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Abstract

We conducted an empirical analysis on the hypothesis on auto parts procurement in Japan, raised by Asanuma (1989; 1992). The Asanuma hypothesis of Japanese subcontractors claims that there is a new classification of auto parts and their producers according to the degree of initiative for product and process designs. The initiative results in "relation-specific skills" acquired by the suppliers in relation to the auto manufacturers in the first tier. Among the responses to the hypothesis, Milgrom and Roberts (1992) and Holmstrom and Roberts (1998) focused upon a role of the supplier association in the Japanese hierarchy system, where communication among the suppliers alleviates opportunistic misbehavior of the automakers. This paper, instead of the reputational role of the association, takes an alternative stand on the technology cooperation association, from the property rights theory, especially a general setup of Whinston (2003). Participation in the associations should be considered as non-contractible investments for the relation-specific skill. The empirical implications of some specified models concern the effects on a vertical integration likelihood of both the importance of buyers' or sellers' non-contractible investments and specificity in the acquired relation-specific skills. We estimate an equation of vertical integration wherein the determinants are dummy variables of the parent firm and the subsidiary's participation in the cooperation associations and variables representing the degree of their relation specificity. The significance and the signs of these variables suggest that, other than a model of exogenous acquisition of relation-specific skills, a model can be also applicable to the Japanese auto parts suppliers-manufacturers, where it is not the manufacturers' but instead are the suppliers' investments which create their own relation-specific skills through the association activities. The Asanuma hypothesis turns out to be alive.

Keywords: Property rights approach; Vertical integration; Technology cooperation.

JEL classification: L14; L62.

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Introduction

The property right approach to the Coasian firm's boundaries, pioneered by Hart and Moore(1990), has been developed in many applied fields such as industrial organization, banking theory, or macroeconomics including Kiyotaki and Moore (1997). Despite of the explosive popularity in the theoretical development, empirical analyses on the approach itself have been surprisingly rare (a recent survey is Lafontaine and Slade (2013)). This paper aims at filling in the gap. Our specific interest is in the Asanuma hypothesis emphasizing roles of 'relation-specific skills' in the Japanese auto parts industry. To explore the empirical analysis, we rely upon a general setup of Whinston(2003), where noncontractible investments by a buyer or a seller create the relation-specific skills. The comparative statics is conducted with respect to effects on integration likelihood of changes in the parameters pertinent to importance of the relation-specific skill or the specificity of the skill. In a comparison with the qualitative implications, we estimate via Tobit and regressions of censored data on endogenous regressors (IV Tobit and special regressor probit (Lewbel, Dong and Yang, 2012)), a single equation of vertical integration with determinants of those importance and specificity.

Does the Asanuma hypothesis hit the nail on the head? Which types of the property right model do fit to the Japanese auto-parts suppliers? Are there any positive roles of the associations for knowledge sharing in "the hold-up problem"? Yes, the Asanuma hypothesis turns out to be alive. The model of exogenous acquisition of relation-specific skill, or the model of a seller's self investment for the relation-specific skill would be applicable to the auto parts procurement in Japan. Some associations find it a place to make noncontractible investments, and others are not likely to do. As Asanuma(1989; 1992) insisted once, the Japanese auto parts industries are still diversity-carrying.

The structure of the paper is as follows: in Section 1 the Asanuma hypothesis is reconsidered; in Section 2 the property right approach to the hold-up problem is explicated; For comparison with the comparative statics, in Section 3 we estimate the likelihood of vertical integration via Tobit, IV Tobit or special regressor probit models; and finally, in Section 4 we conclude.

1 The Asanuma Hypothesis Revisited

Asanuma(1989;1992), based upon astounding times of interviews with business persons, make a hypothesis stand out on subcontractors in the Japanese auto industries. He disaggregated the classical dichotomy of parts and the suppliers, either drawings supplied (DS abbreviated; *taiyozu*, in Japanese) or drawings approved (DA; *shoninzu*) into a new classification according to the degree of initiative in design of the product and the process.

There are three different categories in the DS parts : I. the core firm provides minute instructions for the manufacturing process; II. the supplier designs the manufacturing process based on blueprints of products provided by the core firm; III. the core firm provides only rough drawings and their completion is entrusted to the supplier. Lowering the priority of the core-firm's initiative on the list, the DA parts are divided into other three taxonomies: IV. the core firm provides specifications and has substantial knowledge of the manufacturing process; V. intermediate region between IV and VI; VI. although the core firm issues specifications it has only limited knowledge concerning the process. Finally, subordinate to the DA parts, marketed goods are ranked seventh: VII. the core firm selects from a catalog offered by the supplier.

The close relation between the core firms and the parts' suppliers, as the initiative classification suggests, fosters on the suppliers' side "relation-specific skills" classified into four categories: X1. capabilities that become visible through interactions held during the early development stage; X2. capabilities that become visible through interactions held during the late development stage; X3. capabilities that become visible at deliveries during the production stage; and X4. capabilities that become visible at price renegotiations during the production stage. Asanuma(1989) also shows the rigid relation of each core firm to a small number of member suppliers belonging to associations for technology cooperation.

The Asanuma hypothesis on the relation-specific skills in the Japanese auto-parts industries once gained the international attention. Among the responses to the hypothesis, Milgrom and Roberts(1992) and Holmstrom and Roberts(1998) focused upon a role of the supplier association in the Japanese hierarchy system, saying

> "Perhaps the major problem in the system may be that the automakers are inherently too powerful and thus face too great a temptation to misbehave opportunistically. ... One counterbalance to this power asymmetry is the supplier association, which facilitates communication among the suppliers and ensures that if the auto company exploits its power over one, all will know and its reputation will be damaged generally. This raises the cost of misbehavior."(p.82, Holmstrom and Roberts, 1998)

What happens to the specific relation in the Japanese auto-parts industries? Can the Asanuma hypothesis still apply as convincingly as when Milgrom and Roberts raised it? Especially, do the supplier associations for technology cooperation play a substantive role in the formation of the relation-specific skills? These questions are reminiscent of the classical Coasian issues of the firm's boundaries, in terms of which the Japanese auto-part suppliers still seem to lie in a grey zone. To answer the questions, the contemporary property-right-approach to the firm's boundaries (Hart, 1995) should be considered. More concretely, instead of the Milgrom and Roberts manner of the view on the relation-specific skills, this paper considers those skills might require 'noncontractible investment', which is executed either by both manufacturers and suppliers, or one of them. The return to the noncontractible investment are considered as accruing through the interactions among suppliers joining the technology cooperation associations.

2 The Property Right Approach

The property right approach to firm's investment hold-up relies upon the incomplete contract theory, where since contracts cannot fully state possible contingency occurring between concerned agents, noncontractible investments, even though efficient ex ante, generate ex post quasi-rent among them. The inefficient quasi-rent leads to the hold-up problem in making a bargain between them (Hart, 1995). The approach has ever gained popularity in theoretical developments and its applications to some fields, such as macroeconomics seen in Kiyotaki and Moore(1997) (Segal and Whinston, 2013 for a comprehensive survey).

In contrast, empirical studies based on the property right approach remain surprisingly rare (Lafontaine and Slade, 2013). There seem to be possible reasons for the lean heap. One is difficulties in distinguishing either the transaction cost economics (TCE) or the property right theory (PRT). Another, but least difficulty is in measuring 'marginal' return to 'noncontractible' investment, which testing the PRT requires.

This paper aims at filling in the gap, overcoming the difficulties both by drawing upon a general setup of Whinston (2003) for the pure PRT, and extracting information from "a natural experiment" of participation of the suppliers into the auto-parts associations for technology cooperation.

2.1 A General Setup of Whinston(2003)

We consider a general setup of a bilateral trade between a buyer B and a seller S. The seller S uses an upstream asset for the production of its product. Though there are seller integration or joint ownership possible in principle, we confine the possible ownership form to buyer integration[1], where a buyer B owns the upstream asset. We denote the ownership state by A_B. If the buyer B owns the asset, then $A_B = 1$ where vertical integration occurs. When the seller S owns it, there is nonintegration $A_B = 0$.

The timing of the setup is as follows. At time 0, the two parties decide who will own the asset and also agree on some 'contractible' investments given without any choices for the parties. The returns to the contractible investments are regarded as accruing in constant terms independent of levels of 'noncontractible' investments both in profits available from a bilateral trade between the parties and in payoffs to the parties in their next-best alternative to trading with each other. At time 1 then, each of the parties make 'noncontractible investments' i_B and i_S which are associated with costs $c_B(i_B)$ and $c_S(i_S)$, respectively. Finally at time 2, they do 'Nash' bargaining over trade, being assumed to have equal bargaining power and split any available surplus in half. For the buyer B when $A_B = 0$, the alternative to the bilateral trade with the seller S is either

[1] As a matter of fact, the TSR (Tokyo Shoko Research, LTD.) data indicates quite low probability of upstream seller's integrations, relative to that of the buyer integration in Japan. The parent-company's ownership ratio of a subsidiary is on average around 45% since 2000, while the subsidiary's ownership ratio of a parent company is on average around 4%.

to conduct procurement from another supplier or shut down. When $A_B = 1$, the buyer B might either procure the part from another supplier, hiring another manager to produce the input using the upstream asset owned by the B, or shut down. Likewise, for the seller S when $A_B = 0$, the alternative to trading with B is either to sell the product to another buyer or shut down. When $A_B = 1$, the seller S might either sell the part to another buyer using a technology without the asset owned by the B, or shut down.

The profits from the bilateral trade of the buyer and the seller $\pi(i_B, i_S)$ and the disagreement payoffs to each of them $\omega_B(i_B, i_S|A_B)$ and $\omega_S(i_B, i_S|A_B)$ are assumed to be expressed in such linear functional forms as follows: profits from the efficient trade with each other

$$\pi(i_B, i_S) = \alpha_0 + \alpha_B i_B + \alpha_S i_S;$$

payoffs to the buyer B in his next-best alternative to trading with S (B's disagreement payoffs)

$$\omega_B(i_B, i_S|A_B) = (\beta_0 + \beta_{B0} i_B + \beta_{S0} i_S)(1 - A_B) + (\beta_1 + \beta_{B1} i_B + \beta_{S1} i_S)A_B;$$

payoffs to the seller in his next-best alternative to trading with B (S's disagreement payoffs)

$$\omega_S(i_B, i_S|A_B) = (\sigma_0 + \sigma_{S0} i_S + \sigma_{B0} i_B)(1 - A_B) + (\sigma_1 + \sigma_{S1} i_S + \sigma_{B1} i_B)A_B.$$

The cost functions are quadratic for simplicity: $c_B(i_B) = 0.5(i_B)^2$ and $c_S(i_S) = 0.5(i_S)^2$. We assume that parameter values satisfy the inequalities $\alpha_0 \geq \max\{\beta_0 + \sigma_0, \beta_1 + \sigma_1\}$, $\alpha_B \geq \max\{\beta_{B0} + \sigma_{B0}, \beta_{B1} + \sigma_{B1}\}$, and $\alpha_S \geq \max\{\sigma_{S0} + \beta_{S0}, \sigma_{S1} + \beta_{S1}\}$. These equations ensure that regardless of who owns the upstream asset, it is ex post efficient for the parties to trade with each other. The ex post efficiency sets off the hold-up problem.

It is of too much importance in testing the PRT, especially the assessment of the Asanuma hypothesis where a participation into the suppliers associations plays a role in acquiring the relation-specific skills, that as well as 'self-investments' we allow 'cross-investments' in the disagreement payoffs. For instance, S might invest in training B how to produce the product more efficiently, or S might invest in raising the quality of the goods produced with the upstream asset. In the former case, the physical capital i_S invested by S matters a great deal for B's disagreement payoff ω_B. Also in the latter case, the efforts i_S made by S for the quality improvements would not only affect the S's own disagreement payoff ω_S but also the B's disagreement payoff ω_B if B owns the asset. According to the Asanuma hypothesis described above, those cross-investments are likely to exemplify the suppliers' cooperative activities with the manufacturers in the technology cooperation associations. Note that a setup of Hart(1995) is a restricted case without any cross-investments $\beta_{S0} = \beta_{S1} = \sigma_{B0} = \sigma_{B1} = 0$, in addition to $\alpha_B > \beta_{B1} > \beta_{B0} \geq 0$, and $\alpha_S > \sigma_{S0} > \sigma_{S1} \geq 0$.

2.1.1 The First-Best Investments

First, we find the first-best solution to the investment decisions of each party. The efficient levels of the investments (i_B^{**}, i_S^{**}) are

$$\arg\max \pi(i_B, i_S) - c_B(i_B) - c_S(i_S) \tag{1}$$

where the solution $(i_B^{**}, i_S^{**}) = (\alpha_B, \alpha_S)$. Then the decisions result in a joint surplus $W^{**} = \alpha_0 + 0.5(\alpha_B)^2 + 0.5(\alpha_S)^2$, to be split equally.

2.1.2 The Second-Best Investments and Integration Likelihood

We next consider equilibrium levels of the investments (i_B^*, i_S^*) given the ownership $A_B = 0$ or 1. The buyer B maximizes

$$\omega_B(i_B, i_S|A_B) + 0.5[\pi(i_B, i_S) - \omega_B(i_B, i_S|A_B) - \omega_S(i_B, i_S|A_B)] - c_B(i_B),$$

where the second term means a half of the quasi-rent received in the Nash bargaining between the buyer and the seller. The solution is

$$i_B^* = 0.5[\alpha_B + (\beta_{B0} - \sigma_{B0})(1 - A_B) + (\beta_{B1} - \sigma_{B1})A_B]. \tag{2}$$

Similarly, a decision of the seller S given the ownership A_B is

$$i_S^* = 0.5[\alpha_S + (\sigma_{S0} - \beta_{S0})(1 - A_B) + (\sigma_{S1} - \beta_{S1})A_B]. \tag{3}$$

The equilibrium welfare level $W^*(A_B; \alpha, \beta, \sigma)$ is obtained by substituting the second-best investments Eq.(2) and Eq.(3) into Eq.(1).

Now we undertake some comparative statics analyses for how changes in the parameters affect the likelihood of vertical integration. The likelihood is determined by a difference in the welfare levels between the ownership structures $A_B = 0$ or 1: $\Delta = [W^*(A_B = 1; \alpha, \beta, \sigma) - W^*(A_B = 0; \alpha, \beta, \sigma)]$. A positive change in the equilibrium welfare level increases a likelihood of vertical integration.

First, changes in the parameters $(\alpha_0, \beta_0, \beta_1, \sigma_0, \sigma_1)$ are irrelevant to the welfare level changes, so that so are 'contractible' investments.

Second, we move to changes in marginal returns to noncontractible investments. Partial derivatives of the difference Δ with respect to each parameter show the following results:

$$\frac{\partial \Delta}{\partial \alpha_B} = 0.5[i_B^*(1; \cdot) - i_B^*(0; \cdot)],$$

where positive if B more invests under $A_B = 1$ than $A_B = 0$;

$$\frac{\partial \Delta}{\partial \alpha_S} = 0.5[i_S^*(1; \cdot) - i_S^*(0; \cdot)],$$

where negative if S more invests under $A_B = 0$ than $A_B = 1$;

$$\frac{\partial \Delta}{\partial \beta_{B0}} = -\frac{\partial \Delta}{\partial \sigma_{B0}} = -0.5[\alpha_B - i_B^*(0; \cdot)],$$

where negative if B underinvests under $A_B = 0$ relative to the first-best investment;

$$\frac{\partial \Delta}{\partial \beta_{B1}} = -\frac{\partial \Delta}{\partial \sigma_{B1}} = 0.5[\alpha_B - i_B^*(1; \cdot)],$$

where positive if B underinvests under $A_B = 1$ relative to the first best;

$$\frac{\partial \Delta}{\partial \sigma_{S0}} = -\frac{\partial \Delta}{\partial \beta_{S0}} = -0.5[\alpha_S - i_S^*(0; \cdot)],$$

where negative if S underinvests under $A_B = 0$ relative to the first best;

$$\frac{\partial \Delta}{\partial \sigma_{S1}} = -\frac{\partial \Delta}{\partial \beta_{S1}} = 0.5[\alpha_S - i_S^*(1; \cdot)],$$

where positive if S underinvests under $A_B = 1$ relative to the first best.

Note that it is apparent that these signs of the partial derivatives crucially depend upon whether to more invests under the ownership of the asset, and whether to underinvest relative to the first-best investment. If B (or S, in parallel) invests more under integration (nonintegration) $A_B = 1$ ($A_B = 0$), an increase in α_B (α_S) increases the joint return from the B's (S's) investment, resulting in higher (lower) probability of integration. Also in an underinvestment case, an increase in investment levels under a ownership structure raises the surplus generated under that structure. Those two conditions are in turn dependent upon specific models for the Asanuma hypothesis describing whose noncontractible investments create the relation-specific skill for the seller S, as will be explained later.

2.1.3 Theoretical Implications

It would be convenient for us to summarize some theoretical implications from the comparative statics of the Whinston(2003)'s general setup. Broadly classified, the comparative statics are twofold, with respect to either importance or specificity of the noncontractible investment.

The importance of the B's investment in improving the upstream asset raises α_B, β_{B1}, and σ_{B0}, meaning increases in marginal returns to the B's noncontractible investment i_B. With the underinvestment and the more investment under a self-ownership, these parameter-changes have the effect of increasing the integration likelihood. Likewise, the importance of the S's investment in improving the asset raises α_S, β_{S1}, and σ_{S0}, that is increases in marginal returns to the S's noncontractible investment i_S. The changes would reduce the integration likelihood, under the same conditions as above.

As for specificity, there are two types of marginal specificity: marginal people specificity for B of i_B indicated by a difference $\alpha_B - \beta_{B1}$; and marginal asset specificity for B of i_B measured by a difference $\beta_{B1} - \beta_{B0}$. The marginal people specificity for B is the amount by which marginal return to the investment i_B is reduced when B has the asset ownership but does not deal with S. The marginal asset specificity for B is the amount by which marginal return to B's investment is further reduced without the asset ownership. An increase in the marginal people specificity, holding the marginal asset specificity fixed, is represented as equal-sized reductions in β_{B1} and β_{B0}, while an increase in the marginal asset specificity holding the people specificity fixed, is as a decrease in β_{B0}. Likewise, the marginal people specificity for S of i_S is measured by a difference $\alpha_S - \sigma_{S0}$, while the marginal asset specificity by a difference $\sigma_{S0} - \sigma_{S1}$. An increase in the marginal people specificity, holding the marginal asset specificity fixed, is represented as equal-sized reductions in σ_{S0} and σ_{S1}, while an increase in the marginal asset specificity holding the people specificity fixed, is as a decrease in σ_{S0}.

2.2 Some Specific Models for the Asanuma Hypothesis

For an empirical analysis on the comparative statics in the general setup above, we construct some specific models applicable to the Asanuma hypothesis, each of which has a difference in "the degree of initiative in design of the product and the process," that is whose noncontractible investments create the relation-specific skills for the seller S. The noncontractible investment also involves a participation into the cooperative activities among suppliers joining the technology cooperation associations.

We have three empirical questions: Does the Asanuma hypothesis hit the nail on the head?; Which types of the PRT model do fit to the Japanese auto-parts suppliers?; Are there any positive roles of the associations for knowledge sharing in “the hold-up problem”? Each of the simplified models constructed below provides differential implications from the comparative statics with respect to the effects of both the importance and the specificity on the integration likelihood, the qualitative results which in Section 3 will be tested using the Japanese auto-parts firms’ data.

2.2.1 Model 1: Exogenous Relation-Specific Skill

Suppose that ‘relation-specific skill’ is exogenously given and B makes noncontractible self-investment complementary to S’s acquisition of the skill. For the purpose, it is assumed that only B has a noncontractible investment and that $\sigma_{B0} = \sigma_{B1} = 0$, in addition to that $\alpha_B > \beta_{B1} > \beta_{B0}$. Then, B underinvests under either ownership, and B more invests under $A_B = 1$ than $A_B = 0$.

The comparative statics suggests that an increase in levels (importance) of the relation-specific skill for B falls into increases in α_B, β_1, and β_{B1}, enhancing the integration likelihood. An increase in the relation-specific skill for S also increases σ_0 and σ_1, since S can use the skill in dealing with another potential buyers without the bilateral trade with B. These parameter-changes however, are irrelevant to a change in the likelihood of the vertical integration.

Regarding the specificity, an increase in levels of specificity corresponds to decreases in σ_0 and σ_1 for S, with irrelevant effects on the integration. The increased specificity also reduces the parameters β_0, β_1, β_{B0}, and β_{B1}. When we interpret the reductions as an increase in the marginal *people* specificity without any changes in the asset specificity, the equal-sized reductions in β_{B0}, and β_{B1} lead to increasing the integration likelihood. Otherwise, when interpreting instead as an increase in the marginal *asset* specificity without changes in the people one, the fall of β_{B0} by more than β_{B1} would also increase the probability of the vertical integration.

2.2.2 Model 2: B's Investment Creates Relation-Specific Skill for S

As an alternative to the Model 1 with the exogenous acquisition of the relation-specific skill for S, suppose that B's investments create the relation-specific skill for S. There are assumed that only B has a noncontractible investment, that $\alpha_B > \sigma_{B0} > \sigma_{B1} > 0$ and that $\alpha_B > \beta_{B1} \geq \beta_{B0} = 0$. The second assumption corresponds to a situation where the benefits for S are largest in a trade with B exclusively making a noncontractible investment. Then, B underinvests and more invests when owing the asset.

An increase in levels (importance) of the relation-specific skill for B increases α_B and β_{B1}, resulting in an enhanced integration-probability. An increase in the importance of the skill for S also increase σ_{B0} and σ_{B1}, since S can use some of the relation-specific skill in dealing with another buyers. The importance of the skill for S would also increase the likelihood of the vertical integration.

More specificity of the skill for S is depicted by decreases in σ_0, σ_1, σ_{B0}, and σ_{B1}, which falls into an increase either in the marginal *people* specificity (equal-sized reductions of σ_{B0}, and σ_{B1}) or in the marginal *asset* specificity (a decrease in σ_{B0} at least as much as one in σ_{B1}, due to close ties of the skill to the asset) of i_B for S. These reductions in the parameters would decrease the vertical integration. Also an increase in the specificity for B arises in reductions of β_0 and β_1, still having no effects on the vertical integration.

2.2.3 Model 3: S's Investment Creates Relation-Specific Skill for S

Finally, as the other extreme case, suppose that the seller's investments create the relation-specific skill for S, where it is assumed that only S has a noncontractible investment, that $\alpha_S > \sigma_{S0} > \sigma_{S1}$, and that $\beta_{S1} \geq \beta_{S0} = 0$. The last assumption implies that some of S's relation-specific skill is embodied in the upstream asset. Then, S underinvests and more invests when owing the asset.

More importance of the relation-specific skill for S increases α_S, σ_{S0}, and σ_{S1}, the relative magnitudes of those rises matter to the integration likelihood. If α_S, σ_{S0}, and σ_{S1} have an equal increase, then the increase importance of the skill would not have any effect on the probability. Otherwise if an increase in α_S is at least as large as one in σ_{S0}, in turn at least as large as in σ_{S1}, then the net effect of these three parameters is to decrease the integration. More importance for B increases β_{S1}, resulting in a reduction of the integration probability.

As for the specificity, more specificity of the skill for S decreases σ_0, σ_1, σ_{S0}, and σ_{S1}. Equal-sized reductions of these values would decrease the integration likelihood. If a decrease in σ_{S0} is at least as large as one in σ_{S1} because of the marginal asset specificity, then the net effect on the integration likelihood would be ambiguous, with a sign of the effect depending upon the parameter values. The larger the decline of σ_{S0} is than the one of σ_{S1}, the more likely the positive sign would be. More specificity of the skill for B also decreases β_0 and β_1, still being irrelevant to the likelihood.

2.3 Comparative Statics Results

Figure 1 summarizes the signs of the effect on the integration likelihood, resulting from the comparative statics analysis. The specific three models address the extreme situations where the relation-specific skill for the seller is created either exogenously, by a noncontractible investment of the buyer, or by an investment of the seller itself. The models also provide qualitatively different implications in terms of the effects on the integration likelihood. With the qualitative implications, we match our estimation results gained later on.

3 Estimation

3.1 Data

We use a combined panel data of *Basic Survey of Japanese Business Structure and Activities*(Ministry of Economy, Trade and Industry)[2], *the Census of Manufactures*(Ministry of Economy, Trade and Industry)[3], and an annual magazine *Japanese Automotive Parts Industry*(Japan Auto Parts Industries Association) from 1995 to 2006, compiled from works of name-based aggregation with a key code of permanent enterprise-numbering in enterprise-name lists provided by the Research Institute of Economy, Trade and Industry (RIETI).

The data set consists of the Japanese enterprises from 1995 to 2006, with a sample size 603505. *Basic Survey of Japanese Business Structure and Activities* reports for each enterprise a name of if any, a parent company (the number of the observations 492241), and the parent-company's ownership ratio of a subsidiary. A subsidiary is a company in which a certain company (parent company) owns more than 50% of the voting rights. It includes a company in which the subsidiary, or the parent company and the subsidiary combined, own more than 50% of the voting rights (deemed subsidiary) and a company practically controlled by the subsidiary or jointly by the parent company and the subsidiary, even in the case they own only 50% or less of the voting rights. The *Survey* also reports sales value and purchase ratios of a subsidiary with the affiliated companies. An affiliated company is a company in which a certain company (parent company) directly owns no less than 20% but no more than

[2] The scope of the survey covers enterprises with 50 or more employees and whose paid-up capital or investment fund is over 30 million yen, whose operation falls under the mining, manufacturing, and wholesale and retail trade, and eating and drinking places (excluding "Other eating and drinking places").

[3] We covers Questionnaire A for the establishments with 30 or more employees, Questionnaire B for the establishments with 29 or fewer employees, and The Report by Commodity.

50% of the voting rights. It includes any company that may have a significant impact due to owning more than 15% of the voting rights.

By virtue of the data links, we can also identify each enterprise not only by names of products it produces at the establishments acquired by *the Census of Manufactures*, but also by a participation into the associations for technology cooperation founded between auto-manufacturers and the subcontractors on a first tier, as reported in the annual *Japanese Automotive Parts Industry.* Among the numerous auto parts, we pick up five major components as product items in the Census of *Manufactures*: "parts, attachments and accessories of internal combustion engines for motor vehicles"; "parts of driving, transmission and operating units"; "parts of suspension and brake systems"; "parts of chassis and bodies"; and "parts, attachments and accessories of auxiliary equipment for internal combustion engines." Enterprises have a dummy variable of 1 for the establishments with these product items, or 0 otherwise. *Japanese Automotive Parts Industry* also reports affiliations with the largest 10 associations for technology cooperation: Daihatsu Kyoyu-kai; Hino Kyoryoku-kai; Isuzu Kyowa-kai; Youko-kai(for Mazda Motor Corporation); Nissho-kai(for Nissan); Subaru Yuhi-kai; Suzuki Kyoryoku-kyodo-kumiai; Kyoho-kai(for Toyota); Kyoryoku-kai in 2006 or affiliations in other years for Mitsubishi; and ones for Honda. Unfortunately, we omit a dummy variable for Suzuki Kyoryoku-kyodo-kumiai, due to some discontinuities in the listing. Whether a parent company or the subsidiary joins any associations is measured with each set of 9 dummy variables running 0 or 1. We alternate two of the parent's association dummy variables, one where zeroes are assigned for companies without parent in a year; and the other where the concerned companies are processed as missing values.

We are interested in how rigid the membership of the supplier associations are, as qualified by the Asanuma hypothesis. The industrial composition of the member suppliers is almost constant over time in our data. Manufacture of transportation equipment accounts for, though gradually declining, a half of the members. The second largest sector is wholesale trade with around 10% share. Those industries else with more than 5% of the membership figure are only three sectors: manufacture of iron and steel; manufacture of general machinery; and manufacture of electrical machinery, equipment and supplies. Our data also indicates drastic changes in the membership participations. Figure 2 shows entry and exit rates of changes in the enterprises belonging to each supplier association from 1995 to 2000 or from 2000 to 2006. Few enterprises have entered into whatever associations to cooperate the technology concerning the auto-parts. In contrast, some firms exited from the associations during 1995 to 2000, with the exit rates accelerating even higher during 2000 to 2006. The low metabolic rates look indicative of a declining role of the supplier associations played in acquisition of the relation-specific skill, invalidating the Asanuma hypothesis.

3.2 Method and Result

We estimate a single equation of the likelihood of vertical integration with regressors of proxy variables for the importance of the relation-specific skill and the degree of the specificity. Our methodology takes into account both censored data on a dependent variable and endogenous regressors in the estimated single equation.

3.2.1 Censored Data

The dependent variable in the estimated equation is a parent-company's ownership ratio of a subsidiary. Without any parent's name on an entry on the questionnaire for an enterprise, the producer should be assigned a value of zero. The dependent variable has data censoring and thus is required to apply censored regression models, among of which we choose a Tobit model as follows:

$$\begin{aligned} y_{it} &= \max(0, y_{it}^*) \\ y_{it}^* &= x_{it}\gamma + z_{it}\delta + u_{it} \end{aligned} \tag{4}$$

where an error term u_{it} follows normal distribution $N(0, \sigma^2)$ conditional upon realized values x_{it} and z_{it}. The general setup of the PRT suggests that the parent's ownership ratio y_{it} of a subsidiary i at a year t has two determinants, the importance x_{it} of the relation-specific skill for a subsidiary or a parent, and the degree of the specificity z_{it} for each of them.

The proxy variables for the importance x_{it} of the relation-specific skill are the 10 dummy variables for a participation of either a subsidiary or a parent into each association. The proxies for the specificity z_{it} of the skill for a subsidiary or a parent are the sales value or purchase ratios of a subsidiary with the affiliated companies, respectively. Moreover, we add to the estimated equation some control variables, year-dummy variables for 1995-2005 and industry-dummy variables. We pick up the 24 industries which are listed by enterprises belonging to any supplier association, according to 2-digit codes in the Japan Standard Industrial Classification[4]. We present first estimation results in case of the parent's association dummy variables with zeroes assigned for no-parent companies. Later for robustness, results are shown when we use the other measurement of the parent's association dummy variables.

The estimates of the Tobit models are shown in Figure 3. We alternate a set of the independent variables chosen for the importance and the specificity proxies. It is evident, on one hand, that both of the specificity variables (sale

[4] Among 26 relevant industry dummy variables containing collinearities detected among instruments in the estimation below, we use 24 industry-dummy variables for construction work, general including public and private construction work; manufacture of food; manufacture of textile mill products; manufacture of lumber and wood products, except furniture; manufacture of furniture and fixtures; manufacture of pulp, paper and paper products; printing and allied industries; manufacture of chemical and allied products; manufacture of petroleum and coal products; manufacture of plastic products; manufacture of rubber products; manufacture of ceramic, stone and clay products; manufacture of iron and steel; manufacture of non-ferrous metals and products; manufacture of fabricated metal products; manufacture of general machinery; manufacture of electrical machinery, equipment and supplies; manufacture of transportation equipment; manufacture of precision instruments and machinery; miscellaneous manufacturing industries; transport; wholesale trade; retail trade; and services, n.e.c..

value and parent's purchase ratios) are significant with positive signs. It suggests that the model 1 of exogenous relation-specific skill might be plausible enough to render the Japanese auto parts industries. On the other hand, almost all coefficients on the dummy variables for the subsidiary's participation into any of the association are significantly negative, while a few coefficients on the parent's dummy variable for the participation are significantly negative for Toyota and Mitsubishi or significantly positive for Nissan and Mazda. The patterns imply that for Toyota and Mitsubishi, it is likely that the model 3 is valid where a seller's noncontractible investment creates the relation-specific skill for itself. Also to Nissan and Mazda, if anything, the model 1 of exogenous skill acquisition would be applicable.

3.2.2 Endogenous Regressors

In the Tobit regression models above, the proxy variables x_{it} and z_{it} for the importance and the specificity on the right-hand side should be likely treated as endogenous. In the general setup of the PRT, investment decisions i_B and i_S made by a buyer and a seller are contingent upon the asset ownership $A_B = 0$ or 1. The importance of the B's and S's investments in improving the upstream asset affects the likelihood of vertical integration, in turn having a bearing upon the investments themselves. Also for the degree of the specificity, the proxy variables cannot break down a change in the specificity a buyer or a seller incurs into exogenous parameters α_B, β_{B1} and β_{B0}, or α_S, σ_{S0} and σ_{S1} indicating the marginal people and asset specificity. Changes in the parameters affect the integration likelihood and the specificity proxy measures simultaneously. For the reasons, it is possible for us to take into account endogeneity of the regressors in the binary regression models.

One estimation is the Tobit model with endogenous regressors of only continuous variables instrumented with some instruments. Otherwise if we include binary, discrete or censored variables as endogenous regressors in the estimation, the estimator would generate inconsistent estimates(Angrist, 2001). The other method is the special regressor estimator of Lewbel, Dong and Yang(2012), where in order to address the problems of endogenous regressors of binary variables, a linear 2-stage least-square estimator can be applied to a probit model. A special regressor is chosen among the continuously distributed, possibly exogenous regressors with a large support.

IV Tobit Models First, in the Tobit models we allow some of the variables z_{it} to be endogenous.

$$\begin{aligned} y_{it} &= \max(0, x_{it}\gamma + z_{it}\delta + u_{it}) \\ z_{it} &= w_{it}\theta + \omega_{it} \end{aligned} \tag{5}$$

where (u_{it}, ω_{it}) are zero-mean normally distributed, and instruments w_{it} are incorporated for identification. The IV Tobit model, however, can address as endogenous regressors in the Tobit model continuous variables like a proxy for the specificity z_{it}, not binary variables like a proxy x_{it} for the importance of the skill. We estimate the IV Tobit model with the endogenous variables z_{it} and instruments w_{it}. The instruments are the 5 products dummy variables, and a logarithm of capitals, besides the independent variables.

The estimates of the IV Tobit models using the two-step estimator (Newey, 1987) are indicated in Figure 4. After the IV regressions, coefficients only on the subsidiary's specificity proxy variables remain significantly positive in all the cases. It suggests that the model s is close to what happens in the auto parts industries in Japan. As for the effect of the importance, there seems to be weaker evidence supporting the model 3, relative to the original Tobit regressions. A few exceptions for the model 3 to apply are to Daihatsu, Hino and Mitsubishi. The similar results are seen in Figure 5 and Figure 6 when we use the other measurement of the parent's association dummy variable with missing values assigned for the companies without parent.

Special Regressor Probit Models Second, for the special regressor probit model, we consider a binary choice dependent variable d_{it} which takes a value 1 if the parent's ownership ratio y_{it} of a subsidiary i at a year t is larger than or equal to 50%, or a value 0 otherwise. The special regressor estimation of a probit model (Lewbel, Dong and Yang, 2012) assumes a exogenous regressor v_{it}, continuously distributed with a large support.

$$\begin{aligned} d_{it} &= I(v_{it} + x_{it}\gamma + z_{it}\delta + u_{it} \geq 0) \\ v_{it} &= w_{it}\eta + \epsilon_{it} \end{aligned} \tag{6}$$

where an indicator function $I(\cdot)$ takes a value 1 if its argument $\cdot$ is true and a value 0 otherwise. The special regressor estimator is obtained by first constructing $T = \frac{d_{it} - I(v_{it} \geq 0)}{f(v_{it}|w_{it}, x_{it}, z_{it})}$ where the special regressor v_{it} is demeaned and a one-dimensional kernel density estimator is used for the conditional density $f(v_{it}|w_{it}, x_{it}, z_{it}) = f(v_{it}|w_{it}) = f(\epsilon_{it})$ of a residual estimate ϵ_{it}, and second applying a 2-stage least square regression to $T = x_{it}\gamma + z_{it}\delta + \widetilde{u}_{it}$with instruments w_{it}. The estimation can be carried out even when including the endogenous binary-choice regressors x_{it} proxying the importance of the relation-specific skills.

However, since we have the 18 endogenous binary-choice regressors x_{it} measured with a participation of either a subsidiary or a parent into 9 associations, we cannot practically find at least equal number of the relevant instruments. So we have to count only a partial set of the 18 regressors as the endogenous variables, especially a pair of the dummy variables for a subsidiary and a parent's participation into each association. Accordingly, the number of the endogenous regressors is 4 including two continuous variables proxying the specificity z_{it}.

Regarding the special regressor v_{it} which is required to be an exogenous continuously-distributed variable with a large support, we specify either of two firm-attributes: a current asset ratio to total assets; and a firm-age (both from *Basic Survey of Japanese Business Structure and Activities*).

Figure 7 to 15 indicate the regression results. As measured with the coefficients on the sale value ratio in the estimations, the effects of the subsidiary's specificity are still evident. Among the evidence, there are significantly negative effects in the cases where the current asset ratio is used as the special regressor when missing values are applied ti companies without parent. It suggests validity of the model 3's comparative statics. Concerning the effects of the importance of the subsidiary or parent's participation into the association, more meager results are shown, except for a few cases suggestive of the model 3 where the subsidiary's self-investment creates the relation-specific skill.

4 Conclusion

Does the Asanuma hypothesis hit the nail on the head? Which types of the PRT model do fit to the Japanese auto-parts suppliers? Are there any positive roles of the associations for knowledge sharing in "the hold-up problem"? In order to answer these questions, we construct some specific models based upon the general setup of Whinston(2003). The simplified models provide differential implications with respect to the comparative statics concerning the effects on vertical integration. Comparisons the qualitative implications with our Tobit and IV Tobit regressions lead to a conclusion. Yes, the Asanuma hypothesis turns out to be alive. The model of exogenous acquisition of relation-specific skill, or the model of a seller's self investment for the relation-specific skill would be applicable to the auto parts procurement in Japan. Some associations find it a place to make noncontractible investments, and others are not likely to do. As Asanuma(1989; 1992) insisted once, the Japanese auto parts industries are still diversity-carrying.

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Effect on likelihood of integration	More importance of relation-specific skill		More specificity			
	Buyer	Seller	Buyer		Seller	
			People	Asset	People	Asset
Model 1: Exogenous relation-specific skill	(+)	(0)	(+)	(+)	(0)	
Model 2: B’s investments create relation-specific skill for S	(+)	(+)	(0)		(-)	(-)
Model 3: S’s investments create relation-specific skill for S	(-)	(-)	(0)		(-)	?

Figure 1: Comparative Statics: "People" means the marginal people specificity for B or S of i_B or i_S. Similarly, "asset" does the marginal asset specificity for B or S of i_B or i_S.

Supplier Associations	Entry		Exit	
% Changes	From 1995 to 2000	From 2000 to 2006	From 1995 to 2000	From 2000 to 2006
Daihatsu	0.05	0.04	5.63	12.35
Hino	0.04	0.12	5.88	14.86
Honda	0.11	0.24	4.32	24.68
Isuzu	0.06	0.12	12.11	20.86
Mazda	0.02	0.02	5.85	18.45
Mitsubishi	0.03	0.02	3.68	60.07
Nissan	0.02	0.05	15.03	18.71
Subaru	0.02	0.04	9.21	19.05
Toyota	0.06	0.03	5.2	13.37

Figure 2: Entry and Exit Rates of Changes in Enterprises of Supplier Associations

Ownership Ratio	(1)# of obs.=18665		(2)# 18665		(3)# 85803		(4)# 28504		(5)# 31735	
	Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
Sale Value Ratio	.142***	20.18	.159***	22.31			.137***	27.02		
Purchase Ratio	.085***	13.27	.084***	12.98					.069***	14.74
Subsidiary										
Toyota	-11.50**	-2.44			-10.45***	-6.21	-4.05	-1.16		
Nissan	-23.84***	-5.57			-23.18***	-12.46	-16.13***	-4.75		
Mitsubishi	-13.71***	-3.52			-10.37***	-6.13	-16.80***	-5.41		
Mazda	-4.39	-1.12			-12.89***	-7.58	-2.93	-0.96		
Isuzu	-10.03**	-2.49			-11.12***	-6.54	-2.46	-0.83		
Daihatsu	-5.89	-1.30			-11.38***	-5.88	-19.99***	-5.85		
Hino	-14.03***	-3.50			-12.64***	-7.04	-16.91***	-5.51		
Honda	-14.30***	-4.60			-26.16***	-20.26	-15.97***	-6.82		
Subaru	-6.63	-1.47			-6.25***	-3.21	-17.12***	-4.98		
Parent										
Toyota	-1.93*	-1.76			-1.83***	-3.55			-1.99***	-2.70
Nissan	6.03***	4.92			3.74***	7.15			5.21***	6.30
Mitsubishi	-4.81***	-4.34			-2.29***	-4.07			-2.70***	-3.55
Mazda	4.59***	3.33			3.71***	5.96			4.18***	4.36
Isuzu	2.18	1.47			1.82***	2.89			.166	0.16
Daihatsu	-.384	-0.28			1.10*	1.76			-.037	-0.04
Hino	2.20*	1.69			1.76***	2.84			.655	0.73
Honda	1.86*	1.67			3.45***	7.55			2.04***	2.63
Subaru	-1.72	-1.22			-1.48**	-2.55			-1.57	-1.61

Figure 3: Tobit regression: the parent's association dummy variables with zeroes assigned for companies without parent in a year; asterisk symbols *, ** and *** mean significance level 10%, 5% and 1%.

Ownership Ratio	(1)# of obs.=18575		(2)# 18575		(3)# 28327		(4)# 21789	
	Coef.	z-value	Coef.	z-value	Coef.	z-value	Coef.	z-value
Sale Value Ratio	3.52***	13.42	2.62***	25.02	2.31***	29.79		
Purchase Ratio	-.871	-1.25	.157	1.24			5.05***	8.35
Subsidiary								
Toyota	17.87	1.01			-4.59	-0.50		
Nissan	34.46**	2.16			17.60**	2.00		
Mitsubishi	1.15	0.08			-.268	-0.03		
Mazda	12.72	0.89			4.36	0.55		
Isuzu	3.67	0.21			14.64*	1.87		
Daihatsu	-18.52	-1.13			-17.61**	-1.99		
Hino	-45.40***	-2.95			-31.58***	-3.92		
Honda	20.94*	1.76			9.94	1.59		
Subaru	5.92	0.36			-11.74	-1.35		
Parent								
Toyota	-18.88***	-4.41					-13.61**	-2.23
Nissan	-6.93	-1.40					18.01***	2.62
Mitsubishi	4.41	0.64					-38.11***	-5.22
Mazda	-6.95	-1.03					25.54***	3.21
Isuzu	10.25*	1.81					-1.80	-0.22
Daihatsu	18.00*	1.95					-47.79***	-5.05
Hino	12.06*	1.74					-34.95***	-4.20
Honda	-12.59*	-1.78					40.87***	5.30
Subaru	-2.71	-0.50					.914	0.12

Figure 4: IV Tobit regression: the parent's association dummy variables with zeroes assigned for companies without parent in a year; asterisk symbols *, ** and *** mean significance level 10%, 5% and 1%.

Tobit	(1)# of obs.=4768		(3)# 20896		(5)# 9181	
	Coef.	t-value	Coef.	t-value	Coef.	t-value
Sale Value Ratio	.097***	9.98				
Purchase Ratio	.027***	2.88			.031***	4.02
Subsidiary						
Toyota	-11.23***	-2.79	-12.41***	-8.29		
Nissan	-27.89***	-8.27	-23.71***	-14.89		
Mitsubishi	-20.55***	-6.37	-13.40***	-8.94		
Mazda	-10.29***	-2.99	-11.84***	-7.98		
Isuzu	-4.67	-1.25	-11.53***	-7.36		
Daihatsu	-1.67	-0.38	-9.43***	-5.16		
Hino	-9.59***	-2.65	-10.00***	-6.02		
Honda	-25.24***	-9.08	-33.80***	-29.67		
Subaru	-5.22	-1.41	-6.88***	-4.13		
Parent						
Toyota	-2.64***	-3.09	-1.82***	-4.52	-2.42***	-3.54
Nissan	3.34***	3.60	1.31***	3.23	2.73***	3.67
Mitsubishi	-3.47***	-4.27	-1.50***	-3.51	-2.16***	-3.26
Mazda	1.13	1.10	1.68***	3.48	2.14**	2.53
Isuzu	2.09*	1.93	2.32***	4.82	1.32	1.47
Daihatsu	.244	0.24	.509	1.07	-.146	-0.18
Hino	1.74*	1.83	.926*	1.96	.510	0.65
Honda	1.47*	1.66	1.87***	4.88	1.03	1.42
Subaru	-1.44	-1.41	-1.28***	-2.93	-1.17	-1.39

Figure 5: Tobit regression: the parent's association dummy variables with missing values assigned for companies without parent in a year; asterisk symbols *, ** and *** mean significance level 10%, 5% and 1%.

IV Tobit	(1)# of obs.=4745		(2)# 4745		(3)# 8288		(4)# 5336	
	Coef.	z-value	Coef.	z-value	Coef.	z-value	Coef.	z-value
Sale Value Ratio	1.49***	6.21	1.60***	14.46	1.09***	12.47		
Purchase Ratio	-.545	-1.10	-.030	-0.38			1.21***	5.06
Subsidiary								
Toyota	-1.34	-0.13			-5.21	-0.95		
Nissan	2.63	0.27			-1.79	-0.35		
Mitsubishi	-18.64*	-1.77			-9.30*	-1.92		
Mazda	-2.76	-0.30			-6.92	-1.44		
Isuzu	4.96	0.46			11.94**	2.38		
Daihatsu	-6.74	-0.64			-20.29***	-3.53		
Hino	-20.67**	-2.32			-23.19***	-4.51		
Honda	-12.72*	-1.69			-11.13***	-2.78		
Subaru	4.11	0.47			-16.50***	-3.29		
Parent								
Toyota	-10.70***	-3.74					-1.67	-1.01
Nissan	-1.98	-0.66					7.50***	3.65
Mitsubishi	.942	0.20					-12.46***	-5.23
Mazda	-.756	-0.19					6.45***	2.76
Isuzu	4.19	1.44					2.09	0.99
Daihatsu	8.44	1.42					-10.63***	-3.51
Hino	6.31	1.34					-10.16***	-3.57
Honda	-5.44	-1.22					10.86***	4.03
Subaru	-3.15	-1.18					-1.29	-0.64

Figure 6: IV Tobit regression: the parent's association dummy variables with missing values assigned for companies without parent in a year; asterisk symbols *, ** and *** mean significance level 10%, 5% and 1%.

Probit	Missing values for companies without parent				Zeroes for companies without parent			
Special Regressor	Current Asset Ratio: # of obs.=4529		Firm Age: #4514		Current Asset Ratio: # of obs.=17731		Firm Age: #17674	
	Coef.	z-value	Coef.	z-value	Coef.	z-value	Coef.	z-value
Endogenous Variables								
Sale Value Ratio	−0.93	−2.48**	0.60	1.45	0.60	5.09***	2.14	10.8***
Purchase Ratio	0.08	0.09	0.36	0.38	−0.28	−0.92	−0.69	−1.28
Toyota Subsidiary	200.05	2.22**	−33.01	−0.17	96.76	1.04	189.53	1.04
Toyota Parent	−100.69	−0.84	121.27	1.24	−24.30	−0.26	−192.51	−1.16
Exogenous Variables								
Subsidiary Nissan	−63.90	−2.74***	24.40	1.06	−5.19	−0.22	−14.92	−0.37
Mitsubishi	−11.75	−0.66	−4.53	−0.37	−4.72	−0.7	4.57	0.41
Mazda	−13.97	−1.04	12.80	0.61	−0.90	−0.08	−13.12	−0.5
Isuzu	−22.64	−0.78	−23.51	−0.6	−11.54	−1.05	−9.59	−0.49
Daihatsu	−91.60	−1.59	−15.93	−0.16	−42.33	−1.18	−48.45	−0.79
Hino	−23.54	−1.5	−14.01	−0.5	−24.83	−1.53	−56.74	−1.86*
Honda	−50.93	−3.93***	−4.98	−0.24	−12.39	−1.13	−11.18	−0.52
Subaru	−16.51	−1.34	3.98	0.3	−2.67	−0.3	−9.11	−0.57
Parent Nissan	33.73	1.03	−32.50	−1.28	1.65	0.05	57.39	0.99
Mitsubishi	−4.08	−0.72	1.67	0.22	0.73	0.17	−2.63	−0.34
Mazda	9.40	0.79	−11.06	−0.88	−4.88	−0.32	28.57	0.96
Isuzu	8.39	1.72*	−4.70	−1.27	6.97	1.27	8.25	1.2
Daihatsu	40.78	0.96	−40.75	−1.22	19.56	0.7	61.08	1.31
Hino	17.99	0.66	−28.07	−1.27	7.61	0.42	40.64	1.22
Honda	5.53	0.77	−0.10	−0.01	0.93	0.12	8.99	0.54
Subaru	−11.09	−1.2	8.49	1.33	−4.96	−0.53	−15.30	−1.05

Figure 7: Special Regressor Probit Regression (1)Endogenous Toyota Dummy Variables

Probit	Missing values for companies without parent				Zeroes for companies without parent			
Special Regressor	Current Asset Ratio: # of obs.=4529		Firm Age: #4514		Current Asset Ratio: # of obs.=17731		Firm Age: #17674	
	Coef.	z-value	Coef.	z-value	Coef.	z-value	Coef.	z-value
Endogenous Variables								
Sale Value Ratio	−0.90	−1.7*	−0.59	−0.65	0.60	4.2***	2.00	8.63***
Purchase Ratio	−0.05	−0.08	0.66	0.74	−0.28	−0.84	−0.48	−0.97
Nissan Subsidiary	2.08	0.01	−419.85	−1.65	31.86	0.35	−48.40	−0.29
Nissan Parent	−37.41	−0.48	172.15	1.43	0.41	0.01	103.40	1.05
Exogenous Variables								
Subsidiary Toyota	−24.55	−1.43	44.94	1.45	1.59	0.11	34.00	1.52
Mitsubishi	−21.56	−1.26	15.15	0.74	−6.90	−0.63	10.25	0.65
Mazda	4.25	0.29	3.05	0.17	1.50	0.17	12.18	0.92
Isuzu	−23.34	−0.65	96.60	1.53	−7.85	−0.44	17.38	0.54
Daihatsu	5.23	0.41	−35.33	−1.34	−1.23	−0.14	−12.80	−0.83
Hino	5.44	0.43	11.02	0.47	−12.20	−1.39	−31.40	−2.36**
Honda	−28.03	−3.2***	−14.04	−1.2	−3.56	−0.66	5.26	0.62
Subaru	−14.90	−0.31	132.06	1.59	−7.79	−0.23	33.97	0.47
Parent Toyota	9.15	0.5	−34.90	−1.49	−9.79	−0.56	−42.32	−1.58
Mitsubishi	5.91	0.45	−30.12	−1.38	0.71	0.08	−13.38	−0.8
Mazda	−7.72	−0.94	17.29	1.45	−7.71	−2.03**	0.76	0.13
Isuzu	18.89	0.82	−61.55	−1.51	5.23	0.28	−35.82	−1.03
Daihatsu	5.50	0.56	14.64	1.07	16.27	1.71*	27.55	1.81*
Hino	2.41	0.39	−5.93	−0.81	4.87	1.29	2.83	0.53
Honda	6.13	1.47	−0.82	−0.13	−1.12	−0.22	−16.20	−1.97**
Subaru	7.42	0.39	−36.96	−1.3	−5.14	−0.33	−29.93	−1.12

Figure 8: Special Regressor Probit Regression (2)Endogenous Nissan Dummy Variables

Probit	Missing values for companies without parent				Zeroes for companies without parent			
Special Regressor	Current Asset Ratio: # of obs.=4529		Firm Age: #4514		Current Asset Ratio: # of obs.=17731		Firm Age: #17674	
	Coef.	z-value	Coef.	z-value	Coef.	z-value	Coef.	z-value
Endogenous Variables								
Sale Value Ratio	−0.96	−2.2**	0.93	2.38**	0.52	3.53***	2.17	5.25***
Purchase Ratio	0.99	0.94	−0.99	−0.99	0.09	0.15	−1.17	−0.6
Mitsubishi Subsidiary	−154.94	−0.74	33.53	0.2	−298.78	−0.87	194.44	0.2
Mitsubishi Parent	181.76	1.33	−138.20	−0.97	129.78	0.75	−193.92	−0.36
Exogenous Variables								
Subsidiary Toyota	−27.11	−1.27	15.31	0.83	3.64	0.39	16.70	0.87
Nissan	−9.78	−0.29	−7.97	−0.27	45.68	0.84	−11.85	−0.08
Mazda	6.09	0.2	1.54	0.05	50.17	0.94	−13.02	−0.08
Isuzu	−14.93	−0.59	−1.97	−0.09	26.89	0.75	−16.75	−0.19
Daihatsu	66.54	0.89	−33.01	−0.55	61.66	0.81	−55.49	−0.28
Hino	55.23	0.88	−45.37	−0.86	56.03	0.73	−79.73	−0.36
Honda	−15.39	−0.64	−9.70	−0.54	25.14	0.76	−7.93	−0.09
Subaru	−6.85	−0.38	10.96	0.64	15.13	0.88	9.44	0.28
Parent Toyota	8.48	1.06	−13.66	−1.39	−3.78	−0.6	−19.87	−1.03
Nissan	−24.59	−1.13	22.45	0.92	−24.89	−0.91	29.59	0.32
Mazda	−29.72	−1.44	22.40	1.08	−23.82	−1.05	22.84	0.36
Isuzu	−14.20	−0.82	15.67	0.78	−9.69	−0.44	33.04	0.39
Daihatsu	−48.43	−1.08	50.07	0.99	−22.37	−0.45	73.20	0.42
Hino	−45.31	−1.3	33.76	0.97	−26.18	−0.62	48.00	0.42
Honda	3.17	0.43	−5.24	−0.82	−7.86	−0.74	−0.90	−0.06
Subaru	6.93	0.82	−9.32	−0.87	2.94	0.31	−14.04	−0.42

Figure 9: Special Regressor Probit Regression (3)Endogenous Mitsubishi Dummy Variables

Probit	Missing values for companies without parent				Zeroes for companies without parent			
Special Regressor	Current Asset Ratio: # of obs.=4529		Firm Age: #4514		Current Asset Ratio: # of obs.=17731		Firm Age: #17674	
	Coef.	z-value	Coef.	z-value	Coef.	z-value	Coef.	z-value
Endogenous Variables								
Sale Value Ratio	0.76	0.36	0.51	0.49	0.51	4.13***	3.75	0.67
Purchase Ratio	−2.89	−0.66	2.92	0.6	−0.16	−0.39	−8.41	−0.33
Mazda Subsidiary	1105.37	0.81	−523.41	−0.63	−123.45	−1.04	−1051.56	−0.35
Mazda Parent	−148.32	−0.47	378.95	0.65	27.20	0.38	−1246.46	−0.3
Exogenous Variables								
Subsidiary Toyota	−79.04	−0.86	46.46	0.64	12.00	1.12	63.08	0.46
Nissan	−114.27	−1.25	13.55	0.36	11.38	0.7	256.98	0.37
Mitsubishi	−220.74	−0.86	86.04	0.56	16.33	0.71	312.94	0.34
Isuzu	−190.37	−0.84	110.00	0.6	18.14	0.89	172.53	0.36
Daihatsu	−187.60	−0.79	84.71	0.62	12.30	0.76	134.68	0.33
Hino	−139.06	−0.8	26.54	0.31	4.64	0.33	36.73	0.2
Honda	−47.54	−1.29	13.50	0.34	−2.73	−0.53	25.70	0.39
Subaru	−88.72	−0.73	97.11	0.61	20.80	1.51	−62.45	−0.21
Parent Toyota	4.03	0.18	−33.36	−0.73	−12.03	−1.58	112.65	0.27
Nissan	−17.55	−0.53	31.76	0.64	−3.67	−1.33	−46.28	−0.34
Mitsubishi	32.24	0.54	−62.02	−0.65	−2.95	−0.3	176.45	0.31
Isuzu	43.95	0.49	−115.50	−0.67	−4.09	−0.18	402.46	0.3
Daihatsu	37.96	1.04	−12.39	−0.47	16.07	3.97***	7.94	0.22
Hino	38.83	0.6	−63.97	−0.66	0.74	0.07	198.61	0.31
Honda	−3.56	−0.21	−7.99	−0.48	−2.30	−0.51	23.78	0.21
Subaru	38.57	0.38	−130.73	−0.64	−16.36	−0.6	458.89	0.3

Figure 10: Special Regressor Probit Regression (4)Endogenous Mazda Dummy Variables

Probit	Missing values for companies without parent				Zeroes for companies without parent			
Special Regressor	Current Asset Ratio: # of obs.=4529		Firm Age: #4514		Current Asset Ratio: # of obs.=17731		Firm Age: #17674	
	Coef.	z-value	Coef.	z-value	Coef.	z-value	Coef.	z-value
Endogenous Variables								
Sale Value Ratio	−0.72	−1.53	0.45	1.31	0.56	2.88***	2.23	8.01***
Purchase Ratio	−0.18	−0.27	0.08	0.16	−0.27	−0.57	−0.96	−1.37
Isuzu Subsidiary	−29.48	−0.25	−190.48	−2.01**	−104.68	−0.84	45.46	0.15
Isuzu Parent	−92.39	−0.62	136.89	1.67*	30.50	0.19	−131.39	−0.72
Exogenous Variables								
Subsidiary Toyota	8.79	0.35	1.72	0.09	11.60	0.54	30.33	0.91
Nissan	−31.49	−1.79*	34.76	2**	16.95	0.87	20.16	0.39
Mitsubishi	−21.66	−0.93	14.24	0.96	9.36	0.44	−6.00	−0.16
Mazda	2.45	0.09	36.88	1.59	21.44	0.82	0.31	0.01
Daihatsu	−1.92	−0.15	3.46	0.32	−0.12	−0.01	−11.43	−0.74
Hino	7.74	0.32	10.01	0.56	5.75	0.3	−37.02	−0.86
Honda	−28.39	−1.51	16.71	1.14	7.66	0.46	−1.34	−0.04
Subaru	−7.63	−0.26	23.98	1.39	17.71	0.62	−16.07	−0.35
Parent Toyota	0.36	0.12	−3.24	−1.12	−8.56	−1.77*	−10.64	−2.57**
Nissan	24.21	0.76	−34.59	−1.74*	−10.39	−0.29	26.78	0.61
Mitsubishi	8.67	0.63	−12.86	−1.45	−0.36	−0.03	17.45	0.91
Mazda	22.10	0.55	−37.91	−1.58	−14.30	−0.33	34.47	0.67
Daihatsu	7.16	0.91	6.30	0.93	16.45	2.29**	5.85	0.58
Hino	19.73	0.7	−23.54	−1.68*	1.22	0.04	27.63	0.89
Honda	18.66	0.89	−21.36	−1.83*	−4.10	−0.18	10.54	0.41
Subaru	16.35	0.56	−24.06	−1.59	−8.43	−0.27	23.98	0.72

Figure 11: Special Regressor Probit Regression (5)Endogenous Isuzu Dummy Variables

Probit	Missing values for companies without parent				Zeroes for companies without parent			
Special Regressor	Current Asset Ratio: # of obs.=4529		Firm Age: #4514		Current Asset Ratio: # of obs.=17731		Firm Age: #17674	
	Coef.	z-value	Coef.	z-value	Coef.	z-value	Coef.	z-value
Endogenous Variables								
Sale Value Ratio	−1.07	−2.41**	0.88	1.83*	0.32	1	1.93	7.53***
Purchase Ratio	1.01	0.44	−1.09	−0.43	0.73	0.64	0.01	0.02
Daihatsu Subsidiary	−446.04	−1.59	29.36	0.11	−90.42	−0.7	41.30	0.31
Daihatsu Parent	224.19	0.59	−154.90	−0.38	279.41	1.22	174.89	0.95
Exogenous Variables								
Subsidiary Toyota	163.09	1.39	17.51	0.18	5.60	0.08	−31.96	−0.47
Nissan	−71.72	−1.98**	19.51	0.47	−19.47	−1.06	19.97	1.06
Mitsubishi	83.62	0.84	−41.46	−0.4	33.38	1.12	20.03	0.71
Mazda	26.59	0.61	8.98	0.24	−0.79	−0.04	2.42	0.15
Isuzu	−34.13	−0.72	14.75	0.26	−22.20	−0.96	−17.13	−0.88
Hino	94.02	1.03	−54.56	−0.51	33.81	0.96	−13.59	−0.46
Honda	−25.16	−1.35	−13.51	−0.79	0.54	0.07	10.12	1.17
Subaru	19.70	0.33	−29.30	−0.45	37.16	1.08	25.24	0.82
Parent Toyota	−47.53	−0.54	28.08	0.33	−61.40	−1.31	−43.20	−1.27
Nissan	37.25	0.59	−24.89	−0.39	38.07	1	19.53	0.7
Mitsubishi	−47.56	−0.55	37.71	0.38	−51.15	−1.09	−31.34	−0.78
Mazda	12.45	0.32	−13.98	−0.32	16.48	0.71	13.25	0.71
Isuzu	24.44	0.67	−16.97	−0.46	29.03	1.45	17.96	1.06
Hino	−105.14	−0.53	79.28	0.37	−130.85	−1.09	−79.34	−0.84
Honda	−22.21	−0.4	18.56	0.34	−29.93	−1.16	−26.96	−1.27
Subaru	−42.33	−0.6	30.80	0.4	−53.80	−1.22	−31.89	−0.89

Figure 12: Special Regressor Probit Regression (6)Endogenous Daihatsu Dummy Variables

Probit	Missing values for companies without parent				Zeroes for companies without parent			
Special Regressor	Current Asset Ratio: # of obs.=4529		Firm Age: #4514		Current Asset Ratio: # of obs.=17731		Firm Age: #17674	
	Coef.	z-value	Coef.	z-value	Coef.	z-value	Coef.	z-value
Endogenous Variables								
Sale Value Ratio	−0.72	−0.54	0.39	0.31	0.68	3.06***	2.18	5.86***
Purchase Ratio	−0.84	−0.23	0.36	0.19	−0.65	−0.88	−1.18	−0.92
Hino Subsidiary	−540.98	−0.35	445.49	0.49	−49.09	−0.15	−506.97	−0.83
Hino Parent	560.74	0.35	−444.25	−0.49	132.75	0.34	637.39	0.7
Exogenous Variables								
Subsidiary Toyota	49.67	0.26	−67.78	−0.48	5.99	0.1	103.86	0.9
Nissan	0.79	0.01	−33.86	−0.37	5.90	0.19	78.35	1.13
Mitsubishi	65.56	0.28	−71.31	−0.57	−1.37	−0.03	56.19	0.81
Mazda	55.61	0.37	−41.05	−0.56	6.17	0.23	36.33	1
Isuzu	124.30	0.32	−114.56	−0.53	8.73	0.15	85.35	0.74
Daihatsu	169.51	0.36	−135.93	−0.5	11.88	0.18	104.93	0.69
Honda	11.27	0.1	−54.19	−0.57	0.67	0.03	38.49	0.9
Subaru	−130.38	−0.35	99.45	0.47	−18.61	−0.25	−125.51	−0.71
Parent Toyota	−82.01	−0.36	63.81	0.46	−24.92	−0.48	−100.86	−0.8
Nissan	3.69	0.29	−4.26	−0.39	−7.53	−1.07	−10.24	−1.03
Mitsubishi	−76.41	−0.36	60.74	0.5	−16.31	−0.27	−86.58	−0.68
Mazda	−74.17	−0.37	60.48	0.51	−24.80	−0.51	−82.24	−0.72
Isuzu	−110.97	−0.33	81.80	0.47	−18.77	−0.24	−121.38	−0.68
Daihatsu	−255.47	−0.34	212.25	0.49	−44.88	−0.23	−306.65	−0.68
Honda	79.54	0.38	−57.20	−0.52	11.94	0.28	60.16	0.62
Subaru	103.94	0.34	−83.41	−0.48	21.66	0.28	124.73	0.7

Figure 13: Special Regressor Probit Regression (7)Endogenous Hino Dummy Variables

Probit	Missing values for companies without parent				Zeroes for companies without parent			
Special Regressor	Current Asset Ratio: # of obs.=4529		Firm Age: #4514		Current Asset Ratio: # of obs.=17731		Firm Age: #17674	
	Coef.	z-value	Coef.	z-value	Coef.	z-value	Coef.	z-value
Endogenous Variables								
Sale Value Ratio	−1.27	−0.74	−0.09	−0.16	0.49	3.22***	1.87	7.2***
Purchase Ratio	−0.62	−0.51	0.29	0.59	−0.23	−0.72	−0.44	−0.9
Honda Subsidiary	−48.00	−0.13	−210.13	−1.93*	−119.20	−0.89	−194.12	−0.96
Honda Parent	−131.59	−1.19	98.53	2.1**	75.66	1.27	164.33	1.95*
Exogenous Variables								
Subsidiary Toyota	−16.44	−0.25	35.58	1.65	29.27	0.92	59.90	1.3
Nissan	−46.46	−1.23	−3.13	−0.26	5.41	0.65	41.31	2.65***
Mitsubishi	−23.24	−0.51	8.19	0.64	10.79	0.53	23.43	0.95
Mazda	3.07	0.22	−4.14	−0.46	7.99	1.17	18.11	1.73*
Isuzu	−2.96	−0.04	43.27	1.64	17.74	0.75	40.05	1.1
Daihatsu	25.60	1.16	−9.39	−0.84	−4.93	−0.43	−11.65	−0.89
Hino	11.36	0.29	0.54	0.03	−3.73	−0.32	−23.51	−1.49
Subaru	−17.11	−0.2	45.27	1.88*	33.83	1.18	60.06	1.2
Parent Toyota	−1.38	−0.21	−0.86	−0.25	−14.06	−2.85***	−27.69	−3.53***
Nissan	10.60	1.08	−0.76	−0.2	−11.72	−1.67*	−20.73	−2.4**
Mitsubishi	10.75	0.89	−5.16	−1.09	−5.14	−0.85	−7.34	−1.04
Mazda	5.96	0.64	−5.28	−0.99	−15.34	−2.09**	−19.47	−2.12**
Isuzu	35.15	1.47	−27.37	−2.51**	−14.40	−0.88	−45.52	−1.91*
Daihatsu	46.87	1.47	−24.23	−1.88*	0.54	0.04	−24.79	−1.31
Hino	−16.29	−1.12	8.38	1.13	15.42	1.59	27.90	2.25**
Subaru	34.61	1.07	−27.15	−1.98**	−27.53	−1.53	−54.67	−2.05**

Figure 14: Special Regressor Probit Regression (8)Endogenous Honda Dummy Variables

Probit	Missing values for companies without parent				Zeroes for companies without parent			
Special Regressor	Current Asset Ratio: # of obs.=4529		Firm Age: #4514		Current Asset Ratio: # of obs.=17731		Firm Age: #17674	
	Coef.	z-value	Coef.	z-value	Coef.	z-value	Coef.	z-value
Endogenous Variables								
Sale Value Ratio	-1.03	-4***	0.55	1.42	0.41	2.77***	1.93	9.12***
Purchase Ratio	-0.22	-0.15	1.51	1.11	0.43	0.83	0.02	0.03
Subaru Subsidiary	52.72	0.51	49.21	0.4	67.15	0.91	96.80	0.94
Subaru Parent	24.14	0.28	-110.78	-1.41	-84.26	-1.87*	-76.62	-1.39
Exogenous Variables								
Subsidiary Toyota	-24.49	-1.89*	4.98	0.35	-3.40	-0.34	7.96	0.62
Nissan	-62.34	-2.27**	0.41	0.01	-15.10	-0.61	-2.90	-0.07
Mitsubishi	-25.41	-1.15	7.62	0.47	-3.74	-0.47	1.95	0.19
Mazda	5.46	0.2	-38.04	-1.17	-4.88	-0.5	0.61	0.04
Isuzu	-12.26	-0.31	-35.68	-1.11	-23.87	-1.61	-20.06	-1.2
Daihatsu	8.87	0.65	-10.43	-0.62	-7.05	-0.85	-12.84	-1.24
Hino	7.71	0.47	-4.55	-0.23	-0.44	-0.05	-21.77	-1.87*
Honda	-38.28	-2.41**	-15.45	-0.81	-10.71	-1.12	-2.79	-0.21
Parent Toyota	1.01	0.25	-4.79	-1.25	-13.48	-3.79***	-16.18	-4.4***
Nissan	-2.80	-0.12	28.39	1.35	13.63	1.3	12.52	0.96
Mitsubishi	3.51	0.23	-18.57	-1.27	-7.38	-1.3	-4.51	-0.61
Mazda	-16.75	-0.42	52.37	1.5	25.89	1.35	27.37	1.2
Isuzu	0.54	0.02	23.37	1.23	25.26	2.44**	18.92	1.57
Daihatsu	9.52	1.66*	0.25	0.03	21.32	4.14***	17.12	2.5**
Hino	7.86	0.29	-32.73	-1.4	-14.05	-1.27	-12.81	-0.94
Honda	-2.48	-0.09	33.98	1.28	20.31	1.67*	12.19	0.78

Figure 15: Special Regressor Probit Regression (9)Endogenous Subaru Dummy Variables