

# China's Horizontal University-Industry Linkage: Where From and Where To

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This study aims to explore the emerging horizontal university-industry linkage (UIL) in China, which is hardly addressed in existing literature. For that purpose, we conducted two separate but closely related questionnaire surveys: one for university professors in China, and another for firms. From the surveys, we determined that horizontal UIL is now replacing the traditional mode of knowledge industrialization in China. We also discovered that the current horizontal UIL in China is heavily dependent on "formal contracts." According to our preliminary econometric analyses, the characteristic Chinese preference towards formal contract-based UIL could be explained by the lack of "institutional thickness" in China. This implies that China should utilize more varied channels of horizontal UIL, including informal and open science channels, as the institution becomes more sophisticated. Currently, most Chinese firms appear to be very positive in evaluating their own experiences of collaboration with universities. However, we have also confirmed that promoting direct and formal UIL is not without social costs (*e.g.*, damaging university education), which policy makers should carefully consider.

*Keywords:* University-industry linkage (UIL), Questionnaire, China

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## I. Introduction

Many researchers have been interested in the usefulness of knowledge created in and disseminated from universities for the innovation of firms. Literature on the “National Innovation System (NIS)” has emphasized the importance of interactions or linkages between industrial firms and various institutions, including universities (Freeman 1987; Lundvall 1992; Nelson 1993). Consequently, researchers agree on the potentially positive impact of academic research on the development of industrial innovation (Mansfield 1991, 1998; Salter and Martin 2001).<sup>1</sup>

However, little consensus has been achieved regarding the ideal function of universities in supporting industrial innovation, as well as the most effective channel of university-industry linkage (UIL) (Bekkers and Bodas Freitas 2008; Giuliani and Arza 2009). Some authors have focused on the effectiveness of direct and formal collaboration between university and industry (Etzkowitz *et al.* 1998; Swann 2002; Monjon and Waelbroeck 2003), while others have emphasized the fundamental importance of indirect and informal collaboration between the two (Branscomb *et al.* 1999; Cohen *et al.* 2002; Lundvall 2004).

An increasing, albeit small, number of studies addressing UIL has paid attention to the distinctive situation in *developing* countries. Eun *et al.* (2006) have proposed a new theoretical framework under which the university-industry relationship in developing countries could be discussed more accurately. Particularly in the case of China, some authors have managed to deepen the understanding of the characteristic Chinese UIL, which has been affected by both the legacy of the planned era and Chinese-style socialism (Kroll and Liefner 2008; Eun 2009; Eun and Lee Forthcoming).<sup>2</sup> They seem to agree that Chinese UIL is now largely in the process of transition from a vertical hierarchy-based system to a horizontal network-based system.

However, studies on horizontal UIL in China show that it is still in its infancy. Against this backdrop, this study aims to explore China's horizontal UIL and gather empirical evidence on its underlying characteristics. To accomplish these aims, we conducted two separate surveys,

<sup>1</sup> Mansfield (1991, 1998) argued that around 10% of new products and processes introduced by firms would not have been developed (or only with great delay).

<sup>2</sup> For background knowledge about the gradual process of the economic transition in China, refer to Lin and Tsai (2004).

one for Chinese university professors and another for Chinese firms. Using the survey results, we attempted to determine the driving forces for the transition of Chinese vertical UIL to horizontal, and also to discover the distinct features of the current Chinese horizontal UIL. In addition, a preliminary econometric analysis was conducted to explain Chinese characteristics. We also examined how the Chinese horizontal UIL actually works and where it is headed. Obstacles and limitations perceived by university professors and firms in China have been underlined in order to draw policy implications.

The rest of the paper is organized as follows. Section 2 describes the process of data collection and brief sample characteristics. Section 3 analyzes how the once-prevalent university-run enterprise (URE) model, which can be characterized by the vertical U-I relationship, recently gave way to more horizontal channels of UIL in China. Section 4 analyzes the distinct features of the current Chinese horizontal UIL compared with the case of the United States. In addition, three logistic regression models estimate the underlying causes of the Chinese characteristics. Section 5 discusses the prospects of the Chinese horizontal UIL by examining the actual pattern of how Chinese firms exploit various channels of UIL and the problems in U-I collaboration perceived by university professors and firms in China. Section 6 summarizes the discussion and concludes the paper.

## II. Data Collection and Sample Characteristics

This study made use of data collected *via* two surveys conducted in China on December of 2007 and January of 2008. One was directed at technology managers in industrial firms (firm survey) while the other was directed at university professors (professor survey). In the firm survey, we followed the basic design of the Carnegie Mellon Survey, with some adaptations reflecting the Chinese context. The professor survey was prepared to examine the issues from the point of view of professors.

Our sample for the firm survey was obtained from three source groups: (1) the list of Chinese large manufacturing firms from the *2006 Yearbook of the Chinese Large Manufacturing Firms*,<sup>3</sup> (2) the list of

<sup>3</sup> Large manufacturing firms are defined as (both indigenous and foreign-invested) manufacturing firms with above 2,000 employees, above RMB 300 million sales revenues, and above RMB 400 million total assets in China.

**TABLE 1**  
SAMPLE CHARACTERISTICS (FIRM SURVEY)

Sample source	Number of respondents	Location of headquarters				Ownership type			
		East	Mid	West	Overseas	State	Private	Foreign	Others
Group 1	102	54	29	13	6	63	20	17	2
Group 2	73	64	6	3	0	0	70	2	1
Group 3	127	112	7	3	5	32	67	25	3
Total (%)	302 (100)	230 (76.2)	42 (13.9)	19 (6.3)	11 (3.6)	95 (31.5)	157 (52.0)	44 (14.6)	6 (2.0)

  

Sample source	Number of respondents	Scale (number of employees)					
		1~20	21~50	51~200	201~1,000	1,001~5,000	5,001~
Group 1	101	0	0	0	0	66	35
Group 2	73	19	24	19	10	1	0
Group 3	127	16	18	27	38	18	10
Total (%)	301 (100)	35 (11.7)	42 (14.0)	46 (15.3)	48 (15.9)	85 (28.2)	45 (15.0)
Mean		2,834					
Median		600					

member firms registered in the Chinese Private Science and Technology (S&T) Entrepreneurs' Network (*Zhongguo Minying Keji Wang*) ([www.mykj.gov.cn/group.aspx](http://www.mykj.gov.cn/group.aspx)), and (3) the list of member firms registered in China Small and Medium-sized Enterprise (SME) Online ([www.sme.gov.cn](http://www.sme.gov.cn)).<sup>4</sup> The second and third groups were added to the first group to lessen the expected bias in the first group toward state-owned, large-scale enterprises.

In the phone survey, firms that did not disclose their correct phone numbers were excluded from the sample. The final sample consisted of 2,484 firms. Our survey team contacted the technology manager or the equivalent in each sample firm by phone to fill out the questionnaires. We completed 302 questionnaires (102 from the first group, 73 from

<sup>4</sup>The membership for China SME Online is available only for the small and medium-sized firms that fall short of the requirements for large enterprises.

TABLE 2  
SAMPLE CHARACTERISTICS (PROFESSOR SURVEY)

Total (# Univ)	Location			Academic field			
	Beijing/ Tianjin	Shanghai	Guang- dong	IT	BT	Chemical	Mechanical
203(24)	120(14)	69(8)	14(2)	63	53	39	48
100.0%	59.1%	34.0%	6.9%	31.0%	26.1%	19.2%	23.7%

the second group, and 127 from the third group), yielding a response rate of 12.2%. Table 1 shows the basic sample characteristics in terms of geographical location, ownership type, and scale.

The professor survey was conducted as follows. We shortlisted Chinese universities with a University Science Park (*Daxue Kejyuan*) authorized by the central government from three different major regions (*i.e.*, Beijing and Tianjin, Shanghai, and Guangzhou).<sup>5</sup> We identified 24 universities and contacted 1,238 professors in four research fields: (1) Information Technology (IT; including electronics, telecoms, and computers), (2) Biomedical Technology (BT), (3) Chemical Engineering, and (4) Mechanical Engineering (including machine, automotives, and ship-building). As in the firm survey, our survey team contacted professors by phone and completed 203 questionnaires, yielding a response rate of 16.4%. The basic sample characteristics in terms of geographical location and academic field are shown in Table 2.

### III. From Vertical to Horizontal UIL

Based on our results, we determined that the overall UIL in China has been strengthened in recent years. When asked to report any change between 2004 and 2007, 127 out of the 203 professors (62.6%) said that the UIL in their universities has been strengthened. Only five professors stated that it has weakened during the same period.

However, we also discovered that not all the possible channels of the links have been strengthened. The so-called UREs (*Xianban qiye*),

<sup>5</sup>We assumed that Chinese universities with University Science Parks authorized by the central government have both strong research capability and willingness to participate in industrializing scientific knowledge. In this vein, we confined our survey to these universities.

**TABLE 3**  
**PROFESSORS' EVALUATION OF VARIOUS UIL CHANNELS**

Channels of UIL	Average Likert score
1 Collaborative research between universities and firms	3.7833
2 Education and training	3.5616
3 Information exchange between universities and firms	3.4778
4 Academic research	3.4729
5 Transferring proprietary technology (patent licensing)	3.3202
6 University science park	3.0788
7 Spin-off companies	2.8522
8 UREs	2.8374

which prevailed in the 1990s (Eun *et al.* 2006; Eun 2009) seems to have lost its importance in recent years. Data in Table 3 show that the characteristic Chinese traditional mode of UIL is no longer welcome. The score for UREs at the bottom of the ranking list in Table 3 is based on the professors' evaluation of each channel of UIL. This indicates that the extremely hierarchical mode of UIL has been weakened, and horizontal or network-based modes (*e.g.*, collaborative research, information exchange, and patent licensing) have begun to replace it.

The survey results also hint on why the UREs have declined. In theory, as Eun *et al.* (2006) pointed out, there are three possible reasons for the decline of UREs. These include (1) the development of intermediary institutions (*e.g.*, organizations such as technology licensing office (TLO) and related regulatory framework) that would at least partially replace UREs as a channel of industrializing science and technology (S&T) knowledge in universities, (2) the relative deterioration of the internal resources of universities, and (3) industrial firms' enhanced absorptive capacity (Cohen and Levinthal 1990). The last reason enables firms to exploit S&T knowledge produced by universities, even though they do not have exclusive relationships with universities. Table 4 shows that the respondent professors emphasized the enhancement of firms' absorptive capacity more than the other two possible causes. Although this finding falls short of a rigorous test to identify determinants of the UREs' decline, it might allow us to tentatively regard the enhanced absorptive capacity of ordinary Chinese firms as the main cause of the change.

In the next section, we discuss how we determined the major chan-

TABLE 4  
THREE POSSIBLE CAUSES BEHIND THE DECLINE OF UREs

	Intermediary institutions	%	University's internal resource	%	Firm's absorptive capacity	%
Improvement	19	<b>13.7</b>	33	19.8	39	<b>23.8</b>
No change	104	74.8	131	78.4	122	74.4
Deterioration	16	11.5	3	<b>1.8</b>	3	1.8
No. of respondents	139		167		164	

Note: University's internal resource was evaluated in absolute terms in this survey, although Eun *et al.* (2006) discussed it in relative terms.

nels that link universities to industrial firms in China. Our professor survey results enabled us to examine in greater detail the degree of utilization or usefulness (at least from the firms' perspective) of individual channels of UIL in China. In theory, firms can communicate with, and absorb S&T knowledge from academic institutions through various channels, which include joint research, technology licensing, personnel exchange (including graduates), consultations, public conferences and meetings, informal information exchange, and so on. Often, however, these channels are not equally utilized; some channels may be actively utilized while others are neglected. Moreover, the degree of utilization differs from country to country because it may depend on specific conditions (*e.g.*, transaction costs, regulations, and culture) in the country being studied. Therefore, we may deepen our understanding of the Chinese characteristics by examining the major channels of UIL in China.

#### IV. Characteristics of the Chinese UIL: Favoritism toward Formal Contract-based Channels

In the previous section, we saw that Chinese professors do not attach a huge importance on the once-prevalent *vertical* channel of UIL, the UREs. This indicated that the Chinese UIL has become more *horizontal*. We also determined that the reconfiguration of the Chinese U-I relationship was partly due to the enhanced absorptive capacity of Chinese industrial firms. Thus, in this section, the newly emerging horizontal UIL in China is further explored, more specifically, the horizontal channels of the UIL which are preferred by Chinese firms

**TABLE 5**  
**CHINESE FIRMS' EVALUATION OF INDIVIDUAL CHANNELS OF UIL**

Rank	UIL channel that contributes to innovation in the firm	Frequency (moderately or very important)	% (moderately or very important)
1	<b>Joint or cooperative research and development (R&amp;D) projects</b>	193	63.9
2	<b>Licensed technology</b>	178	58.9
3	<b>Patents</b>	174	57.6
4	Contracting research	159	52.6
4	Consulting with individual researchers	159	52.6
4	Recently hired graduates with above-Master's degree	159	52.6
7	Science and/or technology parks	141	46.7
8	<b>Publication and reports</b>	130	43.0
9	Temporary personnel exchanges	120	39.7
10	<b>Informal information exchange</b>	118	39.1
11	<b>Public conferences and meetings</b>	110	36.4
12	Incubators	109	36.1
13	Participation in networks that involve universities	96	31.8

and which have an increasing influence in forging the UIL. The reasons why Chinese firms prefer specific channels of UIL are also examined in this section.

Table 5 presents the individual channels of UIL in order of the frequency of the respondent firms that evaluated the channel as at least "moderately important" for the firms' innovation. It also shows that Chinese firms highly regard "joint or cooperative research and development (R&D) projects," "licensed technology," and "patents" as important.

We can categorize individual channels of UIL in various ways: formal versus informal, contract-based versus non-contract-based, public (open science) versus private (proprietary), direct versus indirect, and so on. Among these categories, we can see that the average Chinese firms prefer formal, contract-based, private (proprietary), and direct channels (hereafter referred to as "formal contract-based channels").

**TABLE 6**  
**MOST FREQUENTLY USED UIL CHANNEL IN CHINESE UNIVERSITIES**  
**(PROFESSOR SURVEY)**

Channels of UIL	%
1 Collaborative or trusted research under formal contracts with industries	35.5
2 Non-periodic consultation, on-site supervision, lecture, and other activities for industry	14.7
3 Student internships to industries	13.1
4 Participation and discussion in industry-related conferences and seminars	10.9
5 Sharing of research facilities and equipment between universities and industries	9.3
6 Cooperative research with a company researcher leading to the publication of articles or registration of intellectual property, all without a formal contract with the company	5.8
7 On-campus training for industry personnel	4.8
8 Consultation, supervision, and other activities for companies as official consultants	4.2
9 Your own participation in industries as the director or staff	1.0
10 Creating own start-up company	1.0

Despite having a slightly different survey design, our professor survey results also verified the Chinese-characteristic preference found in the firm survey. In the professor survey, the “collaborative or trusted research under formal contracts with industries” was most preferred by the Chinese universities as a channel of UIL (see Table 6).

These findings were surprising because they were contrary to those obtained by Cohen *et al.* (2002) in their U.S. case study, in which “public (or open science),” “personal,” and “informal” channels (*e.g.*, publication, conferences, graduates, and so on) were reported to be more highly appreciated than the formal and contract-based channels, although the shares of positive answers are generally low in the U.S. case. The channels most highly evaluated by Chinese firms placed at the bottom of the U.S. list (see Table 7). Likewise, the top three channels in the U.S. list (*i.e.*, publications/reports, informal interacting, meeting/conference) placed the lowest on the Chinese list (see Table 6).

What then makes Chinese firms prefer formal contract-based channels

**TABLE 7**  
**U.S. FIRMS' EVALUATION OF INDIVIDUAL CHANNELS OF UIL**

Rank	UIL channel that contributes to innovation in the Firm	%
1	<b>Publications/Reports</b>	41.2
2	<b>Informal interaction</b>	35.6
3	<b>Meeting or conference</b>	35.1
4	Consulting	31.8
5	Contract research	20.9
6	Recent hires	19.6
7	<b>Cooperatives/Joint Ventures</b>	17.9
8	<b>Patents</b>	17.5
9	<b>Licenses</b>	9.5
10	Personal exchange	5.8

Note: % share of respondents rating the individual channel as at least moderately important.

Source: Excerpt from Cohen *et al.* (2002, p. 15) Table 6.

in their interaction with academic institutions? From the widely acknowledged differences between China and the U.S. (in terms of developmental stage of the firm, level of technological sophistication of the firm, and level of institutional sophistication of the society), we can formulate several hypotheses explaining the Chinese inclination toward formal contract-based channels.

First, we should pay attention to the developmental stage (or size, for operational convenience) of the firm. Generally, Chinese firms lag behind their U.S. counterparts in terms of the developmental stage. The sample firms included in the U.S. and Chinese surveys are significantly different in size. In the U.S. case, the median firm has 2,263 employees, and the average firm has 20,263 employees (Cohen *et al.* 2002, p. 4). In the Chinese case, however, median and average firms have only 600 and 2,834 employees, respectively. This difference may explain the Chinese firms' inclination toward formal contract-based channels. In the same way, we can hypothesize that firms at the earlier stage of development (operating as smaller firms in terms of number of employees) would prefer formal contract-based channels (H1-1).

On the other hand, one can also assume that formal contract-based channels may be more suitable for larger companies with stronger internal capability. From this, we can generate an opposite (in terms of size) hypothesis (H1-2). Hence we have two hypotheses in terms of the

developmental stage (size) of a firm.

**H1:** Developmental stage (or size) of the firm (individual firm factor)

**H1-1:** Firms at the earlier stage of development (or smaller firms) prefer formal contract-based channels in interacting with universities.

**H1-2:** Larger firms prefer formal contract-based channels in interacting with universities.

Chinese firms' lower level of technological sophistication (compared to U.S. firms) may also explain their inclination toward formal contract-based channels. Hypothetically speaking, firms with weak technological capability may want to guarantee the completion of knowledge transfer from universities through formal contracts because these firms have only limited absorptive capacity and encounter difficulties in fully exploiting abstruse academic knowledge without the active involvement of universities. However, as in the case of H1, the opposite argument is also plausible because firms with stronger technological capabilities may be more interested in new knowledge developed in/by universities and become more aggressive in acquiring the knowledge through formal contracts. Therefore, we have two hypotheses in terms of a firms' level of technological sophistication.

**H2:** Technological sophistication of the firm (individual firm factor)

**H2-1:** Firms with a lower level of technological sophistication prefer formal contract-based channels in interacting with universities.

**H2-2:** Firms with a higher level of technological sophistication prefer formal contract-based channels in interacting with universities.

H1 and H2 focus on individual firms' *internal* characteristics in explaining Chinese firms' inclination toward formal contract-based channels. However, one can also conclude that *external* or *environmental* factors may influence individual firms' preference for specific channels of UIL. Literature on "institutional thickness" indicate that the average economic performance and the dominant behavioral pattern of individual firms in a region are affected by the region's institutional thickness (see *e.g.*, Evans and Harding (1997)). Institutional thickness is defined as the totality of social, cultural, and institutional forms and supports

available to enterprises.<sup>6</sup> In this context, one can reasonably infer that firms in institutionally underdeveloped regions where opportunistic behaviors are more probable and enforcement mechanisms are limited would more strongly insist on formal contracts in interacting with universities for knowledge transfer. Therefore, we hypothesize that the institutional imperfection in China would drive Chinese firms to resort to formal contract-based UIL channels (H3-1). China can be considered as lagging behind in terms of “institutional thickness,” at least compared with the U.S.

On the other hand, one may also argue that formal contracts can be effectively enforced only when the institutional environment is sufficiently sophisticated, indicating that firms located in regions with a higher level of institutional sophistication (or thickness) would prefer formal contract-based channels in interacting with universities. Thus, we have another set of competing hypotheses.

**H3:** Institutional thickness of the region (environmental or social factor)

**H3-1:** Firms located in regions with a lower level of institutional sophistication (or thickness) would prefer formal contract-based channels in interacting with universities.

**H3-2:** Firms located in regions with a higher level of institutional sophistication (or thickness) would prefer formal contract-based channels in interacting with universities.

To test the hypotheses introduced above, three binary logistic regression models (one model for each of the three most preferred formal contract-based channels in China) were calculated. In each model, the dependent variable is the respondent firms' evaluation of the channel in terms of its contribution to the firms' innovation, and is binary in nature (at least moderately important (1) or otherwise (0)). The independent variables are listed in Table 8.<sup>7</sup>

In these regression models, we limited our data to information

<sup>6</sup> According to Amin and Thrift (1995), institutional thickness refers to the webs of supporting organizations such as financial institutions, chambers of commerce, trade associations, training organization, local authorities, and marketing and business support agencies. Often, invisible institutions such as unwritten laws, shared views, and beliefs are also considered important ingredients of the institution.

<sup>7</sup> No statistically significant correlation was found among the independent variables.

**TABLE 8**  
**LIST OF INDEPENDENT VARIABLES USED**

Independent variable	Proxy for (Related hypothesis)	Definition	Type
Ln (Size)	Size or developmental stage of the firm (H1)	Log number of employees	C
RDP_ratio	Technological sophistication of the firm (H2)	Share of R&D personnel among the total employment	C
Eastern_dum	Institutional thickness of the region where the firm is located (H3)	Location (Eastern provinces (1) versus Mid or Western provinces (0))	D
IT_dum	control	IT and electronic industry	D
BT_dum	control	Biotechnology and medical industry	D
Chemical_dum	control	Petrochemical industry	D

Note: C, continuous; D, dummy.

**TABLE 9**  
**RESULTS OF BINARY LOGISTIC MODELS**

Dependent variable	Joint or cooperative R&D projects (Model 1)			Licensed technology (Model 2)			Patents (Model 3)			
	Coef.	Exp(B)	p-value	Coef.	Exp(B)	p-value	Coef.	Exp(B)	p-value	
Ln(Size)	<b>0.254*</b>	1.290	0.066	<b>0.316**</b>	1.371	0.021	-0.001	0.999	0.997	
RDP_ratio	0.668	1.950	0.463	0.736	2.088	0.410	0.279	1.322	0.750	
Eastern_dum	-0.090	0.914	0.776	-0.428	0.652	0.174	<b>-0.860***</b>	0.423	0.007	
Independent variables	IT	0.023	1.023	0.950	0.417	1.517	0.269	-0.157	0.854	0.664
	High-tech Industry	<b>1.294**</b>	3.646	0.012	0.025	1.025	0.950	0.114	1.121	0.772
	Dummy Chemical	0.028	1.029	0.950	-0.214	0.807	0.630	-0.039	0.961	0.930
Goodness-of-fit test (Hosmer & Lemeshow test)	<b>0.980</b>			<b>0.308</b>			<b>0.974</b>			

Notes: 1) \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

2) If the Hosmer and Lemeshow goodness-of-fit test statistic is greater than 0.1 (as desired for well-fitting models), we do not reject the null hypothesis that there is no difference between observed and model-predicted values, implying that the model's estimates fit the data at an acceptable level.

acquired from China. It is ideal to merge the Chinese and U.S. data in analyzing China-U.S. differences; however, we were unable to do so because the original U.S. data (gathered by Cohen and his colleagues) were not available at the time of our analysis (although the U.S. data are believed to be comparable with the Chinese data). Thus, direct comparison between the two countries is left for future study and the regression analyses in this study should be regarded as a preliminary exploration of the underlying causes behind Chinese characteristics.

The regression results in Table 9 show that larger firms would more highly appreciate “joint or cooperative R&D” and “licensed technology” in China. Although firm size does not matter in the case of “patents,” we can argue that larger firms would prefer formal contract-based channels of UIL in China. This also means that Chinese firms’ inclination toward formal contract-based channels does not stem from its smaller size (or lower developmental stage).

On the other hand, the level of technological sophistication of industrial firms proved to be irrelevant to their preference for formal contract-based channels. Although all the coefficients of “RDP\_ratio” in the three models have consistently positive values, suggesting that firms at a higher level of technological sophistication would prefer formal contract-based channels, none of the coefficients were statistically significant. Therefore, it is safe to say that the pronounced preference of Chinese firms for formal contract-based channels is not caused by their lower level of technological sophistication either. Individual firm factors cannot successfully explain the difference of preferences between Chinese and American firms in selecting channels of linkage with universities (see Table 10).

Regarding the environmental (or external) factor (H3), Model 3 shows that the firms located in Eastern provinces, assumed to be *institutionally thicker* regions, resort less to “patents” (see Table 9). Additionally, in Models 1 and 2, the coefficients of “Eastern\_dum” have consistently negative values, although these are not statistically significant. From these results, we can tentatively deduce that the distinct inclination of Chinese firms toward formal contract-based channels is due to the lack of institutional thickness in the region where they are located. Moreover, this can be further supported by the findings of Eun, Wu, and Wang (2009) in their interviews with senior engineers from some Chinese firms conducted on April and May 2008:

TABLE 10  
SUMMARY OF TESTS

Focus of Hypothesis	Hypothesis	Explaining China-US difference	Joint or cooperative R&D projects (Model 1)	Licensed technology (Model 2)	Patents (Model 3)
Individual firm factor	H1-1	Yes	X	X	X
	H1-2	No	○	○	X
	H2-1	Yes	X	X	X
	H2-2	No	X	X	X
Environmental factor	H3-1	Yes	X	X	○
	H3-2	No	X	X	X

Note: Accepting the hypothesis with statistically significant evidence, ○; otherwise, X.

A senior engineer in Antai S&T (a technology intermediary agent) pointed out the “lack of trust” as a main reason of Chinese firms’ preference of formal contract-based UIL channels. Another senior engineer in Beijing automotive group said that China’s incomplete legal system and limited experience of U-I collaboration drive both firms and academic institutions to stick to formal contracts in order to protect their own interests and to prevent opportunistic behaviors of their partners (Eun, Wu, and Wang 2009, p. 50)

## V. Prospects and Limitations of Burgeoning UIL in China

In the previous sections, it was established that horizontal UIL is currently rising in China. However, we also found that China’s current horizontal UIL was mainly forged with the help of “formal contracts.” Moreover, our regression analyses indicated that the Chinese partiality toward formal contracts could most likely reflect the lack of “institutional thickness” in China. This fact implies that China may utilize diverse channels of UIL as the related institution becomes thicker in the future.

Through trial and error, Chinese universities and firms are currently accumulating experiences in communicating and interacting with each other. If these experiences were positively assimilated, they would help build “trust” between universities and firms, leading to more flexible and non-contract-backed horizontal UIL.

According to our survey findings, most Chinese firms appear to be very positive in evaluating their own experiences of collaboration with

TABLE 11  
Factor Analysis of China's UIL Channels

Individual channel	Factor loading	
	Factor 1	Factor 2
Incubators	<b>0.748</b>	0.221
Contracting research	<b>0.745</b>	0.232
Joint or cooperative R&D projects	<b>0.730</b>	0.233
Science and/or technology parks	<b>0.724</b>	0.228
Temporary personnel exchanges	<b>0.715</b>	0.232
Participation in networks that involve universities	<b>0.694</b>	0.278
Recently hired graduates with above-Master's degree	0.473	0.405
Consulting with individual researchers	0.439	0.480
Patents	0.404	0.582
Licensed technology	0.388	0.584
Publication and reports	0.262	<b>0.757</b>
Public conferences and meetings	0.211	<b>0.781</b>
Informal information exchange	0.103	<b>0.758</b>
Eigenvalue	5.971	1.220

Note: The threshold for factor loading: 0.600.

universities. The survey results showed that the majority of firms (93.5%) have already reached their pre-set goals in their partnership with universities or expect to do so in the near future. Less than 7% of the firms stated that the collaboration with universities has already failed or would eventually fail. This seems to indicate that China's horizontal UIL would prosper in the future.

Chinese firms appear to be already utilizing other types of UIL channels as a supplement to formal contract-based channels. In order to demonstrate this trend, we conducted factor analysis. Factor analysis is a statistical method used to describe variability among observed variables in terms of fewer unobserved variables called factors. We applied this method to our respondent firms' evaluations on the usefulness of individual UIL channels in order to see how Chinese firms combine (or mix) individual channels in forging links with universities. In other words, through factor analysis, we can determine how different channels relate to one another.

Table 11 shows that channels that load on the first factor include not only formal contract-based channels (*i.e.*, "contractual research with universities" and "joint or cooperative R&D projects") but also loose network-based channels (*i.e.*, "incubators," "science and/or technology

**TABLE 12**  
**DIFFICULTIES IN UIL PERCEIVED BY PROFESSORS**

(Multiple choice)

Rank	Perceived obstacles (Number of respondents: 160)	Frequency (moderately or very relevant)	% (Moderately or very relevant)
1	Restriction on research time due to conflicting schedule of the industry	70	43.8
2	Time restriction that results from confounding of already-existent research and education with additional industrial involvement	62	38.8
3	The industry's lack of understanding of the technology or the information involved	44	27.5
4	The university's insufficient reward system	16	10.0
5	The government's excessive regulations or inappropriate policies or laws	15	9.4
6	The industry's prejudice against the university researcher	13	8.1
7	Excessive regulations from the university	11	6.9
8	Unsatisfactory reward for the research results and unreasonable distribution of profits	10	6.3
9	Decrease in reputation and activities within the academic community	4	2.5
10	Negative opinions of fellow researchers or students within the university	3	1.9
11	Problems regarding co-authorship of the article	2	1.3

parks," "temporary personnel exchanges," and "participation in networks that involve universities"). On the other hand, "publication and reports," "public conferences and meetings," and "informal information exchange," which represent the public (or open science) and informal channels of UIL, load on the second factor. These results imply that Chinese firms often combine the use of formal contract-based channels with efforts to construct general networks with universities. This indicates that the Chinese UIL's heavy dependence on narrow formal contracts could possibly be diluted by the use of more evolved "network-based" channels in the future.

As discussed, it is probable that China's horizontal UIL would

further prevail in the future while its dependence on “formal contracts” would gradually decrease. However, the progress of horizontal UIL is not without difficulties. Chinese professors emphasized several problems and side effects concerning the burgeoning UIL in China. Table 12 illustrates the difficulties perceived by Chinese professors in collaborating with firms.

According to Table 12, the most frequently reported problem is time restriction. This indicates that professors typically have difficulty in meeting the hasty (at least from the standpoint of professors) requirements of industrial partners who are most likely also pressed for time. This may be due to the cultural difference between liberal universities and the tightly disciplined firms. It can also be attributed to the fact that professors, who are mostly tied up with teaching and academic research, have only limited time to devote themselves to collaboration with industrial firms. This results in a “trade-off” between education and research on one hand, and collaboration with industrial firms on the other.<sup>8</sup>

For that reason, it should be taken into account that universities may suffer from “opportunity costs” when they excessively allocate resources (including professors’ time and commitment) while making direct linkages with industrial firms. Technically, universities can contribute to firms indirectly, for instance, by providing well-educated graduates for the society. However, we discovered, through this study, that there exists a trade-off between different university functions in China. Furthermore, our survey findings showed that even firms do not always place top priority on “industrializing S&T knowledge” as an important function of universities; rather, the respondent firms in our survey attached more importance to “education and training” (see Table 13). This implies that maximizing the strength of the UIL at the expense of traditional but core functions of universities (*i.e.*, education and training) may not be the right policy to implement.

In addition, Chinese professors also complained about industrial partners’ lack of understanding regarding technology, insufficient reward systems, and excessive regulations from universities and governments (see Table 12). This implies that a higher technological capacity (or

<sup>8</sup>This is in line with the ongoing global debate on whether we should further promote direct and formal UIL, considering the concerns about the costs and time consumed by U-I networking that may be detrimental to education and long-term academic research (Poyago-Theotoky *et al.* 2002; Giuliani and Arza 2009).

**TABLE 13**  
**CHINESE FIRMS' PERCEPTION OF IMPORTANT ROLE OF UNIVERSITIES**

Role of university (Total respondents: 302)	% (Moderately or very important)
Education and training	72.5
Industrializing S&T knowledge	71.9
Academic research	65.9
Social service	55.3

absorptive capacity) on the part of industrial partners and better balanced policy measures are the pre-requisites for the full exploitation of the UIL.

## VI. Summary and Conclusion

Until recently, Chinese universities established their own business firms (*i.e.*, UREs) and commercialized new technological knowledge through firms under their control. The previous university-industry relationship was based on an administrative hierarchy or vertical linkage. However, things have changed, and the growing absorptive capacity of ordinary Chinese firms has resulted in the growth of horizontal UIL in China.

This study aimed to explore the emerging horizontal UIL in China. Towards this purpose, we conducted two separate but closely related surveys using questionnaires (one for universities and another for industrial firms) in China. Using the survey results, we verified that the vertical channel of knowledge industrialization (*e.g.*, UREs) is being replaced by a more horizontal UIL, mainly due to the enhanced absorptive capacity of Chinese firms. In addition, we found that the current Chinese horizontal UIL could be characterized by its heavy dependence on formal contracts. This finding is interesting because it is the opposite of the result obtained by Cohen and his colleagues in a similar study in the U.S., where informal and open science channels were highly appreciated by firms.

To determine the underlying causes of the inclination of Chinese firms toward formal contract-based UIL, we estimated three logistic regression models. From the regression analyses, we determined that larger firms prefer formal contract-based channels in China. However,

China's heavier dependence on formal contracts than the U.S. could only be explained by the difference in institutional thickness of the regions where firms are located, rather than individual firms' internal characteristics. Nevertheless, this conclusion should be regarded as tentative because it was only derived from the comparison between the relatively rich and industrialized (thus assumed to be institutionally thicker) Eastern China and the rest of China. Therefore, a more rigorous econometric analysis of the China-U.S. difference is left for future studies.

If institutional thickness is significant in a firm's choice of UIL channels, as our preliminary analysis indicates, China would utilize more channels of UIL, including informal and open science channels in the future, as the institutional environment becomes more sophisticated. According to our survey findings, Chinese firms are trying to combine formal contract-based channels with efforts to establish more general networks with universities.

These findings imply that China is on the path towards establishing full-fledged horizontal UIL with less dependence on formal contracts, although it will take time for China to reach that objective. However, we also discovered that the strengthening of horizontal UIL in China could be challenged by side effects. Our survey findings show that Chinese professors have experienced uncomfortable trade-offs between education and research on one hand, and collaboration with industrial firms on the other. A policy suggestion that we can draw from this finding is that policy makers (in universities and governments) should pay closer attention to the less visible means by which universities contribute to industry and society, that is, by providing well-educated graduates. Ignorance of these contributions, and the excessive emphasis on apparent and direct UIL, may be disadvantageous not only to education and long-term academic research, but also to social welfare.

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