Empirical Study Regarding the Leakage of Technological Know-How in Japanese Firms

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Abstract--**Recently, technological know-how has become a significant option to keep the results of research and development confidential, especially in terms of using an open/close strategy. However, since the mobility of human resources and the expansion of firms overseas have increased, the leakage of confidential, technological know-how is of particular concern. Despite its importance, details of its leakage have not been sufficiently revealed since the information regarding technological know-how is not normally open to the public. Therefore, this study focuses on governance and detection activities, and conducts multiple linear regression analysis using the data from a questionnaire survey of Japanese firms to clarify what factors are related to the leakage of technological know-how. As a result, although governance activities are not significantly related to the leakage, the existence of an inverted U-shaped relationship between international detection activities and the leakage of technological know-how is revealed. The results suggest that detection activities themselves possess the deterrent capabilities to prevent the leakage of technological know-how.**

I. INTRODUCTION

As the global economy becomes increasingly knowledge-based, firm-specific knowledge constitutes the most strategically significant source of competitive advantage [6][7][10][15]. Accordingly, intellectual property (IP) management has become increasingly important and complex.

With respect to IP management related to research and development (R&D), firms traditionally attempt to protect their R&D results by patenting. According to Hussinger [9], "patent is a legal instrument for protection of IP by granting the patent holder a temporary monopoly on the patented technology including the right to sue for infringement. However, patents bear the disadvantage that the patented technology has to be disclosed in order to show the court and competitors what is protected." In order to avoid this, firms prefer to keep their R&D results secret. In today's emerging business environment, firms need to adequately consider and select whether they should protect an R&D result as a patent or keep it secret as technological know-how. Thus, technological know-how has recently become the subject of focus.

Conversely, the leakage of confidential, technological know-how is of particular concern since the mobility of human resources and the expansion of firms overseas have increased. Using patent data, Fujiwara [4] shows that many researchers in Japanese firms have moved to other Asian firms after which they engage in R&D activities in the same technological fields. The spread of technological know-how along with such mobility of human resources has resulted in unwanted knowledge leakage [5]. In addition, firms are increasingly collaborating outside of their own boundaries and attempting to acquire external knowledge in order to innovate [3][14][16]. While knowledge sharing is necessary for innovation, collaboration with external partners includes the risk of losing knowledge [2][8][14], and more specifically, technological know-how.

Despite the importance of technological know-how, details of its leakage have not been sufficiently revealed since the information regarding technological know-how is not normally open to the public. Therefore, this study focuses on both governance and detection activities and empirically analyzes the data from a questionnaire survey of Japanese firms in order to clarify the factors related to the leakage of technological know-how.

II. THEORY AND HYPOTHESES

A. Governance activities

Technological know-how is a significant option in terms of an open/close strategy, which is defined as the strategic utilization of a patent or know-how. Yamauchi et al. [18] argue that maintaining optimal balance between a patent and know-how (for example, by protecting peripheral technologies through patents and by keeping core technologies secret as know-how and preventing imitation) enables firms to achieve high innovation performance. However, the leakage of vital, technological know-how undermines the competitive advantage of firms. Thus, protective measures must be adopted.

According to the knowledge leakage literature, there are different protective measures to prevent such knowledge loss. For example, Jiang et al. [10] discuss formal contracts in strategic alliances. When alliance partners have an incentive to behave opportunistically [11], they may illegally and intentionally acquire a focal firm's confidential knowledge [10]. Even if opportunistic partners abuse a focal firm's trust in an effort to acquire proprietary knowledge, formal contracts can counter the breach of trust [10][12]. As other protective measures, Ahmad et al. [1] address measures to prevent unauthorized access to information and data such as security policy and risk management in the realm of information systems security. Furthermore, examining the literature on knowledge leakage and conducting an Australian field study, Ahmad et al. [1] cite the following: identifying

knowledge protection roles; developing policies, procedures, and guidelines; and developing a security culture as protective measures. As seen above, various measures to protect knowledge exist, and the importance of implementing such measures has been pointed out by many researchers.

Governance activities, which we define as protective activities or measures to prevent the leakage of technological know-how, are essential for firms, especially for the ones that conduct R&D. According to Kale et al. [11], the risk of knowledge loss increases if a firm fails to take measures to protect its confidential knowledge. Hence, a low level of governance activities might be associated with a high risk of the leakage of technological know-how. Conversely, achieving a high level of governance activities can decrease the risk of the leakage of technological know-how. Accordingly, the present study posits the following hypothesis:

Hypothesis 1: *Governance activities are negatively associated with the leakage of technological know-how.*

B. Detection activities

Although governance activities are necessary as protective measures, detection activities, which are defined as activities to detect the leakage of technological know-how, are also important. Since such leakage causes loss of competitive advantage, it is important to be aware of it in order to minimize any damage and improve its governance. Although Ahmad et al. [1] cite monitoring of knowledge flows as an example of implementing protection processes and mechanisms, there are no studies that investigated the relationship between leakage detection and knowledge leakage in depth. However, when the level of governance activities of technological know-how is controlled, the more a focal firm implements detection activities, the more it could detect the leakage of technological know-how. In other words, a high level of detection activities increases the number of such leakages detected by a focal firm. Accordingly, this study posits the following hypothesis:

Hypothesis 2: *Detection activities are positively associated with the leakage of technological know-how.*

III. METHOD

A. Sample

The present study used data from a questionnaire survey undertaken at the Research Institute of Economy, Trade and Industry (RIETI). We identified the top 5,000 Japanese organizations (according to the number of patent applications in 2012) and sent 4,807 questionnaires after excluding municipalities and universities. The respondents were asked to answer questions regarding their respective firm's situation from April 2013 to March 2014. A total of 778 responses (gathered from February 2015 to March 2015) were returned, which was a response rate of 16.2%. After the questionnaires with missing data were eliminated, the final usable samples were 770 Japanese firms.

In this questionnaire survey, technological know-how was defined as "IP in the form of a body of technological information that is of a confidential nature, has proprietary value, and can be specified or identified in an appropriate way, but that is not covered by patent rights or copyrights" including "explicit know-how" and "tacit know-how." Explicit know-how was defined as "technological know-how that can be codified and objectively recognized," whereas tacit know-how was defined as "technological know-how that is embedded in the human brain and not easily expressed."

The leakage of technological know-how was defined as "the case or the possibility of technological know-how that is under specific control and not supposed to be known outside a focal firm being unexpectedly lost or leaked - whether deliberately or unintentionally to unauthorized personnel" including unfair acts relating to trade secrets, and not including inevitable information spillovers through public information and products. Mohamed et al. [13] mention "there are different terms used in the literature of knowledge leakage." Although knowledge leakage is sometimes defined in positive terms as Vöhringer et al. [17] do, the present study's definition is perceived as negative knowledge leakage.

B. Measures

Dependent Variables

This study utilized the numbers of governance and detection activities as dependent variables. It also counted a total of nine governance activities and six detection activities implemented by each firm in Japan and in countries other than Japan, respectively. Details of these activities are presented in Table 1.

Independent Variables

In this study, domestic and international leakage of technological know-how was investigated. It utilized the number of events in which the leakage of technological know-how occurred in Japan and the number of events in countries other than Japan as independent variables.

Control Variables

It included the following as control variables: the total R&D expenses in ¥ 1,000,000s, the ratio of outside R&D, the number of total employees, the ratio of retired full-timers, the ratio of new products, the number of group firms, the number of related countries, license experience, the number of patents held, the number of explicit know-how held, the number of tacit know-how held, the ratio of utilized patents, the ratio of utilized explicit know-how, the ratio of utilized tacit know-how, and industry dummy. The ratio of outside R&D was the ratio of the expenses of outside R&D, such as R&D commissioned to other firms and collaborative R&D with

other firms, divided by total R&D expenses. The number of total employees included both full-time employees and part-time ones. The ratio of retired full-timers was the ratio of the number of retired full-time employees divided by the number of total full-time employees. The ratio of new products was the ratio of the number of new products released within the last year divided by the number of total products in the market. The number of group firms included subsidiaries and affiliates in Japan and overseas. The number of related countries was the number of countries in which overseas offices were located. License experience was coded as "1" if a focal firm had experience in licensing technological know-how. The number of patents held was operationalized on a six-point scale, namely 1 ("none"), 2 ("1- 9"), 3 ("10-99"), 4 ("100-999"), 5 ("1,000-9,999"), and 6 ("more than 10,000"). The number of explicit know-how held and that of tacit know-how held were operationalized on a five-point scale, namely 1 ("none"), 2 ("1-9"), 3 ("10-99"), 4 ("100-999"), and 5 ("more than 1,000"). The ratio of utilized patents, the ratio of utilized explicit know-how, and the ratio of utilized tacit know-how were the ratios of the number of utilized patents or technological know-how divided by the number of held patents or technological know-how. The industry dummy was coded as "1" if a focal firm's type is production-use machinery industry.

TABLE.1 GOVERNANCE AND DETECTION ACTIVITIES

Governance activities	
1	Develop policies on the protection of technological know-how.
2	Establish a department and/or appoint a person for the governance of technological know-how.
3	Conclude nondisclosure agreements with the majority of business partners.
4	Develop information security policies.
5	Conclude nondisclosure agreements with board members and employees.
6	Conclude noncompete agreements with board members and employees.
7	Establish a consulting system and/or service that an employee can consult regarding whether his/her business violates applicable laws and regulations beforehand.
8	Routinely audit from the perspective of protecting technological know-how.
9	Have a reward system for the development of technological know-how.
Detection activities	
1	In order to detect leakage of technological know-how, check similar products in the market.
2	In order to detect leakage of technological know-how, analyze main competitors' products.
3	In order to detect leakage of technological know-how, analyze competitors' patents.
4	In order to detect leakage of technological know-how, control and monitor access to information (log management, etc.) in information security.
5	In order to detect leakage of technological know-how, monitor retired employees.
6	In order to detect leakage of technological know-how, audit outsourcing companies based on a clause related to auditing in a contract.

IV. RESULTS

In order to examine the relationship between governance and detection activities and the leakage of technological know-how, this study conducted multiple linear regression analysis. Table 2 shows the descriptive statistics, while Tables 3 and 4 present the multiple linear regression estimates. Table 3 indicates that the dependent variable is the leakage of technological know-how in Japan, whereas Table 4 indicates that the dependent variable is the leakage of technological know-how in countries other than Japan.

Model 1 includes the control variables, Model 2 includes the independent variable of governance activities, Model 3 includes the independent variable of detection activities, and Model 4 includes the independent variables of both governance and detection activities. The independent variable of governance activities is not significant in all models. Therefore, Hypothesis 1 is not supported.

The independent variable of detection activities is not significant in models in Japan, as shown in Table 3. Although the variable of detection activities is significantly positive at the $p < 0.05$ level in Model 3 in which the dependent variable is the leakage of technological know-how in countries other than Japan, it is not significant in Model 4 including the variable of governance activities, as shown in Table 4. This means that Hypothesis 2 is also not supported.

This study also tested for nonlinear relationships between governance and detection activities and the leakage of technological know-how in Models 5 to 9. The squared term of governance activities is not statistically insignificant. Although the squared term of detection activities is not significant in models in Japan (as shown in Table 3), the variable of detection activities is significantly positive at the $p < 0.01$ level and the squared term of detection activities is significantly negative at the $p < 0.05$ level in Models 7 to 9 in countries other than Japan, as shown in Table 4. This indicates the existence of an inverted U-shaped relationship between detection activities and the leakage of technological know-how. Finally, Fig. 1 shows the one-way analysis of variance result that the factor is the variable of detection activities and the dependent variable is the leakage of technological know-how in countries other than Japan. Fig. 1 also reveals the inverted U-shaped relationship between international detection activities and the international leakage of technological know-how.

TABLE.2 DESCRIPTIVE STATISTICS: CORRELATIONS

Valiables	1	2	3	4	5	6	7	8	9	10	11
1 Domestic leakage	1										
2 International leakage	0.100**	1									
3 Standardized domestic governance activities	-0.074	0.029	1								
4 Standardized international governance activities	-0.043	0.036	0.533**	1							
5 Standardized domestic detection activities	0.081*	0.105**	0.372**	0.177**	1						
6 Standardized international detection activities	0.018	0.030	0.275**	0.441**	0.531**	1					
7 The total R&D expenses	-0.024	0.009	0.158**	0.248**	0.151**	0.292**	1				
8 The ratio of outside R&D	-0.007	0.008	-0.141*	-0.058	-0.036	0.014	0.022	1			
9 The number of total employees	-0.021	0.026	0.178**	0.188**	0.080*	0.089*	0.453**	-0.005	1		
10 The ratio of retired full-timers	0.006	0.067	-0.070	-0.059	-0.040	-0.020	-0.029	0.115*	-0.059	1	
11 The ratio of new products	-0.017	0.084	-0.025	0.047	-0.004	0.027	0.040	0.052	0.048	-0.025	1
12 The number of group firms	-0.036	0.014	0.246**	0.256**	0.156**	0.085*	0.458**	-0.014	0.552**	-0.039	0.009
13 The number of related countries	-0.030	0.053	0.209**	0.278**	0.046	0.059	0.632**	-0.089	0.377**	-0.051	-0.015
14 License experience	0.076*	0.057	0.139**	0.138**	0.095*	0.061	0.153**	0.056	0.176**	0.021	0.063
15 The number of patents held	-0.005	0.024	0.331**	0.372**	0.155**	0.183**	0.297**	-0.119*	0.405**	-0.085	-0.025
16 The number of explicit know-hows held	0.117**	0.024	0.340**	0.237**	0.258**	0.163**	0.217**	-0.056	0.284**	-0.045	0.028
17 The number of tacit know-hows held	0.106*	0.075	0.272**	0.301**	0.245**	0.210**	0.195**	-0.028	0.224**	-0.051	0.019
18 The ratio of utilized patents	0.045	0.140**	-0.038	-0.031	0.153**	0.017	-0.003	-0.064	-0.026	-0.052	0.152**
19 The ratio of utilized explicit know-hows	0.043	-0.049	0.020	0.044	0.107*	0.037	0.037	-0.064	0.061	-0.062	0.033
20 The ratio of utilized tacit know-hows	0.017	-0.010	0.055	0.048	0.060	0.073	0.059	-0.105	0.061	-0.155*	0.006
21 Industry dummy	0.024	0.079*	0.047	0.052	-0.009	0.017	0.029	-0.074	-0.004	0.054	0.050

Valiables	12	13	14	15	16	17	18	19	20	21
12 The number of group firms	1									
13 The number of related countries	0.453**	1								
14 License experience	0.174**	0.088*	1							
15 The number of patents held	0.435**	0.375**	0.262**	1						
16 The number of explicit know-hows held	0.229**	0.275**	0.278**	0.408**	1					
17 The number of tacit know-hows held	0.114**	0.185**	0.256**	0.329**	0.637**	1				
18 The ratio of utilized patents	-0.054	-0.041	-0.007	0.039	0.111*	0.033	1			
19 The ratio of utilized explicit know-hows	0.131**	0.039	-0.036	0.070	0.046	0.062	0.306**	1		
20 The ratio of utilized tacit know-hows	0.134*	0.038	-0.030	0.065	0.076	0.105*	0.190**	0.710**	1	
21 Industry dummy	-0.006	0.038	0.034	0.045	0.021	0.025	0.075	-0.039	-0.069	1

*p<0.05, **p<0.01

TABLE.3 MULTIPLE LINEAR REGRESSION RESULTS

Variables	Domestic leakage of technological know-how (leakage in Japan)								
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Standardized domestic governance activities		-0.038		-0.127	-0.014	-0.087		-0.122	-0.085
Standardized domestic governance activities^2					-0.056	-0.115			-0.113
Standardized domestic detection activities			0.201	0.240		0.267	0.255	0.276	0.286
Standardized domestic detection activities^2							-0.031	-0.021	-0.012
The total R&D expenses	-0.00002	-0.00002	-0.00001	-0.00001	-0.00002	-0.00001	-0.00001	-0.00001	-0.00001
The ratio of outside R&D	-0.314	-0.404	-0.513	-0.533	-0.376	-0.491	-0.536	-0.548	-0.500
The number of total employees	0.0001	0.0002	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001
The ratio of retired full-timers	-0.427	-0.481	-0.417	-0.379	-0.610	-0.631	-0.420	-0.383	-0.628
The ratio of new products	-0.072	-0.076	-0.078	-0.084	-0.078	-0.089	-0.081	-0.086	-0.090
The number of group firms	-0.041**	-0.052**	-0.049**	-0.048**	-0.052**	-0.048*	-0.050**	-0.049**	-0.048*
The number of related countries	0.104*	0.106*	0.088	0.094*	0.106*	0.092*	0.087	0.094*	0.092
License experience	0.519	0.529	0.501	0.506	0.543	0.532	0.494	0.502	0.528
The number of patents held	0.413	0.407	0.442	0.442	0.396	0.425	0.433	0.436	0.421
The number of explicit know-hows held	-0.274	-0.269	-0.345	-0.320	-0.275	-0.339	-0.350	-0.324	-0.341
The number of tacit know-hows held	0.073	0.083	0.089	0.100	0.092	0.119	0.092	0.101	0.120
The ratio of utilized patents	0.006	0.007	0.005	0.004	0.007	0.004	0.005	0.004	0.004
The ratio of utilized explicit know-hows	0.002	-0.012	-0.014	-0.017	-0.014	-0.021	-0.014	-0.017	-0.021
The ratio of utilized tacit know-hows	-0.011	-0.013	-0.008	-0.003	-0.011	0.003	-0.009	-0.003	0.003
Industry dummy	1.068**	1.143**	1.193**	1.198**	1.135**	1.189**	1.197**	1.201**	1.190**
N	147	141	141	141	141	141	141	141	141
R^2	0.171	0.183	0.198	0.202	0.184	0.207	0.199	0.203	0.207
Adjusted R^2	0.076	0.078	0.094	0.092	0.071	0.090	0.088	0.085	0.083

*p<0.05, **p<0.01, ***p<0.001

TABLE.4 MULTIPLE LINEAR REGRESSION RESULTS

Variables	International leakage of technological know-how (leakage in countries other than Japan)								
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Standardized international governance activities		0.095		0.017	0.036	-0.026		-0.041	-0.077
Standardized international governance activities^2					0.043	0.032			0.027
Standardized international detection activities			0.161*	0.155		0.153	0.536**	0.566**	0.563**
Standardized international detection activities^2							-0.132*	-0.137*	-0.137*
The total R&D expenses	-0.00003*	-0.00002*	-0.00002*	-0.00002*	-0.00002*	-0.00002*	-0.00002	-0.00002	-0.00002
The ratio of outside R&D	-0.052	-0.026	-0.103	-0.094	-0.061	-0.120	-0.155	-0.178	-0.198
The number of total employees	0.00007	0.00007	0.00005	0.00005	0.00008	0.00006	0.00005	0.00004	0.00005
The ratio of retired full-timers	1.149	1.040	1.020	1.002	1.161	1.093	1.054	1.099	1.175
The ratio of new products	0.052	0.052	0.047	0.047	0.054	0.049	0.043	0.043	0.044
The number of group firms	-0.014	-0.015	-0.013	-0.014	-0.015	-0.014	-0.015	-0.014	-0.014
The number of related countries	0.084**	0.080**	0.075**	0.075**	0.081**	0.075**	0.073**	0.074**	0.075**
License experience	0.109	0.082	0.102	0.099	0.083	0.100	0.105	0.113	0.113
The number of patents held	0.051	0.032	0.058	0.054	0.030	0.053	0.048	0.056	0.054
The number of explicit know-hows held	0.014	0.016	-0.027	-0.024	0.011	-0.027	-0.007	-0.012	-0.015
The number of tacit know-hows held	-0.0004	-0.014	-0.001	-0.002	-0.028	-0.012	-0.038	-0.036	-0.044
The ratio of utilized patents	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004
The ratio of utilized explicit know-hows	-0.003	-0.002	0.003	0.003	-0.003	0.002	-0.010	-0.010	-0.011
The ratio of utilized tacit know-hows	0.019	0.019	0.014	0.014	0.018	0.013	0.020	0.020	0.019
Industry dummy	0.357	0.362	0.431	0.425	0.387	0.443	0.456	0.470	0.485
N	147	141	141	141	141	141	141	141	141
R^2	0.139	0.147	0.173	0.173	0.149	0.174	0.216	0.217	0.218
Adjusted R^2	0.040	0.037	0.066	0.059	0.032	0.053	0.107	0.101	0.095

*p<0.05, **p<0.01, ***p<0.001

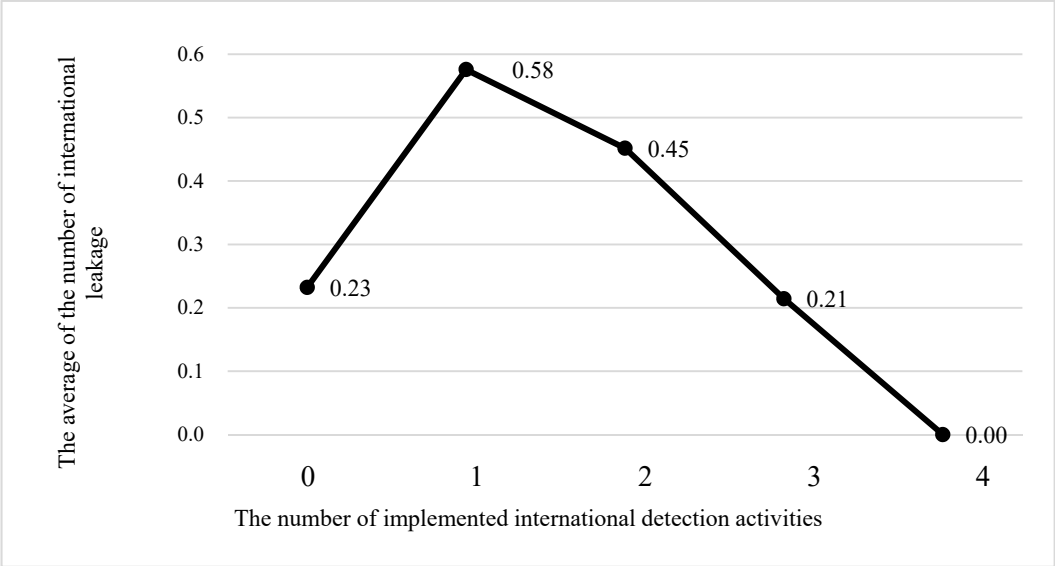

Figure.1 One-Way Analysis Of Variance Result

V. DISCUSSION

By conducting empirical analysis, this study found that detection activities rather than governance activities are related to the leakage of technological know-how.

It found that neither domestic nor international governance activities significantly affect the leakage of technological know-how. In the literature of knowledge leakage, Jiang et al. [10] empirically analyze the effect of formal contracts and trust in strategic alliances as governance mechanisms on knowledge leakage, and indicate that, although formal contracts by themselves are not significantly associated with the likelihood of knowledge leakage, formal contracts with trust are significantly associated with such leakage. Hannah [8] also empirically reveals that familiarity with trade secret protection procedures influences employees' beliefs regarding their obligations to protect trade secrets. Thus, this study did not find a significant relationship between governance activities and the leakage, since the social and psychological factors of those dealing with technological know-how and their governance (rather than the level of implemented governance activities) are associated with the leakage of technological know-how.

Conversely, this study found an inverted U-shaped relationship between international detection activities and the leakage of technological know-how. This result indicates that the more a focal firm implements detection activities, the more it can detect the leakage of technological knowledge until it reaches a certain level of detection activities. In addition, above a certain level, the more a focal firm implements detection activities, the less it can detect the leakage of technological knowledge. The number of leakages of technological know-how that is determined by a focal firm is considerably low when the firm rarely implements international detection activities. The reason being that it is difficult for a firm which rarely implements detection activities to determine even if the leakage of technological know-how is occurring. On the other hand, the number of leakages of technological know-how determined by a focal firm is also low when the firm strenuously implements international detection activities. This is because the number of leakages of technological know-how itself is low. Ahmad et al. [1] suggest that the most risk-aware enterprises tend to track and watch employees who deal with confidential knowledge, especially in terms of knowledge leakage. Therefore, detection activities themselves possess the deterrent capabilities to prevent the leakage of technological know-how.

However, the results of this study show that domestic detection activities do not significantly affect the leakage of technological know-how. This is because the independent variable in this study is the number of leakage events of technological know-how which a focal firm is aware of. Compared with overseas, it is easy to detect the leakage of technological know-how without detection activities since firms can easily obtain information about competitors' products and patents in the domestic country. Hence, detection activities have relatively less impact on the leakage of technological know-how in the domestic country.

Previous studies have mainly focused on governance, management, and mechanisms of knowledge protection, such as identifying knowledge protection roles; developing policies, procedures, and guidelines; and developing a security culture [1] as a way to prevent knowledge leakage. However, the present study reveals the possibility that detection activities are more important to prevent the leakage of technological know-how than governance activities, especially overseas. Governance activities are internal firm

activities such as developing information security policies, whereas detection activities are external firm activities such as checking competitors' products and patents. Since the leakage of technological know-how is an event that occurs outside a firm's boundaries, it is anticipated that activities that possess external deterrent capabilities, such as detection activities, can help prevent such leakage. Moreover, the findings of this study offer useful insights into knowledge management, as managerial implications. According to Fig. 1, firms that implement one international detection activity have the most experience of the leakage of technological know-how. Therefore, firms should establish a system and a mechanism that they can implement two or more detection activities.

Finally, this study includes some limitations. First, since it used the number of leakage events until 2013 as dependent variables and governance and detection activities implemented in 2013 as independent variables, the preceding/following time relationship between the leakage and these activities is unclear. Although additional analysis results in which the dependent variables are governance and detection activities and the independent variable is the number of leakage events are not convincing (data not shown), future studies should conduct an analysis that considers the preceding/following time relationship. Second, there are some properties of technological know-how such as those that cannot be patented and those that are not daringly patented. Therefore, future studies should consider such properties.

ACKNOWLEDGMENTS

This study was conducted as a part of the "Study on Technology Know-how and its Protection via Questionnaire Survey on the Japanese Manufacturing Industry" undertaken at RIETI, and an expansion of the earlier discussion paper in this project. This author gratefully acknowledges the support from RIETI and the study group members.

REFERENCES

[1] Ahmad, A., R. Bosua and R. Scheepers, "Protecting organizational competitive advantage: a knowledge leakage perspective," *Computers & Security*, *42*, 27-39, 2014.

[2] Baughn, C. C., J. G. Denekamp, J. H. Stevens and R. N. Osborn, "Protecting intellectual capital in international alliances," *Journal of World Business*, *32*(2), 103-117, 1997.

[3] Duysters, G., and B. Lokshin, "Determinants of alliance portfolio complexity and its effect on innovative performance of companies," *Journal of Product Innovation Management*, *28*(4), 570-585, 2011.

[4] Fujiwara, A., "IP system and corporate R&D activities -Empirical analysis of the effect of worker mobility on innovation-," *Institute of Intellectual Property*, 2014. World Wide Web, http://www.iip.or.jp/summary/pdf/detail13j/h25_t05.pdf (in Japanese)

[5] Fujiwara, A. and T. Watanabe, "The effect of researcher mobility on organizational R&D performance: researcher mobility and innovation," In *ISPIM Innovation Symposium* (p. 1). The International Society for Professional Innovation Management (ISPIM), December 2013.

[6] Grant, R. M., "Toward a knowledge - based theory of the firm," *Strategic management journal*, *17*(S2), 109-122, 1996.

[7] Grant, R. M., and C. Baden - Fuller, "A knowledge accessing theory of strategic alliances," *Journal of management studies*, *41*(1), 61-84, 2004.

[8] Hannah, D. R., "Should I keep a secret? The effects of trade secret protection procedures on employees' obligations to protect trade secrets," *Organization Science*, *16*(1), 71-84, 2005.

[9] Hussinger, K., "Is silence golden? Patents versus secrecy at the firm level," *Economics of Innovation and New Technology*, *15*(8), 735-752, 2006.

[10] Jiang, X., M. Li, S. Gao, Y. Bao and F. Jiang, "Managing knowledge leakage in strategic alliances: The effects of trust and formal contracts," *Industrial Marketing Management*, *42*(6), 983-991, 2013.

[11] Kale, P., H. Singh and H. Perlmutter, "Learning and protection of proprietary assets in strategic alliances: Building relational capital," *Strategic management journal*, *21*(3), 217-237, 2000.

[12] Li, J. J., L. Poppo and K. Z. Zhou, "Relational mechanisms, formal contracts, and local knowledge acquisition by international subsidiaries," *Strategic Management Journal*, *31*(4), 349-370, 2010.

[13] Mohamed, S., D. Mynors, A. Grantham, K. Walsh and P. Chan, "Understanding one aspect of the knowledge leakage concept: people," In *Proceedings of the European and Mediterranean Conference on Information Systems (EMCIS)* (pp. 6-7), July 2006.

[14] Ritala, P., H. Olander, S. Michailova and K. Husted, "Knowledge sharing, knowledge leaking and relative innovation performance: An empirical study," *Technovation*, *35*, 22-31, 2015.

[15] Somaya, D., "Patent strategy and management an integrative review and research agenda," *Journal of Management*, *38*(4), 1084-1114, 2012.

[16] Spithoven, A., D. Frantzen and B. Clarysse, "Heterogeneous firm - level effects of knowledge exchanges on product innovation: Differences between dynamic and lagging product innovators," *Journal of Product Innovation Management*, *27*(3), 362-381, 2010.

[17] Vöhringer, F., T. Kuosmanen and R. Dellink, *A proposal for the attribution of market leakage to CDM projects*. HWWA, 2004.

[18] Yamauchi, I., Y. Furusawa, K. Edamura and S. Yoneyama, "Know-how management and innovation performance," *Second Theory-Oriented Research Group, National Institute of Science and Technology Policy*, DISCUSSION PAPER;084, 2012 (in Jananese).