A centrality analysis between transactions and cross shareholdings in Mazda's Keiretsu

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Abstract: Firm's relationship is one of the important issues in the field of corporate management. The authors review network literature related with the automotive industry, and focus their study on the firm's relationship in the Keiretsu of Mazda, Yokokai, in this paper. The authors collected the data of transactions, cross shareholdings, and sales from all firms in Yokokai, and calculated the centrality index based on graph theory in order to discover the rational relationship between transactions and sales m and between cross shareholdings and sales. Generally centrality index are calculated based upon degree, betweenness and closeness indicators. Certain correlation between transactions and sales, and between cross shareholdings and sales have been found. Implications of these findings are discussed. This paper provides a new perspective to find the determinants of the successful corporate management.

Keywords: degree, betweenness, closeness, transaction, cross shareholdings, the Keiretsu

I. INTRODUCTION

Firm's relationship is one of the important issues in the field of corporate management. The Keiretsu, as one special type of group companies is known broadly today. One of the Keiretsu's characteristics is cross shareholdings. The purpose of cross shareholdings can be expressed as follows [1].

The first is to secure long-term strong stockholders for stabilization of corporate governance under the regulation of financial policy. The second is to acquire the latent profits of stock-holding brought by rising of stock prices as a buffer to stabilize corporate performance. And the third is to realize the high productivity by attempting stabilization of the so-called reciprocal business transactions.

However, only a few empirical studies to prove the correlations between transactions and cross shareholdings have been reported until now [2, 3]. And further research is required in this area to improve corporate management relationships and priorities. Therefore, it is necessary to measure the quantitative relationships among the firms, and verify the correlation between transactions and cross shareholdings. This research focuses on the firm's relationship in the keiretsu of Mazda.

The main contributions of this paper are: 1) To uncover the correlation between transactions and sales, and between cross shareholdings and sales, measures of graph theory such as centrality index, including degree and betweenness are measured using computer software called Ucinet. 2) Certain correlation between transactions and cross shareholdings, and between transactions and sales has been found. All of these new findings have been discussed.

This paper is organized as follows. In Section 2, we introduce some basic concepts and explain the centrality model including degree, closeness and betweenness. Section 3 shows the measurement results, and discusses the implications of the new findings. Finally in Section 4 we conclude by a summary of this paper.

II. METHOD

A graph consists of a set of points and a set of lines connecting pairs of point. The point, which composes a network, is called node, and the line, which connects any two nodes directly, is called an edge in graph theory.

The shortest path linking a given pair of nodes is called geodesic. A graph is a model with an undirected dichotomous relation. In other words, a tie is present or absent between each pair of nodes. The data consists of valued and directed relationship in which the strength or intensity of each tie is recorded. The authors collected directed and valued data to compute the centrality of each firm.

1. Outline of the centrality model

Freeman proposed centrality of each node from three viewpoints of degree, betweenness and closeness [4].

1.1 Degree

Freeman defines a degree of node p_k is the number of node connect with it directly. Therefore, Freeman calculated it using the measurement developed by Nieminen [5]. The centrality index of degree of node k can be defined in the following way.

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

where

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

$a(p_i, p_k)=0$ otherwise

The number of nodes adjacent to a given node in a symmetric network is the degree of that actor. For asymmetric network the in-degree of a node p_k is the number of ties received by p_k and the out-degree is the number of ties initiated from p_k.

The degree means the proportion of other nodes that are adjacent to p_k and is viewed as important index of its potential communication activity.

1.2 Betweenness

The index of betweenness is calculated as a probability that node p_k falls on a randomly selected geodesic linking p_i and p_j. Freeman defines the centrality index of betweenness of node k as follows [6].

$$C_B(p_k) = \sum_{i}^{n}\sum_{j}^{n} \frac{g_{ij}(p_k)}{g_{ij}} = \sum_{i}^{n}\sum_{j}^{n} b_{ij}(p_k) \quad \ldots\ldots (2)$$

where

i ? j ? k ;

$g_{ij}(p_k)$: The number of geodesics linking p_i and p_j that contains p_k

g_{ij}: The geodesics linking p_i and p_j

Betweenness is useful as an index of the potential of the node for control of communication, and it is also useful as an index of network structure.

1.3 Closeness

The third is an index of closeness that is a distance from p_k to all other node linking with p_k directly or indirectly. It expresses the distance conditions from a node p_k to other nodes in a network. Closeness index may be useful when measures based upon independence or efficiency is desired.

Closeness index is excluded because all nodes in the networks of transactions and cross shareholdings are not connected with each other. Therefore the distance among firms is infinite. It could not be calculated technically.

2. Data collection

Data of transactions and cross shareholdings in the Keiretsu of Mazda has been collected from the publications and investigation by interviews [8].

The process of data-collection can be expressed as follows.

Step 1: Determine the boundary of the network;

Step 2: Collect the data of transactions and cross shareholdings. Basically the data is a percent value of the transactions or stock holdings between two firms. And input the data into a matrix table.

Step 3: Remove singletons in the matrix table.

The data of each cell in the matrix means transactional relationship which the firm in column accepts auto-components from other suppliers in row of the network of transactions, or capital relationships which the firm in row invests in stocks to other firms in column of the network of cross shareholdings.

The total number of the firms which hold capital relationship with each other in the network of cross shareholdings is 230. It includes 177 firms, 42 financial institutions, and 11 carmakers. The total number of the firms in the network of transactions is 188, including 177 firms and 11 carmakers.

Part of them is isolated in the network. It means that these companies have no any relation with other companies. They are called singletons. All of the singletons are removed from the networks of transactions and cross shareholdings because no essential difference exists between the entire network and the entire network excluded singletons. The network of transactions and cross shareholdings of Mazda can be illustrated as Figure 1.

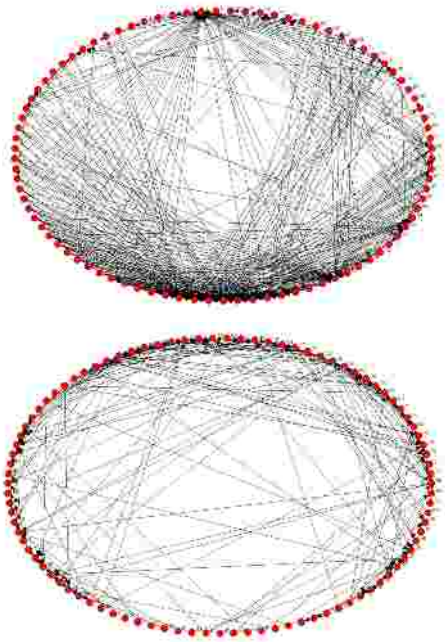

Figure 1 Network of transactions (upper) and cross shareholdings (lower) of Mazda in 2004

In Figure 1, a dot represents a company and an edge means a relation of transactions or cross shareholdings. 89 companies and 95 companies are included in the networks of transactions and cross shareholdings respectively.

III. MEASUREMENT AND ANALYSIS

The authors calculated the centrality including degree and betweenness of each firm in the networks of transactions and cross shareholdings of Mazda. The top ten of each centrality index in 2004 are summarized in Table1.

It means the volume of the firm's purchasing power is big if the value of in-degree is high. If the value of out-degree is high, it means the firm has strong selling power in its network. And if the firm has high value of betweenness, it means the firm purchases and sells its parts simultaneously.

In Table 1, only Hitachi has high values of in-degree, out-degree, and betweenness. It means Hitachi plays an important role in Yokokai because it has extremely power of centrality.

The second finding is that part of the firms such as Denso and Calsonic Kansei Corp. are included in in-degree and betweenness both. It means that certain correlation between in-degree and betweenness exists in the transaction network.

Table 1 Top ten of the centrality index in the transactions network of Mazda in 2004

(1) Top ten of in-degree

No#	Name of firms	In-degree
1	Mazda Motor Corpration	901.13
70	Denso Corp.	205.24
25	Jatco Ltd.	54.74
44	Hitachi, Ltd.	22.14
58	Aisin AI, Ltd	15.3
20	Calsonic Kansei Corp.	12.7
52	Mitsubishi Electric Corporation	11.54
19	Kayaba Industry Co., Ltd.	11.11
27	Stanley Electric Co., Ltd.	9.2
22	Kurarion Co., Ltd	8.8

(2) Top Ten of Out-degree

No#	Name of firms	Out-degree
46	The Furukawa electric Co., Ltd.	100
28	Takata Corporation	99.99
44	Hitachi, Ltd.	99.96
43	Piolax. Inc.	99.96
29	Tokyo Roki co., Ltd.	95.04
61	Imasen Electric industrial Co., Ltd.	92.6
8	Japan Climate Systems Corporation	92
34	Nisshinbo Industries, Inc.	91.63
71	Tokai Rika Co., Ltd.	91.3
4	Keylex Corporation.	90.6

(3) Top Ten of Betweenness

No#	Name of firms	Betweenness
70	Denso Corp.	35.5
38	Japan Brake Industrial Co., Ltd.	28
20	Calsonic Kansei Corp.	11
65	Hikari Seiko Co., Ltd.	8
44	Hitachi, Ltd.	6
73	Toyota Gosei Co., Ltd.	6
72	Toyo Tire&Rubber Co., Ltd.	4
61	Imasen Electric industrial Co., Ltd.	2.5
57	Aisan Industry Co., Ltd Hiroshima Sale	2
19	Kayaba Industry Co., Ltd.	2

The third finding is that part of the firms are selling their parts in the network of transactions because the top ten firms in the group of in-degree is quite different with the top ten firms in the group of out-degree.

In order to discover the relationship mentioned above, the relationship between in-degree, out-degree, betweenness and sales is required. The results are shown in Table 2.

Form Table 2, we can get three new findings as follows.

The first is that the correlation coefficient between out-degree and in-degree is -0.499 ($p=0.01$). It means the more the firms sell, the less the firms purchase. In other words, it means most of the parts sold out in the network are produced out of this group. The second is that certain correlation between transactions and cross

Table 1 The correlation coefficient of centrality between network of transaction and cross shareholdings[#]

	Out-degree (T)	In-degree (T)	Betweenness (T)	Out-degree (C)	In-degree (C)	Betweenness (C)	Sales
Out-degree (T)	1						
	–						
	89						
In-degree (T)	**-.499****	1					
	0	–					
	89	89					
Betweenness (T)	0.127	0.026	1				
	0.237	0.811	–				
	89	89	89				
Out-degree (C)	**-.354****	**.723****	0.226	1			
	0.006	0	0.086	–			
	59	59	59	95			
In-degree (C)	**.542****	**-.380****	0.116	-.218*	1		
	0	0.003	0.383	0.034	–		
	59	59	59	95	95		
Betweenness (C)	0.03	-0.015	**.414****	.243*	0.1	1	
	0.82	0.907	0.001	0.018	0.337	–	
	59	59	59	95	95	95	
Sales	-0.19	**.441****	**.392****	**.727****	-0.11	**.770****	1
	0.12	0	0.001	0	0.453	0	–
	68	68	68	49	49	49	68

C means cross shareholdings network and T means transactions network. These data means correlation ratio/probability/number of sample. **p<0.01 (two-sided); *p<0.05 (two-sided)

shareholdings among out-degree, in-degree and betweenness are significant. Especially the correlation coefficient between out-degree (C) and in-degree (T) reach 0.723(p=0.01). It means the more investment on other suppliers the stronger purchasing power they have. And from the fact that correlation coefficient between in-degree (C) and out-degree (T), we can say the more investment the firms accept the stronger selling power the firms hold. The third is that almost of the centrality indices have strong impacts on sales, one of the important indices of corporate performance.

One of the interest issues is that the correlation coefficient between out-degree (T) and sales, between in-degree (C) and sales are not significant. The main reason is considered as most of the parts are not purchased by the firms in Mazda's group.

IV. CONCLUSION AND FUTURE WORKS

The authors calculated the centrality of network index of Yokokai, and find strong correlation between transactions and cross shareholdings. To discover the effective network structure, more research such as capacity analysis and comparative research of different networks such as Toyota and Honda are required in the near future.

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