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Strategic Intent of University-Industry Transfer Collaboration

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***Abstract*--This paper examines the rationales the firms collaborate with the universities. Using information from a mail survey, this study examines the optimal collaboration mode for conveying the firms' strategic intents to interact with the universities. We test hypotheses from the knowledge-based view of the firm using information from a survey of 91 usable questionnaires out of 645 Taiwanese firms. Our empirical results suggest the firms tend to collaborate with the universities when they aim at 'passive' intents but it is less likely for firms to license in university technologies based on 'proactive' intents. The firms may collaborate with the universities by taking account of 'efficiency-seeking, resource-seeking or internalization-seeking' intent. However, the firms tend not to license in university technologies when they aim at resource-seeking or internalization-seeking intents.**

I. INTRODUCTION

Starting from the passage of the Bayh-Dole Act in 1980, the university has made varying efforts to push academic technologies into marketplace, especially patenting and licensing. According to reference [31]'s estimation, academic research advances industrial R&D about ten years in biotechnology and six to seven years in non-biotechnology. If most of academic research is at the early stage of development [8; 33], why do firms transfer university technology in? How about the firm's ultimate goal of transfer is not the eventual commercial use of the university technologies but to leverage university technologies for strengthening their innovation capabilities? It is possible that the university-industry linkage perceived by the firm is merely an entry ticket for knowledge-access relationship. Therefore, our research question is what drives the firm to transfer technology from the university.

University-industry collaboration is a matter of strategic choice. One of the reasons is varying channels for transferring technological knowledge from the university to the firm such as open science, R&D contracting and partnering. Technology transfer is dependent on the access intents [11]. This study therefore explicates the relationship between channels of transfer modes and strategic intents.

Most studies on university-industry collaboration do not take account of strategy management. When firms intend to learn by collaboration, the proxy for measuring the efficacy of academic research transfer such as patent application or start-up formation becomes inappropriate. Therefore, understanding of the firms' strategic intents significantly contributes to the action plans of academic technology providers and agents. We wish to provide the differing effects on university-industry collaboration and marginally contribute to technology marketing strategy development.

In the next section, we first review prior studies and offer hypotheses. After that, we describe our research method and discuss our results. We close by considering the implications and limitations of our study and suggesting opportunities for future research.

II. LITERATURE REVIEW

A. Relational contracting

Transactional and relational exchange is common inter-organizational governance mechanisms in which distinction is that how a relation is built, maintained, and terminated [14;18]. Transactional exchange and relational exchange is a transactional-relational continuum which ranges from the discrete, short-term, price-focused, and arm's-length end to the multidimensional, cooperative, and long-relationship end [18]. Transactional exchange is characterized as its short-term nature or by one-time exchange independent of past and future relations, with no commitment beyond the limited interaction between the parties. Transactional exchange is inherently short term and directly tied to the ownership transfer of a transaction.

Relational exchange highlights the cooperation to achieve common goals between exchange parties and depends on relational norms to guide transaction activities. The exchange parties seek to eliminate goal divergence and align incentives *ex ante* in consideration of past and future relations and they jointly develop ways to achieve mutuality of interest. Incentives under relational contracting distribute rewards based on jointly long-term commitments to the achievement of certain goals, which parties could forego present rewards based on expectations of long-term profits.

Although not centered on academic technology transfer, Stock and Tatikonda [30] offer a helpful framework for us to analyze the intents of the university-industry collaboration from the perspective of the relational contracting. They summarize inward technology transfer typology into four types -- arms-length purchase, facilitated purchase, collaborative hand-off, and co-development. When the firm has the enough information to integrate the external technology, the simple market transaction, i.e. arms-length purchase, is appropriately matched. Facilitated purchase applies where the firm buys a newer, more complex and explicit technology through a market transaction but the university provides the information how to use the technology. Collaborative hand-off applies when the firm needs customized technology, the technology of interest is much newer and more tacit and complex for the firm to use the technology. It takes time to interact for the successful meeting of transfer goals. Compared to facilitated purchase, collaborative hand-off needs more interaction between the source and recipient. Co-development is prevalent in R&D cooperation. When the firm has less knowledge to utilize the technology, the firm requires higher level of cooperation, communication, and coordination. In sum, arms-length purchase, facilitated purchase, collaborative hand-off, and co-development are distributed along the transactional-relational continuum.

B. University Technology Transfer

The university provides knowledge with which the firm can develop new technology and promote economic development. The university technology transfer is a process of moving ideas from the university into the market place that consists of several steps [26; 32]. The process starts from the inventor disclosing the information about his research results and then transferring to the firm. After the technology transfer agreement is executed, the university may begin earning income from the transfer.

University technology transfer involves various routes. Major routes from the university to the firm include informal information exchange, publications and reports, public meetings and conferences, recently hired graduates, (patent) licensing, joint research, contract research, consulting, and temporary personnel exchanges [7]. These routes involve three types of personal face-to-face contacts. The first type is the transfer of intellectual property such as licensing, patenting and commercialization in which face-to-face contacts is relatively low. Here, legal use rather than relationship building is the focus. The second is the mobility that includes academic entrepreneurship and human resource transfer. The mobility type has intermediate face-to-face contacts. The third is research partnerships and research services. Face-to-face contacts in this type are high where the teams from the university and the firm co-work on specific projects and jointly produce certain outputs [23].

In this study, we consider the second and the third types - licensing, joint research and contract research as major commercial transfer modes. There are a couple of rationales. Firstly, technology transfer works better when a mixture of commercial and non-commercial knowledge transfer channels is adopted. Specifically, joint learning and knowledge co-production are simultaneously optimal to drive the firm's innovation activities and to benefit the academic research career [15].

Secondly, consulting does not reflect formal institutional links because most of the time the payment of consulting is paid to the consultant rather than to the university [7; 23]. Thirdly, licensing refers to the transfer of university-generating intellectual property such as patents and copyrights to the firm against a fee [23]. The transfer of intellectual property involves less tacit knowledge transfer and less personal face-to-face interaction [29]. Most of university licensing is supplemented by consulting when the technology is embryonic [32].

Finally, the boundary between contract research and joint research is blurred in practice [3; 9; 19]. Universities and the firms provide complementary knowledge resources over the period of R&D cooperation in which we name contract research and joint research as R&D cooperation. R&D cooperation is highly personal face-to-face interaction required throughout the period of the interaction agreement [2; 9; 29].

C. Strategic Intent

Technological knowledge search depends importantly on the firm's R&D intent. Knowledge flow across organizational boundaries is a matter of strategic choice and the level of inter-organizational knowledge flow is dependent on the intents for accessing the knowledge sources [11].

The prior studies find that most firms interacting with the university are based on two intents – the passive intent versus the proactive intent [2; 7; 23; 27; 28]. On one hand, when the firm aims to obtain technological advice, to solve relatively concrete problems or to commercialize new products by exploiting the university existing technology [2; 7; 23; 28], there will be hard performance criteria to evaluate the collaboration [11]. Such intent is more passive, short-term and applied oriented along an established trajectory [2]. On the other hand, when the firm is interested in accessing advanced but tacit knowledge to discover new possibilities, the collaboration focus will be the engagement of interactive learning and knowledge co-creation, not the concrete commercial output [2; 11; 28]. This intent is more proactive and learning oriented [2].

Most studies analyzing the relationship between the transfer modes and the strategic intents reveal inconsistent findings. For instance, Bishop et al. [5] find that the firm interacts with the university for problem-solving via personal contact, while for updated technical information via open-science channels. Perkmann and Walsh [23] conclude that joint research is suitable for accessing the new knowledge and contract research is suitable for problems known to the firm. But Cohen et al. [7] find that contract research is important to firms for initiating new R&D projects but licensing and joint research are important for completing existing projects.

Perkmann and Walsh [23] find that licensing is suitable for the ready-to-commercialized objects and access to the early-stage technology. Licensing technologies that protected by the university often enables firms to access to new technologies because most university licensing involves early-stage technologies that need considerable further development [33]. In other cases, licensing is short-term oriented where licensee firms target on the licensed objects. Collaborative research may supplement the licensing deals to get into industrial use.

If we categorize the strategic intents into a transactional-relational continuum, what drives the firm to transfer the university technology? Most firms are more effective in applied research. The firms may address particular needs or problems through contract research or joint research with the university. R&D cooperation can be supplemented by a licensing deal to facilitate the licensed technology commercialization. At times, R&D cooperation works when the technology involves a platform development or process improvement [23; 28]. The firm may approach for the university licensing when the solutions to its problems are ready-to-use but protected by the university [8; 23; 24].

The firm may concentrate on learning by cooperating with the university rather than licensing for the following reasons. Firstly, it is possible that the firm focuses on strategically access to advanced knowledge rather than acquiring the technology [12]. R&D cooperation tying the firm with the university promotes the firm to access advanced technologies by a formal and informal interaction during a protracted period of time. Secondly, most of embryonic technologies are uncodified, complex, and causally ambiguous that requires considerably further development. R&D cooperation results in close interaction and knowledge co-production [31]. Finally, licensing is acquiring the use of university technology legally for a payment. Although Perkmann and Walsh [23] propose that licensing in university-generating technologies and engaging the inventors with consulting or collaborative research may meet the firm's needs to acquire advanced technology [24], we argue that the long-tern time horizon occurs through R&D cooperation rather than licensing. Hence, we hypothesize that:

H1. The firm is more likely to license in university technology when its primary intent approaches transactional exchange.

H2. The firm is more likely to employ R&D cooperation with the university when its primary intent approaches relational exchange.

III. METHOD

A. Sample

We conducted a survey to collect data for the study. This survey uses a cross-sectional methodology to maximize the variation in the variables and increase the generalizability of the findings. A self-collected name list of 2429 firms is used for sampling. The list contained firms that transferred technology funded by National Science Committee of Taiwan, firms that got subsidy from Technology Development Program (TDP) of Ministry of Economic Affairs (MOEA), and public firms. We used 11 out of 145 firms that responded at the first-stage study for the pretest. These firms were contacted by email with the cover letter and questionnaire. The cover letter explained the purpose as importance of the survey and highlighted a nondisclosure principle that the responses would be treated confidentially. We offered to share the results in summary form if the informants so desired. A follow-up questionnaire was mailed one week later. The final survey was sent out to 500 firms and thus comprised 645 firms. Of these 645 firms, 4 firms did not have the experiences in university-industry collaboration. Finally, the survey generated 91 usable questionnaires for an effective response rate of 14.1%.

B. Measures

In this study, the construct of strategic intents was operationalized using a multiple measures methodology. The actual measures were derived from the prior literature.

1) Transfer mode

The dependent variable refers to the extent to which the firm has engaged in university licensing or R&D cooperation. For each type of channel, the respondents were asked how they had engaged in the consulting, licensing, joint research or contract research [3; 23]. This item is a multiple choice question because the firm may simultaneously employ licensing coupled and joint research or contract research. Licensing was coded as a categorical variable where a "1" represented the firm involves licensing from the university, otherwise 0. R&D cooperation was coded as a categorical variable where a "1" represented the firm involves contract research or joint research with the university, otherwise "0".

2) Strategic intent

Three factors were extracted from the eleven items where eigenvalue was over 1, explaining 69% of total variance. The first factor was labeled as internalization-seeking intent that is firms' aim at internalization. The second and third factors were labeled efficiency-seeking intent and resource-seeking intent, respectively (see Table 1). These three intents were drawn from factor analysis. We place these intents at a continuum of time horizon from short–term to long-term where the efficiency-seeking and internalization-seeking intents at the extreme ends and the resource-seeking intent in the middle.

- Internalization-seeking intent (Cronbach's α=0.78)
  - ✓ Access to licensed research findings or prototype [7; 28]
  - ✓ Obtain advanced knowledge [28]
  - ✓ Reduce internal R&D costs [16]
  - ✓ Expand product assortment
  - ✓ Accumulate R&D experience
- Efficient-seeking intent (Cronbach's α=0.91)
  - ✓ Reduce use of materials [16]
  - ✓ Increase yield rate [16]
  - ✓ Replace outdated products [16]
- Resource-seeking intent (Cronbach's α=0.74)
  - ✓ Use equipment and facilities unavailable internally [7; 28]
  - ✓ Access key materials
  - ✓ Facilitate technology commercialization [17]

TABLE 1. MEASUREMENT AND FACTOR LOADINGS OF STRATEGIC INTENT

Variable	Factor loading Internalization-seeking	Factor loading Efficiency-seeking	Factor loading Resource-seeking	Item-to-total correlation Internalization-seeking	Item-to-total correlation Efficiency-seeking	Item-to-total correlation Resource-seeking
Obtain advanced knowledge	0.77	0.13	0.27	0.67		
Accumulate R&D experience	0.75	0.28	0.00	0.63		
Reduce internal R&D costs	0.73	0.21	-0.15	0.58		
Access licensed research findings or prototype	0.64	-0.04	0.36	0.46		
Expand product assortment	0.61	0.32	0.04	0.49		
Reduce use of materials	0.24	0.89	0.23		0.91	
Increase yield rate	0.14	0.85	0.22		0.78	
Replace outdated products	0.39	0.79	0.19		0.78	
Use equipment and facilities unavailable internally	-0.06	0.40	0.73			0.60
Access key materials	0.02	0.30	0.81			0.56
Facilitate technology commercialization	0.47	0.00	0.69			0.46
Eigenvalue	4.71	1.69	1.19			
Percent variance explained	42.81%	50.62%	69.04%			
Cronbach's α of scale				0.78	0.91	0.74

Note: Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization.

3) Patent

Appropriability is a major concern for firms to choose the collaboration modes [11]. Patent was coded as a categorical variable where a "1" represented the firm involves patented technology collaborating with the university, otherwise "0".

4) Collaboration experience

Collaboration experience was coded as a categorical variable where a "1" represented the firm has experiences in collaboration with the university, otherwise "0". If there is a level of experience in external, industry-oriented knowledge interactions, organizational barriers to knowledge interactions are likely to be less important. Moreover, previous collaboration experiences will enhance interorganizational collaboration capability and thus increase the probability of future collaboration [29].

5) Firm Size - SME

Firm size is recognized as a key variable affecting organizational learning [34]. van Wijk et al. [35] in their meta analysis find firm size has been suggested to positively affect organizational knowledge transfer, we here expect it has a positive effect on initiation intent. Following the small and medium administration's classification, firm size was measured by the number range of employees within the firm and paid-in capital, and collected via the survey. SME was coded as a categorical variable where a "1" represented small firms, those having < 200 employees and paid-in capital < NT$ 80 million, otherwise "0".

6) Industrial sector

The intensity of use of different forms of interaction is sector, field and/or technology specific [3; 7]. Firms in certain industries frequently work with universities in transferring and applying external knowledge [4; 28]. For instance, firms in mechanical engineering or software development prefer contract research and consulting. Licensing is predominantly used in pharmaceuticals and biotechnology [7].

Santoro and Chakrabarti [28] find that high-tech firms (e.g. biotechnology, microcomputers, semiconductors, electronics, pharmaceuticals, optical equipment, medical laboratories, and research and development services) are positively associated with technology transfer and cooperative research, while resource-intensive firms (e.g. lumber and paper products, petroleum, and mining) are positively associated with knowledge transfer and support relationships. Schartinger et al. [29] suggest that science-based industries heavily rely on new scientific knowledge and should show more intense interactions with universities. They find that R&D intensive manufacturing industries tend to use research cooperation more intensively and service industries rest more on personnel mobility and training related interactions.

In our study, industrial sector was collected via the survey. We categorized the industry sectors into three groups – ICT, biotech, and the others. The rationales for the three groups are as follows. Taiwan government has invested more infrastructure resources in ICT and biotechnology industries. Infrastructures and market opportunities might affect the external knowledge transfer and commercialization. According to 2007 Biotechnology industry annual report, Taiwan's biotech industry consists of pharmaceuticals, medical equipment, food, agriculture, chemistry, medical service, environmental preservation, etc.

7) Exploitative capability and exploratory capability

Innovation can be characterized by exploitation or exploration. He and Wong [13] argue that exploration versus exploitation should be used with reference to a firm's *ex-ante* strategic innovation objectives, whereas the radical versus incremental innovation is often used in an *ex-post* outcome measure. Following He and Wong's position, we regarded exploratory innovation and exploitative innovation as a firm's *ex-ante* strategic objectives in pursuing innovation and as two distinct dimensions of innovation [13]. Items of exploratory capability measures how frequent technological innovation aimed at entering new product-market domains (Cronbach's α=0.89), and items of exploitative capability measures how frequent technological innovation aimed at improving existing product-market positions(Cronbach's α=0.90) [4; 13].

C. Analysis techniques

Convergent validity was assessed by the magnitude of the factor loading of each manifest indicator on its proposed construct. Nunnally [21] suggests that 0.7 as a benchmark for 'modest' reliability was applicable in the early stages of research.

A binary logistic regression was undertaken to assess the effect of the variables on the probability of the dichotomous collaboration modes, using the statistical software package SPSS 12. This logit model allowed us to quantify the collaboration mode associated with various individual explanatory variables. The significance level of model chi-square helps to predict the collaboration mode odds provided by the explanatory variables and that of Hosmer-Lemeshow chi-square helps to assess the goodness of fit. Nagelkerke R-square helps to evaluate the prediction accuracy of the model estimation [36].

The regression coefficients were able to be converted to odds ratios. The P value was calculated based on the Wald test statistic with chi-square distribution with 1 degree of freedom. A positive regression coefficient on an independent variable indicates that higher values increase the likelihood that a company will employ a relational exchange strategy. Negative coefficients indicate a reduced likelihood of a relational choice and so favor a discrete choice. The classification results compare the number of cases correctly and incorrectly classified to the number of cases that we would expect to correctly and incorrectly classify. The proportion expected to be correctly classified was based on the most conservative criterion (maximum group), although with an approximately even number of cases in both groups this choice of criterion makes little real difference.

Due to the single informant in each questionnaire, we conducted two preliminary analyses to check common method bias. First, we used two different sources to collect the number of capital. Because all firms register their number of capital at the government, we compared the interval of capital indicated by the respondent with that of the government to assess the inter-rater reliability for the firm size. The number of capital is confirmed. Second, we employed Harman's one factor model. The results of this analysis showed our main effect variables generates 8 factors, each with eigenvalues greater than 1.0, accounting for 73.83% of the total variance. The percentage of variance explained of the first factor addresses 40.82%. Since no single factors dominate the factor structure, the common method bias should not be a threat in this study [25]. Second, we examined the early versus late response bias in terms of paid-in capital. No statistically significant difference emerges from the student test, suggesting that response bias seems not to be a potential problem [1].

IV. RESULTS

A. Descriptive statistics

Table 2 provides the item-averaged descriptive statistics and the reliability of perceptual variables. Fifty-six percent (56%) of the university technology in our sample has been transferred through licensing, seventy-eight percent (78%) of the sample through contract research or joint research. Fifty-four percent (54%) of the sample is related to patent and fifty-eight (58%) of the firms have collaboration experiences with universities. Twenty-one percent (21%) of the technology is transferred to small and medium enterprises (SMEs). The resulting sample is most represented by the electronics manufacturing industry (ICT) (40%), followed by the biotechnology, food, and chemicals industry (33%), and the machinery, metal, and construction industry (27%).

Table 3 presents the Pearson correlation matrix between the variables for the samples of sourced-in technology from universities. The highest correlation coefficient is between ICT industry and Biotech industry (r= - 0.57). Moreover, linear regression is used to assess multicollinearity between the independent variables. All the variance inflation factors (VIF) in Table 4 are 1.76 or less, implying that there is no strong linear relationship between variables.

TABLE 2. ITEM-AVERAGED DESCRIPTIVE STATISTICS

	Item	Mean	S.D.	Minimum	Maximum	Reliability
Licensing	1	0.56	0.499	0	1	-
R&D cooperation	1	0.78	0.416	0	1	-
Internalization-seeking	5	5.47	1.076	1.8	7.00	0.78
Efficiency-seeking	3	3.87	1.891	1.0	7.00	0.91
Resource-seeking	3	4.41	1.494	1.0	7.00	0.74
Patent	1	0.54	0.501	0	1	-
Collaboration experience	1	0.58	0.496	0	1	-
SME	1	0.21	0.409	0	1	-
ICT industry	1	0.40	0.492	0	1	
Biotech industry	1	0.33	0.473	0	1	-
Other industry	1	0.27	0.449	0	1	-
Exploitative capability	4	5.08	1.526	1.75	7.00	0.90
Exploratory capability	4	5.86	1.187	2.00	7.00	0.89

Note: Number of observations is 91.

TABLE 3. PEARSON CORRELATION MATRIX

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	Licensing										
2.	R&D cooperation	**-0.36**									
3.	Internalization-seeking	-0.14	**0.29**								
4.	Efficiency-seeking	**0.18**	0.01	0.00							
5.	Resource-seeking	**-0.19**	**0.26**	0.00	0.00						
6.	Patent	-0.11	-0.12	0.07	0.04	**0.23**					
7.	Collaboration experience	0.10	-0.07	0.02	0.01	-0.05	0.16				
8.	SME	-0.14	0.14	0.04	**-0.19**	-0.05	-0.12	-0.06			
9.	ICT industry	-0.14	-0.11	-0.02	**-0.28**	**-0.21**	**-0.20**	0.05	-0.08		
10.	Biotech industry	0.15	-0.08	-0.05	0.04	0.09	0.09	-0.12	0.16	**-0.57**	
11.	Exploitative-Exploratory capability	**0.22**	**-0.23**	-0.03	**0.39**	0.15	0.04	-0.02	-0.08	-0.02	0.15

Note: Figures in bold indicate p<0.10 when |correlation|≧0.173, p<0.05 when |correlation|≧0.208, p<0.01 when |correlation|≧0.28, and p < 0.001 when |correlation| ≧0.36. Number of observations is 91.

B. Logit results

Table 4 reports the logit results. Model a and model b are significant and Hosmer-Lemeshow chi_squared are insignificant, suggesting both models fit well. These equations correctly classified at least 70% of firms that use the mode to transfer the university technology.

Based on the strategic intent, we expect that the firm is more likely to license in the university technology when the primary intent approaches the transactional exchange. The firm is more likely to cooperate with the university when the primary intent approaches the relational exchange. Model a shows that the firm is **less** likely to license the university technology when the primary intent is resource-seeking. The relationship between the choice of licensing and the efficiency-seeking or internalization-seeking intent is not significant. All the coefficients of the three intents of Model b become significant, suggesting that the firm is more likely to employ R&D cooperation with the university whatever their primary intent is internalization-seeking, resource-seeking, or efficiency-seeking. The finding is consistent with Cohen et al.'s [7] and Cassiman et al.'s [6] work. Hypothesis 2 is supported.

V. DISCUSSION AND CONCLUSION

This study examines the impact of the strategic intents of Taiwanese firms on the choice of university-industry collaboration mode. One hypothesis is supported. The implications of the analyses are below.

B. Theoretical Implications

Our study suggests that the firm collaborates with the university by taking account of efficiency-seeking, resource-seeking, or internalization-seeking intent. The efficiency-seeking intent is that the firm aims to reduce some operating or development costs or to seek technological advice for solid problems. The efficiency-seeking intent matters for the firm to collaborate with the university. However, such intent is not the intent for the firm to license in the university technology. The finding is inconsistent with Perkmann and Walsh's [23] arguments. One possibility for the efficiency-seeking intent that has no significant impact on the choice of licensing is that most of the university technologies do not fit the industrial needs.

TABLE 4. LOGISTIC REGRESSION ESTIMATES

Model	Licensing (a)			R&D cooperation (b)			VIF
Internalization-seeking intent	- 0.30	(0.246)		**0.83**	**(0.336)**	*	1.02
Efficiency-seeking intent	0.06	(0.269)		**0.82**	**(0.451)**	+	1.36
Resource-seeking intent	**- 0.59**	**(0.270)**	*	**1.22**	**(0.401)**	**	1.12
Patent	- 0.71	(0.529)		- 1.64	(0.844)		1.15
Collaboration experience	0.84	(0.515)		- 0.78	(0.709)		1.09
SME	- 0.94	(0.614)		1.37	(0.996)		1.10
ICT industry	- 0.67	(0.639)		- 1.45	(1.028)		1.76
Biotech industry	0.61	(0.627)		- 1.05	(0.986)		1.57
Exploitative-Exploratory capability	**0.51**	**(0.246)**	*	**- 1.50**	**(0.579)**	**	1.28
Constant	0.93	(0.674)		2.672	(1.114)	*	
Correctly classified		70.3%			82.4%		
Model χ^2		**20.94**	*		**34.76**	***	
-2 Log likelihood		103.88			61.09		
Pseudo Nagelkerke R^2		0.275			0.49		
H&L χ^2		10.01			12.47		

Note: + p<0.10, * p<0.05, **p<0.01, *** p < 0.001. Number of observations is 91.
Figures shown are beta coefficients of the logistic regressions. Figures in the parenthesis are standard errors. Positive coefficients are associated with greater probability of dependent variable.

The negative sign of the resource-seeking intent on the choice of licensing but the positive sign on the choice of R&D cooperation make us to posit that the firm believes that the collaboration promotes technology commercialization. We conjecture that internalization-seeking intent is proactive, efficiency-seeking intent is passive, and resource-seeking intent is amid these two. However, the firm tends to cooperate with the university but not to license in the university-generating technology when it aims at seeking resources from the university. Our evidence suggests that the firm might use open-science channels or R&D cooperation to access to new technology rather than licensing. Obviously, this evidence is bad news for university licensing officers, but good news for university-industry promotion officers.

Moreover, our finding echoes with the prior studies that the level of inter-organizational technology transfer is dependent on the intents for accessing the knowledge. However, we argue that the intents are not discrete as passive versus proactive intent. Prior studies argue that the passive intent applies when the firm aims to obtain technological advice or to solve relatively concrete problems. The proactive intent applies when the firm aims to learn the updated technology. Time horizon matters for the technology transfer decision.

Furthermore, the firm will more likely to licensing and less likely to cooperate with the university when the firm owns higher level of explorative capability than level of exploitative capability. The evidence suggests that the firm has more knowledge to utilize the patent licensing at a market base without the engagement of the university inventor.

C. Managerial Implications

We find that patenting is negatively associated with the use of R&D cooperation, suggesting that the policy encouraging the university to patent licensing might be misaligned with the diverse nature of the university-industry interaction. Finding out the potentials firms to license in university-protected technologies is one of important responsibilities of university licensing officers. The brokerage of university research faculty and the potential firms is always challenging to these officers. Officers may interact with such collaborative firms more frequently for understanding industrial needs and consequently increase the possibility of getting university technology into practice.

D. Limitations and Outlook

A couple of limitations and future research are worth mentioning. One of limitations of collaboration modes are the possibilities of the multiple use of licensing and R&D cooperation. Some firms may license valuable university technologies and conduct subsequent research projects with the university. Limited by the sample size, we have difficulties in splitting the samples into licensing only, R&D cooperation only, and licensing coupled with R&D cooperation. To cite our findings should be cautious about it. Future studies may extend to more collaboration modes.

Another limitation in our study is that we do not take account of consulting and start-ups. Certainly, start-ups bring university technologies out of ivory towers but do not play a dominant role in university technology commercialization [20]. Most of consulting is viewed as an informal collaboration mode because consulting does not generate income for university. Rather, consulting may be coupled with training programs or licensing. Hence, it is difficult to clear the impact of firms' innovation on consulting.

An additional limitation of this study is related to licensing. In this study, we neither distinguish between patent pools and single patents, nor consider the issues of cross-licensing. Perhaps this is one of the reasons that the relationship between the internalization -seeking intent and the choice of licensing is not significant. Hence, additional research in this area might be fruitful.

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