An analysis of structure importance in Mazda's Keiretsu

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Abstract: Centrality is one of the effective indices to measure organizational structure. Freeman once proposed a set of centrality indices including degree, closeness, and betweenness. However, Ito discussed the implications of centrality, and found that differences exist even when the centrality is same. In this paper, the authors collected the data of transactions and cross shareholdings from Mazda's Keiretsu Yokokai, and calculated the structural importance based on the new method, so-called SNW model. Furthermore, the authors discussed the implication based on the results of correlation coefficient between the SNW results and corporate performance such as sales and profits. This paper provides a new perspective to discover the structural importance of the network organizations.

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

I. INTRODUCTION

According to the conventional organization theories, corporate organizations can be basically categorized into at least three types. The first one is line organizations, the second is line-and-staff organizations, and the third is functional organizations. Other types such as matrix organizations and project-team organizations have been developed recently. As a new type of successful organizations, Davidow and Malone suggested a new idea of virtual organization in the beginning of 1900's [1]. Another typical successful organization is considered as the Keiretsu in Japan [2]. The authors reviewed the previous research and completed a comparative study of the virtual organizations and Keiretsu theoretically. The authors found many common characteristics between them. One is that they both can be defined as a network organization with mutual transactions and shared information. The common issue in these different organizations is how to discover the effective structure. Centrality is one of the effective indices to measure organizational structure.

The main contributions of this paper are: 1) the new quantitative analysis, so-called SNW model, is discussed; 2) centrality index of all firms including in Mazda's group Yokokai are calculated; 3) correlation coefficient between the new findings of the results of the SNW and corporate performance such as sales and profits are analyzed. Therefore, this paper provides a new perspective to discover the structural importance of the network organization.

This paper is organized as follows. In Section 2, the relevant literature of organizational structure is reviewed briefly. In section 3, the authors introduced some basic concepts, and explained the SNW model. Section 4 shows the measurement results, and discusses the implications of the new findings. Finally in Section 5 we conclude by a summary of this paper.

II. BACKGROUND

Most of the research of network organizations can be characterized by qualitative approach and quantitative approach. One of the most important issues in this field is to discover what kind of relationship is the most effective for corporate management in the IT age today. To determine the relationship in the network organizations, many different models have been developed. A classic but typical method is called Freeman model proposed by Freeman in 1979 [3]. It includes a set of centrality index to calculate the network organizations from the viewpoint of degree, closeness and betweenness. Many new measurements

have been discovered on the basis of Freeman model later. For instance, Tyler et al. proposed a new method applying a betweenness algorithm to identify community within a network [4]. For calculating the relationship of cross shareholdings between firms in the Keiretsu of Toyota, as a revised Freeman model, Ito introduced directed and valued connection lines into Freeman model, and developed new computer program to calculate the centrality index using the data of Toyota's Keiretsu. Strong correlation among out-degree, betweenness and corporate performance has been found [5]. Centrality index is a useful tool for the structure analysis of the network organizations. The structure analysis could be carried out from many different viewpoints, such as position, size in any network organizations. It is obvious that importance analysis of each firm would be one of the most important steps for the structure analysis.

II. METHOD

Freeman proposed centrality of each node from three viewpoints of degree, betweenness and closeness [3]. Degree index is calculated as follows.

1 Degree

Freeman defines a degree of node p_k is the number of node connect with it directly. Therefore, Freeman calculated it with the measurement developed by Nieminen [6]. 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 node. 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.

2 The SNW analysis

In order to discuss the implication of the Freeman model, following example was given [7].

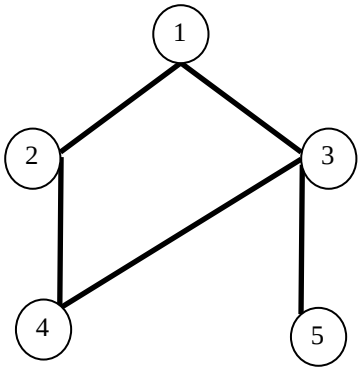


Figure 1 A 5-Node Network

According to Freeman model, the degree index of node 1, 2 and 4 are 2. It is obvious that their structural importance is quite different. The degree index of the entire network is 0.417. But the degree index of the sub-network excluded node 1, 2 and 4 are 0.33, 1 and 0.33 respectively. Node 2 and 3 are more important because the degree index of sub-network excluded node 3 is less than the degree of the entire network.

Therefore, a third method called the SNW model is proposed in 2005 [7]. The SNW model is expressed as follows.

$$I_D(p_k) = C_D - C_D(\bar{p_k}) \quad \ldots\ldots (2)$$

where

$$C_D = \frac{\sum_{i=1}^{n} [\max C_D(p_i) - C_D(p_i)]}{n^2 - 3n + 2}$$

Node k is called strengthening node if the centrality index of sub-network excluded node k is less than that of the entire network. In this case, $I_D(p_k)$ is larger than zero. The opposite is called weakening node when $I_D(p_k)$ is less than zero. Node k is called neutral node if the centrality index excluded sub-network of node k is equivalent to that of the entire network. In this case, $I_D(p_k)$ is equivalent to zero.

III. MEASUREMENT

To avoid conceptual confusions, some important concepts of network organization are given as below.

1 Keiretsu and network

The definition of network organization means a group of nodes, such as persons or firms, having certain relationships among themselves under the condition of having common purpose and willingness to participate. In accordance with this definition, Keiretsu could be interpreted as one kind of network organization in management science.

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. 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 connections in which the strength or intensity of each tie is recorded. Therefore, a graph could be considered as one specific type of network organizations. In network organization, generally the firm should be the node, and the edge should be the different types of relationships such as transactional relationship and friend relationship.

2 Data collection

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

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

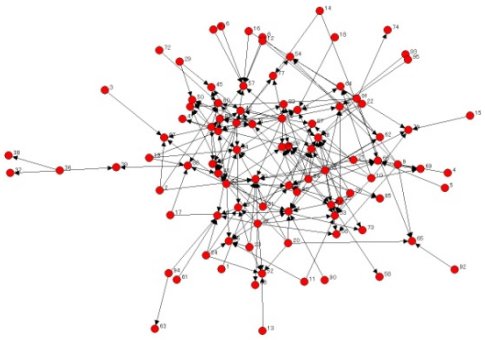
Step1: Determine the boundary of the network;
Step2: Collect the data of transactions and cross shareholdings; basically the data is percent value of the transactions or stock holdings between two firms. And input the data into a matrix table.
Step3: Remove singletons in the matrix table.

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 transactions network, or capital relationships which the firm in row invests in stocks to other firms in column in the network of cross shareholdings.

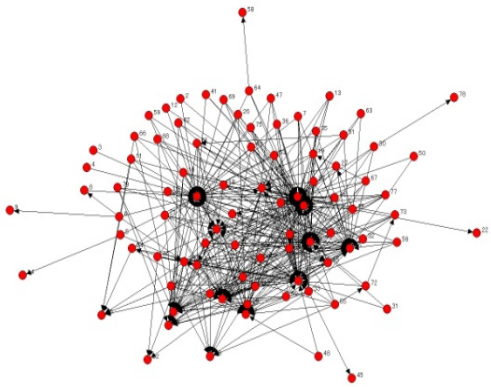
The authors removed the singleton in Keiretsu of Mazda. Singleton means that the node has no any relation with other nodes. They are isolated in the network. The total number of the firms which hold capital relationship with each other in the network of cross shareholdings is 230. It includes 177 parts suppliers, 11 carmakers, 42 banks and financial institutions. The total number of the firms in the network of transactions is 188, including 177 parts suppliers and 11 carmakers.

The numbers of singletons in the networks of transactions and cross shareholdings are 99 and 135 respectively. Therefore, there are 11 car makers and 77 parts suppliers which have reciprocal transaction relationships, 87 companies including Mazda, 51 suppliers and 35 banks and financial institutions have reciprocal capital relationship in Yokokai.

The network of transactions and cross shareholdings of Mazda can be illustrated as Figure 2.



Network of transactions



Network of cross shareholdings

Figure 2 Network of transactions and Cross shareholdings of Mazda in 2004

IV. RESULTS AND DISCUSSIONS

It is difficult to determine which firm is more important in Figure 2. To calculate the importance of each firm, two methods mentioned above are applied in this paper.

The results of the first method can be expressed in Table 1.

Table1 Selected part of degree of each firm in Yokokai

No	out-degree(T)	in-degree(T)	out-degree(C)	in-degree(C)
1	0	0	3	0
2	0	0	9.4	0
3	0	0	5.4	0
4	0	0	2.6	0
5	0	0	3.5	0
6	0	0	1.9	0
7	0	0	1.9	0
8	0	0	6.2	0
9	0	0	23.7	0
10	0	0	24.8	0
11	0	0	13.2	0
12	0	0	6.9	0
13	0	0	3.1	0
14	0	0	10.8	0
15	0	0	3.8	0
16	0	0	8	0
17	0	0	4.4	0
18	0	0	3.4	0
19	0	0	4.8	0
20	0	0	17.9	0
21	0	0	13.7	0
22	0	0	6.8	0
23	0	0	12.5	0
24	0	0	16	0
25	0	0	16.5	0
26	0	0	13	0
27	0	0	46.1	0
28	0	0	59.4	0
29	0	0	7.4	0
30	0	0	31.5	0
31	0	0	19.5	0
32	0	0	40.7	0
33	0	0	86.4	0
34	0	0	107.1	0
35	0	0	52.4	0
36	0	901.13	143.3	0
37	66	0	0	0
38	70	0	0	0
39	90.6	0	0	35
40	66.8	0	0	75
41	89	0	0	0
42	48.9	0	0	0
43	92	2	0	66.6
44	0	2	0	0
45	84	0	0	0
46	76.5	0	0	0
47	40	0	0	0
48	81.3	0	0	0
49	0	4.9	0	0
50	66.6	0	0	31.3

In Table 1, (T) and (C) means transaction and cross share holding respectively. Generally the firm which has high value of out-degree and in-degree of cross shareholdings, and the firm which has high value of out-degree and in-degree of transactions is an important hypothesis in the network organization.

In order to identify the rational relationship between degree and corporate performance, the authors calculated the correlation coefficient among degree and sales, profits. It can be illustrated as Figure 3.

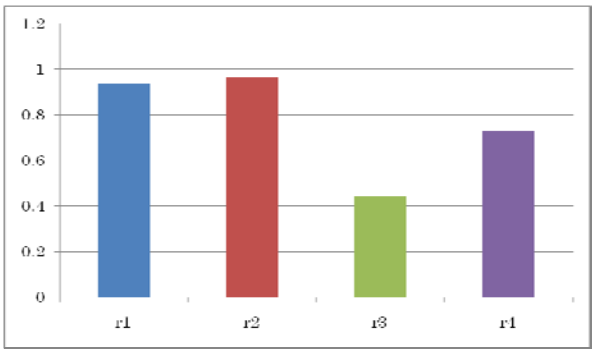


Figure 3 Correlation coefficients between degree and corporate performance

In Figure 3, r1 and r2 means correlation coefficient between profits and in-degree (T), profit and out-degree (C) respectively. And r3 and r4 is correlation coefficient between sales and in-degree (T) and sales and out-degree (C) respectively. All of them are significant. Basically the suppliers which have high value of out-degree (C) have strong control power for other suppliers. And the suppliers which have high value of in-degree (T) should have specific skills of production and manufacturing. From this result, higher degree, stronger sales and profit is hold. Unfortunately, not only the value of all correlation coefficients between corporate performance and degree out-degree (T) and in-degree (C) are very low, but also they are not significant. Therefore, the authors calculated the structural importance using the SNW model. The results are shown in Table 2.

The authors calculated the correlation coefficient between the SNW and sales, profits. Not only the value of the results between the SNW and sales are very low, but also all of them are not significant. The results of the SNW and profit can be illustrated as Figure 4.

In Figure 4, r5 and r6 means correlation coefficient between out-degree (T) of the SNW and profit, and between in-degree (C) and profit respectively. All of them are significant. High value of out-degree means strong selling power. Therefore, stronger selling power, more profit is hold. The suppliers which accept investment higher should be considered as they are under control of the investment companies. Therefore, the prices of the orders comes from investment companies may be very low. This is the considerable reason to explain why correlation coefficient of r6 is negative.

Table 2 Structural importance of each firm in Yokokai based on the SNW analysis

No	Out-degree(T)	In-degree(T)	Out-degree(C)	In-degree(C)
	Criterion=0.54	Criterion=9.85	Criterion=2.99	Criterion=0.87
1	–	–	W	W
2	–	–	W	W
3	–	–	W	W
4	–	–	W	W
5	–	–	W	W
6	–	–	W	W
7	–	–	W	W
8	–	–	W	W
9	–	–	W	W
10	–	–	W	W
11	–	–	W	W
12	–	–	W	W
13	–	–	W	W
14	–	–	W	W
15	–	–	W	W
16	–	–	W	W
17	–	–	W	W
18	–	–	W	W
19	–	–	W	W
20	–	–	W	W
21	–	–	W	W
22	–	–	W	W
23	–	–	W	W
24	–	–	W	W
25	–	–	W	W
26	–	–	W	W
27	–	–	W	W
28	–	–	W	W
29	–	–	W	S
30	–	–	W	W
31	–	–	W	W
32	–	–	W	W
33	–	–	W	W
34	–	–	W	W
35	–	–	W	W
36	W	S	W	W
37	W	S	–	–
38	W	S	–	–
39	W	S	W	W
40	W	S	W	W
41	W	S	–	–
42	W	W	–	–
43	W	S	W	W
44	S	W	–	–
45	W	W	–	–
46	W	S	–	–
47	W	S	–	–
48	W	W	–	–
49	S	W	–	–
50	W	W	S	W

IV. CONCLUSION AND FUTURE WORKS

The authors calculated the degree, one of the centrality indices, and the structural importance using the SNW model. In order to identify the determinants of corporate performance, correlation coefficients between degree and sales and between degree and profit, between the results of the SNW and sales and profit have been measured. Degree and the SNW are both very effective. And it is shown that these two methods are practical for the empirical study in this paper.

Needless to say, some problems are still left. For instance, the data collected is only one fiscal year in this paper. Much more data are required for further analysis. Correlation coefficient between sales and the results of the SNW model is also needed to be analyzed more. Moreover, the SNW is only applied into degree, more analysis applying into other centrality indices such as closeness and between need to be done in the near future.

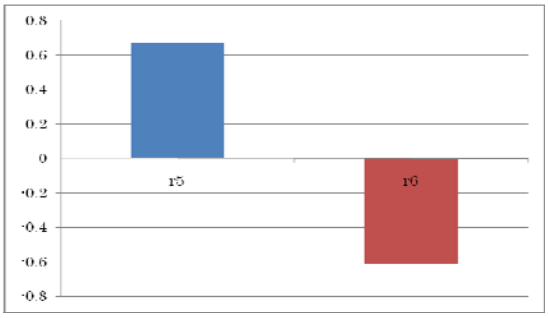


Figure 4 Correlation coefficients between the SNW and Profit

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