THE RISK SHARING MECHANISM IN JAPAN'S AUTO INDUSTRY: THE *KEIRETSU*- VS. INDEPENDENT-PARTS SUPPLIERS [1]

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THE RISK SHARING MECHANISM IN JAPAN'S AUTO INDUSTRY: THE *KEIRETSU* VS. INDEPENDENT PARTS SUPPLIERS

Abstract

This study investigates whether the risk sharing behaviors of subcontractors have changed over the two decades (1973-94); whether there are any differences between *keiretsu* and independent firms in sharing risk; whether an automaker's ownership of its parts suppliers affects the suppliers' risk sharing behaviors under the linear contract price model. Empirical results support the risk sharing hypothesis in general. The *keiretsu* firms are more risk averse than independent firms in the first period (1973-85). In the second period (1985-94) independent firms become more risk averse than keiretsu firms. This may suggest that *keiretsu* system may work as a shock absorber in an unfavorable business environment.

1. INTRODUCTION

During last few decades Japanese automakers have developed a complex system of relationships with their suppliers. The presence of a manufacturing group namely the *keiretsu* group is frequently cited in explaining the high efficiency and business environmental adaptability of Japanese firms. Usually, this group structure reduces the transaction costs and enhances coordination between the automaker and its suppliers. The precise nature of this *kigyo keiretsu* system started to come to light after the seminal work of Aoki (1984a, 1984b). Aoki's theoretical framework together with Asanuma's (1984a, 1984b) fieldwork in the diffusing of information economics and transaction cost economics put forward the subcontracting system in the automobile industry.

The nature of the *kigyo keiretu* organization is based on the answers to the following questions: What are the incentives for the automakers to form *keiretsu* organizations? Why do some suppliers join a *keiretsu* or corporate group, while others remain as independent suppliers? These questions can be answered by the principal-agent framework. Within this framework there are two major conventional views. One is related to the risk-shifting hypothesis, and the other to the risk sharing or the risk-absorption hypothesis. The risk-shifting hypothesis stems from the traditional view of the subcontracting system symbolized by “passing on,” “exploitation,” and “dual structure” (Nakamura, 1981, and Friedman, 1988). In this view, the automakers exploiting their suppliers by using strong bargaining power as monopsonists. At the same time, the automakers utilize their outside suppliers as a buffer against business fluctuations. That is, the subcontracting system functions as a device through which the automakers can shift the risk involved in business income onto their suppliers.

Contrary to this traditional view, the risk-absorption hypothesis is based on Aoki’s inherent insurance hypothesis (1984b). This hypothesis states that within a *keiretsu* organization, the automaker provides an insurance service against fluctuations of sales or of the profit rate for its suppliers. In return, the member firms pay a risk premium to the parent automaker. This indicates that the more risk-taking firm will take a bigger piece of the pie if there is the common rent made by efficient risk sharing. Kawasaki and McMillan (1987) developed an empirical model based on the principal-agent model. Asanuma and Kikutani (1992) applied their model to analyze the subcontracting system in the Japanese automobile industry. In this paper, we further investigate Asanuma and Kawasaki’s study. More specifically, these two studies did not take into consideration of comparison between firms in a *keiretsu* group and independent firms and also recent structural changes since the mid 80’s. Thus, the purposes of this paper are to empirically test (1) whether the risk sharing behaviors of subcontractors have changed over the two decades; (2) whether there are any differences between *keiretsu* firms and independent firms in sharing risk; (3) whether an automaker's ownership over its parts suppliers (i.e., minority shareholdings, and sending the directors to the supplier) affects the suppliers' risk sharing behaviors under the linear contract pricing model.

The plan of the paper is as follows. Section 2 describes the *kigyo keiretsu* group and the nature of the contract. The basic hypotheses and their respective models are developed in Section 3. The empirical investigation using *Keiretsu* and Independent parts suppliers data sets are presented in Section 4. Finally, we conclude the paper in Section 5.

2. THE *KIGYO KEIRETSU* GROUP AND NATURE OF THE CONTRACT

In order to appreciate the underlying reasons for a risk sharing mechanism, it is important to understand the industrial structure in Japan, which has been characterized by the unique interfirm arrangements known as the *keiretsu* organization and the nature of contract.

Subcontracting and the *Kigyo Keiretsu* Group

There are some distinguishing features to the Japanese automobile manufacturing industry in that the most of the parts and subassemblies of the industry are purchased from external suppliers under long-term subcontracting arrangements. A substantial proportion of these external suppliers are members of a well-defined group of firms closely associated with one of the primary automobile manufacturers.[2] The manufacturing group or the *kigyo keiretsu* refers to the arrangement wherein a primary auto assembler surrounds itself with a grouping of suppliers bound together by long-term buyer-supplier

[2] Manufacturing corporate groups are to be distinguished from the six financial corporate groups, or *kigyo shudan*, which consist of firms surrounding a main bank. Some are so-called "ex-*zaibatsu*" groups, such

agreements. Furthermore, it is a vertical or a pyramid organization, which is made up of one large company and hundreds of small companies subservient to it.[3] In the auto industry, these supplier groups provide the automaker with variety of parts such as engines, carburetors, transmissions, steering assemblies, axles, wheels and electrical components. The firms that belong to the group clearly and openly identify themselves as members of the group, for instance, Toyota, Nissan, or Honda. However, not all parts-makers belong to a group and such firms (e.g., Akebono Brake, Kayaba, Daikin Manufacturing, Shiraki Corp., Topre Corp., Toyo Radiator, Stanley Electric) clearly identify themselves as independent.[4]

The relationships between the firms in a group are informal, but are clearly defined. For example, a typical member in one of the major groups sells a majority of its product to either the primary manufacturer or to other firms in the group. Although the group member is not precluded from selling to firms in the group, until very recently selling to the group's main competitor was done very rarely (e.g., the Toyota group versus the Nissan group). Usually, a group member's outside sales are to independent parts suppliers or to one of the secondary groups e.g., Honda, Mazda, Mitsubishi and Isuzu. In contrast, independent parts suppliers sell their parts to all types of buyers, irrespective of group affiliation. The *kigyo keiretsu* group is also characterized by interfirm holdings of common stock. For the parts suppliers that we sampled, the average percentage of independent

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as Mitui, Mitsubishi, Sumitomo and Yasuda. For further descriptions of corporate groups, see Aoki (1987, 1988), Nakatani (1984), Lawrence (1993) and Miyashita and Russell (1994).

[3] According to Asanuma (1985), the ancillary suppliers of the core automakers in Japan have been hierarchically organized in three tiers based on the type of product they produce. Usually, the first-tier suppliers produce finished components (e.g., completed seats), and deal directory with the automaker.

[4] Odaka, et al. (1988) also classified the first-tier suppliers into two broad categories of "group" and "independent."

suppliers' common stock owned by a core automaker was 11.4% in 1994, whereas for *kigyo keiretsu* group suppliers it was 32.8% (See Table 5 in Appendix). Toyota and Nissan hold shares of every firm in their respective group. In addition, the major suppliers in the Toyota or Nissan group often hold shares of firms in the second-layer subcontractors. Interfirm shareholding tends to be asymmetric in the sense that the smaller parts suppliers rarely hold the automaker's shares in their group, although it can happen that the largest group members are corporate shareholders in the primary auto maker.[5]

The primary auto assembler tends to maintain close contact with the leaders of its member firms. For instance, the presidents of the various companies have regular meetings with their own group members. Often the boards of directors of the leading firms in the group are interlocked wherein a director of one company sits on the boards of several others. The former directors of the primary automaker also become the group member firm's directors. There are frequent exchanges of top executives and managers between the primary automaker and its member firms. This may reduce the information gap between the two parties, and hence limit opportunism.

The *kigyo keiretsu* group serves as an internal capital market for its members. by providing financial assistance to its members. Technological innovation and know-how are also disseminated within the group as a way of encouraging each firm to cut production costs and improve efficiency.

Aoki (1987: 280-281) hypothesizes that interfirm shareholding in a non-*zaibatsu* group is a substitute for risk diversification in the absence of perfect capital markets.

[5] In the sample of 52 parts suppliers in this study, only three member firms held shares of common stock of the primary automaker. This is unlike the financial groups in which corporate shareholding is much more symmetric (Nakatani, 1984).

While his argument has an intuitive appeal, it does not explain the practice of interfirm shareholding between *kigyo keiretsu* firms and independent firms. He offers an alternative theory based on transaction costs. His argument is that mutual shareholding provides for an effective bond for interfirm relations that serves to reduce transaction costs. However, as he rightly points out, if this were so, then one would expect firms in the *kigyo keiretsu* groups to be more profitable than independent firms. This is not supported by the empirical evidence (Caves and Uekusa, 1976; Nakatani, 1984).

To explain why the automakers earn higher profits relative to parts suppliers, Aoki (1984b) also describes the inherent insurance mechanism. The more risk-taking firm will tend to take a higher risk in return for a bigger part of the pie (i.e., higher risk premium), whereas the parts suppliers which join a *keiretsu* group are as if paying the membership fees in return for the stability of their sales. Therefore, one may claim that the profit rate of the big assemblers is higher than that of the suppliers over some periods as a result of risk sharing among *keiretsu* member firms. If this is true, then one may ask what happens to independent firms who do not pay such membership fees. Specifically, are they earning higher profits at the cost of unstable sales because of not paying such fees? In addition, is there any difference in contracting with them?

Nature of contract

The work of subcontracting system in the automobile industry is mostly based on the studies of Asanuma (1984a, 1984b, 1985, 1992). According to his work[6] (1984a, 1984b, 1985), the selection of parts manufacturers begins after the automaker has announced the development of a new vehicle model. The selection of parts suppliers is based on their reported cost estimates of producing parts (i.e., an informal bidding process). Then a contract with a selected parts supplier is made regarding the production of a particular component of the automobile model within a stipulated time. A typical automobile model is produced over a four-year period.[7] The automaker guarantees not to switch the parts supplier or not to produce the parts in house during the period. Indeed, the same suppliers are frequently contracted with, from model to model, while the supplier's performance is compared with its competitor's performance.

The contract as agreed upon at the inception of a four-year period does not specify rigid quantities. Instead, the automaker specifies target quantities based on a forecast and delivery dates. Rather than specifying a rigid price over a four-year period, the contract specifies the rules by which the price is to be determined. An initial unit price (or target price) is established in the contract as basis for subsequent price calculations. This initial unit price is determined from detailed cost estimates submitted by the subcontractor and carefully examined by the automaker. Then every six months, the price can be adjusted in response to changes in the subcontractor's production cost. At the end of each month, the

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[6] Asanuma interviewed executives of six automakers and six parts suppliers.

[7] This four-year period is typically the cycle of full model change for an automobile. However, engines and transmissions, the contract may last for 10 years.

automaker submits the demand schedule for the next month to its parts supplier.[8] For example, under the four-year contract, the automaker sets the target quantity of auto parts, say 480,000 units. The automaker pays the costs of molds and castings. The average set-up cost of producing parts is estimated as the cost of molds and casting over the target quantity. This cost is added to the unit cost at the beginning of the contract. Suppose that the target quantity of 480,000 units of parts is met within one year and a half. In this case, the automaker requests the reduction of price of parts by the average set-up cost to the subcontractor till the end of the contract. On the other hand, suppose that, due to sluggish demand for the automobile, the target quantity is not accomplished and only 380,000 units have been sold during the contract period. In this case, the automaker compensates the subcontractor by paying the amount of 100,000 unit losses. Thus, the automaker takes the risk of uncertain demand for the automobile. In return, the automaker continuously requests the suppliers to reduce part production costs.

The subcontractee expects continual cost reduction and productivity growth from its subcontractor. In adjusting the price of parts the automaker will allow increases in the cost of materials to be passed on as price increases. However, labor and energy costs are not allowed to be passed on. There are provisions in the contract for changing price in response to either cost changes resulting from design changes made by the automaker or cost reduction due to the subcontractor’s rationalization. In addition, the automaker rewards the subcontractor for improving production processes by raising the mark-up ratio. This mechanism of price determination provides the motivation to attain a high level of productivity growth among subcontractors. Asanuma (1984a) moderately mentioned

[8] This demand schedule specifies daily quantity demanded by the automaker.

that this contracting rule is, more or less, applied to all types of suppliers. In section 4, we will test whether the contracting scheme -more specifically, the risk sharing parameter or the principal-agent relationship- is the same for independent firms.

3. THE MODEL AND TESTABLE HYPOTHESES

Risk sharing Parameter:

As stated in the previous section, the automaker establishes the basic contract quantity target based on estimates of the expected total demand for the final product. Since the target quantity of parts is specified in the contract, we assume that this value is given to the parts suppliers. The only major provisions of the contract that remains to be considered are the contract price or a target price.

Within a principal-agent framework, Kawasaki and McMillan (1987) originally developed the linear contract model[9] wherein the auto assembler's optimal function is given as:

$$p = t + \alpha(c - t), \qquad (1)$$

where p is the unit price for a parts-component, t is the target price including negotiated profit margin based on the estimate of normal cost, c is the realized average cost during the interval preceding the price revision and α is the risk sharing parameter. If $\alpha = 0$, then the contract is fixed price, which means all of the risk of cost fluctuation is borne by the parts supplier. If $\alpha = 1$, then the contract is cost plus, which indicates the auto assembler bears the entire risk. If $0 < \alpha < 1$, then the risk is shared. Suppose that the realized unit cost can be decomposed into three components as follows:

[9] According to MacDonald (1984), the comparative static properties will not hold in general if the contract is non-linear. This is a special case of MacAfee and McMillan (1986).

$$c = c^* + w - e, \quad (2)$$

where c* stands for the *ex ante* expected cost including profit margin and w is a random variable representing unpredictable cost fluctuations observed only by the parts supplier in the course of operation and is assumed to be normal with mean zero and variance σ^2. The value of c* is known through the cost analysis and price negotiation. The last term, e in eq. (2) stands for the reduction of cost achieved due to the parts supplier's innovation effort. The innovation effort is costly to the parts suppliers. Let us denote this cost by H(e), which is financed from the gross profit of the parts supplier. Here we assume that H(e) shows increasing marginal cost or diminishing returns to scale with respect to effort, which can be defined as

$$H(e) = e^2/2\delta, \quad (3)$$

in which δ is a measure of effectiveness of cost-reduction effort. Note that it is not easy to find adequate proxies for the moral hazard parameter (Kawasaki and McMillan, 1987). In section 5, we will discuss the proxies of the moral hazard parameter.

Our argument with Kawasaki and McMillan's model is that they did not take into consideration of a monitoring effect by the automaker on its member supplier. In other words, the automaker's partial ownership and practice of sending directors or engineers to the supplier may affect the supplier's cost reduction effort. In this regard, Holmstrom (1982: 325) also mentioned that group incentives can also work quite well under uncertainty but their effectiveness will be limited if there are many agents and the agents are risk averse.[10] This makes monitoring important. More specifically, if potential moral hazard or shirking behavior exists when the automaker lacks important information about the supplier's cost reduction efforts, then the acquisition of share of the supplier's common stock is one way to access some of information on production. As a shareholder, the primary automaker can establish lines of communication with supplier's board of directors. Indeed, as the automaker acquires more of the parts supplier's shares, it might be able to place its own candidates on the board or even choose the chairperson on the board. In effect, as the primary automaker increases its stock ownership, it gains greater power within the firm until specific information about supplier is known to it.

The *kigyo keiretsu* group permits an even closer relationship between the core automaker and the parts supplier than stock ownership alone. Interlocking directorships and exchange executives and managers as well as engineers, all serve to strengthen the communication links between the core automaker and its group members. Under the *kigyo keiretsu* system, the supplier's shirking behavior or other opportunistic behaviors will be diminished as the combined number of the ex-directors of the automaker to its parts supplier and number of interlocking directors between the two firms increases.

Let M be the management control power by the automaker as a proxy of the automaker's monitoring power to its suppliers, and a measure of effectiveness of the cost-reduction effort is given as $\delta = f(M) = \exp(\beta M) > 0$, where $M = b_{ij}/\sqrt{A_i S_j}$, in which b_{ij} is the combined number of the interlocking directors and ex-directors of the *ith* automaker to *jth* parts supplier. A_i and S_j are the number of directors on the board of automaker *i* and parts supplier *j*, respectively, and $0 \leq M \leq 1$.[11] Since the supplier's shirking behavior of reducing production cost will decrease as M increases due to better information exchanges

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[10] We extend his word, "group" for a *kigyo keiretsu* group. Yet, this statement holds.
[11] When the parts supplier is fully owned by the automaker, M = 1. On the other hand, M = 0, when the parts supplier is totally independent from the automakers.

between the two parties, we therefore expect the sign of coefficient M to be negative (i.e., $\beta < 0$). However, the administrative cost of monitoring the agent's effort will increase as M increases. As a result, H(e, M) is an increasing function of M. In short, there is a trade-off between the supplier's cost reducing effort (e) and monitoring cost of the agent (M). Therefore, eq. (3) can be

$$H(e, M) = (e^2/2)\exp(-\beta M) \text{ for } \beta < 0, \text{ and } 0 \leq M \leq 1.\text{[12]} \qquad (4)$$

Then the parts supplier's unit profit π is obtained as

$$\pi = (1 - \alpha)(t - c) - H(e, M) = (1 - \alpha)(t - c^* - w + e) - H(e, M). \qquad (5)$$

Let us denote the variance of the parts supplier's profit as s^2. Then from (2), we have:

$$s^2 = (1 - \alpha)^2\sigma^2 . \qquad (6)$$

Therefore, the risk sharing parameter is obtained as

$$\alpha = 1 - (s / \sigma). \qquad (7)$$

To solve for the optimal contract, the supplier first maximizes its expected utility of profit [i.e., using eq. (4) and eq. (5)], and, hence, the subcontractor will choose a level of effort as

$$e = (1 - \alpha) \exp(\beta M). \qquad (8)$$

The supplier's cost reduction effort decreases as α increases. In addition, it decreases as the degree of monitoring power, M increases.[13] Such a trade-off relationship between monitoring costs and cost reduction efforts prevents the automaker from fully vertically integrating its parts suppliers unlike its American counterparts (Tsuru, 1995: 74). In fact,

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[12] Note that H (0, M) = 0. Note also that H′(0, M) = 0 is assumed to avoid discontinuity at $\alpha = 0$.
$\partial H(e, M)/\partial M = (-\beta e^2/2)\exp(\beta M) > 0$ if $\beta < 0$.

Aoki (1990: 24-26) regarded the buyer-supplier relationships as quasi (vertical) integration.

Assume also that subcontractors are risk averse, while the automakers are risk neutral or at least the automaker is no more risk averse than its suppliers. This assumption makes sense, since the automaker is a larger firm than its subcontractors. For example, Toyota and Nissan have approximately 63,000 and 58,000 employees, respectively, while one of the largest suppliers in Toyota group Nippon Denso is almost as half as Toyota. The largest independent firms, such as Akebono Brake, and NOK, have fewer than 3,000 employees each. In addition to the firm-size, the fluctuations associated with this single contract are extremely small compared to the automaker's total profit. As a result, the automaker's utility function is linear in profit from this contract. On the other hand, the subcontractor's profit fluctuation from the single contract may change its total profit significantly. Thus, suppliers are more risk averse than the automakers.

In the traditional view, the automaker may shift its risk to its suppliers during business recessions. We test the validity of such traditional dual hypothesis that a large automaker uses its monopsonic power over the suppliers as a business cycle buffer. If the large automaker exploits its monopsonic position to make use of the supplier as a business cycle buffer, then the recent unfavorable business environment (i.e., the period, 1985-94) such as the appreciation of the yen against the US dollar and disappearance of a Japanese cost advantage of production causes the automaker to use monopsonic power. This may force the supplier to bear the brunt of cost and demand fluctuations. If this risk-shifting hypothesis is true, then the value of α becomes smaller, and the contract may be closer to

[13] This can be a case that the x-inefficiency occurs after the automaker owns its supplier, and the firm size

a fixed price wherein all of the risk of cost fluctuation must be borne by the parts supplier. Under the linear contract model in eq. (1), $\alpha = 0$ is an extreme case in which the suppliers bear all the risk and the risk of production totally shifts to subcontractor. Based on the above discussion, we test the following hypothesis:

[H1] The risk sharing behaviors between the automaker and its suppliers will change (i.e., the value of α will be smaller) if the business cycle or the business environment becomes unfavorable to the automakers [The Risk-shifting Hypothesis].

Under the inherent insurance mechanism, those suppliers who join a *keiretsu* group are as if paying the risk premium for stability of sales, and the parent automaker covers a risk of fluctuations of production costs. This implies that the risk sharing parameter for *keiretsu* firms must be larger than that for independent firms if the inherent insurance mechanism works in a *keiretsu* firms. Thus we set up the following hypothesis:

[H2] The value of risk sharing parameter (α) for *keiretsu* firms is greater than that for independent parts suppliers if the inherent insurance mechanism works.

Let us consider why some suppliers join a *kigyo keiretsu* group. One answer to this question is that they want to stabilize fluctuations of sales and of production costs, since they are more risk averse than those who do not join a group. This leads to the following hypothesis:

[H 3] The parts suppliers in a *keiretsu* group are more risk averse than independent parts suppliers. Let $R_{keiretsu}$ and $R_{\text{independent}}$ be the absolute risk averse values for the *keiretsu* and independent firms respectively. Then

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becomes too big to monitor each worker's effort.

$R_{keiretsu} > R_{\text{independent}} > 0$ is expected.

Measurement of Risk-Averse Parameter:

Followed by Kawasaki and McMillan (1987), we use the subcontractor's utility function of profit as

$$U(\pi) = [1 - \exp(- R\pi)] / R, \qquad (9)$$

where π represents the supplier's profit and R is the Arrow-Pratt measure of absolute risk aversion, and hence, $R \geq 0$. Assume that all subcontractors follow this utility function.

Since $\pi \sim N(\mu, s^2)$, and $w \sim N(0, \sigma^2)$ by assumptions, the supplier's expected utility of profit, $EU(\pi)$ is obtained by taking expectation of $U(\pi)$ in eq. (9). This yields

$$EU(\pi) = \{1 - \exp[- R\mu + (1/2)R^2 s^2]\}/ R. \qquad (10)$$

Solving eq. (10) with respect to μ, we have obtained

$$\mu = (1/2)Rs^2 + k, \qquad (11)$$

where μ, and s^2 are the mean and variance of the supplier's profit, and

$$k \equiv - (1 / R) \ln[1 - R\, EU(\pi)]. \qquad (12)$$

The term k indicates criteria that determine whether or not the subcontractor will accept the contract. More specifically, $k = 0$ iff $EU(\pi) = 0$, which means the subcontractor is expected to make normal profit from this contract. However, if $k < 0$ and hence $EU(\pi) < 0$, then the supplier will not accept the contract. Therefore, we expect to attain a feasible contract if the sign of k is non-negative. From eq. (11), doubling the magnitude of the coefficient of s^2 tells us the Arrow-Pratt measure of absolute risk. $R = 0$ means that the parts suppliers are also risk neutral like the automaker. First of all, a positive sign of the coefficient of s^2 is expected if the subcontractors are risk-averse, compared to their automakers. Second, the coefficient of s^2 for independent firms is greater than that for *keiretsu* firms if H3 is true.

Principal - Agent Model:

Let us consider the automaker's optimization problem. The automaker chooses the sharing parameter, α so as to minimize its payment to the supplier, given the following two constraints: the first constraint is that the parts supplier's expected utility must be no less than its expected utility from its alternative activity; the second constraint is that the parts supplier responds to any choice of the value of α by choosing its cost reducing effort, H(e, M). This can be denoted as

$$\text{Min}_{\alpha}\, E[\pi + c + H(e, \lambda)],$$

$$\text{subject to } \mu = (1/2)R(1 - \alpha)^2\sigma^2,$$

$$\text{and } e = (1 - \alpha)\exp(\beta M).$$

The first-order condition for the automaker's optimal choice for α is obtained as

$$\alpha = R\sigma^2/[\exp(\beta M) + R\sigma^2]. \qquad (13)$$

Eq. (13) leads us to the following testable hypotheses:

[H4] The risk sharing parameter, α, (for $0 < \alpha < 1$) will increase as (i) as the automaker's monitoring power to its supplier (M) increases if $\beta < 0$; (ii) the variance of the production cost (σ^2) increases; and (iii) the risk-aversion coefficient (R) increases.

By inverting and taking the natural logarithm, eq.(13) can be modified as

$$\ln[(1/\alpha) - 1] = \ln(1/\sigma^2) + \ln(1/R) + \beta M. \qquad (14)$$

As we discussed above, if the automaker's role of organizing a *keiretsu* group is to monitor a subcontractor's cost-reduction effort, and to improve coordination under the principal-agent relationship, then we expect the coefficient of M to be negative in eq. (14). This also implies that there is a trade-off between an increment of monitoring power and an increment of production costs due to an increase in administrative costs known as the x-inefficiency.

4. THE DATA SETS AND ESTIMATION RESULTS

Data Description

In order to validate these models, an empirical investigation has been carried out using 54 auto parts suppliers data sets. The data are obtained from *Kaisha Nenkan* and *Kaisha Zaimu Karute* for the periods of 1973 to 1985 and 1986 to 1994 respectively. The sample includes only the large first-tier subcontractors. Smaller firms were excluded because most of them subcontract mainly with the larger subcontractors of the primary automakers. That is, these small firms are second-layer subcontractors or sub-subcontractors. The focus of this research is on the subcontracting relationship between the first-tier suppliers and the primary automakers, independent vs. *keiretsu* firms.

As for classification of suppliers, *Kigyo Keiretsu Soran* (*Survey of Corporate Groups*) and *Industrial Grouping in Japan*(various years) and *Industrial Groupings in Japan* (1986) by Marketing Consultants were used in order to identify group affiliations.

Compared to Asanuma and Kikutani's data base (1992), our data sets include large independent parts suppliers in addition to the core *keiretsu* member firms (i.e., mainly focusing on the Toyota and the Nissan groups). This also covers the longer time span; namely, from 1973 to 1994.

Our overall sample period, 1973-94 is classified into two periods: the export driven growth period (i.e., 1973-84); and the globalization or the localization era (i.e., 1985-94). After the 1973 oil crisis, the demand for small cars increased, particularly in the US. For example, between 1973 and 1980, automobile exports increased about 288%, reaching 5.97 million vehicle units, surpassing Japan's domestic sales of 5.02 million units. At that time, Japanese automakers also had a cost advantage by the amount of $1,000 to $ 2,000 (Abernathy et al., 1983: 61; Altshuler and Roos, 1984: 161; Cusumano, 1985: 186). During the second period (1985-94), the radical yen appreciation (*endaka*), and the escalation of the auto-trade conflict have encouraged the Japanese direct investment. Moreover, further appreciation of the yen against the US dollar occurred after 1993, and the Japanese cost advantage of production totally disappeared. At the same time, the Japanese economy had a stubborn recession from 1991 to 1994 after the burst of the bubble-economy. Thus the second period, 1985-1994 seems to have been an unfavorable business environment for Japanese automakers. As a result, most Japanese economists believe that there has been a structural change in the automobile manufacturing industry and the subcontractor relationships since the mid-80s. Thus we divided the overall sample period into the two periods in order to conduct this study.

Table 5 in the Appendix shows descriptive statistics of our data. With regard to the firm size measured by total employment (TE), total assets (TA), and revenue (Rev), the firms in *kigyo keiretsu* groups tend to be smaller than the independent firms. One may infer that independent firms behave less risk averse than *keiretsu* firms if the degree of absolute risk aversion decrease as an increment of firm size. The average profit (π) of independent firms is greater than that of the *keiretsu* firms. With regard to the automaker's ownership

(λ), there is not much difference for *keiretsu* firms between 1984 and 1994, while it sharply increased for the independent firms in these two years. This may indicate that the automaker tried to control independent firms more tightly by holding more equity shares after the burst of the economy. More importantly, the variances of profit or revenue for the independent firms are larger than those for the *keiretsu* firms. In our calculations, in the period of 1973-94 the average profit rate of automakers is 3.45%. The profit rates of independent and *keiretsu* suppliers parts suppliers are 5.04% and 3.62% respectively in the same period.[14] This may weakly support the inherent insurance mechanism between the automaker and its member suppliers. On the other hand, we can confirm that independent firms earn higher profit and sales in return for instability of sales and profit, while *keiretsu* firms seem to stabilize their sales. In addition, independent firms even earn higher profit rate than the automakers. One explanation may be the fact that independent firms do not pay such *keiretsu* entry fees and they capture most of the quasi-rents.[15]

Estimation results

Table 1 shows the estimation results of eq. (7). In order to estimate the risk sharing parameter, we use operating income [*Eigyo Rieki*] as profit (π), and cost of sales [*Uriage Genka*] as production cost (c). Both values are adjusted by the wholesale price index (WPI = 100 in 1990). In the period of 1973-94 the risk sharing parameter (α) for all firms is 0.9333. Our estimated values of α for *keiretsu* firms in this study are similar to

[14] Note that a simple one-tail t-test confirms that the sample means of profit rate between independent and *keiretsu* group firms, and that between independent and automakers in the period 1984-94 are clearly different at the 5% level of significance, respectively. However, we fail to reject the sample means of profit rate between the automakers and *keiretsu* suppliers at the 5% level of significance.

[15] For more detailed discussions on the quasi-rents and the opportunism hypothesis in the *keiretsu* organization, see Inaba and Tabeta (1995). Alternative view to explain why *keiretsu* supplier's profits

those of Asanuma and Kikutani (1992). The sample means of risk sharing values for all firms are not different in these two periods at the 5% level of significance by a simple one-tail t-test. However, a simple one-tail t-test confirms that the sample means of risk sharing value for *keiretsu* firms are statistically different in these two periods at the 5% level of significance. That is, risk sharing value decreased from 0.9403 to 0.9194 in the second period, 1985-94. This supports the hypothesis, H1 that the risk sharing behaviors by the two parties will change (i.e., the value of α will be smaller) if the business cycle or the business environment becomes unfavorable to the automakers. This may also indicate that risk of producing parts may shift to the *keiretsu* parts suppliers to an extent in these two periods. As for the hypothesis H2, the values of risk sharing parameter α, for *keiretsu* firms are greater than those for independent firms in the two periods and in overall period. They are all statistically different at the 1% level of significance by a simple one-tail t-test. These results support the hypothesis that the value of α is smaller for independent parts suppliers than for the firms in the *keiretsu* group since independent firms are less risk averse than suppliers in a *keiretsu* group. This result is counter to Asanuma's claim (1984) that the contracting rule is more or less applied to all types of suppliers. In fact, this is plausible. Since independent firms do not pay the insurance premium, the automaker may cover less of the risk of production cost fluctuations.

To estimate the value of absolute risk (*R*), we modify eq. (11) as

$$\mu_i = b_0 + b_1 s_i^2 + u \quad \text{for } i = 1, 2, ..., 52 \qquad (15)$$

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tend to be less than independent firms are provided in Inaba and Tabeta (1996), wherein the authors used switching-supplier's hypothesis.

where u is an error term. We expected $b_0 = k \equiv - (1 / R)\ ln\ [1 - R\ EU(\pi)] > 0$. If $b_0 < 0$, then $EU(\pi) < 0$. This indicates that the supplier will not accept the contract. We also expect $b_1 > 0$ if parts suppliers are risk averse. Similarly, to test H3, we modify eq. (15) as

$$\mu_i = b_0 + b_1 s_i^2 + b_2 D^* s_i^2 + v \text{ for } i = 1, 2, ...,52 \qquad (16)$$

where v is an error term, D is the dummy variable which takes value one for *keiretsu* firms and zero otherwise. We expect that independent firms are less risk averse than *keiretsu* firms. Therefore, the expected sign of b_2 is positive. Table 2 shows the estimation results of eq. (15) and eq. (16). In both cases we have obtained consistent signs of b_0, and b_1, which are positive at the 0.5% level of significance for the two periods and the overall periods. These results suggest that parts suppliers are more or less risk averse in general. Note that adjusted R^2 are ranged from 0.7245 to 0.9565. Based on the estimation results in Table 2, we calculate the degree of absolute risk aversion. From eq. (11), doubling the magnitude of the coefficient of s^2 indicates the Arrow-Pratt measure of absolute risk. We summarize the results of the degree of absolute risk aversion in Table 3. Comparing the two periods, the degree of absolute risk aversion for *keiretsu* firms decreased remarkably from 4.099 ($\times 10^{-4}$) to 2.0754 ($\times 10^{-4}$). On the other hand, that value for independent firms sharply increased from 1.4405 ($\times 10^{-4}$) to 5.6496 ($\times 10^{-4}$).

Hypothesis H3 seems to be supported in the first period. That is, in 1973-84 *keiretsu* firms were more risk averse than independent firms. This is plausible since independent firms tend to share more business risk and appropriate the effects of their own cost reduction effort. However, independent firms become more risk averse than *keiretsu* firms in the second period, 1985-94. One explanation for this very interesting finding is that the unfavorable business- and macro-environments, such as the rapid yen appreciation and instability of automobile sales after the burst of the bubble economy affected independent firms more due to their lack of a close relationship with automakers. Under these circumstances, their risk averse attitudes may have changed drastically. In other words, the independent firms may be more vulnerable to shock from drastic changes in the market conditions. Conversely, the *keiretsu* organization has the merit of shielding its members from such drastic market changes.

To test the hypothesis H4, eq. (14) is modified by adding the intercept term β_0 because of misspecification of other explanatory variables or other random factors. The estimation model is then obtained as

$$ln\ [(1 / \alpha_i) - 1] = \beta_0 + \beta_1\ ln\ (1 / \sigma_i^2) + \beta_2\ ln\ (TE_{it}) + \beta_3 M_t + \varepsilon \qquad (17)$$

for i = 1,2, ...,52, and t = 1984 or 1994. In this specification ε is an error term; TE_{it} is the total employment for *ith* supplier at time t; M_t is the management control at time t. As Asanuma and Kikutani (1992) argued, we use the inverse of total employment (TE) as a proxy for risk aversion (R). This means that the larger the firm size, the lower the degree of risk aversion because of their higher degree of diversification of business and stronger financial power. As mentioned in section 3, the expected signs of each slope coefficient in eq. (17) are positive. These signs simply indicate that the risk sharing parameter α, (for $0 < \alpha < 1$) will increase as (i) the monitoring power by the automaker (M) increases if $\beta_3 < 0$; (ii) the variance of the production cost (σ^2) increases; and (iii) the risk-aversion coefficient (R) increases.

Table 4 shows the *OLS* regression results of eq. (17).[16] Signs of each coefficient are consistent with our expected ones. The hypothesis H4 is supported in general. Of particular interest is the fact that the coefficients of monitoring power M show all negative signs. These are statistically significant at the 5% level. This means that the risk sharing parameter α, will increase as the monitoring power of the automaker over its suppliers increases. By using the Chow test, we fail to reject the structural change of regression models between these two periods at α = 5% level of the significance. Nevertheless the Japanese subcontracting system (or the principle-agent relationship) is believed to be dramatically changed after the mid-80s. This is also an interesting finding.

Table 6 in Appendix shows that there is a positive correlation between an automaker's ownership of suppliers (λ) and management control or monitoring power (M) in 1984 and in 1994 respectively. This implies that the automaker's ownership and management control of its suppliers are complementary. Indeed we obtain similar results even if the independent variable M, is replaced by λ (the automaker's ownership) in eq. (17). However, adjusted R^2's are smaller in this case (See Table 7 in Appendix). This indicates that the risk sharing parameter α, will increase as the automaker's ownership to its parts suppliers (λ) increases.

5. SUMMARY AND CONCLUSION

Compared to independent firms, *keiretsu* group firms are smaller with specialized production of parts, and they are more risk averse. Therefore, they may have entered a *keiretsu* group to reduce risk of fluctuations in part production or to stabilize their sales in

[16] By using the White test, we reject an possibility of heteroscedasticity, and the weighted regression is not conducted.

exchange for paying an insurance premium to the parent automaker. The automaker tends to possess certain amount of the parts supplier's equity in order to gain more monitoring power and to enhance coordination with suppliers by sending the automaker's directors or engineers to the parts supplier.

On the other hand, independent firms tend to take more business risk and appropriate the effect of their own cost reduction effort under stable market conditions (i.e., 1973-84). However, when the market conditions drastically changed after the mid-80s because of the rapid yen appreciation and the emerging globalization era, they may have changed their risk averse attitudes. This implies that the *keiretsu* organization may shield its members from these external shocks to an extent and work as a shock absorber. This may be an advantage of joining a *keiretsu* group. This is also an interesting finding.

Empirical results support the risk sharing hypothesis in general. However, changes in the economic environment after the mid-80s seem to have weakened the effect of the inherent insurance mechanism between the automaker and its member firms. In this regard, there still seems to be some room for the risk-shifting hypothesis. In fact, the risk sharing parameter (α) for *keiretsu* firms decreased from 0.9403 to 0.9194 when the business or the macroeconomic environment became unfavorable for the automakers, although this difference is not statistically significant at the 5% level (See Table 1). It will be the next task for us to robustly test the validity of the risk-shifting hypothesis.

Finally, we point out some limitations of this study and future studies. First, although our data include longer span(i.e., 1973 to 94), the sample is relatively small (N = 52). Second, our focus is limited to Toyota and Nissan *keiretsu* groups vs. typical large independent firms. Third, due to data limitation, we used total production costs as a proxy of the unit production cost for estimating the risk sharing parameter. As an extension of this kind of analysis, a study of the mechanism of distribution *keiretsu*, or the relationship between the automaker and its dealers should be conducted.[17]

[17] For a general review on contracts and control in Japanese distribution, see Marvel (1993). On the automobile industry in particular, see "Final Report for the MOSS Motor Vehicle Study" (1993) conducted by Booz, Allen & Hamilton, Inc. and Nomura Research Institute, Ltd., and Shimokawa (1985).

MAIN TABLES

Table-1: Estimates of the Risk sharing Parameter (α)

Types\Periods	1973 - 1994	1973 - 1984	1985 - 1994
All Firms (N = 52)	.93332 (.00897)	.91737 (.01196)	.90996 (.00782)
***Keiretsu* Groups** (N = 42)	.95135 (.00156)	.94027 (.003195)	.91943 (.00291)
Independent (N = 10)	.85689 (.03572)	.82118 (.04046)	.87022 (.02887)

Note: Variances of α's are shown in the parentheses.

Table-2: *OLS* Regression Results of eq. (15) and eq. (16)

	1973 - 1994		**1973 - 1984**		**1985 - 1994**	
	eq. (15)	eq. (16)	eq. (15)	eq. (16)	eq. (15)	eq. (16)
Constant	2137.9 (6.454)	2137.1 (6.386)	2835.7 (2.976)	2135.1 (5.600)	1918.9 (4.152)	1603.3 (15.401)
s^2 (x 10^{-4})	.75958 (26.69)	.76336 (17.67)	.98182 (11.62)	.72023 (19.36)	1.1711 (12.79)	2.8248 (14.07)
$D*s^2$ (x 10^{-4})	------------	- .00577 (- .1091)	-------------	1.3295 (16.35)	-------------	-1.7871 (-8.607)
Adjusted R^2	.9452	.9441	.7245	.9565	.7612	.9030

Note: t-values are in the parentheses.

D = 1 for *keiretsu* groups; D = 0 Otherwise.

Size: N = 52.

Table-3: Estimates of the Degree of the Absolute Risk Aversion ($R \times 10^{-4}$)

Types\Periods	1973 - 1994	1973 - 1984	1985 - 1994
All Firms	1.5192	1.9636	2.3422
***Keiretsu* Groups**	1.5152	4.0995	2.0754
Independent	1.1658	1.4405	5.6496

Note: Variances of *R*'s are shown in the parentheses.

Table-4: OLS Regression Result of eq (17)

Variable\Year	1973 - 1994	1973 - 1984	1985 - 1994
Constant	.5219 (.5568)	- .2011 (- .2045)	-.1717 (- .1984)
***ln* (1 / σ^2)**	.5396 (3.203)	.3847 (3.774)	.3185 (3.353)
***ln* (TE)**	.9744 (2.424)	.6683 (2.748)	.4899 (2.150)
M	- 2.2135 (- 2.130)	- 1.8315 (- 2.033)	- 2.2115 (- 2.281)
Adjusted R^2	.2812	.2545	.2365

Note: t-values are in the parentheses.

Size: N = 52

Appendix: Other Tables

Table-5: Means and Variances of Various Parameters (1973 - 1994)

Variable\Type	All Firms	*Keiretsu* Firm	Independent
$\pi_{73\text{-}94}$	4307.98 (11166.80)	3809.84 (10101.40)	6400.18 (14673.86)
$TA_{73\text{-}94}$	83429.46 (147865.43)	73204.29 (137293.24)	126375.19 (179933.69)
$Rev_{73\text{-}94}$	109439.08 (162889.33)	105269.37 (165962.33)	126951.86 (148369.49)
$TE_{73\text{-}94}$	3595.45 (4776.71)	3371.37 (4784.29)	4536.56 (4638.31)
λ_{84}	.26133 (.15456)	.31382 (.12008)	.03980 (.04782)
λ_{94}	.28655 (.14723)	.32760 (.11491)	.11411 (.14756)
M_{84}	.15914 (.13204)	.19623 (.11973)	.00337 (.01066)
M_{94}	.15246 (.10874)	.18506 (.09329)	.01557 (.03971)

Note: SD's are shown in the parentheses.

Table 6 Correlation between I and λ in 1984 and 1994

	M_{84}	M_{94}	λ_{84}	λ_{94}
M_{84}	1.0000			
M_{94}	.88324	1.0000		
λ_{84}	.76772[a]	.81147	1.0000	
λ_{94}	.65490	.67537[b]	.90466[b]	1.0000

Note: [a] indicates $p < .01$; [b] indicates $p < .05$.

Table-7: *OLS* Regression Result of eq. (17′)

Variable\Year	1973 - 1994	1973 - 1984	1985 - 1994
Constant	.4540 (.4559)	.1221 (.1271)	- .3803 (- .4067)
ln $(1 / \sigma^2)$	.5681 (3.256)	.3665 (3.721)	.3128 (3.164)
ln (TE)	1.0500 (2.510)	.6155 (2.613)	.4926 (2.061)
λ	- 1.0064 (- 1.253)	- 2.1473 (- 2.882)	- .8910 (- 1.182)
Adjusted R^2	.2381	.3097	.1777

Notes: t-values are in the parentheses.

Size: N = 52.

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