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Research Article

Predicting the State of Interfirm Relationships: An Empirical Investigation Using Integrative Forecasting Techniques

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ABSTRACT
The formation of successful corporate strategy among vertically integrated organizations is predicated upon a plethora of dynamic relationships among buyer-seller firms. Albeit growing in interest, there is a paucity of research that focuses on predicting the nature of interfirm relationships among Japanese keiretsu members. Discerning this knowledge can help formulate successful strategic decisions, such as whether to continue procuring parts or increasing future investments in partner firms. As studies on predicting interfirm relationships among keiretsu member firms has been scant, this research offers insights by illustrating a newer approach for making decisions regarding corporate strategy. Using data collected on transaction from Yokokai—parts suppliers of Mazda—in this study a new model is developed to predict the nature of interfirm relationships using the degree index and DEA model. The primary contribution of this research is that interfirm relationships not only depend on future trends, but are also determined by the interactions among member firms of a keiretsu.

1. Introduction

In vertically integrated arrangements, formulation of successful corporate strategy is predicated upon a plethora of dynamic interrelationships among member organizations, such as frequently engaging in interfirm transactions, cross-firm investments, and jointly coalesce towards attaining collective, supra-organizational goals. Although there is growing interest, research on these vertically integrated organizational forms has been fragmentary. Indeed, research that focuses on predicting the nature of interfirm relationships among Japanese keiretsu members is scant. Discerning this knowledge can direct determine strategic decisions, such as whether to continue procuring parts or increasing future investments in partner firms. Accordingly, this study makes a contribution to the extant literature by illustrating a novel integrative forecasting approach for predicting the state of interfirm relationships, which is not only dependent on future economic conditions, but also determined by the interactive relationships among keiretsu member organizations. This manuscript is structured as follows. Section 2 reviews the relevant literature on forecasting methods and interfirm relationships. In Section 3, the model building procedure and process for predicting interfirm relationships using our new proposed method is explicated. In Section 4, the application of the integrative forecasting approach is exemplified. In Section 5, the results of this empirical study using the data drawn from Yokokai, Mazda's

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Keiretsu, is compared and contrasted to validate our new proposed integrative forecasting method vis-à-vis traditional prediction methods and approaches. Section 6 identifies limitations and offers directions for future research.

2. Background

As well-known organizational structures, Japanese keiretsu typically comprise a family of interfirm cooperative arrangements among member automotive manufacturers and their component parts suppliers. It is widely recognized that the success of corporate management of these inter-family structured business constellations and alliances depends to a large extent on interfirm relationships among partner firms. A plethora of studies on interfirm relationships have been published. For instance, Bensaou illustrated a framework for managing a portfolio of relationships among partner firms. More specifically, he (a) proposed the type of relation design a firm should choose under different external contingencies, and (b) what is the appropriate way to manage different types of relationships [1]. In another investigation, Mathijs De Vaan clarified how the composition and stability of network ties affect firm performance in industries characterized by rapid technological change [2]. All of these research studies focused on the interfirm relationships using past data sets. While offering explanations to past occurrences is important, forecasting the future developmental trends of interfirm relationships would be even more salient. Indeed, businesses place tremendous importance on the prediction in different fields, such as weather forecasting, and stock price movements [3]. In the context of keiretsu, as studies on prediction of interrelationships among interfirm partners have been sparse, this research offers insights by showing a newer approach for making decisions regarding corporate strategy. Using data collected on transaction from Yokokai—parts suppliers of Mazda—in this study a new model is developed to forecast interfirm relationship using graph theory.

3. Model Building

Generally, all forecasting methods, which include moving average and ARMA models, have focus on future trends and rate of change for time series data depending on past values of the variable being forecasted and on past prediction errors. Moreover, the input data sets are basically independent with each other. However, in case of network organizations, all indexes are connected with each other; thus, the criterion variable will vary if one of the indexes, such as degree and influence change [4], [5]. Consequently, the prediction of interfirm relationships basically comprises two aspects. The first is future trends, which may exhibit increasing or decreasing values. And, the second is the rate of change for time series data. Thus, future trend will be determined by not only time series change, but also cross-sectional interaction of interfirm relationship. In this paper, time series change can be measured by least square method, and future trend will be identified by using comparative study between different term's efficiency. That is indicative of a strong incentive to develop next transaction if the t+1 term' efficiency is larger than its previous term. Therefore, to calculate relative efficiency another forecasting method—the DEA procedure—is proposed. Cross-sectional interaction can be calculated using graph theory, such degree, and influence of interfirm relationships. Accordingly, the procedure can be shown as below.

1. Collect adjacent matrix data from Keiretsu.
2. Calculate network indexes such as degree using graph theory. In asymmetric network, degree will be divided into out-degree and in-degree. They will used as input data sets in DEA model. Degree will be calculated as below.

$$\mathrm{Deg} = \sum_i^n a(p_i, p_k) \tag{1}$$

3. Put the network indexes as input data set into DEA model with output data set. The generalized model of the CCR model is formulated as follows:
   Objective function

$$\max \ \theta = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \tag{2}$$

   Subject to

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \tag{3}$$

$$u_r \geq 0 \ \ (\mathrm{r} = 1,2,\cdots,\mathrm{s}) \tag{4}$$

$$v_i \geq 0 \ \ (\mathrm{i} = 1,2,\cdots,\mathrm{m}) \tag{5}$$

4. Select specific firm from the keiretsu and forecast the value of interfirm relation using regression model.
5. Calculate the rate of change of the specific firm. The rate of change *r* will be calculated as below.

$$\mathrm{r} = \frac{Deg_{t+1} - Deg_t}{Deg_t} \leq 1 \tag{6}$$

where

Deg_{t+1} predicted value of degree at t+1 term

Deg_t existed value of degree at t term

6. Input the degree index as input data into DEA model, and calculate the relative efficiency (θ_0).
7. Determine the transaction firms of the specific firm, and predict the value of interfirm relation using the rate of change for each firms.
8. Calculate degree index again, and input the degree as input data sets of DEA model; calculate the efficiencies of each firms: θ_1, θ_2, $\cdots \theta_n$.
9. Determine the direction of the transaction firms, to keep going up if $\theta_i \geq \theta$; Otherwise keep going down.
10. Predict the values of interfirm relationship.
11. Check the difference between prediction and observed value, find the reason if the big gap exists.

4. An Example

Suppose a five node network shown in Fig. 1 is given

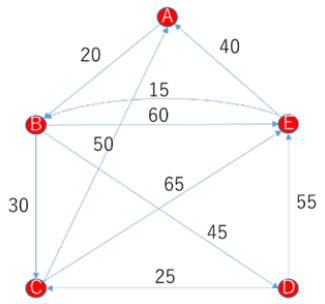

Fig. 1. An Example of Five-node Network.

[4].

Based on degree equation, in-degree and out-degree will be calculated in Table 1 as below.

Table 1. This is the caption.

	Out-degree	In-degree
A	20	90
B	135	35
C	115	55
D	80	45
E	55	180

The relative efficiency of the five firms are 0.714, 1, 0.322, 0.543, 1 respectively when the sales revenue of the five firms are 100, 90, 250, 300, and 400 respectively. Suppose the regression model of out-degree of node D is y=20x-100 based on data sets of 9 historical term. Thus, the out-degree of B in next term will be 100. The rate of change is 0.25. Consequently, the relationships with C, and E will be 31.25, and 68.75, respectively. The new value of interfirm relation of D-C and D-E are 0.505, and 0.482, respectively. They are less than θ_0=0.543; therefore, the direction of the future trend will be negative. The prediction value of D-C and D-E will be 18.75, and 41.25. It means that the relationship between D and C, and D and E will be weaker than before.

5. Empirical Studies

In order to predict the relationship of the keiretsu, data for the duration 2004 to 2008 was obtained from Yokokai, a network organization of the automotive parts suppliers. The network of Yokokai in 2004 is illustrated as in Fig.

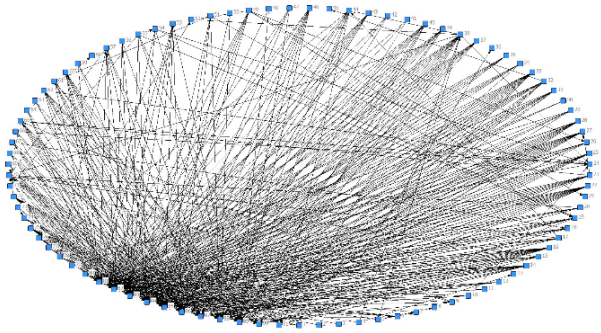

Fig. 2. An Example of Transaction of Yokokai in 2004.

2.

To predict interfirm relationships in 2008, the out-degree of Hiroshima Aluminum are calculated in Table 2.

Table 2. Out-degree of Hiroshima Aluminum.

	Out-degree
2004	76.5
2005	76
2006	79
2007	78.8

The relative efficiency of Hiroshima Aluminum is 0.04. The prediction value of out-degree in 2008 will be calculated as 80.05 using regression model. The observed value in 2008 is 81.2. The rate of change will be calculated as 1.58%. There are four companies have transactions with Hiroshima Aluminum in 2007. They are Mazda, Honda, Jatco, and Aishin AW. This rate is used to calculate the relationship and efficiency. The new efficiencies of Mazda, Honda, Jatco, and Aishin AW are 0.039, 0.092, 0.088, and 0.101, respectively. Thus, only the efficiency with Mazda is less than the former. It indicates that the future trend of the relationship with

Mazda will be negative. The results of prediction and efficiency can be shown in Table 3 below.

Table 3. Prediction Results and Observed Data.

	Prediction	Observed Data Set
Mazda	53.04	48
Honda	8.84	6.9
Jatco	10.46	11.5
Aishin AW	5.99	14.8

Basically, the traditional approach of prediction is only to calculate the trend based on time series change. To compare the traditional approach with our newer proposed method, the prediction of interfirm relationships is conducted. The value of interfirm of Hiroshima Aluminum with Mazda, Honda, and Jatco are 54.7, 7.2, and 11.25 respectively using the regression model without considering the interaction among firms to predict. The relationship with Aishin AW cannot be calculated because of lack of data. Using the observed data, prediction using our proposed method, versus prediction without considering the interaction is illustrated in Fig. 3.

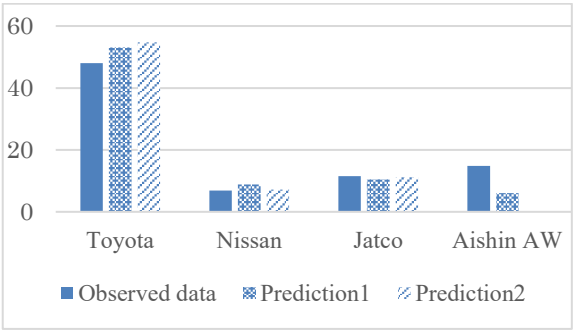

Fig. 3. Prediction Results of the Relationships between Hiroshima Aluminum and its Suppliers.

Prediction 1 indicates the proposed method, which is compared with the results of Prediction 2 (or the traditional approach) in Fig. 3. All other firms exhibit similar results. Similarly, we selected KYB and compared the results using the same method, which is reported in Fig. 4.

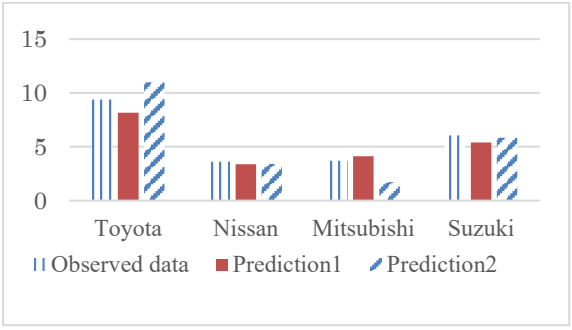

Fig. 4. Prediction Results of the Relationships between the KYB and its Suppliers.

This study corroborates that the result of our newer proposed method is much more accurate than the traditional approach. Accordingly, the results obtained in this empirical investigation find validation and support of our integrative forecasting method.

6. Conclusion

In this paper, a new method using two integrative forecasting techniques was proposed. Using transaction data drawn from Mazda's Yokokai, the value of interfirm relationship of Hiroshima Aluminum and KYB were selected and predicted. The results validate and corroborate that the newer method has met with empirical support.

A limitation of this paper, however, is that only one network index—degree—is used. Additional network indices, such as influence and closeness, should also be investigated to test the validity of the newer forecasting model. Furthermore, in future research studies not only transactional data, but also cross-shareholdings among member firms, should be employed.

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