhen (RITS) was jointly established by Tsinghua University and Shenzhen municipal government. RITS has established 6 research centers, under which there are 14 laboratories. As Tsinghua University has established Tsinghua University Science Park, RITS also has its affiliated Business Incubator. However, compared with Tsinghua University which had an accumulation of nearly 90 years of scientific research, RITS has established a different technological innovation system, which has a short history but a market – oriented research focus. In 2000, RITS built its first laboratory. Until 2012, RITS has established 14 laboratories. These 14 laboratories conduct abundant applied research with tenant firms in RITS's business incubator, and these laboratories are the main university technological resources that offered by RITS (Sun et al., 2009).

IV. Data

The questionnaires were distributed to tenants in the Tsinghua University Science Park in Beijing (TusPark, surveyed in 2008, valid response: 68/80) and the Research Institute of Tsinghua University in Shenzhen (RITS, surveyed in 2011, valid response: 68/68). In TusPark, the targets of the survey were 80 tenant venture companies at the "Innovation Square". Motohashi (2013) provided a detailed analysis of this survey. In RITS, the targets of the survey were 68 tenant ventures in the business incubator.

V. Preliminary Analysis

1. Industry Distribution for Tenants

Figure 2 describes the industry types of surveyed tenants. Internet and communication technology (ICT) related businesses are the majority of surveyed tenants in TusPark and RITS incubator. In our sample, there are less ICT related businesses, but more bio-medical, and environmental and clean energy related business in TusPark than in RITS incubator. The category "Others" include industry types such as machinery, consulting services, construction etc. The percentage of "Others" in our sample is only 3% from RITS incubator and is 19% from TusPark, suggesting that RITS incubator has more focused industrial areas, whereas in TusPark there is more variety of industry types.

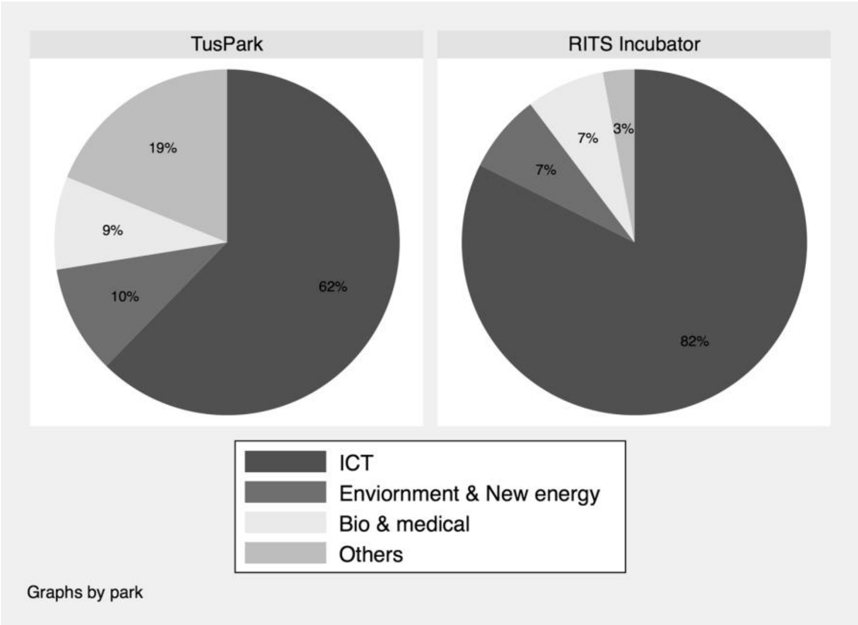

Figure 2 Industry types in TusPark and RITS

2. Innovation and Financial Performance

The survey examined whether there is new product development (product innovation) or the evolution of major production processes (process innovation) that are resulted from R&D activities. We find that the percentage of surveyed businesses that have product innovation is higher in RITS Incubator than in TusPark, where 83.58% of surveyed businesses have product innovation. In TusPark, the percentage of surveyed firms that have process innovation is slightly higher than that in RITS Incubator. For the status of intellectual property related activities of surveyed companies, surveyed firms in RITS are more likely to apply patents, trademark, and copyrights (see Table 1).

Table 1 Innovation outputs of tenants

	TusPark	RITS Incubator
	Share (%) (N=57)	Share (%) (N=65)
Product Innovation	76.27	83.58
Process Innovation	69.49	68.66
	Share (%) (N=49)	Share (%) (N=61)
Patent	53.06	77.05
Trademark	30.61	57.38
Copyrights	38.78	65.57

For those tenants that launched new products in the past three years, the survey asked them to evaluate their degree of satisfaction about the new product market performance. Figure 2 shows the difference. Overall, tenants in RITS have more satisfied new product sales as compared with tenants in TusPark. In TusPark, 25% of firms evaluate the new product sales as “unsatisfied”. However, only 9% of firms in RITS evaluate the new product sales as “unsatisfied”, the rest of firms evaluate the new product sales as relatively success or very success.

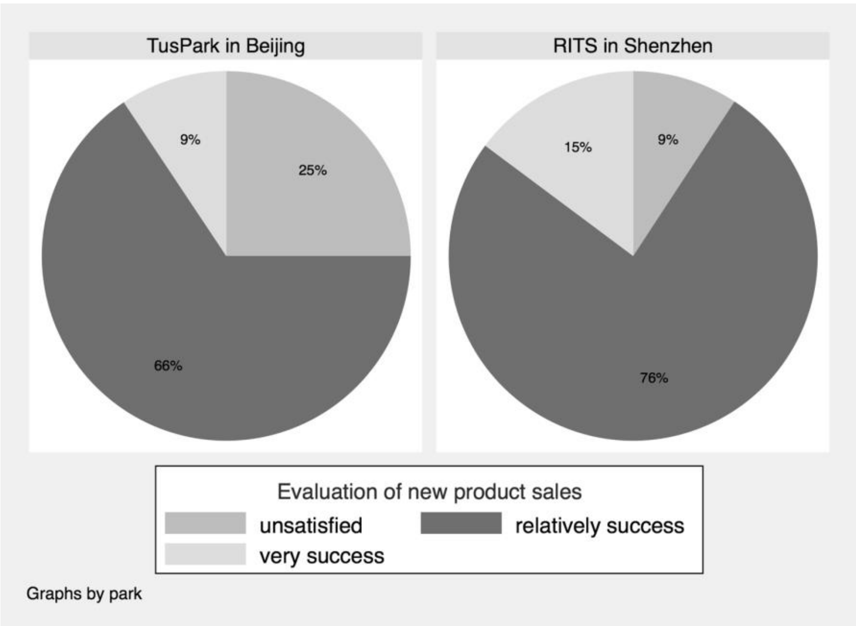

Figure 3 Evaluation of new product sales in TusPark and RITS

Figure 3 shows the difference of new product market penetration. Similar to the difference of new product sales, we found that firms in RITS are also more satisfied with the new product market penetration as compared with firms in TusPark. In TusPark, around 30% of firms think that the new product market penetration as "unsatisfied". This percentage is 18% in RITS.

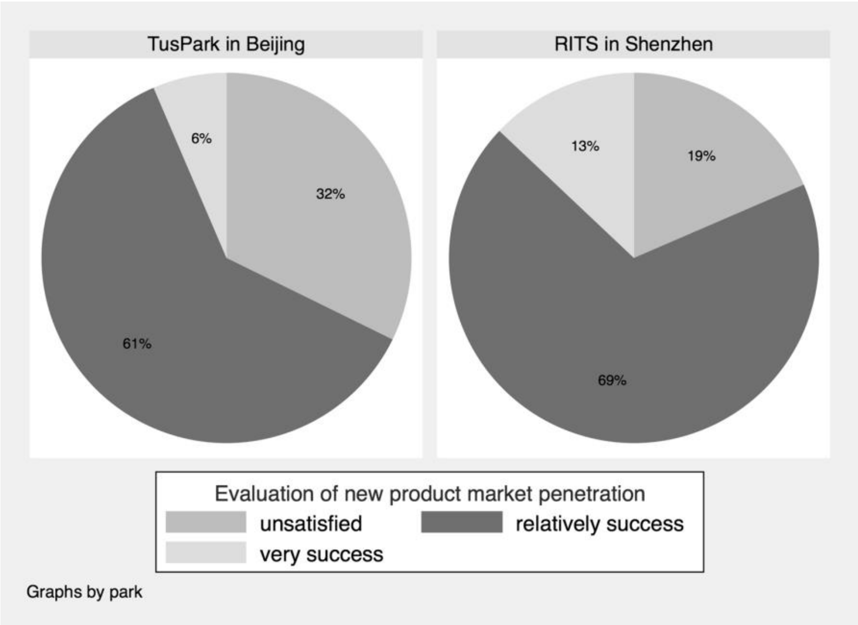

Figure 4 Evaluation of new product market penetration in TusPark and RITS

3. Innovation Sources Used in Firms' R&D

The survey asked the tenants to evaluate the importance of a broad range of knowledge sources of innovation ideas. Figure 4 shows that, in both TusPark and RITS Incubator, the importance of "Customers" as knowledge source is evaluated as "from medium to high", and is ranked as the most important knowledge source. On the other hand, in terms of importance of "Technical documents", "University" and "Research Institute" as knowledge sources, tenants in TusPark give slightly higher evaluation than tenants in RITS Incubator. It suggests that tenants in TusPark focus more on basic scientific knowledge-based sources for innovation.

Figure 5 demonstrates that tenants in RITS have significant higher evaluation than tenants in TusPark in terms of the importance of "Customers", "Suppliers", and "Competitors". This indicates that tenants in RITS Incubator focus more on "market-driven" knowledge source.

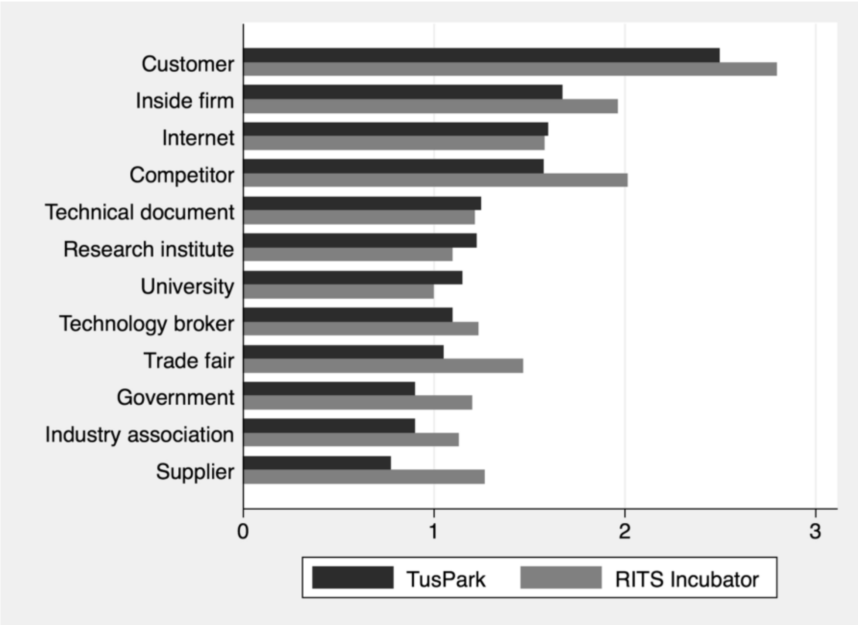

Figure 5 Importance of various sources of innovation information

	i-Variable	j-Variable[a]	Mean Difference (i-j)	Significance levels of ANOVA[b c]	Pairwise comparisons[d]
1. Inside firm	1	2	0.292	0.149	
2. Customer	1	2	0.300	0.020	(1, 2)
3. Supplier	1	2	0.492	0.012	(1, 2)
4. Competitor	1	2	0.442	0.039	(1, 2)
5. Technology broker	1	2	0.133	0.547	
6. Industry association	1	2	0.233	0.232	
7. University	1	2	-0.150	0.462	
8. Research institute	1	2	-0.125	0.538	
9. Government	1	2	0.300	0.139	
10. Trade fair	1	2	0.417	0.053	
11. Technical document	1	2	-0.033	0.875	
12. Internet	1	2	-0.017	0.938	

[a] 1: RITS; 2: TusPark.
[b] The mean difference is significant at the 0.05 level.
[c] Adjustment for multiple comparisons: Bonferroni.
[d] (1, 2) means that RITS has significantly higher mean than TSP at 0.05 significant level.

Figure 6 Results of pairwise comparisons for RITS and TusPark

4. University-Industry Collaboration

The survey asked tenants in TusPark and in RITS Incubator to evaluate the importance of a variety of formal and informal university linkages. Figure 6 describes the results. We found that in both TusPark and RITS Incubator, the importance of "accessing to faculty staff" and "recruiting students" rank at the first place, suggesting that for tenants, informal university linkages such as mobility of university researchers and students are important channels of knowledge flow.

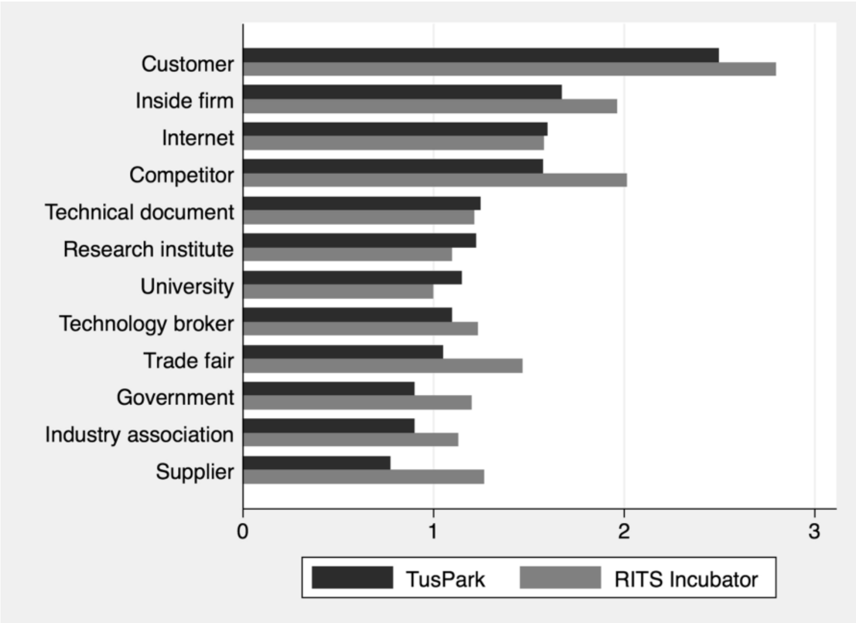

Figure 7 Importance of university linkages

Because the rating of the importance of university linkages is highly correlated with each other, we use network analysis software Ucinet's function - Hierarchical clustering method to group highly correlated items into clusters. At each step, the two clusters that are most similar are joined into a single new cluster. In figure 7, the vertical axis represents the clusters. The horizontal position of the split of horizontal lines shows the correlation "distance".

Figure 8 Dendrogram of hierarchical clustering for university linkages

Based on the hierarchical clustering results, we construct three new components of university linkages. The three main groups of university linkages are: (1) University technical resource, including "Access to university research", "Access to research facilities", "Access to technical documents", and "Attend academic conference". (2) University collaborative R&D, including "Professor advisory", "Contract research", "Joint research", and "Recruiting researchers". (3) Recruiting students. Because "recruiting students" is regarded as an important type of university linkage in terms of university labor input, and it cannot be grouped into another clusters, we use "recruiting students" as a separate variable.

5. University Linkages and Product Innovation

The survey asked firms to answer whether they launched new products or not in the past three years, and whether the innovation sources of making the new product come from university / research institute. Table 2 shows the correlation between the rating of importance of university linkages and whether firm has launched new products that used university knowledge as innovation sources. We found that the importance of the channels of access to university research, access to university research facilities, attend academic conference, recruiting researchers, professor advisory, contract research, joint research, and recruiting students are highly correlated with the product innovation dummy. These types of university linkages are exactly the sub-components of the three main groups of university linkages.

Table 2 Correlation between importance of URI linkages and product innovation

Types of linkages	New product developed through university collaboration
1. Access to faculty staff	0.16
2. Access to technical documents	0.21
3. Access to university research	0.31***
4. Attend academic conference	0.25***
5. Access to research facilities	0.28***
6. University training	0.08
7. Student involvement	0.15
8. Recruiting students	0.24***
9. Recruiting researchers	0.37***
10. Professor advisory	0.24***
11. Contract research	0.26***
12. Joint research	0.30***

VI. Empirical Analysis

1. Methodology

As discussed above, we found that compared with tenants in TusPark, tenants in RITS have better new product sales and market penetration. In this empirical analysis part, we empirically investigate the reason why firms in RITS have better new product performance in the market. We concluded that the main difference between RITS and TusPark is that tenant firms in RITS rely more on "market-driven" sources, such as information from customers, suppliers, and competitors. We hypothesize that such focus on "market-driven" sources in RITS may contribute to the better new product performance of firms in RITS. On the other hand, because university collaboration may help firms to solve current technological bottle-necks, such new products developed using university technical know-how may be more competitive in the market.

Table 3 Definition of variables

Variables	Definition of variables
Dependent variables	
1. Product_uni	=1 if the new product is developed through university / research institute collaboration; =0 otherwise
2. New product sales	Degree of satisfaction on sales of new products in the past three years
3. New product penetration	Degree of satisfaction on market penetration of new products in the past three years
Independent variables	
1. RITS dummy	=1 if located in RITS; =0 if located in TusPark
2. Market-driven sources	the average score of "Customer, supplier, and competitor"
3. Unitech	the average score of group "university technology resources"
4. Unico	the average score of group "university collaborative R&D"
5. Recruiting students	the score of "Recruiting students"
Control variables	
6. Marketing experience	the year of marketing experience of founder
7. R&D employee ratio	the percentage of R&D personnel
8. Firm age	firm age until the survey year
9. Firm size	the log of firm's number of employees
10. Industry dummies	ICT, biotech, new energy and environment, and others

We hypothesize that the positive relationship between better new product performance and locating in RITS may be jointly determined by the interaction between the degree of dependency on market-driven knowledge sources and product innovation through university collaboration. We use the Two-Stage Least Squares Estimation in Simultaneous Equation Models for our empirical analysis. We model new product sales as a function of RITS dummy, dependency on market-driven sources, and product_uni (new product developed through university collaboration), controlling for evaluation of recruiting students, marketing experiences, firm age, firm size, and industries. Where μ is the error term.

$$\text{new product sales} = \beta_0 + \beta_1 \text{product}_{\text{uni}} + \beta_2 \text{RITS} + \beta_3 \text{market force} + \beta_4 \text{recruiting students} + \beta_5 \text{marketing exp} + \beta_6 \text{firm age} + \beta_7 \text{firm size} + \beta_8 \text{industries} + \mu$$

We hypothesize that university linkages are positively associated with new products developed through university collaboration, we expect that the three groups of university linkages have an impact on whether firms launched new products resulting from university collaboration, we treat product_uni as endogenous. In the first stage of structural estimation, we use the Probit estimation, where v is the error term.

$$\text{Product}_{\text{uni}} = \pi_0 + \pi_1\text{Unitech} + \pi_2\text{Unico} + \pi_3\text{Recruiting students} + \pi_4\text{market force} + \pi_5\text{R\&D employee ratio} + \pi_6\text{firm age} + \pi_7\text{firm size} + \text{v}$$

Our samples are 93 firms that launched new products in the past three years (38 firms from TusPark, and 55 firms from RITS). We constructed the variables based on the three questions. Table 3 describes the measurement of the dependent, independent, and control variables.

2. Research Findings

Firstly, as shown in table 4, in the first stage Probit estimation model, we found that the three groups of university linkages: accessing to university technical resources, building university collaborative R&D, and recruiting university students all have positive and significant impact on firm's new product innovation, which resulting from university collaboration.

Table 4 Structural estimation first stage

First stage Probit estimators	Product_uni		
	(1)	(2)	(3)
RITS	-0.276(0.395)	-0.608(0.390)	-0.458(0.356)
Unitech	**0.699***(0.174)**		
Unico		**0.607***(0.166)**	
Recruiting students			**0.261*(0.142)**
R&D employee ratio	-0.473(0.561)	-0.633(0.542)	-0.992*(0.509)
log (N. of employees)	0.0940(0.152)	0.0670(0.147)	0.152 (0.135)
Firm age	0.0316(0.0566)	0.0277(0.0537)	0.0370(0.0500)
Constant	-0.387(0.457)	0.144(0.407)	0.0974(0.434)
Observations	93	93	93

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Secondly, in the second stage model, we investigate the reason why firms in RITS have better new product sales and market penetration? In table 5 and table 6, we construct the three-way interaction term among RITS dummy, dependency on market-driven sources, and product_uni dummy. We found that the coefficient of the three-way interaction term is positive and significant in all the four models. However, the coefficients of the interaction term "RITS

× product_uni", "market-driven sources × product_uni", and "RITS × market-driven sources" are negative and significant. Scholars suggest that when interpreting three-way interactions, the lower-order interactions cannot be interpreted in the presence of significant higher-order interactions (Skarlicki, Folger, and Tesluk, 1999), only the highest order of interaction between RITS dummy, dependency on market-driven sources, and product_uni dummy is the interest of this study.

Table 5 Structural estimation second stage

Second stage liner prediction	New product sales		
	(1)	(2)	(3)
Product_uni	$1.219^{**}(0.602)$	$1.421^{**}(0.602)$	-0.117(1.124)
RITS	$1.484^{***}(0.574)$	$1.500^{***}(0.570)$	$1.484^{***}(0.504)$
Market-driven sources	0.341(0.301)	0.363(0.298)	$0.442^{*}(0.234)$
RITS × Market-driven sources × Product_uni	$1.093^{**}(0.492)$	$1.075^{**}(0.490)$	$1.280^{***}(0.439)$
RITS × Product_uni	$-2.055^{**}(0.806)$	$-2.004^{**}(0.807)$	$-2.316^{***}(0.752)$
Market-driven sources × Product_uni	-0.586(0.359)	$-0.601^{*}(0.356)$	$-0.680^{**}(0.309)$
RITS × Market-driven sources	$-0.762^{*}(0.404)$	$-0.766^{*}(0.401)$	$-0.901^{***}(0.325)$
Recruiting students	-0.0115(0.0742)	-0.0202(0.0733)	0.101(0.128)
Marketing experience	0.0124(0.0155)	0.00940(0.0161)	0.0130(0.0155)
Firm age	0.0178(0.0215)	0.0168(0.0217)	0.0237(0.0292)
log (N. of employees)	$0.133^{**}(0.0664)$	$0.130^{*}(0.0670)$	$0.174^{*}(0.0910)$
Industry dummy	Yes	Yes	Yes
Constant	0.486(0.530)	0.340(0.521)	$1.094^{*}(0.656)$
Observations	93	93	93

Standard errors in parentheses
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

For better interpreting the three-way interaction, we create a graph of new product sales as a function of RITS_dummy, product_uni dummy, and dependency on market-driven sources. The graph in figure 9 illustrates how the slope of dependency on market-driven sources varies as a function of RITS_dummy and product_uni dummy.

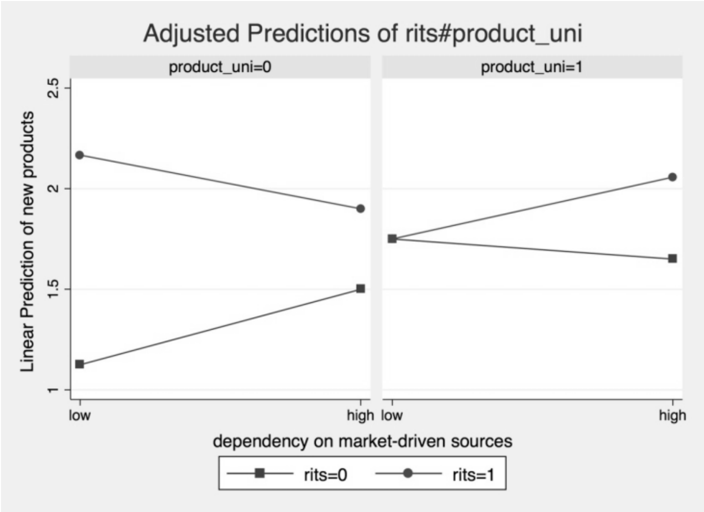

Figure 9 The effect of three-way-interaction on new product market penetration

On the right hand part of the graph, we found that in RITS, new products resulting from university collaboration and with more dependency on market-driven sources are associated with better new product sales. This result suggests that in RITS, the new products, which are responding to the latest trend of current market needs and are also combined with university technology, are more competitive in the market. However, in TusPark, the dependency on market-driven sources does not lead to better performance of new product resulting from university collaboration.

The left hand part of the graph shows that in TusPark, new products which are not resulting from university collaboration but with more dependency on market driven sources are associated with better product sales. However, left part of the graph shows that in RITS, new products which are not resulting from university collaboration but with low dependency on market driven sources are associated with better new products. We infer that those firms in RITS with low dependency on market driven sources but have better new product sales may be the ones that already have established and matured market channels.

Table 6 and figure 10 shows the result for new product market penetration. The right part of figure 10 shows that in RITS, new products resulting from university collaboration and with more dependency on market-driven sources are also associated with better market penetration. However, in TusPark, the dependency on market-driven sources is not associated with better market penetration. The results suggest that the institutional differences between firms in RITS and TusPark lead to the different market performance.

Table 6 Structural estimation second stage

Second stage linear prediction	New product market penetration		
	(1)	(2)	(3)
Product_uni	1.489** (0.594)	1.476** (0.595)	0.454(0.917)
RITS	1.622*** (0.567)	1.609*** (0.566)	1.592*** (0.539)
Market-driven sources	0.401(0.296)	0.398(0.296)	0.441(0.273)
RITS × Market-driven sources × Product_uni	1.071** (0.486)	1.048** (0.487)	1.190** (0.472)
RITS × Product_uni	-1.967** (0.797)	-1.905** (0.801)	-2.129*** (0.784)
Market-driven sources × Product_uni	-0.545(0.354)	-0.535(0.353)	-0.581* (0.336)
RITS × Market-driven sources	-0.856** (0.398)	-0.853** (0.398)	-0.940** (0.373)
Recruiting students	-0.0210(0.0735)	-0.0186(0.0729)	0.0608(0.106)
Marketing experience	-0.000118(0.0154)	-0.00127(0.0159)	0.00227(0.0152)
Firm age	0.0180(0.0216)	0.0180(0.0216)	0.0230(0.0251)
log (N. of employees)	0.155** (0.0665)	0.156** (0.0666)	0.186** (0.0792)
Industry dummy	Yes	Yes	Yes
Constant	0.0272(0.526)	0.0495(0.517)	0.601(0.603)
Observations	93	93	93

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

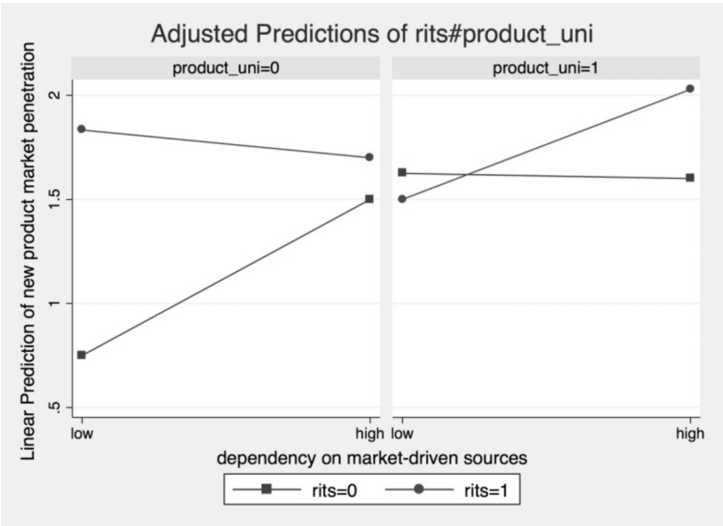

Figure 10 The effect of three-way-interaction on new product market penetration

The left part of figure 10 shows that in TusPark, new products which are not resulting from university collaboration but with more dependency on market driven sources are associated with better market penetration. However, in

RITS, for firms with new products which are not resulting from university collaboration, the dependency on market driven sources has little effect on market penetration. The results suggest that in RITS, products resulting from university collaboration and the high dependency on market-driven innovation sources lead to better market penetration.

3. Implications

This paper explores what factors contribute to the more successful new product sales and market penetration for tenants in RITS. We found that the high dependency on market-driven innovation sources and developing new products through university collaboration lead to higher market performance of new products for firms in RITS in Shenzhen, but not for firms in TusPark in Beijing. One of the possible reasons is that RITS particularly provide market-oriented university technology support for tenant firms, whereas such support is not in place in TusPark.

One of the main differences between RITS and TusPark is that RITS provide very applied-research oriented and market focused technical support to tenant firms, for example, one of university technical support is providing pilot scale experiment platform for tenant firms. RITS provide the space, facilities, and researchers for tenant firms to conduct intermediary pilot experiments with the customers of tenant firms (He et al. 2013). However, such university technology supporting system is not in place in TusPark. Therefore, in RITS, the university collaboration through university technology support can help tenant firms to effectively respond to the information collected from customers, suppliers, and competitors, and coming up with new products which are in current market needs. However, because such market-oriented university technology support is not in place in TusPark, the university collaboration may not help firms to best respond to the information collected from market-driven sources. Thus high dependency on market-driven innovation sources and developing new products through university collaboration lead to higher market performance of new products for firms in RITS in Shenzhen, but not for firms in TusPark in Beijing.

The research findings draw managerial implications for domestic Chinese firms as well as policy implications for Chinese government. Firstly, when making the decision of choosing which university science park to locate on, firms may consider their objective of university collaboration and the institutional differences between university science parks. Scholars suggested that firms' objective of university collaboration is either seeking university technology seeds for new project development, or seeking university technology support for firms' current R&D project completion (Cohen, Nelson, and Walsh, 2002). If firms' aim of university collaboration is more towards seeking new product ideas and opening new markets, locating in TusPark in Beijing is beneficial for finding more university technology seeds; If firms' aim of university collaboration is more towards seeking university technology support for accelerating development of current products, which are highly responding to current market needs, then firms may consider to locate in RITS in Shenzhen.

Secondly, this paper suggests that Beijing and Shenzhen both have their own unique regional innovation characteristic. University science parks are embedded in the city's own regional innovation system, and institutional differences between university science parks in Beijing and Shenzhen are raised. One of the policy implications for the municipal government is to make use of the city's own comparative advantage, which is embedded in its regional innovation system. For example, Beijing has a long history of universities and research institutes, top universities such as Tsinghua University has accumulated abundant university technologies waiting for commercialization. Thus, the Beijing city government could consider giving preferential policies on commercializing university technology and on helping firms to expand the new market.

On the other hand, Shenzhen has a long history of industrial development, but a short history of universities and research institutes. Local universities in Shenzhen play a role in technology supporting for local high-tech firms. The findings in our research suggest that the institutional difference between TusPark in Beijing and RITS in Shenzhen lies in that tenants in RITS rely more on market-driven sources. Such market-driven knowledge sources and the market-oriented university R&D support together give a positive impact on the new product market performance for tenants in RITS. Thus, the Shenzhen city government could consider giving preferential policies on encouraging company sponsored university industry collaboration projects, and university R&D support for firms' development of those new products that are highly responding to current market needs.

VII. Conclusions

This paper explores the role of University Science Park on tenant firms' innovation and business performance by conducting quantitative analysis of tenants in Tsinghua University Science Park (TusPark) and Incubator of Research Institute of Tsinghua University in Shenzhen (RITS). In terms of innovation performance, 86% of firms in RITS have new products in the past three years, and 77% of them have patents. Whereas 77% of firms in TusPark have new products in the past three years, and 53% of them have patents. In terms of business performance, firms in RITS also have better new product sales and new product market penetration as compared with firms in TusPark: 91% of firms in RITS evaluated their new product sale was successful, whereas 75% of firms in TusPark evaluated their new product sale was a success in the market.

We found that the main institutional difference lies in that the innovation sources for firms in RITS are more “market-driven”. Firms in RITS rely more on market-driven innovation sources: such as information from customers, suppliers, and competitors. In the empirical analysis part, we found that the dependency on market-driven knowledge sources (information from customers, suppliers, and competitors) and developing new products through university collaboration jointly contribute to the better performance of new products of firms in RITS.

This paper makes three contributions to the current literatures on University Science Park in China. Firstly, by using Chinese university science park survey data, we provide empirical evidence that inside Chinese university science parks, the three types of university collaboration contribute to tenant firms’ new product innovation. Secondly, we found that the main institutional difference between RITS and TusPark is that the innovation in RITS is more based on “market-driven” knowledge sources, including knowledge from customers, suppliers and competitors. Thirdly, we empirically found that in RITS, collaborating with university and with a market driven focus partially explained the better new product performance of firms in RITS.

This paper examines the role of university science parks, and draws important implications for the domestic Chinese firms as well as municipal government in China. Firstly, when choosing which University Science Park to locate on, domestic firms may consider their type of R&D activities, their aim of university collaboration, and the institutional context of the regional innovation system that the University Science Park is embedded in. Secondly, the municipal government in China should make use of the city’s own competitive advantages, which are embedded in the regional innovation systems, and accordingly issue preferential innovation policies for local University Science Parks.

VIII. Limitations and Further Research

One of the limitations of this research is the different timing of the survey. The survey for tenants in TusPark was conducted in 2008, whereas the survey for tenants in RITS was conducted in 2011. Therefore, the time span for the survey in TusPark is 2006-2008, whereas the time span for survey in RITS is 2008-2011. Only the year 2008 is overlapped. However, as shown in figure 1, from patent statistics we didn't find any significant changes for university and firm innovation before and after 2008. Therefore, the survey data in TusPark and in RITS is still comparable. This paper focused on the comparison between Tsinghua University Science Park in Beijing and the Research Institute of Tsinghua University in Shenzhen. In future research, international comparison is worthwhile. For example, recently studies show the difference of entrepreneurial process and performance for MIT and Tsinghua University alumni entrepreneurship (Eesley, Yang, Li, and Roberts, 2016). The cross-national comparison on University Science Park of MIT and Tsinghua will give more insights on the strengths and weaknesses of each University Science Park.

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