The Impact of Appropriation Strategy on Open Innovation

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Abstract--The purpose of this study is to investigate the relationships between firms' appropriation strategy and open innovation. We identify four distinct groups of appropriation strategy in the electronics sector by Latent Class Analysis of data from the third Taiwan Innovation Survey and Taiwan Economic Journal databank. These four groups of appropriation strategy are proactive group, first-mover group, intellectual property rights (IPRs) group and non-proactive group. We found that firms in proactive group are more open and more likely to cooperate in innovation with competitors than other firms, but less probable to cooperate in innovation with suppliers. Firms belonged to first-mover group are more probable to engage in innovation-related cooperation with suppliers and government research organizations, but less likely to cooperate with clients or customers. Finally, we conclude this study with our findings and implications for further research.

I. INTRUCTION

Open innovation has been viewed as a new paradigm of innovation management. Both academic researchers and practitioners try to understand how to generate inflows and outflows of knowledge to achieve more successful innovation. Previous studies have indicated that open innovation could lead to several benefits to the firms. However, it is not every firm want to open its innovation process to capture these benefits. Why? We conjecture that it depends on whether firm can capture an appropriate return from the outcome of cooperative innovation or not.

To put it more precisely, firms need to cooperate with a large number of external partners to achieve innovation [2]. At the same time, firms also need to protect their knowledge when they engage in innovation-related cooperation and capture as much return as possible from the value created by the cooperative innovation. Appropriability is what allows the innovators to capture a profit from the created value [12], and plays a vital role for open innovation [3], [5].

Several researchers observed that firms pursue a variety of mechanisms beyond patents, such as: secrecy, lead time advantages, complexity of designs, etc, to improve appropriability [4], [6], [9]. That the effectiveness of different mechanisms of appropriation depends on situations has been compared by several studies [4], [6], [8]–[10].

Although most of the researchers compared the effectiveness of each of the appropriation mechanisms separately, firms usually adopt more than one mechanism to protect the same innovation. Cohen, et al. [4] suggested that firms commonly employ a bundle of mechanisms to protect their innovation which is termed the "appropriability strategy" of firms. Some studies used the total number of mechanisms adopted by firms to describe the degree of appropriability of

firms [7], [11]. However, Amara, et al. [1] found that there are complementary and substitute relationships among different appropriability mechanisms. We proposed a new concept called the "portfolio of appropriation mechanisms" or "appropriation strategy" to describe the different emphasis (or weighting) of firms upon various kinds of appropriation mechanisms.

There have been a number of studies on the issue -"How does appropriability influence firms' openness of innovation?" [7], [10], [11], [16]. But little researches have been done on the relationships between firms' appropriation strategy and their choice of innovation cooperators. Thus, the purpose of this study is to investigate the portfolios of appropriation mechanisms of firms and how these portfolios influence firms' openness and cooperators choice of innovation.

The remainder of this paper is organized as follows: The next section reviews relevant literature. Then, section 3 explains our research methods. Section 4 presents the results and discusses the research implications. Section 5 concludes the paper.

II. CONCEPTUAL BACKGROUND

According to the original concept developed by Chesbrough [2], open innovation has been defined as "a paradigm that assumes firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology" [2, xxiv]. Open innovation could lead to several benefits to the firms, for example: reducing of R&D costs, shortening innovation cycles, mitigating risks of innovation, accelerating time to market, and accessing to new market and customers. However, why do some firms not want to open their innovation process? Research has shown that firms need to protect their knowledge when they engage in innovation-related cooperation [3], which means that firms would safeguard the opportunity to capture an appropriate return from the outcome of cooperative innovation. Therefore, we may expect that firms would more likely to carry out open innovation if they have more alternatives to profit from the cooperative innovation.

Appropriability refers to the degree of how the social benefit created by an innovation can be captured by the innovators in a given condition of business environment [12]. Appropriability for each of the involving innovators plays a critical role for open innovation [3], [5].

Several researchers observed that firms pursue a variety of appropriation mechanisms beyond patents, such as secrecy, lead time advantages, etc, to improve appropriability [4], [6],

[9]. Several scholars have compared the effectiveness of different appropriation mechanisms and found that they depend on the innovation situations. [4], [6], [8]–[10]. For example, Harabi [6] found that superior sales and service efforts are the most effective appropriation mechanisms for product innovation, and lead time was the most effective means of appropriation for process innovation. Cohen, et al. [4] noted that secrecy and lead time were considered as the two most effective protect methods for product innovation and secrecy was regard as the most effective one for process innovation.

Although most of the researchers studied the effectiveness of each of the appropriation mechanisms separately, firms usually adopt more than one mechanism to protect the same innovation. According to Cohen, et al. [4], they found that firms commonly employ a bundle of mechanisms to protect the same innovation which is termed the "appropriability strategy" of firms. There are several reasons why this might occur. For example, different mechanisms might be casually connected. Secondly, different mechanisms could be relied on at different stages in a given innovation process. Thirdly, different mechanisms were used at the same time for a given innovation, when an innovation is comprised of separately protected components or features. Some studies have used the total number of mechanisms adopted by firms to describe the degree of appropriability of firms [10], [11]. However, Amara, et al. [1] suggested that there are complementary and the substitute relationships among different appropriation mechanisms. Based on the findings of these literature, we proposes a new concept called the "portfolio of appropriation mechanisms" or "appropriation strategy" to describe the different emphasis (or weighting) of firms upon various kinds of appropriation mechanisms.

Our paper is in a research line of studying the relationship between appropriability and openness of innovation. Moon found that the tightness of appropriability strategy positively influences the firms' openness of innovation by using the data from Korean Innovation Survey of service industries [11]. Lhuillery and Pfister [10] noted that firms are able to appropriate their research results better by presenting lower rates of "cooperation failures". West and Dedrick [16] suggested that open source of software restricts how much firms can capture a return from the value created by an innovation and then effectively forces the openness of innovation. In addition, based on a large-scale survey of UK industries, Laursen and Salter [7] found that the relationship between strength of the firms' appropriability strategy and collaboration breadth is concave. Although there have been a number of studies on the issue, and several researches have used different data analysis techniques to describe the categories of appropriation mechanisms of firms, which includes cluster analysis [13], principal components analysis [9] and factor analysis [4, 13]. But little researches have been done on relationships between the firms' appropriation strategy and their openness of innovation. To bridging this research gap, we first investigate the different types of firms'

appropriation strategy, and then identify how these appropriation strategies influence firms' openness and cooperators choice of innovation.

III. RESEARCH DESIGN

A. Collection of Data
The third Taiwan Innovation Survey (TIS-3)

The third Taiwan Innovation Survey (TIS-3)[1] adopted a questionnaire similar to the CIS 2008 and the sampling procedure of Oslo Manual 2005. A pre-testing was conducted to refine the wordings of the translated questionnaire items. Formal survey was implemented in the period of April to August, 2011. Sampled firms were asked about the information of their innovation activities from 2007 to 2010. This survey successfully collected 13,841 samples, among which 4703 firms are in manufacture sector and 9138 firms in service sector.

Taiwan Economic Journal (TEJ)

In order to obtain financial data of firms, we combined another database－Taiwan Economic Journal (TEJ), which provides corporate information of all listed companies traded in Taiwan Stock Exchange since 1980. TEJ has been recognized as the most authoritative and reliable source of corporate data in Taiwan.

Sample Selection Process

The following sample selection has been employed. After pairing firms both in TIS-3 and TEJ database, 803 firms was matched. In addition, firms were deleted if the variables data are missing. As a result, the 803 firms have been reduced to 496. Furthermore, firms need to belong to electronics industry. Finally, 316 firms were retained for this study.

B. Measurement of Variables
Appropriation mechanisms

The appropriation mechanisms are based on a set of questions in the TIS-3 which ask the firms whether they protected its innovation with different methods in the period 2007 to 2010 or not. The questionnaire lists seven different protection methods, including: (1) patents, (2) registration of design patterns, (3) trademarks, (4) copyrights, (5) secrecy, (6) complexity of designs, or (7) lead-time advantages. Each protection mechanisms is coded as a binary variable, "1" means firm adopted the given protection method, "0" means the method has not been adopted. Table 1 presents the description of other variables used for this study.

TABLE 1 DESCRIPTION OF VARIABLES USED FOR THIS STUDY

Variable	Symbol	Description
Dependent variable		
Openness of innovation	OPENNESS	The degree of cooperative innovation = the number of firm's cooperators (eight external partners including suppliers, clients or customers, competitors, consultants, commercial laboratories/R&D enterprises, universities or other higher education institutes, government research organizations, or private research institutes). The degree ranges from 0 to 8.
Cooperative innovation with suppliers	CO_SUP	1 if firm was engaged in innovation-related cooperation with suppliers, 0 otherwise
Cooperative innovation with clients or customers	CO_CUS	"1" if firm was engaged in innovation-related cooperation with clients or customers, "0" otherwise
Cooperative innovation with competitors	CO_COM	"1" if firm was engaged in innovation-related cooperation with competitors, "0" otherwise
Cooperative innovation with universities or other higher education institutes	CO_UNI	"1" if firm was engaged in innovation-related cooperation with universities or other higher education institutes, "0" otherwise
Cooperative innovation with government research organizations	CO_GMT	"1" if firm was engaged in innovation -related cooperation with government research organizations, "0 "otherwise
Control variable		
Firm size	SIZELN	The natural log of the number of employees
R&D intensity	RDINT	The firm R&D expenditure divided by the firm sales
Subsidiary	SUBS	"1" if firm was a part of an enterprise group, "0" otherwise
Start-up	STUP	"1" if firm was established after 1 January 2000, "0" otherwise

Analysis

First of all, this study used Latent Class Analysis (LCA) to classify appropriation mechanisms since our questions about appropriation mechanisms are binary-type variables. LCA is a multivariate technique based on conditional probabilistic analysis. The objective of this statistical method is to verify whether the association between a set of observed categorical variables could be explained through a latent typology or not which is composed of different classes.

Several researches have used different data analysis techniques to describe the categories of appropriation mechanisms of firms which include cluster analysis [13], principal components analysis [9], and factor analysis [4], [13]. The use of LCA to classify appropriation mechanisms of firms is an original feature of this study.

Secondly, to examine further the effect of appropriation mechanisms from LCA on openness of innovation, we performed Ordinary Least Squares (OLS) to investigate the association of these latent variables with firms' openness of innovation and Probit regressions to assess the relationships between these latent variables and various types of cooperators. This study used Latent Gold version 4.5 for Latent Class Analysis and performed all other analyses with STATA version 12. The proposed research framework is depicted in Fig. 1.
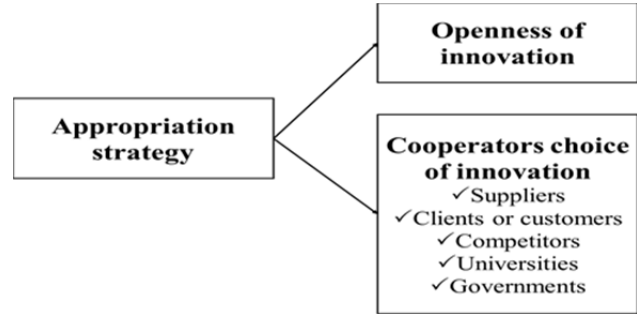

Fig. 1 The proposed research framework

IV. RESULTS

The results of LCA display different solutions, each one with different numbers of classes. The criterion for selecting the most accurate model that fit with the data set was the Bayesian Information Criterion (BIC) due to its consistency in comparison with other criteria, such as the Akaike Information Criterion (AIC). Most of the empirical analysis carried out through LCA has chosen such statistical criterion for model selection. According to this criterion, the accurate model is the one with the lowest value for BIC [14], [15]. The LCA with 4 latent classes provided the best fit for appropriation mechanisms of firms (as Table 2 shown).

TABLE 2 STATISTICAL RESULTS OF LCA USING VARIABLES RELATED TO APPROPRIATION MECHANISMS

	LL	BIC(LL)	Npar	L2	df	p-value	Class.Err.
2-Cluster	-1328.03	2742.395	15	393.1579	112	0.000	0.0619
3-Cluster	-1266.89	2666.161	23	270.8781	104	0.000	0.0363
4-Cluster	-1240.73	**2659.882**	31	218.5528	96	0.000	0.0398
5-Cluster	-1221.54	2667.547	39	180.1727	88	0.000	0.0832
6-Cluster	-1201.20	2672.920	47	139.4995	80	0.000	0.1290
7-Cluster	-1187.54	2691.647	55	112.1805	72	0.002	0.1025

Table 3 and Fig. 2 present results of latent class analysis. We found that firms in "proactive group" (9.49%, Class 1) tended to have high probabilities of using all protection methods to protect their innovation. Those in "first-mover group" (14.88%, Class 2) had mainly high probabilities of adopting registration of design patterns, complexity of designs, and lead-time advantages to obtain a return from their innovation, but the other of probabilities of methods are low. Respondents in "Intellectual Property Rights (IPRs) group" (9.49%, Class 3) had high probabilities of depending on patents, registration of design patterns, trademarks, and copyrights" to protect its innovation, but the probabilities of other methods are low. Finally, respondents in "non-proactive group" (66.9%, Class 4) had low probabilities of using all appropriability mechanisms to protect their innovation.

Table 4 presents results from the regression analysis. The results in Model 1 show that firms in non-proactive group are less open than the other firms. On the contrary, the proactive group is significantly more open.

From Model 2, we found that firms in proactive group are less likely to cooperate in innovation with suppliers than firms in non-proactive group. But firms belonged to first-mover group are more possible to engage in innovation-related cooperation with suppliers than firms in non-proactive group. In Model 3, firms in first-mover group are less probably to cooperate in innovation with clients or customers than those in non-proactive group. We also found that firms in proactive group are more probable to engage in innovation-related cooperation with competitors than firms in non-proactive group (Model 4).

In model 5, we did not find the statistically significant difference among four groups related to cooperating with universities or other higher education institutes. Finally, the results in Model 6 show that firms in first-mover group are more likely to engage in innovation-related cooperation with government research organizations than firms in non-proactive group.
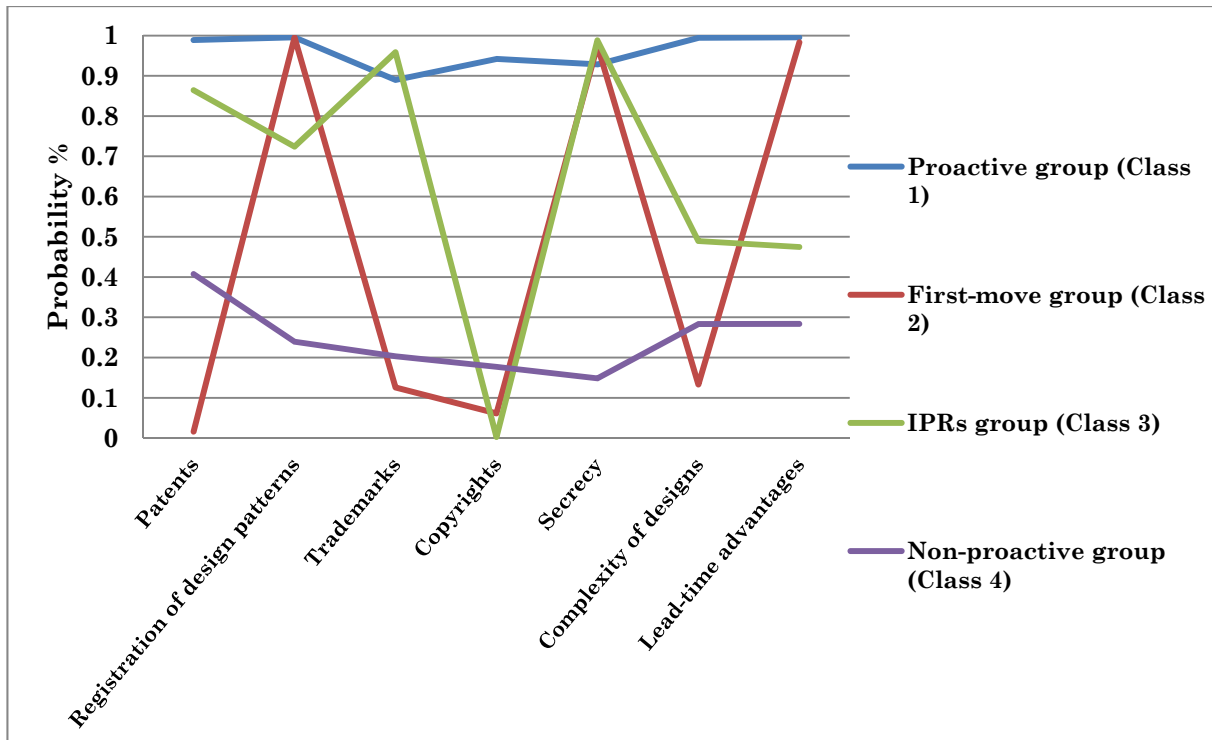

Fig. 2 Probabilities of carrying out the appropriation mechanisms

TABLE 3 SAMPLE DISTRIBUTION AND PROBABILITIES OF CARRYING OUT THE APPROPRIATION MECHANISMS

	Class 1	Class 2	Class 3	Class 4
Label	Proactive group	First-mover group	IPRs group	Non-proactive group
Patents	**0.9888**	0.0161	**0.8641**	0.4074
Registration of design patterns	**0.9954**	**0.9956**	**0.7238**	0.2394
Trademarks	**0.8896**	0.1255	**0.9586**	0.2031
Copyrights	**0.9418**	0.0613	0.0023	0.1768
Secrecy	**0.9281**	**0.9749**	**0.9884**	0.1483
Complexity of designs	**0.9942**	0.1327	0.4895	0.2832
Lead-time advantages	**0.9956**	**0.9830**	0.4746	0.2833
N	30	47	30	209
Share of sample	9.49%	14.88%	9.49%	66.14%

TABLE 4 RESULTS OF REGRESSIONS

	Model 1 OLS OPENNESS	Model 2 Probit CO_SUP	Model 3 Probit CO_CUS	Model 4 Probit CO_COM	Model 5 Probit COUNI	Model 6 Probit CO_GMT
Proactive group	0.988**	-1.088*	-0.504	0.744*	0.506	0.489
	(3.07)	(-2.35)	(-1.45)	(2.26)	(1.72)	(1.66)
First-mover group	0.712**	1.678***	-0.623*	-0.167	-0.483	1.629***
	(2.77)	(7.06)	(-2.17)	(-0.46)	(-1.52)	(7.17)
IPRs group	0.749*	0.457	-0.00136	0.423	0.555	0.286
	(2.42)	(1.77)	(-0.00)	(1.17)	(1.93)	(1.00)
Non-proactive group	Benchmark	Benchmark	Benchmark	Benchmark	Benchmark	Benchmark
SIZELN	0.230	-0.0229	0.191	0.285	0.310	0.00977
	(1.29)	(-0.14)	(1.12)	(1.33)	(1.70)	(0.06)
RDINT	0.0109	0.0316	-0.00465	0.0119	-0.00249	-0.00355
	(0.52)	(1.64)	(-0.24)	(0.44)	(-0.11)	(-0.18)
HO	0.585**	0.304	0.395*	0.174	-0.276	0.306
	(2.81)	(1.71)	(2.12)	(0.65)	(-1.17)	(1.62)
STUP	-0.110	0.167	-0.144	-0.255	0.00845	0.0426
	(-0.47)	(0.77)	(-0.62)	(-0.78)	(0.04)	(0.19)
INDUS (8)	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.909	-0.980	-1.165*	-2.763***	-1.855**	-0.910
	(0.55)	(-1.78)	(-2.04)	(-3.58)	(-2.98)	(-1.60)
No. of obs.	316	315	315	307	307	307
Log likelihood		-158.75668	-145.01419	-75.222893	-116.89763	-145.35805
R^2/Pseudo R^2	0.1112	0.2054	0.0633	0.0795	0.0986	0.1842

t statistics in parentheses
* $p<0.05$ ** $p<0.01$ *** $p<0.001$

V. CONCLUSIONS

The purpose of this study is to investigate the portfolios of appropriation mechanisms (appropriation strategy) of firms, and how these portfolios influence firms' openness and cooperators choice of innovation. A Latent Class Analysis of data from the TIS-3 and TEJ was used to indentify four distinct groups of appropriation strategy in the electronics sector: Proactive, First-mover, IPRs and Non-Proactive group. We further found that firms in proactive group are more open and more likely to cooperate in innovation with competitors than other firms, but less probable to cooperate in innovation with suppliers. We also found that firms belonged to first-mover group are statistically significantly more probably to engage in innovation-related cooperation with suppliers and government research organizations, but less likely to cooperate in innovation with clients or customers.

In summary, our study makes several contributions to theory. First, we identify four distinct types of appropriation strategies. Second, we add to the literature of open innovation by investigating the relationship between appropriation strategy and open innovation. Most of all, we provide insight into the differential impacts of appropriation strategies.

This study is subject to three major limitations. The first limitation is that the survey was mainly designed as "yes" or "no" questions, which limited the richness of the data. Second, this survey was conducted in 2011 and asked respondents to report their innovation activities four years backward (2007-2010). Loss of memory or selected memory may be a concern. Thirdly, we did not understand the characteristics of firms. Future researches should examine this issue by investigating the organizational determinants of

portfolios of appropriation mechanisms. In addition, cross-industry comparison might generate more insights for this research line.

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