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A relationship analysis between centrality and module production in the Keiretsu of Mazda

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***Abstract*:** Relationship analysis is one of the most interesting issues in inter-organizational management. Relationship between auto maker and parts suppliers in the Keiretsu of Japan, as one of the special cases, has been changed greatly due to the diffusion of module production recently. Parts suppliers are required to develop their capacity of R&D and parts integration to cope with the new situation. In order to measure the transactional relationship between centrality and module production, we review the literature of module production and inter-organizational research from the viewpoint of network, and measure eigenvector, one of the centrality indices, of the transaction network in the keiretsu of Mazda using the two fiscal years of 1995 and 2005. We analyze the changes of inter-organizational relationship between the years of 1995 and 2005, and identify the relationship between centrality and module system. Furthermore, we discuss the implications of our new findings of the transactional network in Mazda.

Keywords: module production, supplier, network analysis

I. INTRODUCTION

Module production, as one of the new production system, has been introduced in the keiretsu of Mazda from 2000. Two different types of module production exist in Mazda. The first is sub-assy (assembly) type. Most of the component-parts assembled to a certain extent are called sub-assy type. They can be delivered to Mazda directly. The second is functional integration type. All of the parts integrated functionally based on the idea of combining related parts into one unit called functional integration type.

The formation of keiretsu has been changed greatly because the module production and open policy of the parts transaction are adopted in Mazda. Mazda not only deals with the members of keiretsu of Mazda, but also with the members of other keiretsu such as Toyota and Nissan. Therefore, all of the powerful suppliers such as foreign parts-makers and other parts-makers of other keiretsu would be considered as the competitive rivals for the suppliers of Mazda in Hiroshima area. In order to keep up with the new trend, most of the suppliers concentrate on integrating the production of related parts. One of the most interesting issues is what kind of changes has been taken place in the keiretsu of Mazda.

In this paper, we apply centrality analysis of network theory to the keiretsu of Mazda for identifying the central suppliers. We examine the features of those central suppliers, and analyze the relationship between centrality and module production.

The main contribution of this paper is to provide an empirical perspective to identify the relationship between the centrality and module production in the keiretsu of Mazda. We measure eigenvector, one of the centrality indices, of the transaction network in the keiretsu of Mazda using the two fiscal years of 1995 and 2005. We analyze the change of inter-organizational relationship between the years of 1995 and 2005, and identify the relationship between centrality and module system. Furthermore, the implications of our new findings are discussed in this paper.

This paper is organized as follows. In Section 2, we review some relevant literature of the module production and network research. And then, we introduce the measurement of eigenvector and calculate this index in Section 3. We analyze the results and discuss the implication of our analysis in Section 4. Finally we conclude in Section 5.

II. Background

Whilst module production is not new conception [1], it appears that more and more automotive manufacturers are now realizing that modular strategies for production can offer potential long-term benefits to suppliers and customers. There has been a plethora of discussions of module production given in the literature. For instance, Fujimoto, Takeishi, and Aoshima [2] propose that four kinds of architecture could be classified based on the features of product-process: integral architecture, modular architecture, closed architecture, and open architecture. The integral-closed type product is adopted in the Japanese automobile industry.

Egusa [3] investigated the module production in Mazda and found that the module production is carried out in the production of front-end field, cockpit field, center panel field, door field, and fuel tank field. These parts are composed of many different kinds of parts. One of the most important issues for teir-1 suppliers is to improve their ability of parts integration. The adjustment problem occurred in the supplier is that what kind of parts should be integrated for the module production.

We investigated the keiretsu of Mazda and found that module production has close relationship with transaction. In other words, it is not enough to study module production without considering the transaction among the firms of keiretsu. Inter-organizational relationships in keiretsu have been analyzed with quantitative analysis tools such as centrality analysis [4]. Fukuoka et al. [5] reported a new trend in relationships between firms in the keiretsu of Nissan from the viewpoint of network organization. Furthermore,

Kimura and Ito [6] analyze the transactional network using influence index, and find that the suppliers in Hiroshima area have lower power of influence compared with other suppliers. Furthermore, Kimura and Ito [7] measure the keiretsu network of Mazda with the centrality index of information and eigenvector; and found that most of the suppliers in Hiroshima area occupy an important position although part of them are not ranked at the high centrality group.

III. Measurement

1. Eigenvector

Many methods have been developed to measure the centrality of a network. Eigenvector index of the largest positive eigenvector is a measure of centrality. It also called Bonacich centrality. Eigenvector follows that the centralities will be the elements of the corresponding eigenvector. Given an adjacency matrix 'A', the centrality of node k (denoted c_k), is given by $c_k = a\sum A_{ij}c_j$ where 'A' is a parameter [8].

We apply eigenvector, one of the centrality indices, to measure central suppliers in the keiretsu of Mazda.

2. Measurement

Every car maker has its supplier's organization in Japan. They are called '*Kyoryokukai*'. The *Kyoryokukai* of Mazda is called '*Yokokai*'. *Yokokai*, the cooperative organization of parts suppliers of Mazda, is composed of three regional sub-organizations of Kanto, Kansai, and Nishi Nihon. In order to identify the influence of the module production on transaction, we measure eigenvector of the transaction network in Mazda using the two fiscal years of 1995 and 2005 in this paper.

The total number of the firms in the keiretsu of Mazda in 1995 and 2005 is 192 and 181 respectively. They can be illustrated as in Figure 1 and Figure 2.

Fig.1. Transactional network of Yokokai in 1995

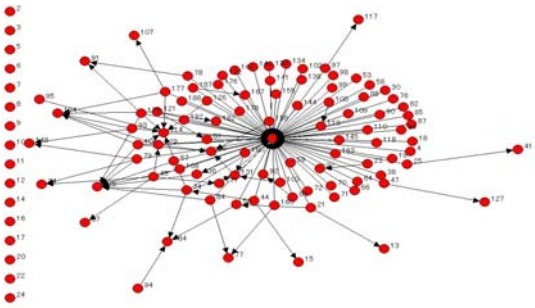
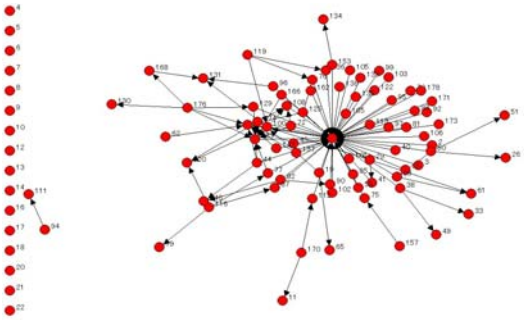


Fig.2. Transactional network of Yokokai in 2005



The result of the measurement is shown in Table 1.

Table 1. Top 10 suppliers in 1995

	Firms	Value
1	Toyo Seat	0.240
2	Mazda Parts Industry	0.228
3	Miura Industry	0.222
4	Hiroshima Seiken Kogyo	0.205
5	Mitsuba Industry	0.205
6	Delta	0.198
7	Sumino Kogyo	0.191
8	Microtecno Corporation	0.189
9	Hiroshima Aluminum Industry	0.176
10	Hirotani	0.164

In 1995, Toyo Seat is ranked at the top in Table 1. Toyo Seat is a firm of supplying seat of compact car to Mazda. Delta, ranked at the sixth, is also a seat supplier of Mazda. It is obviously that Toyo Seat, located in Hiroshima area, is the most central firms in the transactional network. Miura Industry is ranked at the third. Dash panel and rear-end panel are its main

products. Mitsuba Industry is ranked at the fifth. The main products of Mitsuba Industry is cross-member and door arm. Sumino Kogyo specializes in the small parts press is ranked at the seventh.

In order to compare with the result in 1995, we measure the centrality of 2005. The result is shown in table 2.

Table2. Top 10 suppliers in 2005

	Firms	Value
1	Keylex	0.275
2	Japan Climate Systems	0.271
3	Sumino Kogyo	0.255
4	Nishikawa Kasei	0.253
5	Futaba Kogyo	0.207
6	Niitec	0.185
7	Hiroshima Aluminum Industry	0.178
8	Kurashiki Kako	0.161
9	Kokusan Buhin Industry	0.115
10	Meiwa Industry	0.107

In 2005, Keylex is ranked at the top in Table 2. This is a joint-stock company of Miura Industry and Kurata in 2001. The rank of Miura (Keylex) has risen up from the 3rd to the 1st. It covers a wide area with the hood, dash panel, trunk, rear-end panel. The number 2 supplier is Japan Climate Systems. This is a car air-conditioner manufacturer established by the joint investment of Mazda, Matsushita Electric Industrial (Panasonic), and Visteon AP. The rank of Sumino Kogyo has risen up from number 7 to 3. The fourth supplier is Nishikawa Kasei, a plasticization supplier of producing cockpit and other parts. The fifth supplier is Futaba Kogyo. It is a supplier that manufactures the press parts of body in Hiroshima region. The sixth supplier is Niitec. Door parts are produced in Niitec. The main product of the next Hiroshima Aluminum Industry is engine parts made by the plastic and mold. The number eighth is the head office of Kurashiki Kako. It is located in Okayama prefecture, neighbor of Hiroshima. In other words, Kurashiki Kako is one of the suppliers out of Hiroshima area. This firm sells rubber parts from the engine to the wheel widely. The following two suppliers are also not located in Hiroshima area. Their assembly plant is located in the suburbs of Hiroshima City and Hofu City, nearby the Mazda assembly plant, respectively.

IV. Analysis and Implications

1. Analysis

Many interesting results will be found based upon our measurement. The first is the seat and body suppliers such as Toyo Seat and Delta have high value of centrality. The common feature of these parts is large scale with high transportation cost. Therefore, for saving the transportation cost, the nearby suppliers become important supplier of Mazda. The second is some suppliers which produce small parts also have high value of centrality. We find that the firm will become important one when it occupy at an important position in the network of parts transaction, even if it is a small-scale supplier. The third is the fact that some suppliers such as Keylex and Japan Climate Systems in Table 1 and Table 2 will merge other companies for the purpose of expanding their operations aiming at an increase of their long term profitability in the future.

2. M&A and module production

M&A (Merger and acquisition) is one of the most important features in the keiretsu of Mazda. Most of the M&A have close relationship with the module production.

On of the typical examples is Keylex. Keylex is established under the proposal from Mazda. One of the purposes is to improve the ability of the parts manufacturing with global standard. Keylex can produce a variety of parts form dash panel, rear-end panel to bonnet, and trunk after M&A. Therefore, the ability of integration has been improved. The brief outline of Keylex is shown in the Table3.

Table3. The outline of Keylex

	Kurata	Miura Industry
Head office	Hiroshima	Hatsukaichi
Plants	Hiroshima, Yano, Yuu (Yamaguchi)	Saeki, Tsuwano (Shimane)
Capital	150 Million Yen	90 Million Yen
Employee	481	394
Sales(2005)	16,600 Million Yen	8,700 Million Yen
Parts	Bonnet, Trunk	Dash Panel, Rear-end Panel
↓		
	Keylex	
Head office	Hiroshima, Kaita	
Capital	240 Million Yen	
Employee	797	
Sales	27,600 Million Yen	
Parts	Front-end Module, Rear-end Module	

Daikyo Nishikawa, a joint-stock company of Nishikawa Kasei and GP Daikyo, is established in 2007. Nishikawa Kasei manufactures plastic parts of interior and exterior, and GP Daikyo produces plastic parts of engine mainly. The purpose of this M&A is to enlarge

its business scale and to get competitive advantage. The basic information of Daikyo Nishikawa is shown in the Table 4.

Table4. Basic information of Daikyo Nishikawa

	GP Daikyo	Nishikawa Kasei
Head office	Higashi-Hiroshima	Hiroshima
Plants	Higashi-Hiroshima Hofu (Yamaguchi)	Hiroshima, Hofu (Yamaguchi)
Capital	100 Million Yen	343.5 Million Yen
Employee	1,069	780
Sales(2005)	55,930 Million Yen	45,905 Million Yen
Parts	Plastic (Interior, Exterior, Engine)	Plastic (instrument panel)
↓		
	Daikyo Nishikawa	
Head office	Hiroshima-Aki county	
Capital	443.5 Million Yen	
Employee	2,100	
Sales	108,000 Million Yen	
Parts	Plastic (Interior, Exterior, Engine, Instrument panel)	

For improving the abilities of module production, one of the basic conditions is to enlarge its business scale. Therefore, M&A could be considered as one of the most important factors for module production.

3. Centrality and module production

Most of the firms with high value of centrality, not only the large-scale parts suppliers, but also the small-scale suppliers are developing their module production. We investigate these suppliers, and found that some of them are not suitable for the module production. For instance, Sumino Kogyo, one of the small-scale suppliers in Hiroshima area, has high value of centrality in the two years. This firm is producing many kinds of small press parts. All kinds of the parts produced in Sumino Kogyo reaches about 2,500. These parts are used in many large-scale parts, for example, engine, transmission, chassis, and body. It is the subcontractor of other suppliers which manufacture large-scale parts such as seat and body. This firm has main transactional relationship with Mazda, Japan Climate Systems, Nihon Seiko, Visteon AP and other large-scale supplier. So Sumino Kogyo is hardly to be considered as a module oriented company.

V. Conclusion

We identified the central firms of transaction network in Mazda using one of the centrality indices, eigenvector. And we analyzed the relationship between centrality and module production in the keiretsu of Mazda. Most of the central firms with high eigenvector are module oriented companies. They expand their business via M&A in order to improve their integration ability. Module production would be one of the important architectures, but it is obviously not the best practice for all of the suppliers.

Despite some meaningful new findings, the work had several limitations. First, we focused on the analysis of module production, but we did not investigate the actual situation in these firms. Second, not only module architecture, but also other architectures such as integral architecture and open architecture should be discussed. Third, only two fiscal years data was limited in our measurement of Eigenvector. Much more data should be collected to analyze the relationship between centrality and production system.

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