Embedded Profitability: A Network View on the Japanese Automobile Industry

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ABSTRACT

The aim of this study was to investigate the relation between the transaction network among Japanese automobile suppliers and their profitability. The author found a U-shaped relationship between the network distance from major complete carmakers to suppliers and their current profit on sales (it decreases with the network distance, and increases once it becomes larger). This result implies that suppliers' margin is highly "embedded" in the network, suggesting that how to balance the power from carmakers is a key to understanding suppliers' profitability.

Keywords: network distance, supplier, profitability, automobile industry.

1. INTRODUCTION

Several prior works of literature have addressed that business transactions entail two opposable forms: arm's-length ties and embedded ties. This continuum is used to explain how and why a firm builds its unique transaction network among its suppliers. If a firm prefers the stability of business, it will try to build strong ties with others to avoid being betrayed. Instead, the firm might find it harder to form a new relationship that could benefit it more.

Concerning this continuum, the Japanese automobile and Italian knitwear industries are said to be unique because they prefer personal ties characterized by mutual trust, long-term relationship, and mutual learning rather than explicit contracts (Dore, 1983; Asanuma, 1985; Larson, 1992; Lazerson, 1995; Dyer and Nobeoka, 2000; Sako, 2004; Dyer and Hatch, 2006). Considering the Japanese automobile industry as an example, some carmakers have established their own unique "keiretsu" networks, defined as clusters of independently managed firms maintaining close and stable economic ties cemented by a governance mechanism such as presidents' clubs, partial cross-ownership, and interlocking directorates (Grabowiecki, 2006). It is also characterized by long-term transaction relationships, which in turn, prohibit "novice" suppliers from entry. This implies that a keiretsu network involves a hidden risk in terms of searching for better suppliers. Since it plays a role in monitoring suppliers' activities, some of them might rather suffer than benefit from a keiretsu network.

These conflicting views indicate a need for more detailed research on how a network structure facilitates or hinders economic growth. With this objective, this paper investigates a transaction network in the Japanese automobile industry, and explores the relation between the network structure and suppliers' profitability.

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2. THEORETICAL BACKGROUND

Reflecting the diversity of research on transaction networks, their findings are also correspondingly diverse. Uzzi (1996) used the transaction network in the apparel industry to reveal that contractors surrounded by manufacturers that are moderately dependent on them are not likely to survive. Lee, Kang, Kim and Park (2014) investigated the social network structure among on line game makers and found that the further apart two players are socially, the higher is the profit margin.

Contrary to the above industries, the Japanese automobile industry is characterized by relatively high barriers to entry, high start-up cost, and few firms to substitute. In this sense, suppliers are entirely dependent on how their carmakers perform in the industry. Keiretsu networks are, therefore formed to enable the suppliers to meet the technology standards required by their carmakers. Therefore, the distance from carmakers is important in addition to a mere network position because it should represent controlling power from the carmakers. More precisely, network distance from the carmakers will play a major role in determining suppliers' profitability.

Two types of logic exist regarding the relation between suppliers' profitability and their network distance from the carmakers. The first is that since suppliers' businesses are highly dependent on orders from their carmakers, having their strong support will contribute to better profitability.

> *H1: The shorter the network distance from carmakers a supplier has, the higher the latter's profitability will be.*

The second logic opposes the first one. Having excessively strong ties with its carmakers might have potential perils on the supplier's discretion in terms of its free business. Romo and Schwartz's (1995) and Dore's (1983) findings suggest that embedded nodes satisfice rather than maximize on price, and shift their focus from the narrow economically rational goal of winning immediate gain and exploiting dependency to cultivating long-term, cooperative ties (Uzzi, 1997).

> *H2: The longer the network distance from carmakers a supplier has, the higher the latter's profitability will be.*

These contradicting views might both benefit suppliers' performance, that is, a supplier's profitability is determined on a balance between the advantage and disadvantage from the controlling power. If so, the relation between the two will be a U-shaped curve.

> *H3: Profitability of a supplier will be the lowest when it has a "modest" network distance from carmakers.*

The hypothetical relations this paper aims to test are shown in Figure 1.

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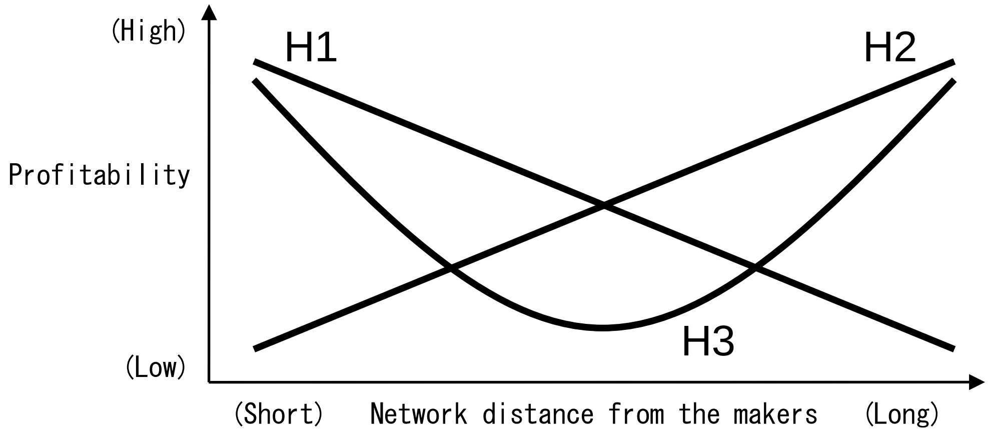

Figure 1. Hypothetical relations

3. METHOD

3. 1 Transaction Network

The transaction network in the Japanese automobile industry was created from the book, "Current Status of the Japanese Automobile Parts Suppliers Industry (*Nihon no Jidosya Buhin Sangyo no Jittai* [in Japanese])" issued by IRC Co., Ltd. This book contains detailed information of over 1,000 major Japanese automobile suppliers including their president's name, main products, manufacturing bases, number of employees, sales, profits, and more importantly, their main suppliers and customers. For this study, books issued in 2000, 2004, and 2007 were used (the book is issued almost every two to four years). This period was chosen to avoid the aftermath of the Lehman crash in 2008 and the Great East Japan Earthquake in 2011. I sampled the suppliers who appeared at least two times among the three different periods. The "two-time" appearance is introduced because of the problem of notation variability (fluctuation) in Japanese characters. Since the books are based on a handwritten questionnaire, terms regarded as notation fluctuation candidates should be absorbed. I, therefore, used data at three different periods. For a supplier to be considered to have a tie with firm A, the focal supplier must have designated firm A (or a very similar name of firm A in terms of Japanese character/pronunciation) as its main customer more than once.

The sample size of suppliers was just 1,000. Including 12 major carmakers: Toyota, Nissan, Honda, Mazda, Mitsubishi Motors, Suzuki, Daihatsu, Subaru (Fuji Heavy Industries), Hino, Isuzu, Mitsubishi Fuso, Nissan Diesel (although their transaction information is not in the books, they are frequently designated as customers), the following analyses are based on the transaction networks among 1,012 firms. Figure 2 is the diagram of the network created by a software (the horizontal and vertical axes do not have any meaning).

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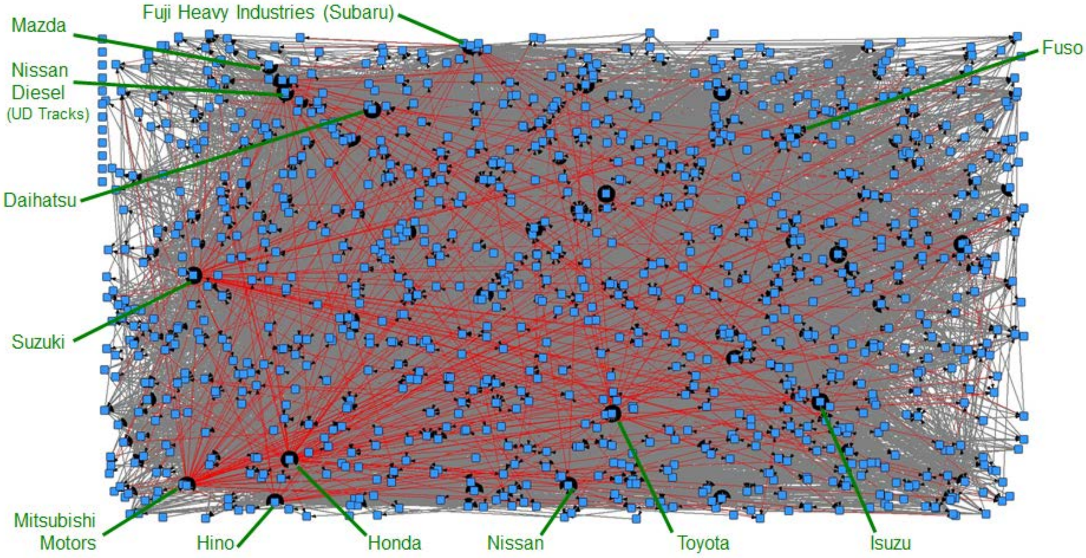

Note: red arrows: reciprocal ties, gray arrows: non-reciprocal ties

Figure 2. The transactional network

3. 2 Network Distance from the Carmaker

Although the transaction network includes 12 carmakers, this paper used the network distance only from the major three—Toyota, Nissan, and Honda. This is because for suppliers, these three carmakers must have a greater impact than the others. In fact, consolidated sales of Toyota, Nissan, and Honda in 2004 were 17295, 7429, and 8163 (Million Yen), respectively. These figures are larger compared to that of the fourth carmaker (Mazda) at 2916. For this reason, including the other nine carmakers might significantly bias the results.

This paper used geodesic as a scale for measuring the network distance. Geodesic is the number of edges in the shortest path between two nodes (notice that there may be more than one shortest path between them). The shortest path is of great concern because it reflects the degree of controlling power from the carmakers. Then, I measured how many steps are required for each supplier to reach each of the three carmakers in the network. For example, if supplier B designates supplier C as its customer, and then, C designates Toyota as its customer, the distance from the supplier B to Toyota shall be two. Similarly, every distance from Toyota, Nissan, and Honda is calculated, and I use the averaged distance as the network distance from the major carmakers (because the distance is defined as infinite if there is no path connecting the two, 20 suppliers that have at least one infinite distance were eliminated from the analyses).

3. 3 Suppliers' Profitability and its Number of Employees

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Unfortunately, not all the suppliers indicated their sales figures and profits in the books. Further, some suppliers only provide the figures specifically for one or two years. Therefore, I calculated the current profit ratios from only the suppliers with figures for at least one year from 2003 to 2005 (for suppliers listed on the stock exchange market, I obtained the missing figures from a commercial database, EOL). The current profit ratio is calculated for every year (if there are figures), and then averaged as suppliers' profitability. Due to missing data, this process limits the number of the suppliers to 458. Additionally, the number of employees of each supplier in 2004 was also obtained from the books (for seven suppliers lacking this information in 2004, I substitute with the average number of employees between 2000 and 2007).

4. RESULT

The network distance from the major carmakers are categorized into 1 (equal to 1), 1.5 (over 1 to 1.5), 2 (over 1.5 to 2), 2.5 (over 2 to 2.5), 3 (over 2.5 to 3), 3.5 (over 3.5 to 4), and 4 (over 4). Figure 2 shows the average number of employees of the suppliers in each category. It is apparent that the number declines as the network distance increases, which implies that the network distance corresponds to the so-called first, second, third and fourth-tier suppliers.

The main interest of this study is shown in Figure 3. As shown, there appears a U-shaped curve between the network distance and current profit ratio. The difference among the categories (ANOVA test) is significant (F=3.422, p=0.002). The result supports the idea of hypothesis 3 (while the others are rejected).

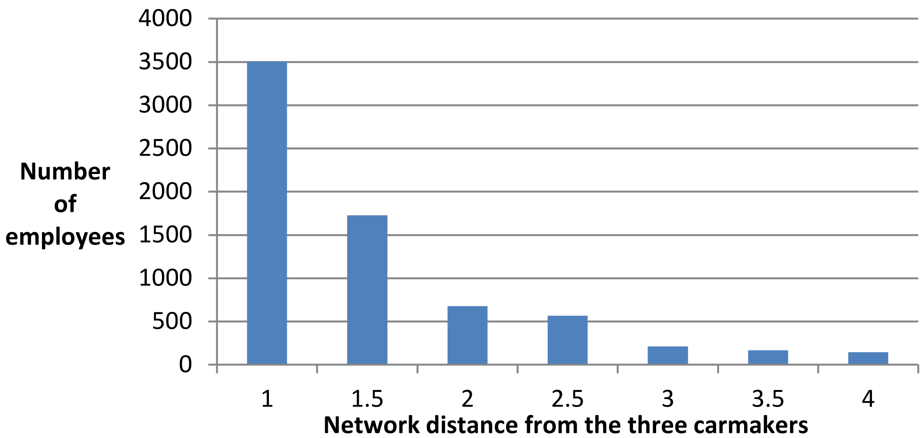

Figure 3. Network distance and number of employees

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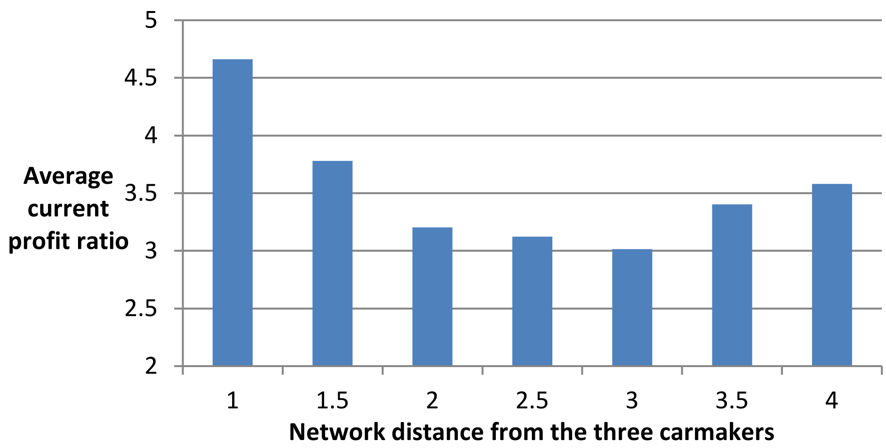

Figure 4. Network distance and current profit ratio

5. DISCUSSION

5. 1 Additional Analysis

Until now, this paper has only focused on the network distance from the major carmakers. However, there must be other network factors affecting suppliers' profitability. I therefore conducted additional analysis to investigate this.

I selected three major variables that are often used for considering network effects. The first variable is *egocentric density*, which means the density around "ego." Consider a node that has four direct paths to other nodes. The number of possible paths among the five nodes (including a focal node) should be 10. If there exist six paths of the 10, egocentric density about the focal node becomes 6/10=0.60. As such, the egocentric density is defined as the density among nodes that are directly connected to a focal node. This egocentric density is considered to be associated with relational embeddedness, which stresses the role of "closure" as a mechanism for gaining fine-grained information (Coleman, 1988). For a variable associated with relational embeddedness, degree centrality is often used. However, I do not use it for two reasons. First, outdegree centrality highly correlates to the network distance from the carmakers. Second, the original data on transactional network is based on a handwritten questionnaire, which seems to make the respondents recall their suppliers and buyers freely. Since there was no limitation about the number of suppliers or buyers, the degree centrality might just reflect the respondents' tendency in answering, and not relational embeddedness.

The second network variable is *betweenness centrality*, which quantifies the number of times a node acts as a bridge along the shortest path between two other nodes. A node with high betweenness centrality has a great impact on a network because it could cut the connectivity among other nodes. I used normalized betweenness centrality, the number of brides through a node divided by the number of pairs of nodes not including the focal node, (N-1)(N-2).

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The third variable is *structural hole*. This concept was proposed by Burt (1992), indicating the extent to which a node is surrounded by brokerage opportunity. Burt developed the concept aggregative constraint to measure the degree of structural hole:

$$Strucural\_hole_i(t) = -1 \bullet \sum_{j \in S} \left(p_{ij} + \sum_q p_{iq} \bullet p_{qj} \right)^2, \qquad q \neq i, j.$$

where p_{ij} is the proportion of i's network time and energy spent on j, p_{iq} is the proportion of i's network time and energy invested in the relationship with q, and p_{qj} is the proportion of q's time and energy invested in the relationship with j. This formula allows us to measure the extent to which a member's external alters sharing relationships with each other. This variable is considered to be associated with structural embeddedness, which emphasizes that the structural position for gaining access to unique information when one's partners are not connected to each other or similar others.

5. 2 Description Analysis

Table 1 shows the description data of the variables. Since the egocentric density requires more than one direct path for each node, 10 suppliers are eliminated from the sample. The correlation matrix (Table 1) depicts that some correlations are rather strong. However, the highest variance inflation factor (VIF) value in the latter multiple regression analysis is quite lower than 10, which is acceptable for conducting the analysis.

Table 1. Correlation matrix

	Variables	Mean	St.dev	1	2	3	4	5
1	Network distance	1.70	0.55	—				
2	Egocentric density	0.16	0.13	0.34 ***				
3	Betweenness centrality	0.00	0.01	−0.17 ***	−0.18 ***			
4	Structural hole	−0.17	0.12	−0.65 ***	−0.63 ***	0.25 ***		
5	Number of employees	1817	4722	−0.22 ***	−0.19 ***	0.41 ***	0.25 ***	
6	Current profit ratio	3.57	2.89	−0.18 ***	0.03	−0.06	0.09 ***	0.02

N=448. Pearson's correlation coefficient (*** p<.001).

5. 3 Multiple Regression Analysis

The current profit ratio of the suppliers is predicted by multiple regression analysis. In Table 2, Model 1 is to confirm the U-shaped curve that appeared above. After controlling for the number of employees, the coefficient of the network distance is seen to be significantly positive, whereas its square has a negative value. This statistically supports the existence of the U-shaped curve.

Models 2 and 3 depict the network effects. As shown, the only network variable with significance is the betweenness centrality, and its sign is not positive. Since the

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betweenness centrality is associated with the network position that enables taking advantages by connecting differing partners, the result implies that suppliers' opportunistic behavior does not contribute to their profitability in this network. It supports the notion that the Japanese keiretsu network is not characterized as opportunistic behavior.

However, it does not mean "closure" works well in this network. The coefficients of egocentric density in the models are surely positive, but not significant. From the facts, Japanese keiretsu network is not necessarily characterized as mutual trust but as the system that each supplier monitors one another to prohibit the opportunistic behavior.

Table 2. Multiple regression analyses for predicting current profit ratio

	Model 1		Model 2		Model 3	
Network distance	−0.668	**	−0.172	**	−0.648	**
Network distance squared	0.545	*	—		0.489	*
Egocentric density	—		0.082		0.095	
Betweenness centrality	—		−0.123	*	−0.121	*
Structural hole	—		−0.010		0.012	
Log (Number of employees)	0.062		0.145	**	0.130	*
adj. R^2	0.035		0.047		0.053	
F	6.567	***	5.377	***	5.157	***

N=448. Standardized regression coefficient (* p<.05, ** p<.01, *** p<.001).
Maximum of VIF value in model 2 is 2.82 (Structural hole).

6. CONCLUSION

It is generally believed that the Japanese keiretsu network is characterized by continuous relationships based on mutual trust and learning. However, the facts that strongly support this view have not been confirmed. Moreover, the existence of the U-shaped curve and the fact that betweenness centrality negatively affects suppliers' profitability lead us to think that another mechanism might exist regarding suppliers' profitability. Further analysis is necessary to fully understand the actual situation in keiretsu.

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