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An Efficiency Analysis using the ICB Model in Mazda's Keiretsu

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Abstract: Performance—an indicant of corporate efficient and effectiveness—is determined by many different factors, such as economic environment and coordination of managerial resources. Only recently has performance, which is based on graph theory, been extended and analyzed to assess structural change of network organizations. Only a few indexes based on graph theory have applied and analyzed in most recent research to measure the structural changes of network organizations. In order to develop a rational model, this empirical research attempts to establish the inter-relational linkages among multiple corporate performance indices. Specially, this paper seeks to assess corporate efficiency using the DEA analysis. Accordingly, the contribution of this research is to propose a new way to build a quantitative model that identifies the efficiency of each individual firm in Mazda's Yokokai Keiretsu.

Keywords: Degree, Closeness, Influence, Efficiency, the DEA

1 INTRODUCTION

Performance—an indicant of corporate efficient and effectiveness—is determined by many different factors, such as economic environment and coordination of managerial resources. Only recently has performance, which is based on graph theory, been extended and analyzed to assess structural change of network organizations. Only a few indexes based on graph theory have applied and analyzed in most recent research to measure the structural changes of network organizations. One of the important issues is to improve the efficiency in corporate management. The position of each individual firm in the Keiretsu instead of the input is calculated using graph theory in this paper. The contribution of this research is to propose a new way to build a quantitative model that identifies the efficiency of each individual firm in Mazda's Yokokai Keiretsu.

2 BACKGROUND

Recently most of the research on network analysis focused on a few indices to determine the position of each individual firm in the Keiretsu. Single index usually express only one aspect of the position. Much more indexes should be used to determine the precise position. Therefore, the authors selected the relevant indexes based on the previous research, and built a quantitative model called ICB (In-degree, Closeness and By-influence) model under the measurement results of the correlation coefficient in this paper.

Many useful indexes to identify the factors of the position have been developed recently.

Centrality index is one of the useful indexes. Basically it includes degree, closeness and betweenness. Degree is one of the centrality indexes to express a firm's potential communication activity. In transaction network, degree includes two categories: in-degree and out-degree, because transaction network is an asymmetric network organization. In-degree means a firm purchases the parts from other firms, and out-degree means a firm sells the parts to other firms. Closeness is another centrality index to express the distance from a firm to all other firms linking with it direct and indirectly. Two indexes are included in transaction networks. They are in-closeness and out-closeness. In-closeness is the summation of the length from a firm to all other reachable firms, and out-closeness is summation of the length from all other reachable firms to it. In transaction network, the firm is located at an easy position if its closeness value is low.

Table 1. Matrix of correlation coefficients between network indexes and corporate performance

		Out-degree	In-degree	Betweenness	Closeness	Influence	By-influence	Sales	Profit
Out-degree	Pearson' correlation coefficient	1							
	Significant Probability (Two side)								
	N	89							
In-degree	Pearson' correlation coefficient	-0.433**	1						
	Significant Probability (Two sid	0							
	N	89	89						
Betweenness	Pearson' correlation coefficient	0.112	0.035	1					
	Significant Probability (Two sid	0.295	0.746						
	N	89	89	89					
Closeness	Pearson' correlation coefficient	-0.329**	-0.389**	-0.194	1				
	Significant Probability (Two sid	0.002	0	0.068					
	N	89	89	89	89				
Influence	Pearson' correlation coefficient	0.977**	-0.420**	0.101	-0.328**	1			
	Significant Probability (Two sid	0	0	0.348	0.002				
	N	89	89	89	89	89			
By-influence	Pearson' correlation coefficient	-0.433**	0.999**	0.03	-0.386**	-0.419**	1		
	Significant Probability (Two sid	0	0	0.778	0	0			
	N	89	89	89	89	89	89		
Sales	Pearson' correlation coefficient	-0.468**	0.766**	-0.018	-0.325**	-0.449**	0.794**	1	
	Significant Probability (Two sid	0	0	0.873	0.003	0	0		
	N	80	80	80	80	80	80	80	
Profit	Pearson' correlation coefficient	-0.302**	0.676**	0.025	-0.345**	-0.288*	0.706**	0.916**	1
	Significant Probability (Two sid	0.009	0	0.834	0.003	0.013	0	0	
	N	74	74	74	74	74	74	74	74

Betweenness is another useful as an index of the potential of a firm to control communication, and it is also useful as an index of the network structure. Ito et al once measured centrality index including degree, closeness and betweenness to determine the positions of each individual firm [1]-[3].

Influence is a power to have impact on other firms. The power is called by-influence when the firm is affected by other firms. Therefore, influence will be divided into two parts: influence and by–influence in transaction networks. Kimura et al once proposed and calculated the influence in 2007 [4][5].

3 METHOD

3.1 Variables selection

Corporate performance index plays important roles in strategy formation. Not only labor productivity and return on investment, but also sales and profit are considered as the index of corporate performance. In this paper, the authors use sales and profit to express the corporate performance.

The following step is needed to build up an effective model.

1. Select the relevant variables which have potential effect on position-determination.
2. Calculate the correlation coefficients between the selected variables and corporate performance.
3. Determine framework of the model.

In this paper, all of these indexes are used as the input factor to determine sales and profit, the output of each firm.

The authors selected the degree, closeness and influence, and calculated the correlation coefficients between the selected variables and corporate performance.

3.2 Data collection

In order to measure all member firms' capacity in networks, transaction data in the Yokokai Keiretsu was collected from personal interviews with senior managers as well as publications of the Japan Auto Parts Industries Association and Automotive Parts Publishing Company [6][7]. In addition, corporate performance as measured by Mazda's revenues and profits for fiscal year 2004 was obtained.

In 2004, 177 component-parts suppliers were members of Mazda's Yokokai Keiretsu. Seventy-two parts suppliers and Mazda have reciprocal transactional relationships, whereas 105 parts suppliers are singletons. A singleton means a firm which has no relationship with other firms in the network. Furthermore, a singleton is an isolate company whose in-degree and out-degree are both zero.

3.3 Outline of the ICB model

The transactional relationships among the companies were identified through graph modeling. A tie shows the percentage of the transaction between each pair of firms. We collected directed and weighted data to measure the selected indexes of each firm.

Table 2. Top ten firms of the selected firms in Yokokai

		In-degree (rank)		Closeness (rank)		By-influence (rank)	
1	Mazda Motor Corporation	774.277	(1)	0.0076	(1)	7.8296	(1)
2	Toyota Motor Corporation	648.605	(2)	0.0065	(3)	7.3868	(2)
3	Nissan Motor Co., Ltd.	541.188	(3)	0.0061	(7)	5.5561	(3)
4	Mitsubishi Motors	508.601	(4)	0.0068	(2)	5.1719	(4)
5	Honda Motor Co., Ltd.	487.596	(5)	0.0065	(4)	5.0799	(5)
6	Suzuki Motor Corporation	231.424	(6)	0.0058	(11)	2.4179	(6)
7	Denso Corporation	190.379	(7)	0.0061	(6)	1.9112	(7)
8	Fuji Heavy Industries Ltd.	172.414	(8)	0.0055	(35)	1.7821	(8)
9	Daihatsu Motor Co., Ltd.	129.521	(9)	0.0051	(60)	1.3638	(9)
10	Hino Motors Ltd.	52.446	(10)	0.0047	(66)	0.547	(10)
17	NSK Ltd.	4.026	(17)	0.0062	(15)	0.0403	(17)
12	Calsonic Kansei	12.278	(12)	0.0058	(8)	0.1233	(12)
40	Nisshinbo Industries, Inc.	0	(*)	0.0058	(9)	0	(*)
11	Hitachi, Ltd.	13.474	(11)	0.0058	(10)	0.1356	(11)

*: less than 21

All of the selected indexes are calculated as follows.

1) Degree

$$C_D(p_k) = \sum_{i=1}^{n} a(p_i, p_k); \quad k = 1, 2, \cdots, n$$

where

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

$= 0$; otherwise

2) Closeness

$$C_C(p_k)^{-1} = \sum_{i=1}^{n} (p_i, p_k); \quad k = 1, 2, \cdots, n$$

where

d(pi,pj): the number of edges in the geodesic linking p_i and p_j

3) Betweenness

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

where

i>j; i≠j≠k;

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

g_{ij}: the geodesics linking p_i and p_k

4) Influence

$$T = A + R = A(I - A)^{-1}$$

where

A: direct influence

I: Identity matrix

In order to determine a significant relationship between input and output, then matrix of correlation coefficients is shown as Table 1. In-closeness and out-closeness cannot be calculated technically because the distance between two firms is infinity even when they are connected separately. For instance, Sumino sells the parts to NSK Co., Ltd, and NSK sells parts to Mazda, but Mazda sells nothing to Sumino. In this case, the distance between Sumino and Mazda is not computable because the distance is infinity. Therefore, the authors modified the transaction network as symmetric organization, and then calculated closeness.

It is easy to find that in-degree or by-influence has positive strong impact when out-degree or influence has negative impact on sales and profit in Table 1. Betweenness means a firm purchase parts from other firms and sells its products to other firms. Thus betweenness should have impact on sales and profit. Unfortunately no significance could be found between betweenness and sales, profit. It is obviously that sales

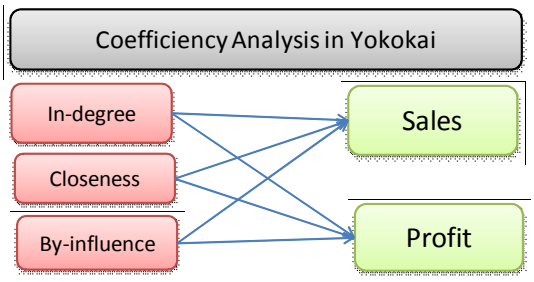

Fig. 1. Framework of the efficiency analysis

and profit are affected by degree, closeness and influence. In this paper, in-degree, closeness and by-influence is used as the input of efficiency. The framework is shown as follows.

4 RESULTS AND DISCUSSIONS

All of the selected indexes are measured based upon on the collected data. Top ten firms of the selected indexes are shown in Table 2. Figure 2 shows the position of all firms including the Yokokai.

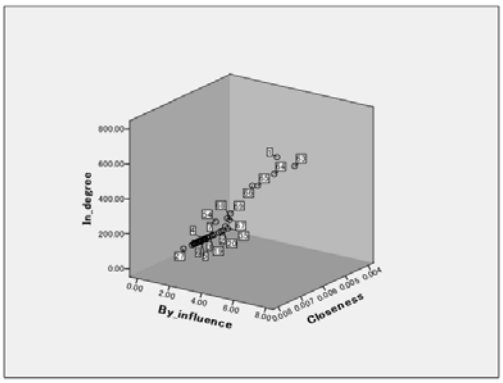

Fig. 2. Efficiency of the firms in Mazda's Keiretsu

The efficiencies of all the firms including parts makers and 11 car-makers are shown in Figure 3.

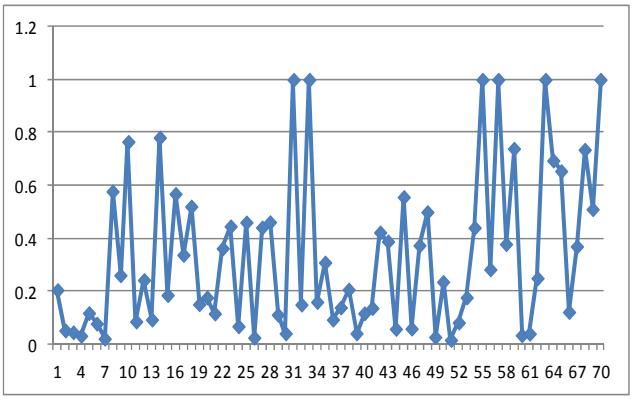

Fig. 3. Efficiency of each firm in Yokokai

In Figure 3, 6 firm's efficiency is 1. They are Pioneer Corporation (31), Hitachi, Ltd. (33), Tokai Rika Co., Ltd. (55), Toyota Gosei Co., Ltd. (57), Toyota Motor Corporation (64), and Hino Motors Ltd. (71). All of these companies are belong to the Toyota group. It is considered as the evidence that Keiretsu is no more centralized or integrated as it was before 1990. It is called loosening of Keiretsu alliance.

Ten firms with lowest value of efficiency are Kokusan Parts Industry Co., Ltd. (0.017), Nippon Thermostat Co., Ltd. (0.022), Ring Techs Hiroshima Co., Ltd. (0.023), Owari Precise Products Co., Ltd. (0.026), Hanshin Electric Co., Ltd.(0.031), Meiwa Industry Co., Ltd. (0.036), Sumino Kogyo Co., Ltd. (0.038), Hikari Seiko Co., Ltd. (0.043), and Kurashiki Kako Co., Ltd. (0.048). In order to improve the efficiency, the detailed relationship between the selected network indices and corporate performance should be analyzed.

5 CONCLUSION AND FUTURE WORKS

In this paper, the authors proposed a new model of efficiency analysis based upon the calculation of the position of each individual firm, such as degree, betweenness, closeness and influence. And the efficiency of all individual firms in the Yokokai is calculated. Further studies such as the solution to improve the input indices, the relationship between selected network indices and corporate performance are considered as the future works of this research.

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