The Reason to Form a "Keiretsu" in Terms of Technology Transfer

Atsushi Inuzuka
Nagoya University, Graduate School of Economics, Japan

Abstract--**"Keiretsu" is a network of businesses that own stakes in each other as a means of mutual security and technology exchange especially in Japan, and usually includes large manufacturers and their suppliers of raw materials and components. This study focuses on a large automobile company, Toyota Corporation which is well known to have a large Keiretsu network, and investigate the contribution of having Keiretsu companies to the parent company in terms of technology transfer.**

The author collected patents with Toyota as an applicant during 1983-1999, and extracted the patent citations between the focal patents and the patents the focal patent cites (backward citations). Each paired-patent between the focal patent and the backward patent was categorized into (a) a citation from parent company (self-citations), (b) a citation from a Keiretsu company (Keiretsu-citations), or (c) a citation neither from a parent company nor from a Keiretsu company (external-citations). Then the author tested which category really contributes to the values of the focal patents in the parent company.

The analysis showed that the Keiretsu-citations have a moderate contribution to Toyota. A strong reason for the parent company to form the Keiretsu was not found in terms of technology transfer.

I. INTRODUCTION

"Keiretsu" is a network of businesses that own stakes in each other as a means of mutual security and technology exchange especially in Japan, and usually includes large manufacturers and their suppliers of raw materials and components. Historically, research on organizational boundaries has been explained by the transaction cost economics: companies should take a buying decision (buying a partner) only when the merits of buying a partner surpass the ones of finding the "righteous" partner. However, in terms of the reason to form a Keiretsu network, it is often explained from a learning perspective: Because Keiretsu companies need sustainable orders from the parent company to survive, they are expected to give their specific knowledge to their parent company. Reciprocal learning [3], institutionalized knowledge sharing routines [4], or long-term cumulative learning [17] is considered to the reason for competitiveness. If this win-win relationship is real, both the parent company and Keiretsu companies must gain higher value each other from the network, however, the value has not been quantitatively tested.

This paper tries to confirm the effect of forming a Keiretsu network using patent information. Patents have ample information to trace the technology flow. In the procedure of granting patents, patent examiners must add information of prior art inventions that are related to the focal patent so that they assure the focal patent is "novel" (for the patents to be granted, they must be useful and novel)[1]. Therefore, in principal, it is considered that a citation of Patent X by Patent Y indicates that Patent Y builds upon previously existing knowledge embodies in Patent X [18]. Additionally, since patent documents have information of the inventor and the organization that will control the patent (i.e., applicants), it is useful to identify from where the original ideas of each of the inventions came.

The remainder of this paper is organized as follows. In the next section, I briefly survey the academic contributions with respect to this issue and present the hypotheses. The following section describes the analytical procedure and the variables used for testing the hypotheses. The results are presented and discussed in the next two sections.

II. THEORETICAL BACKGROUND

It is said that there is a dilemma when a company tries to gain knowledge from other companies. Wuyts, Colombo, Dutta and Nooteboom[20] explained the dilemma borrowing the concept "cognitive distance (the differences of cognition between two companies)." According to their notion, optimal learning in inter-firm relationship entails a trade-off between the advantage of increased cognitive distance for a higher novelty value of a partner's knowledge, and the disadvantage of less mutual understanding. If the value of learning is the mathematical product of novelty value and understandability, there is an inverse U-shaped relation with cognitive distance, with an optimum level that yields maximal value of learning.

Perhaps, the first research who tested the cognitive distance using patent information is Miller, Fern and Cardinal's work [12]. They looked into the U.S. patents granted to financial companies or those with a primary SIC code of 99 (non-classifiable establishments), and examined every patent's citation pattern to determine whether the cited patents were held by the same division (intradivisional self-citations), another division in the same organization (interdivisional self-citations), or another organization (extraorganizational citations). After the determination, they investigated the impact of each category of citations to the focal patent's technological value (the number of citation the focal patent received) and concluded that the interdivisional

[1] Some may concern that since patent examiners all have input to the citation process, citations are a noisy indicator of the knowledge that inventors use in their inventions. Obviously, some citations may not indicate a direct knowledge link but may instead be included to clarify the claims of the new invention, defend against lawsuits, signal the potential application in multiple industries, or demonstrate the feasibility of the proposed invention [11].

self-citations had the most positive effect whereas the intradivisional self-citation had negative one. Besides, the effect of the knowledge outside (extraoranizational citations) turns to be positive but not so strong. The results imply that "moderate distance from knowledge source" is beneficial in terms of transferring technology.

The merit of this "moderate distance" could also be explained by the mathematical product of novelty value and understandability. "Far-distant knowledge" could bring path-breaking insight [5][6][14][15][16], however, viable innovations are hardly expected because it requires an arduous relationship with the source of knowledge [2]. In contrast, bridging of "nearest knowledge" should be easier to understand, however, viable insights are unlikely to occur because "nearest knowledge" often is a refinement of existing technology. From the above reason, "moderate distance knowledge" becomes the reasonable choice from the technology seekers to acquire valuable insights with relative low cost.

This paper thinks that the same logic applies between a parent company and Keiretsu companies. The needs to bridge knowledge outside usually bring about when a parent company cannot solve the technological problems by itself. Therefore, using knowledge within the parent company is not likely to contribute to solve those problems completely, then, the newly created technology also does not likely to have high value. However, since assimilating knowledge outside is far difficult for a parent company, Keiretsu companies become attractive knowledge sources.

From the discussions above, the following hypotheses are given.

H1: For a parent company, the value of patents created by technology from Keiretsu companies is higher than one from the parent company.

H2: For a parent company, the value of patents created by technology from Keiretsu companies is higher than one from external companies (neither the parent company nor Keiretsu companies).

III. METHOD

A. Data

I selected Toyota Corporation as a parent company. Toyota is a well-known automobile company which has a large network with its Keiretsu companies, and from the network, Toyota is said to accept various kinds of technical support. Selecting Toyota as a parent company has a merit from an empirical point of view. Toyota has established its own corporate group "Kyohokai," the voluntary organization of parts suppliers to establish and develop such Toyota-affiliated companies as manufacturers of specialized parts. In 2014, the Kyohokai consists of 220 members (companies). Since it is widely recognized as Toyota's formal Keiretsu organization, Keiretsu companies can be operationally identified as being a member of the Kyohokai.

I collected public patent bulletins filed to the JPO (Japanese Patent Office) from 1983 to 1999 with the condition of "Toyota Corporation" as a patent applicant/holder (this paper calls these patents the "focal patents"). Using a commercial patent database the SRPARTNER (Hitachi, Co., Ltd), 46,025 patents are collected. Referring the information of the citing patents (hereafter, backward patents) on each focal patent, I made paired-data between these (backward patents – focal patents). The number of those (the sample size of this paper) becomes 45,883.

B. Dependent Variables

Miller, Fern and Cardinal [12] investigated the impact of technology inflow (i.e., the number of citation the focal patents cites) by analyzing to what extent those inflows contributed to technology outflows (the number of citations the focal patent received). A number of researchers regarded the forward citations as technological value [1][7][8][13][19]. This notion is also backed up by the fact that highly cited patents lead to more economic profits than patents that are less frequently cited [9].

Following these works, this paper considers technological value of a focal patent as the *total number of times the focal patent is cited by subsequent patents* (i.e., the number of citations focal patent received).

C. Independent Variables

I added dummy variables on each paired data. Each paired data is categorized in the following way. A dummy on *Keiretsu-citations* is 1 when a backward patent has at least one Keiretsu company as applicants (otherwise, 0). A dummy on *external-citations* is 1 when a backward patent does not have "Toyota" nor Keiretsu companies (otherwise, 0). Keiretsu companies are identified by being nominated as a member of the "Kyohokai" at least once from 1984 to 1998. The company-lists of the Kyohokai are captured by the issues: "The current status of Toyota Automobile Group '84-'98 (published by IRC, Co. Ltd)" and "Steps of Kyohokai 50 years (published by Toyota Kyohokai).

D. Controls

I create some control variables that are considered to affect the dependent variables.

The *number of pages of backward/focal patent* designates the complexity of invention. Generally, a complex invention requires many pages to explain.

The *number of patents backward patent cites* relates to the degree of innovativeness. The invention that cites many patents is considered having many insights.

The *number of inventors of backward/focal patent* reflects the importance of the inventions for an applicant(s). When a company put much emphasis on the invention, it would try to

pour more human energy into the invention.

The *number of citations backward patent received* could also be a proxy of the technological value of backward patent.

Finally, since this paper uses the number of forward citations as a dependent variable, it is needed to control the tendency for newer patents to receive fewer citations than older patents. This paper puts the *application year of focal patent* into the analysis. Technically, after computing the number of days passed from 1993/1/1 (the start of the investigation period), the number is divided by 365.25.

IV. RESULTS

I use the weighted linear multiple regression analysis with an inverse of the number of citations focal patent cites as a weight value. The results are shown in the second column (*number of citations focal patent received* as a dependent variable) in Table 1.

Our concerns are the coefficients on the dummy variables. As a dummy for the self-citations is omitted, we can think it as the baseline. The coefficients on Keiretsu-citations (dummy) and external-citations (dummy) are both positive and significant, which supports for H1. However, since the effect on Keiretsu-citation is same as one on external citation, H2 is rejected.

I performed several robustness checks, varying the measures of dependent variables. Since patents have the IPC (International Patent Classification) code, which designates each patent's technology area (for example, the IPC class "B60" represents the technology of "vehicle in general"), I make two types of dependent variables: the number of citations received in the same technology area (the focal patent and backward patent have the same head-IPC class) and one in different technology area (the focal patent's head-IPC class and the backward patent's one are different). The results in Table 1 (in the two right-side columns) show us that results are robust.

V. DISCUSSION

It is considered that sharing knowledge with Keiretsu companies is the main reason to build a Keiretsu network for a parent company. However, the analyses above contradict the idea at least for Toyota because the effect of using technology from Keiretsu companies is almost as same as one from external companies.

As a help for thinking generality of the result, I created another data set for Nissan, one of large automobile companies which also have Keiretsu networks. The same procedure is used for the analysis (Keiretsu companies of Nissan are identified by being nominated as a member of a corporate group, "Syohokai"). The result is shown in Table 2. Surprisingly, the usage of technology from Keiretsu companies is even worse than Toyota's case. This implies that Toyota's case shows a better scenario rather than a worst one.

TABLE 1. RESULTS OF THE MULTI-REGRESSION ANALYSES (TOYOTA)

	dependent variables		
independent variables	number of citations focal patent received	number of citations focal patent received in the same area	number of citations focal patent received in different area
Number of pages of backward patent	−0.003	−0.003	−0.002
Number of patents backward patent cites	0.004	0.001	0.007
Number of inventors of backward patent	0.002	0.006	−0.006
Number of citations backward patent received	0.200 ***	0.167 ***	0.141 ***
Number of pages of focal patent	0.105 ***	0.100 ***	0.057 ***
Number of patents focal patent cites	0.108 ***	0.091 ***	0.076 ***
Number of inventors of focal patent	−0.026 ***	−0.023 ***	−0.017 ***
Application year of focal patent	0.083 ***	0.076 ***	0.049 ***
Dummy on self-citations	—	—	—
Dummy on Keiretsu-citations	0.039 ***	0.019 **	0.049 ***
Dummy on external-citations	0.039 ***	0.019 **	0.048 ***
adj.R2	0.102	0.077	0.045
F	522.2 ***	384.1 ***	217.3 ***

NOTE: numeric values represent standarized pertial regression coefficient（N=45883. * p<.05, ** p<.01, *** p<.001）.

TABLE 2. RESULTS OF THE MULTI-REGRESSION ANALYSES (NISSAN)

	dependent variables		
independent variables	number of citations focal patent received	number of citations focal patent received in the same area	number of citations focal patent received in different area
Number of pages of backward patent	−0.019 ***	−0.006	−0.027 ***
Number of patents backward patent cites	−0.005	−0.010 *	0.005
Number of inventors of backward patent	0.213 ***	0.167 ***	0.161 ***
Number of citations backward patent received	−0.014 **	−0.015 **	−0.004
Number of pages of focal patent	0.170 ***	0.157 ***	0.093 ***
Number of patents focal patent cites	0.113 ***	0.101 ***	0.067 ***
Number of inventors of focal patent	0.028 ***	0.008	0.041 ***
Application year of focal patent	0.035 ***	0.031 ***	0.022 ***
Dummy on self−citations	—	—	—
Dummy on Keiretsu−citations	0.013 *	−0.010	0.040 ***
Dummy on external−citations	0.029 ***	0.012 *	0.037 ***
adj.R2	0.118	0.086	0.053
F	525.6 ***	368.9 ***	221.0 ***

NOTE: numeric values represent standarized pertial regression coefficient（N=39644. * p<.05, ** p<.01, *** p<.001）.

VI. CONCLUSION

The above analyses generally show the importance of finding technology from outside of the company. However, it is also found that transferring technology from Keiretsu companies is not the strong reason to form a Keiretsu network for a parent company. What other reasons must I think?

To unlock the mystery, I have recently found that Toyota had established a strong mechanism not to leak out its technology to other companies [10]. But, I have not still found that how and why Toyota could establish such a mechanism. Maybe, the results tell me the need to focus more on an intangible aspect of technology transfer.

ACKNOWLEDGEMENTS

This research was partially supported by the Ministry of Education, Science, Sports and Culture, Grant-in-Aid for Scientific Research (C), 23530471.

REFERENCES

[1] Albert, M. B., Avery, D., Narin, F., and McAllister, P. (1991), "Direct validation of citation counts as indicators of industrially important patents," *Research Policy*, Vol.20, No.3, pp.251-259.

[2] Cohen, W. M., and Levinthal, D. A. (1990) "Absorptive Capacity: A new Perspective on Learning and Innovation," *Administrative Science Quarterly*, Vol.35, pp.128-152.

[3] Dyer, J. H., and Hatch, N. W. (2006), "Relation-specific capabilities and barriers to knowledge transfers: Creating advantage through network relationships," *Strategic Management Journal*, Vol.27, pp.701-719

[4] Dyer, J. H., and Noveoka, K. (2000), "Creating and managing a high-performance knowledge sharing network: The TOYOTA case," *Strategic Management Journal*, Vol.21, pp.345-367.

[5] Fleming, L. (2001), "Recombinant uncertainty in technological search," *Management Science*, Vol.47, pp.117-132.

[6] Galunic, D. C., and Rodan, S. (1998), "Resource recombinationsin the firm: Knowledge structures and the potential for Schumpeterian innovation. Strategic," *Management Journal*, Vol.19, pp.1193-1201.

[7] Hall, B. H., Jaffe, A. B., and Trajtenberg, M. (2002), "The NBER patent citations data file: Lessons, insights and methodological tools," *NBER working paper*, No.8498, Cambridge, MA: National Bureau of Economic Research.

[8] Hall, B. H., Jaffe, A., and Trajtenberg, M. (2005), "Market value and patent citations," *RAND Journal of Economics*, Vol.36, pp.16-38.

[9] Harfhoff, D., Narin, F., Scherer, F. M., and Vopel, K. (1999), "Citation frequency and the value of patented inventions," *Review of Economics and Statistics*, Vol.81, pp.511-515.

[10] Inuzuka, A. (2014), "The technology flows via an automobile company," a paper will be presented at the International Conference on Business and Information 2014 (in press).

[11] Jaffe, A. B., Trajtenberg, M., and Fogarty, M. S. (2000), "The meaning of patent citations," *NBER Working Paper* No.7631, Cambridge, MA: National Bureau of Economic Research.

[12] Miller, D. J., Fern, M. J., and Cardinal, L. B. (2007), "The use of knowledge for technological innovation within diversified firms," *Academy of Management Journal*, Vol.50, pp.307-326.

[13] Narin, F., Carpenter, M. P., and Woolf, P. (1984), "Technological performance assessments based on patents and patent citations," *IEEE Transactions on Engineering Management*, Vol.31, pp.172-183.

[14] Nelson, R. R., and Winter, S. G. (1982), *An Evolutionary Theory of Economic Change*, Cambridge, MA: Belknap.

[15] Nerkar, A., and Roberts, P. W. (2004), "Technological and product-market experience and the success of new product introductions in the pharmaceutical industry," *Strategic Management Journal*, Vol.25, pp. 779-799.

[16] Rosenkopf, L., and Nerker, A. (2001), "Beyond local search: Boundary-spanning, exploration, and impact in the optical disk industry," *Strategic Management Journal*, Vol.22, pp.287-306.

[17] Sako, M. (2004), "Supplier development at Honda, Nissan and Toyota: Comparative case studies of organizational capability enhancement," *Industrial and Corporate Change*, Vol.13, No.2, pp.281-308.

[18] Song, J., Almeida, P., and Wu, G. (2003), "Learning-by-hiring: When is mobility more likely to facilitate interfirm knowledge transfer?" *Management Science*, Vol.49, pp.351-365.

[19] Trajtenberg, M. (1990), "A penny for your quotes: Patent citations and the value of innovations," *Rand Journal of Economics*, Vol.21, pp.172-187.

[20] Wuyts, S., Colombo, M. G., Dutta, S., and Nooteboom, B. (2004), "Empirical tests of optimal cognitive distance," *Journal of Economic Behavior and Organization*, Vol.58, pp.277-302.