Inter-firm Transactional Relationships in Yokokai: An Empirical Investigation Using the IDE Spatial Model

Takao Ito, Rajiv Mehta, Tsutomu Ito, Makoto Sakamoto, Satoshi Ikeda, Seigo Matsuno, Katsuhiko Takahashi

***Abstract*—**This paper discusses recent fundamental changes in the Japanese alliance networks known as keiretsu, and reports the findings of an empirical investigation on the relationship between these changes and corporate performance. More specially, the performance of Japanese auto manufacturers, such as Toyota, Mazda and Nissan, among others, has significantly improved due to sophisticated production system technologies, highly productive workers, and recurring transaction relationship with other partners in their network organization. One possible determinant of their success could be due to their unique organization forms – the keiretsu– which provides a strong platform to forge their strategic alliance ties with their parts suppliers as well as collaboration into research and development activities with other automobile manufacturers.

After the Lehman Brothers bankruptcy in 2008, the strong ties between automobile makers and their supplier partners underwent significant modifications manifested by a "loosening of network ties due to "external influences". Consequently, this begs the following questions: What is the status quo of automotive keiretsus? Are transactional relationships in keiretsu still associated with improved corporate performance? To answer these questions, this paper reports the results of a study that collected data on transaction to shed light on the relationship between inter-firm transactional relationship and corporate performance. The findings of this empirical investigation reveal that: (1) Keiretsu is a flexible, highly adaptive organizational form; its scale is prone to modifications in response to changes in economic conditions; (2) Transactional relationship is still a significant determinant of increasing profits for keiretsu partners even in the aftermath of the 2008 financial crisis.

***Keywords*—**Corporate performance, Keiretsu, The IDE spatial model, Transactional network, Yokokai.

I. Introduction

JAPANESE automobile manufacturers still show signs of performing at a significantly higher level than their global counterparts. This could possibly be due to the sophisticated technologies deployed for their production systems, highly productive employees, and continuous transaction relationships with other member-partners in the keiretsu network. Possibly, one explanatory factor contributing to their success could be their unique organization forms –the keiretsu– which provides a strong platform to forge strategic alliances with their parts suppliers, as well as collaboration in research and development with other automobile makers. In the aftermath of the 1990s economic bubble, the strong interrelationships between car producers and their automotive parts suppliers in the keiretsu network underwent a significant transition referred to as "keiretsu loosening". Moreover, the 2008 financial crisis is also known to have a significant impact on keiretsu.

What is the status quo of keiretsus post financial crisis? Do transactional relationships, which are emphasized in keiretsus, still conduce to higher levels of corporate performance? To find answers to these as well as related questions, this paper reviews the extant literature on keiretsu to propose a new approach known as the IDE spatial model that sheds light on the interrelationship between transaction and corporate performance.

This manuscript is organized as follows: Section 2 reviews the relevant literature associated with keiretsu networks. Section 3 describes the data collection process and the new network model. Based upon the findings, the corporate managerial implications are discussed in section 4. In section 5, the study limitations are identified and section 6 proffers directions for future research. Conclusion is marked in section 7.

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II. BACKGROUND

As a well-known network organization in Japan, keiretsus, in general, can be of two forms: horizontal and vertical. Horizontal keiretsu consist of zaibatsu, while vertical keiretsu comprise constellation members of a manufacturing group, such as like Toyota's Kyohokai and Nissan's Nishokai. Most manufacturing firms developed with financial support from zaibatsus. Toyota is an exception as it exemplifies a unique keiretsu that developed without financial support from any zaibatsu. Being a typical keiretsu, this paper will focus on Mazda's Yokokai due to the global success it has sustained.

Ties among keiretsu partners are complex and can be of several forms to include equity ties, personal ties, capital ties and work-flow ties. This paper examines transactional ties, which is another derivative of ties, to shed light its interrelationship to corporate performance.

According to McGuire and Dow [1], the benefits and costs of vertical keiretsu affiliation, which are identified in Table 1, are based on described discussions and qualitative analyses.

Having become a successful model of inter-firm cooperation, keiretsu involves any type of relationship between one or more companies attempting to pursue individual and joint corporate and market related goals that each firm alone could not easily attain. It is based on the notion that it is difficult for a firm to "go it alone" and excel in performing all business functions. Keiretsu are formidable organizational forms owing to their global reach and lower investment costs. Most notably, cooperation forms the "heart" of keiretsu without which all alliances fail.

Consequently, it is crucial to shed light on the essential principles of rational inter-firm alliances not only based on theoretical research, but also grounded in quantitative methods.

Although many quantitative methods have been developed, an effective mathematical tool is graph theory. As a network organization, the interrelationships among member partners in keiretsu should be calculated from the viewpoint of factors, such as centrality, density, effective size, and influence, among others. To find new approaches, many studies have been published on keiretsu. Fukuoka et al. calculated correlation ratio between transaction and cross shareholdings data and found a positive relationship between the correlation ratio and corporate performance after comparing Nissan and Toyota [2]. Ito et al. discovered a relationship between network indices such as centrality and capacity and corporate performance in Mazda's Yokokai [3, 4]. Moreover, Tagawa et al. uncovered the relationship between organizational structure and corporate performance such as sales and profits, in Mazda's Yokokai [5]. And more recently, Ito et al. uncovered the relationship between organizational structure and corporate performance in Mazda's Yokokai using DEA model and IDE spatial model [6-9]. All these studies support the theory that mutual assistance and access to stable financing are equally important determinants that leverage the performance of manufacturing firms.

Table 1 Benefits and costs of keiretsu

	Horizontal	*Vertical*
Benefits of affiliation	1) Risk reduction and performance leveling 2) Reciprocal monitoring 3) Reduction of information asymmetry 4) Mutual assistance 5) Access to stable financing 6) Insulation from market pressures	1) Oversight by core firm 2) Encourages co-ordination 3) Long-term perspective 4) Reduces governance problems 5) Stable output market domestically and export markets encouraged 6) Lower transaction costs 7) Technical, managerial and financial assistance 8) Foster innovation 9) Lower costs 10) Better performance
Costs of affiliation	1) Higher borrowing costs 2) Over-investment 3) Poor performance 4) Heightened information asymmetry (between firm insiders and outsiders)	1) Limited scope of customers 2) Limited innovation 3) Tunneling

(Source: McGulre J., and Dow S., (2009) Japanese keiretsu: Past, present, future, pp.335-338)

After the 2008 economic downturn, the strong ties between automobile manufacturers and their suppliers in keiretsu underwent significant changes, which are known as "external influence". McGulre and Dow indicated that the four characteristics that underscore the evolution of keiretsu ties are (1) diminished bank debt; (2) reduced cross-holdings; (3) reduced buyer-supplier ties (vertical keiretsu); and (4) diminished inter-firm exchanges of board and personnel [1]. Thus, review of the literature readily reveals that many scholars have found results consistent to those obtained by McGulre and Dow.

As previously noted, due to the importance of keiretsus in the Japanese economy and role they have played in the success of Japan in the global economy, the present investigation sought to: (1) determine the status quo of present-day keiretsu? (2) Are

transactional relationships in keiretsu still a significant criterion of corporate performance? To our best knowledge, no research provides answers to these questions, which provided the impetus to this line of investigation.

III. DATA COLLECTION AND VARIABLES SELECTION

To shed light on the network relationship between transaction and corporate performance, data were collected from Mazda' Yokokai keiretsu. Mazda's keiretsu and its three sub-organizations: Nishi-Nihon Yokokai, Kanto Yokokai and Kansai Yokokai.

A.Data Collection

Transaction data in the keiretsu of Yokokai for 2006, 2007, 2008, 2010, 2011 and 2012 fiscal years to establish the status quo of keiretsu and ascertain changes in its structure in the aftermath of the 2008 financial crisis have been drawn from personal interviews as well as the publications of the Japan Auto Parts Industries Association and Automotive Parts Publishing Company [10-15].

The relevant information about the Yokokai is shown in Table 2.

Table 2 Yokokai Network Data with Singletons

	Suppliers	Car makers	Total Number
2006	190	11	179
2007	189	11	178
2008	188	11	177
2010	172	11	161
2011	183	11	172
2012	183	11	172

Table 2 also includes data of singletons, which refers to a partner firm in the keiretsu that has no relationship with other member firms. Singletons were removed from the data-set because singletons have no impact on the calculation of network indexes. The revised data is shown in Figure 1.

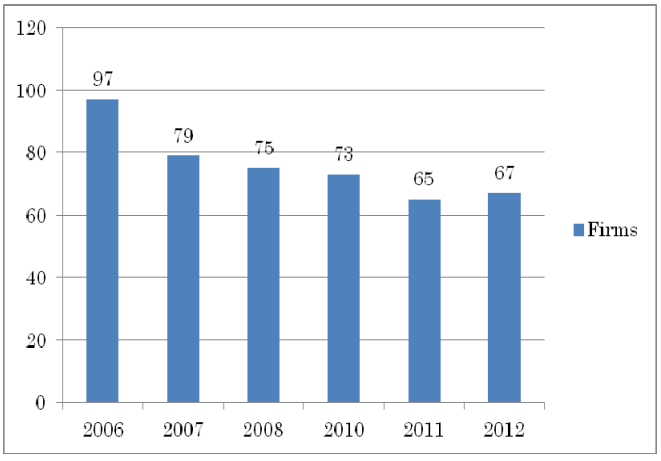


Figure 1 Yokokai network data without singletons

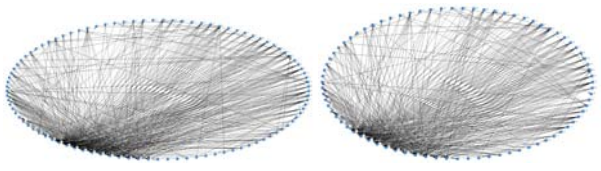
Transactional relationship in Yokokai, which was also collected, refers to the percent of the parts one company purchases from network partners.

Table 3 shows the transactional data in Yokokai. For instance, HI-LEX Corporation (No. 166) sells 7.9 percent parts to Mazda (No. 173). As such, the cell between HI-LEX Corporation and Toyota (No. 174) is 8.9 percent. In other words, Toyota purchases parts from HI-LEX Corporation and it occupies 12.3 percent of HI-LEX Corporation's total sales.

Table 3 Yokokai Network Matrix Data in 2012 (selected part)

		172	173	174	175	176	177	178	179	180	181
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
139	.....	0	0	0	0	0	0	0	0	0	0
140	.....	0	0	0	0	0	0	0	0	0	0
141	.....	0	0	0	0	0	0	0	0	0	0
142	.....	0	41.9	0	0	0	17.4	0	0	0	0
143	.....	0	0	0	0	0	0	0	0	0	0
144	.....	0	0	0	0	0	0	0	0	0	0
145	.....	0	0	0	0	0	0	0	0	0	0
146	.....	0	0	0	0	0	0	0	0	0	0
147	.....	0	0	0	0	0	0	0	0	0	0
148	.....	0	4.18	4.18	4.18	4.18	4.18	0	4.18	4.18	4.18
149	.....	0	0	0	0	0	0	0	0	0	0
150	.....	0	0	0	0	0	0	0	0	0	0
151	.....	0	0	0	3.7	5.7	0	0	0	0	3.2
152	.....	0	0	0	0	0	0	0	0	0	0
153	.....	0	0	0	0	0	0	0	0	0	0
154	.....	0	0	41	0	6	0	0	0	3	0
155	.....	0	0	0	0	0	0	0	0	0	0
156	.....	0	0	0	0	0	0	0	0	0	0
157	.....	0	0	45.4	0	7.1	0	0	2.8	0	0
158	.....	0	0	0	0	0	0	0	0	0	0
159	.....	0	0	0	0	0	0	0	0	0	0
160	.....	0	6.2	6.2	6.2	0	6.2	6.2	6.2	6.2	6.2
161	.....	0	0	0	0	0	0	0	0	0	0
162	.....	0	0	50.6	0	0	4.9	0	2.9	1.1	0
163	.....	0	0	0	0	0	0	0	0	0	0
164	.....	0	0	0	0	0	0	0	0	0	0
165	.....	0	0	0	0	0	0	0	0	0	0
166	.....	0	7.9	8.9	5	25.6	3.2	0	0	4.9	0
167	.....	0	0	0	0	0	0	0	0	0	0
168	.....	0	0	0	0	0	0	0	0	0	0
169	.....	0	2.7	28	0	0	0	0	3.1	0	0

The networks of inter-firm transactional relationship from 2006 to 2012 are illustrated in Figure 2.



2006 2007

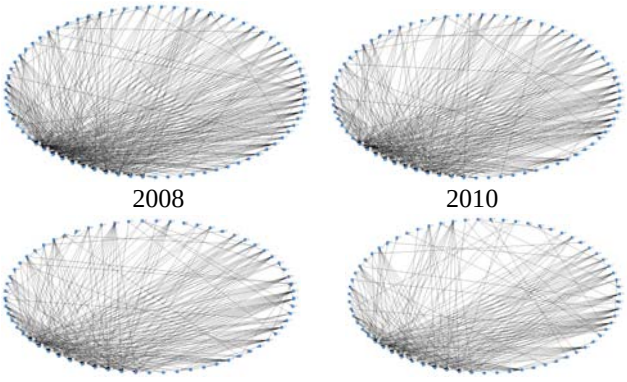


Figure 2 Transactional networks in Yokokai (2006-2012)

B Model and Measurement

As previously noted, many structural indices of network analysis have been developed, but this study selected degree, influence and effective size of the firms included in Yokokai to analyze the relationship between those indices and corporate performance as these interrelationships have not been previously investigated.

Degree is an index of a firm's potential communication activity. In a transaction network, degree includes two categories: in-degree and out-degree. This is because transaction networks are considered to be asymmetric organizations. In-degree refers to a firm purchases parts from other member firms, whereas out-degree reflects a firm that only sell parts to other firms within the network. Degree is calculated as below [16].

$$C_D(p_k) = \sum_{i=1}^{n} a(p_i, p_k) \quad (1)$$

$$i = 1,2,\cdots,n; \quad k = 1,2,\cdots,n$$

where

$a(p_i, p_k) = 1$; if and only if p_i and p_k are connected by a line

= 0; otherwise

Percentage data of inter-firm's transactions were collected from Yokokai. In a transactional network, high value of degree is positively associated with its corporate performance such as sales and profit [7, 9]. Based upon this prior work, the following hypothesis is postulated:

H1a: *Degree will be positively associated with its performance*.

H1b: *Out-degree will be positively associated with its performance, and in-degree will be negatively associated with its performance.*

Influence reflects the power to influence or have an impact on other member firms directly and indirectly in a network. Suppose that A is the matrix of the direct network, and A^n means the indirect influence from one firm to another firm by n steps. Then influence is calculated as follows[17]:

$$T = A + R = A + A^2 + A^3 + \cdots + A^n = A(I - A)^{-1} \quad (2)$$

where

T: Total influence;

A: direct influence;

R: indirect influence;

I: Identity matrix.

In an asymmetric network, influence includes two categories: out-influence and affectedness. Out-influence refers to a firm have strong impact on other member firms, whereas affectedness reflects a firm that only influenced by other firms within the network. In same network, influence has a strong impact on corporate performance [17, 18]. Consequently, the following hypothesis proffered:

H2a: *Influence will be positively associated with its performance.*

H2b: Out-i*nfluence and affectedness will be positively associated with its performance.*

Effective size of the network refer to the number of alters that ego has, minus the average number of ties that each alter has to other alters. As suggested by Borgatti [19], it can be calculated as follows:

$$ES_i = \sum_j [1 - \sum_q p_{iq} m_{jq}] \quad q \neq i, j \quad (3)$$

where

m_{jq}: i's interaction with q divided by j's strongest relationship with node

p_{iq}: proportion of I's energy invested in relationship with q

A recent study investigated the relationship between firm network position and corporate venture capital investment [6]. In another study, Sakamoto et al. reported effective size is one of the key determinants associated with corporate performance in transaction network [9]. Accordingly, the following hypothesis is proposed:

H3: *Effective-size will be positively associated with its performance.*

A three dimension is composed of a set of network indexes: degree, effective size, and influence. The position of each firms located in the three dimension will be considered as one factors of its performance. Euclidean distance in the three dimension space is calculated as follows.

Table 4 Regression Results in Three-Variable Model.

	Models					
	2006	2007	2008	2010	2011	2012
Influence						
Partial regression coefficient	-0.2803*	0.0457	0.011	0.5565*	0.7657**	1.0193**
Standard coefficient	-0.428*	0.0762	0.0178	1.0294*	1.3635**	1.6561**
t value	-2.3046	0.493	0.1167	2.0011	3.1175	4.8621
Probability	0.024	0.6235	0.9075	0.0496	0.0029	0
Correlation coefficient	0.0489	0.1412	0.1554	0.1931	0.156	0.3482
Partial correlation coefficient	-0.2572	0.0584	0.0147	0.2427	0.3817	0.5483
Degree						
Partial regression coefficient	0.2299*	-0.0451	0.0271	0.4992	-0.6584**	-0.7177**
Standard coefficient	0.4379*	-0.0904	0.0424	-1.0128	-1.3924**	-1.538**
t value	2.3859	-0.5999	0.2731	-1.9783	-3.2857	-4.902
Probability	0.0196	0.5505	0.7856	0.0522	0.0017	0
Correlation coefficient	0.0869	0.0174	0.1985	0.1467	0.0127	0.1154
Partial correlation coefficient	0.2656	-0.071	0.0344	-0.2401	-0.399	-0.5544
Effective-size						
Partial regression coefficient	0.4746**	0.3841**	0.4121**	0.3826**	0.3012**	0.176*
Standard coefficient	0.6341**	0.5547**	0.5871**	0.5956**	0.4479**	0.2862*
t value	6.7614	5.456	5.6662	6.0052	3.9446	2.3988
Probability	0	0	0	0	0.0002	0.0199
Correlation coefficient	0.5802	0.5649	0.6006	0.6178	0.6016	0.623
Partial correlation coefficient	0.6154	0.5435	0.581	0.6003	0.4631	0.3078
Intercept						
Partial regression coefficient	-0.0166	-0.0016	-0.0379	-0.0222	0.0021	0.0094
Standard coefficient	0	0	0	0	0	0
t value	-0.4857	-0.0416	-0.8189	-0.8238	0.0718	0.3574
Probability	0.6286	0.967	0.416	0.4131	0.943	0.7221
Coefficient of determination	0.38507	0.32255	0.36374	0.41814	0.46445	0.57746
Multiple correlation coefficient	0.62054	0.56794	0.60311	0.64664	0.68151	0.75991
F value	15.65534	11.26832	12.00559	15.33072	16.47757	25.05516
Degree of freedom	3, 75	3, 71	3, 63	3, 64	3, 57	3, 55
AIC	-109.85	-96.25	-84.72	-101.22	-88.07	-97.02
DW ratio	1.8707	2.1009	2.1728	1.944	1.877	2.1023
Data number	79	75	67	68	61	59

Note: ** $p<0.01$, * $p<0.05$.

Table 5 Regression Results in Five-Variable Model.

	Models					
	2006	2007	2008	2010	2011	2012
Out-degree	0.298	0.2015	0.5799	-0.1027	-0.2463	-0.1003
In-degree	0.8289**	0.0215	0.4393**	-9.2684**	-9.1696**	-6.7785
Influence	-0.1536	-0.0976	-0.1642	0.0015	0.0513	0.0141
Affectedness	0.4075*	0.8263**	0.933**	7.7194**	7.6902**	5.4715**
Effective size	-0.4176*	-0.3768*	-0.5918**	0.0587	0.1592*	0.0402
Adjusted R^2	0.75749	0.69436	0.79038	0.9304	0.90853	0.92695
DW ratio	2.3372	2.4414	2.409	1.6784	1.4781	1.695

Note: ** $p<0.01$, * $p<0.05$.

$$D = \sqrt{(x_i - x_k)^2 + (y_i - y_k)^2 + (z_i - z_k)^2} \quad (4)$$

where

(x_i, y_i, z_i): position of each firm i's

(x_k, y_k, z_k): position of Mazda's

Euclidean distance is the measure to calculate the distance among each firm. Basically the distance between each firm to Mazda should be considered that the longer distance, the less performance. Accordingly, the following hypothesis is posited:

H4: *Distance between each firm and Mazda will be negatively associated with its performance.*

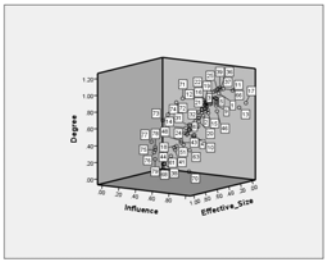
IV. RESULTS AND CORPORATE MANAGEMENT IMPLICATIONS

Degree, influence and effective size were computed. In order to calculate the relationship between network indexes and its corporate performance, the data of corporate performance such as sales and profits were collected. Because of scales difference, all data are standardized.

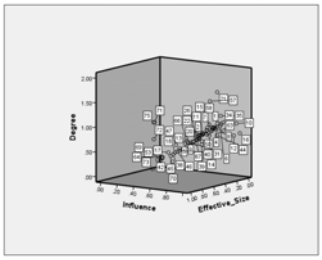
The data standardization is calculates as blow.

$$z_{ij} = \frac{x_{ij} - x_{ij(\min)}}{x_{ij(\max)} - x_{ij(\min)}} \quad (5)$$

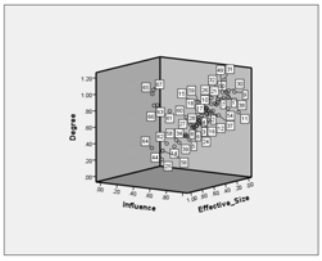
The three dimensional views from 2006 to 2012 are illustrated below.



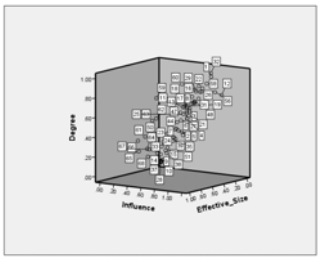
2006



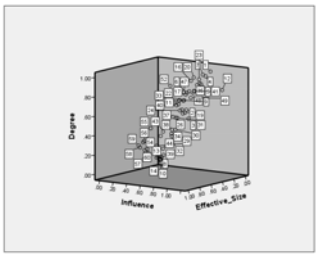
2007



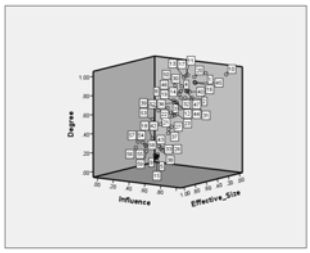
2008



2010



2011



2012

Figure 3 Position of each firm in three-dimension in 2012

Two models have been employed in this study: (1) a three-variable model using degree, influence and effective size, and (2) a five-variable model using out-degree, in-degree, out-influence, affectedness, and effective size. Network is considered as symmetric in the former model and network is calculated as asymmetric in the latter model.

Table 4 and Table 5 show descriptive statistics for three-variable model and five-variable in the regression model, respectively. Table 4 reveals that all of the indices are statistically significant except influence in 2007 and 2008, and degree in 2007, 2008 and 2010. In-degree and affectedness in five-variable model shown in Table 5 are almost statistical significant while out-degree and out-influence are not significant. Effective size are significant except in 2010 and 2012. The value are positive only in 2011.

Euclidean distance between Mazda and each firm in 2012 is illustrated as Figure 4. Mean and variance of Euclidean distance between Mazda and each firm from 2006 to 2012 is shown in Table 6. The values of mean and variance of Euclidean distance in 2010 is extreme high in Table 6. It could be considered as the reflection of structure adjustment after 2008 financial crisis.

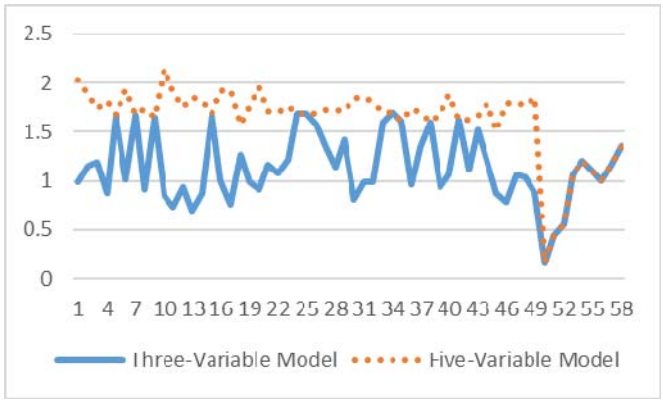


Figure 4 Euclidean distance between Mazda and each firm in 2012

Based on the findings of this empirical study, some corporate management implications can be gleaned. Thus, to augment corporate efficiency, the following suggestions for managing the interrelationships among keiretsu members are offered. First, Euclidean distance could be considered as a new measure for improving corporate performance. Second, position in three-dimension space should be observed as it is an important

factor for determining corporate performance.

Table 6 Mean and variance of Euclidean distance between Mazda and each firm from 2006 to 2012

		Mean	Variance
2006	Three-variable model	1.157391	0.013915
	Five-variable model	1.544506	0.069928
2007	Three-variable model	1.069299	0.06074
	Five-variable model	1.737325	0.147463
2008	Three-variable model	0.9023	0.023391
	Five-variable model	1.268035	0.094926
2010	Three-variable model	1.648897	2.606912
	Five-variable model	6.44588	11.13835
2011	Three-variable model	1.171572	0.101621
	Five-variable model	1.695777	0.109417
2012	Three-variable model	1.136473	0.119452
	Five-variable model	1.629145	0.136377

Based on the findings of this empirical investigation, the following corporate management implications are proffered below.

A.Degree

In transactional network, degree refers to the amount of transaction between two partner companies. From 2006 to 2012, the standard coefficient of degree in three-variable model is 0.4379, -0.0904, 0.0424, -1.0128, -1.3924, and -1.538, respectively. Table 4 shows that degree is significant only in 2006, 2011, and 2012. The value of degree is depicted in Figure 5.

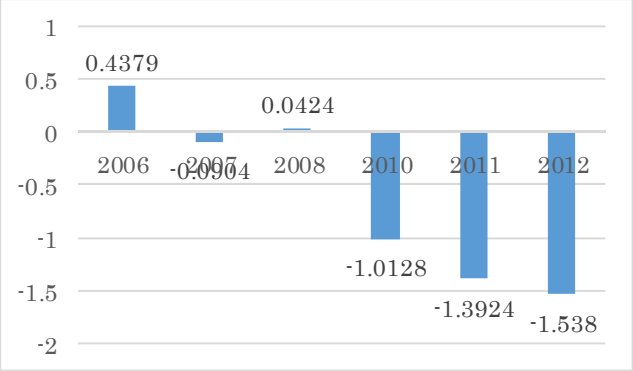


Figure 5 Standard coefficient of degree in the three-variable model in Yokokai (2006-2012).

The degree is significant in 2011 to 2012, but the value is negative. This means that much more transactions are associated with less sales. Thus, based upon the analysis described above, H1a does not hold. However, in McGuire and Dow's study, one of the conclusions is incongruent because degree is negative. One considerable reason is that there is time lag effect between degree and its sales. In other words, maybe degree will give impact on its sales after several years. According to our previous findings, positive relationship between degree and profit is supported in capital network partly [7]. Anyway, much more quantitative research should be done to find support for this arguments.

Figure 6 shows the results of five-variable model.

With the exception of 2007, all in-degree results are statistically significant and the value in 2010, 2011 and 2012 is -9.2684, -9.1696, and -6.7785, respectively. However out-degree is not statistically significant. Thus, there is only partial support for H1b.

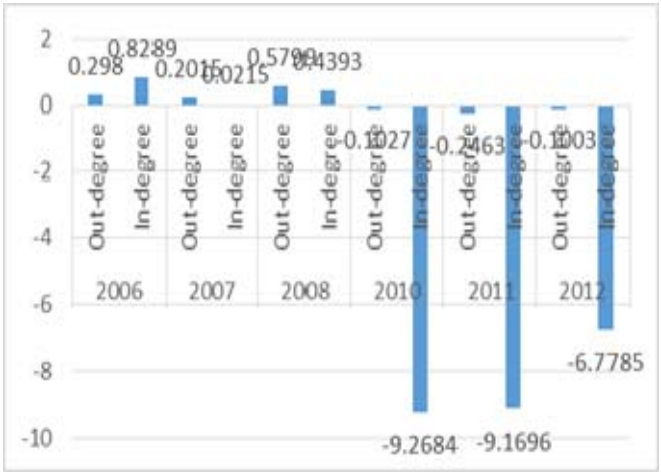


Figure 6 Standard coefficient of degree in the five-variable model in Yokokai (2006-2012).

B. Influence

Influence is one kind of power to affect persons or events without any direct or discernible effort. Influence reflects the power to influence or have an impact on other member firms directly and indirectly in a network. From 2006 to 2012, the standard coefficients of influence is -0.428, 0.0762, 0.0178, 1.0294, 1.3635, and 1.6561 respectively—as depicted in Figure 7.

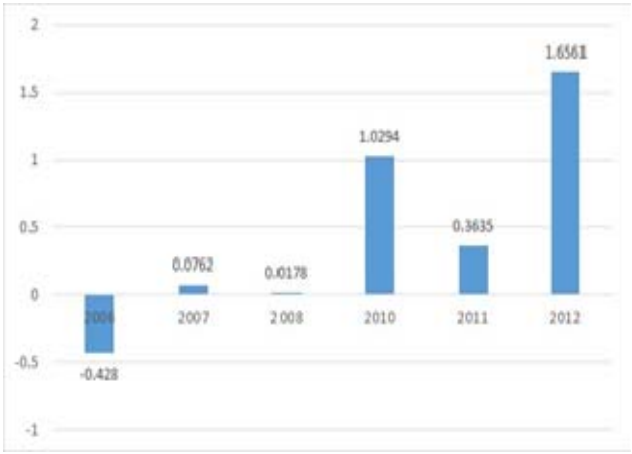


Figure 7 Standard coefficient of influence in the three-variable model in Yokokai (2006-2012).

Table 4 shows that all partial correlation coefficients are positive except in 2006 in Figure 7. They are statistically significant in 2006, 2010, 2011, and 2012, and it is negative only in 2006. It can be considered that change of the rule of influence was happened before and after the failure of the 2008 financial crisis.

Four standard coefficients of affectedness in five variable model are statistically significant, and their values are positive. One exception, however, is out-influence, which is not statistically significant, which is illustrated in Figure 8.

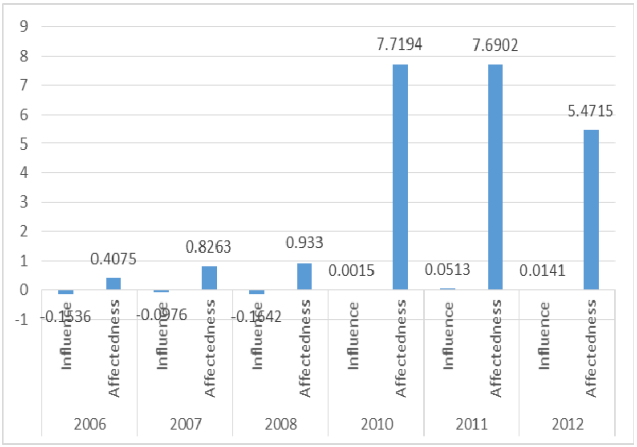


Figure 8 Standard coefficient of influence in the five-variable model in Yokokai (2006-2012).

Therefore, there is partial support for H2b.

C.Effective Size

All standard coefficients of effective size in the three-variable model and the five variable model are shown in Figures 9 and 10, respectively.

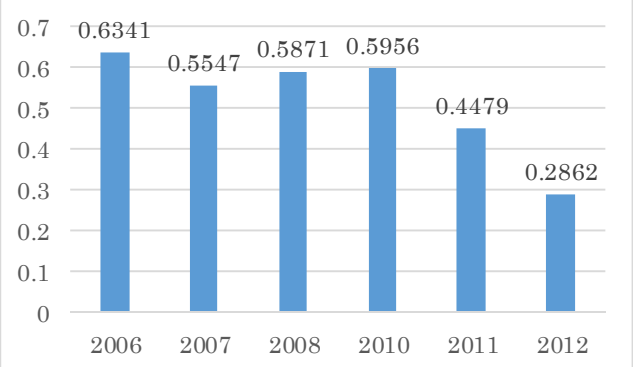


Figure 9 Standard coefficient of effective size in the three-variable model in Yokokai (1985-2004).

Effective size is analogous to the "ego" of a network. The firm has strong connected neighbors if the value of effective size is high. In essence, strong connected neighbors can be considered as good condition to develop transactional relationships because all of the firms have possibility to deal with each other within same keiretsu.

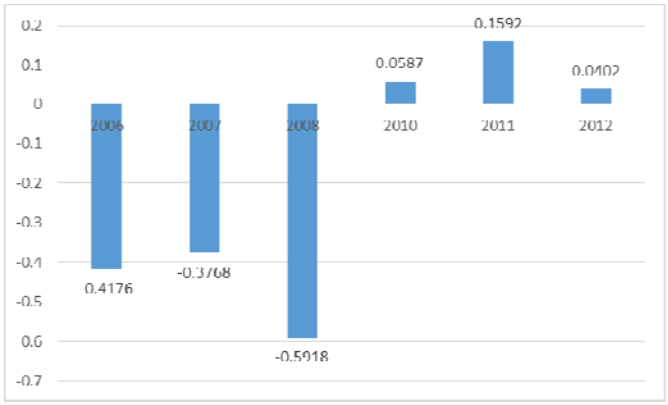


Figure 10 Standard coefficient of effective size in the five-variable model in Yokokai (1985-2004).

Standard coefficients of five-variable model are statistically significant except in 2010 and 2012. The value in 2006, 2007, and 2008 is negative, although the value in 2011is positive. And the values of effective size in three variable model are all statistically significant. Therefore, there is strong support for H3. This could be attributed to the keiretsu having made a major policy shift by breaking away from the so-called "convoy system" of alliance networks. This is also suggestive that much more research is required to answer why the values in 2006, 2007, and 2008 are negative.

D.Euclidean distance

Euclidean distance is calculated in two ways: the three variables of degree, influence and effective size, and the five variables of out-degree, in-degree, out-influence, affectedness and effective size are calculated. The results of the regression analyses are reported in Tables 7 and 8.

Table 7 Regression results of the Euclidean distances and corporate performance

	Correlation Coefficient	Standard coefficient	Adjusted R^2	DW Ratio
2006	-0.3526**	-0.5676**	0.55979	2.2301
2007	-0.2091**	-0.5145**	0.50464	1.7259
2008	-0.1582	-0.1939	0.15098	1.5828
2010	-0.0146	-0.1646	0.11121	1.1292
2011	-0.1451	-0.3347	0.31135	1.2464
2012	-0.1842**	-0.4459**	0.42988	1.414

Note: ** p<0.01, * p<0.05

The results reveal that all of the correlation coefficients are statistically significant. Table 8 also shows all correlation coefficients are negative, which is indicative that longer distance from Mazda are associated with lower sales. (see Figure 11)

Table 8 Regression results of the Euclidean distances and corporate performance

	Correlation Coefficient	Standard coefficient	Adjusted R^2	DW Ratio
2006	-0.2158**	-0.4615**	0.45033	1.9195
2007	-0.2109**	-0.6153**	0.60834	1.9908
2008	-0.1673**	-0.3748**	0.35668	1.7213
2010	-0.0208**	-0.4937**	0.48193	1.5901
2011	-0.2697**	-0.6994**	0.69322	2.0825
2012	-0.2756**	-0.7564**	0.75145	2.3309

Note: ** p<0.01, * p<0.05

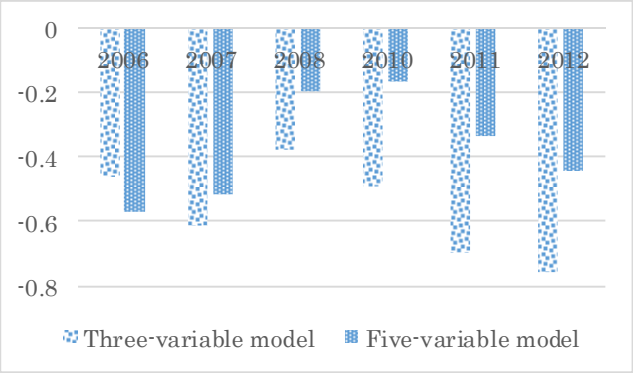


Figure 11 Euclidean distance from Mazda in Yokokai (1985-2004).

Thus, there is strong support for H4 in a transactional network. Moreover, compared with the results in 2006 and 2007, the correlation coefficients are seemingly higher after 2008. According to McGuire and Dow's study, keiretsu, as one of the vertical organization, is over sighted by a core firm, which encourages transactions with its network partners with long-term perspective. All of the basic functions are still working as before even in the aftermath of economic downturn of 2008.

V.LIMITATIONS OF THE STUDY

Although this study makes a contribution to the extant literature, there are some drawbacks that may temper the findings to be held tentative. First, the results of this study should be compared with other factors, such as capital relationship, work flow relationship and friend relationship for identifying the antecedents of corporate management. Second, it is suggested that additional time series data over a period of 10 or 20 years or more should be gathered to longitudinally analyze position and distance trends and changes over time. This will provide a better picture of whether these relationships are stable or vary over time, perhaps owed to economic conditions. Owed to these limitations, the findings of the study should be treated with caution.

VI. DIRECTIONS FOR FUTURE RESEARCH

The findings of this investigation should be viewed in light of the above-noted limitations that are suggestive of future research efforts. First, the interrelationships among the constructs should be verified using data gathered from a sample of keiretsu comprised in different industrial sectors that include machinery, steel, shipbuilding and electronic products. Second, data drawn over a period of six years is a starting point, but insufficient in providing a comprehensive understanding on the real behavior of the firms. Third, three dimension space is only one perspective for analyzing the behavior. Additional indexes should be identified as possible antecedents of corporate performance in network organizations. For example, future studies should investigate the linkage between degree, influence and effective size as determinants of corporate performance.

VII. CONCLUSIONS

In this paper, we proposed a new approach of Euclidean distance with three-dimensional embedding space composed of degree, influence, and effective size using data collected from Mazda Yokokai. Euclidean spatial distance was calculated and its relationship was analyzed relative to distance and corporate performance. The results reveal that inter-firm transactional relationships of Mazda's Yokokai has been changed after the financial crisis in 2008. It shows the detailed quantitative relationship between the structure changes of keiretsu group and its external economic environment. Therefore, Euclidean distance could be considered as one of the crucial determinants of corporate performance. Furthermore, we uncovered time lag effect between out-degree and sales while influence has positive impact on corporate performance.

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