PARTIAL OWNERSHIP ARRANGEMENTS IN THE JAPANESE AUTOMOBILE INDUSTRY; 1990 - 2000

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The end of the 1990's saw a number of foreign automobile manufacturers become the largest shareholders in several Japanese automobile manufacturers. It seems logical to conclude that a firm only enters into a partial ownership arrangement *(POA)* if it is profit maximizing. However, research to date has treated *POA*s as if exogenous to the model. This paper develops a model that assumes *POA*s are determined endogenously. Data for the Japanese automobile industry are then used to investigate the factors that determine whether a firm enters into a *POA*, and the effects a *POA* has on the price-cost margin. The findings of this paper suggest that while both foreign and domestic firms take an interest in product mix when exploring *POA*s in the Japanese market, they have differing profit incentives. Furthermore, the level of ownership has a positive effect on *POA*s.

JEL classification codes: L0; L6
Key words: partial ownership arrangements, price-cost margin, technology transfers

I. Introduction

During the 1990's, partial ownership arrangements (*POA*s) were very common in the Japanese automobile industry. One of the outstanding features associated with this *POA* activity is that, while Japanese automakers did not

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invest in foreign automakers, several foreign automakers did invest in Japanese firms. Ford first invested in Mazda in 1979 purchasing 25% of its shares. In 1996 it increased its ownership in Mazda to 33.4% and sent a new president from the U.S. Similarly, Renault bought 36% of Nissan and 22.3% of Nissan Diesel in 1999. The same year, GM entered into a *POA* with Subaru purchasing 20% of Subaru's stock.[1]

In past literature, the decision of a firm to enter into a *POA* was determined exogenously. Alley (1997) extended the model by Clarke, Davies and Waterson (1984), in order to include *POA*s. However, in his model, automakers only consider output quantities when maximizing profit. We believe that *POA*s between automakers facilitate the transfer of technology and managerial skills, either unilaterally or bilaterally, thereby creating cost-saving synergies which influence current profits. To capture the effects of such knowledge transfers, we present a simple model where *POA* activity is endogenously determined and empirically testable. Because investment in Japanese automakers, by foreign automakers, has been unilateral and exports to Japan from foreign automakers are small, we concentrated on estimating the model with data from the Japanese automobile industry.

In this paper, we investigated two cases. First, we examined whether there are any differences in the determinants of *POA*s when the parent firm is domestic or foreign.[2] Second, we examined the differences in the determinants of *POA*s when a parent firm owns more or less than one-third of stock. In the first case, we are interested in investigating whether the identity of firm owners is an important factor. In the second case we are interested in examining whether ownership of one-third, or more, of stock by the investing firm is critical. We found that there are significant behavioral differences, depending on who the owners are and the level of ownership.

This paper is organized as follows: In section II, we present our basic model, where *POA*s are endogenously determined. In section III, we describe

[1] There has also been activity with respect to domestic *POA*s in the Japanese automobile industry. For example, Toyota increased its influence in Daihatsu and Hino by raising its stock holdings to 54.4% and 33.8%, respectively, in 1999.

[2] The terms Japanese firm and domestic firm are used interchangeably throughout the paper. The term foreign firm refers to a firm based outside of Japan.

several independent variables that may have an impact on *POA*s. In section IV, we derive testable equations for the endogenous determination of *POA*s. In section V, we present a traditional analysis of the determinants of price-cost margins and a description of estimation methods. Section VI provides brief concluding remarks.

II. Theoretical Framework

In this section we develop a model of a general industry where n firms participate in a two-stage game for the purpose of producing a final good, q. In the first stage all firms simultaneously determine how much to invest in each competitor, with the understanding that investment may lead to technology transfers to and from these firms. In the second stage, firms determine their optimal production levels.

We denote the percentage of firm i's stock owned by firm j as s_{ij}, (i ¹ j). Furthermore, we denote the investment portfolio of firm i as a vector s_i and the inclusion of firm i in the investment portfolios of other firms as a vector s_{-i}. Let the profits that firm i derives from production of q_i be given by

$$\pi_i = \pi_i \left(q, T_i(s_i), T_{-i}(s_{-i}) \right), \tag{1}$$

where T_i denotes incoming technology transfers to firm i from the firms in its investment portfolio s_i and T_{-i} denotes outgoing technology transfers to other firms via s_{-i}. The total profit function for firm i will then be given by

$$\Pi_i = \left(1 - \sum_{j \neq i} s_{ij}\right)\pi_i + \sum_{j \neq i} s_{ji}\pi_j. \tag{2}$$

This two-stage game is solved using backward induction. First, we solve the second stage profit maximization problem where each firm determines its optimal production level of q based on a conjectural variations assumption. Simultaneously solving the first order conditions for profit maximization we obtain the optimal output level for each firm as $q_i = q_i(s_i, s_{-i})$. Next, we consider the first stage profit maximization problem. Equation (2) is maximized subject to the following budget constraint

$$F_i - \sum_{j \neq i} s_{ji} I_j \geq 0,$$ (3)

where F_i is the total funds available to firm i for investment and I_j is the total amount invested in firm j. Using the envelope theorem, the necessary condition for profit maximization is obtained as

$$\left(1 - \sum_{j \neq i} s_{ij}\right) \frac{\partial \pi_i}{\partial T_i} \frac{\partial T_i}{\partial s_{ki}} + \pi_k + \sum_{j \neq i} s_{ki} \frac{\partial \pi_k}{\partial T_{-k}} \frac{\partial T_{-k}}{\partial s_{ki}} - \lambda_i I_k = 0,$$ (4)

where k denotes variables associated with firm k, ($k \neq i$), and λ_i is the Lagrange multiplier, which measures the total imputed profits to firm i derived from transfers of knowledge and/or technology. Summing across equation (4) with respect to k and rearranging, we obtain

$$1 + \frac{B}{A} = \frac{C}{A}$$ (5)

where, $A = \left(1 - \sum_{j \neq i} s_{ij}\right) \frac{\partial \pi_i}{\partial T_i} \sum_{k \neq i} \frac{\partial T_i}{\partial s_{ki}}$

$B = \sum_{j \neq i} s_{ji} \sum_{k \neq i} \frac{\partial \pi_k}{\partial T_{-k}} \frac{\partial T_{-k}}{\partial s_{ki}}$

$C = \left(\sum_{k \neq i} I_k \right) \left[\lambda_i - \frac{\sum_{k \neq i} \pi_k}{\sum_{k \neq i} I_k} \right]$

Term A shows the effect of technology transfers on firm i's own profits as a result of ownership in other firms. Since the technologies possessed by firms may overlap, the change of $\sum_{k \neq i} \frac{\partial T_i}{\partial s_{ki}}$ is not simply additive. In the extreme case, if all the technologies possessed by other firms are the same, then $\sum_{k \neq i} \frac{\partial T_{-k}}{\partial s_{ki}} = \frac{\partial T_{-k}}{\partial s_{ki}}$. Term B measures the influence of firm i on the profits of other firms through technology transfers. Term C indicates the net profits that firm i derives from *POA*s.

Now looking at the right-hand side of equation (5), if we assume that both

the direct and indirect effects of *POA*s on firm *i*'s profits are proportional to firm *i*'s market share, then $\dfrac{\partial \pi_k}{\partial T_{-k}} \dfrac{\partial T_{-k}}{\partial s_{ki}} \Big/ \dfrac{\partial \pi_k}{\partial T_i} \dfrac{\partial T_i}{\partial s_{ki}} = \dfrac{MS_j}{MS_i}$, where MS_i and MS_j are the market shares of firms *i* and *j* respectively. This infers that the right-hand side of equation (5) provides the definition for *POA*s as

$$1 + \frac{B}{A} = 1 + \frac{\sum_{j \neq i} s_{ji} MS_j}{(1 - \sum_{j \neq i} s_{ji}) MS_i}. \tag{6}$$

This is similar to the definition given for *POA*s in Alley (1997). In the next section we examine the determinants of *POA*s empirically.

III. Empirical Application

In the previous section, we showed that, under reasonable assumptions, *POA*'s are related to the net profits derived from portfolio investment (see equation (5)). In particular, the shadow price, 1_i, contains the effect of investment on profits through the transfer of technology and management skills (see equation (4)). In this section, we estimate the effects of several independent variables on the right-hand side of equation (5), i.e. *POA*, using eleven years of data for eleven Japanese automobile manufacturers.[3] The independent variables used are:

- Price-cost margin = *PCM* is calculated as operating cost over total sales. Therefore, a higher *PCM* affects firm *i*'s imputed profits positively, *PCM* also induces an increase in firm *i*'s market share and may negatively affect *POA*s.

- Equity ratio = *ER* is the ratio of shareholder's equity to total capital. *ER* is generally believed to describe the health of a firm's management. We anticipate a positive relationship between *ER* and *POA* because a higher *ER* tends to suggest greater financial stability and therefore higher potential profits.

- R&D expenditure = *R&D* is calculated as the ratio of expenditures on research and development to total sales. As the development of new technologies is

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[3] A detailed explanation of the composition and sources of the data set is given in the Data Appendix.

expected to increase profits, we anticipate a positive relationship with *POA* as potential partner firms will attempt to access profit-generating technologies through *POA*s.

- Brands = *BRANDS* is calculated as the ratio of advertising expenditures to total sales. We anticipate a positive relationship with *POA* as potential partner-firms are expected to enter into *POA*s in order to gain access to profits that can be achieved through strong brand recognition.

- Size concentration index = *SCI*. The total number of automobiles produced has been classified into four product groups: light, small, medium, and large. These groups were used to calculate a Herfindahl concentration index.[4] We anticipate a positive relationship with *POA* as potential partner firms are expected to enter into *POA* in order to gain access to technologies associated with a particular class of cars.

IV. Determinants of POA

We estimated the following regression equation using 2SGLS.[5]

$$POA_i = \sum_j a_j x_j + \varepsilon_i \tag{7}$$

where x_j stands for an explanatory variable, a_j is the parameters to be estimated and e_i is the residual term. The sample is separated into *POA*'s with foreign firms and *POA*'s with domestic firms, in order to estimate the effects of the explanatory variables in each case. The regression results are given in Table 1.

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[4] In this case, the Herfindahl index is a convex function of the production shares of each product group for a particular firm. That is, $SCI = \sum \left(\dfrac{s_i}{S} \right)^2$, where s_i is the number of automobiles produced in a particular product group, S is the total number of automobiles produced, and $i =$ (light, small, medium, and large). Concentration in a particular class produces higher values for *SCI*. (Shy (1995)).

[5] Equation (7) was initially estimated using OLS. However, the application of White's General Heteroscedasticity Test and the Durbin-Watson *d* Test detected heteroscedasticity and autocorrelation in the data. As a remedial measure the model was re-estimated using 2SGLS (Two Stage Generalized Least Squares).

Table 1. Empirical Results for Domestic and Foreign *POA*s

| | Domestic | | Foreign | |
	Coefficient	Standard error	Coefficient	Standard error
PCM	0.1911	0.1740	2.3061**	1.2515
ER	-0.5003*	0.0681	-0.5093	0.4015
R&D	0.9434*	0.3654	-1.0738	1.2658
BRANDS	-2.107*	0.8155	-22.4142*	6.5983
SCI	46.7051*	2.8775	62.9763*	10.7838

Notes: * and ** indicate significance at the 1 and 10 percent levels, respectively.

First, looking at Table 1, *PCM*, *BRANDS*, and *SCI* are important factors for foreign firms while for domestic firms *ER, R&D, BRANDS,* and *SCI* are significant. The coefficient of *PCM* for foreign firms is positive suggesting foreign firms are interested in short-term profitability.[6] In the domestic case, the coefficient for *ER* is negative. This result is unexpected. However, Japanese automobile manufacturers in general have high *ER*s which in part stems from a long history of reinvesting profits rather than paying out dividends to shareholders. The negative impact of *ER* on *POA* may be due to an anticipated reduction in the profits available for a firm's own capital formation when it is examining potential *POA*s.

Another point on which foreign firms and domestic firms differ is the evaluation of *R&D* expenditures. The coefficient of *R&D* is significant in the domestic case but not in the foreign case. There are two possible explanations for this result. First, as many Japanese automobile manufactures are part of consortiums which include parts suppliers, a large part of their *R&D*

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[6] The positive coefficient for *PCM* seems to result from the drastic cost cutting measures undertaking by foreign executives sent from parent firms. While Japanese automakers own efficient technologies, their management style, sometimes called "Japanese style" management, was not working well in the 1990's. In particular, both the lifetime employment and seniority wage systems reduced the flexibility of firms faced with increased global competition. As soon as foreign executives were sent, they exercised large layoffs and wage cuts.

investments is directed towards improving the efficiency of this vertical supply chain.[7] Foreign firms may not be as interested in this kind of vertical investment when looking for potential *POA*s. Second, the findings of Branstetter et al. (1998) and Branstetter (2001) suggest that there are significant intranational *R&D* spillovers in Japan. For domestic firms, entering into a consortium is one means of internalizing this "externality". This infers that domestic firms will be interested in entering into *POA*s with firms that are strong in *R&D*. Foreign firms, on the other hand, may simply view entrance into the Japanese market as a means of obtaining access to *R&D* and therefore not be particularly concerned with the *R&D* expenditures of potential partner firms.

Finally, product match seems to be important for both domestic and foreign firms. The coefficient for *BRANDS* is negative for both domestic and foreign firms. This may indicate that automobile manufacturers look for weaker brands when exploring *POA* opportunities. The coefficient of *SCI* is positive and significant for domestic and foreign firms. This suggests that firms are interested in partner firms that specialize in a specific class of automobiles. Their purpose may be the access of technologies related to a class of automobiles. For example, it has been suggested that one reason for the increase in the number of *POA*s between Japanese and foreign automobile manufacturers is the interest of foreign firms in accessing the technology of Japanese firms associated with smaller classes of cars.

Next, we examine whether or not the number of shares that a partner firm holds is significant. We examine the case where the number of shares held by a partner firm is greater than one-third (this is represented by a dummy variable *PRIMARY*).[8] Such a majority holding gives the partner firm the ability to control activities and, therefore, influence profits, for example, by management related decisions. The results for this regression are given in Table 2.

In general these results parallel those given in Table 1. *PCM, ER* and *SCI* are all significant and found to have the same signs as those of the first estimation. However, *BRANDS* and *R&D* are not significant. In this case, we are particularly interested in *PRIMARY*, for which the estimated coefficient is

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[7] For a more detailed discussion on this topic see Qui and Spencer (2002).

[8] *PRIMARY* = 1 when the number of shares held by a partner-firms is greater than one third.

Table 2. Empirical Results for Primary Shareholders

	Coefficient	Standard error
PCM	0.4878*	0.1422
ER	-0.3410*	0.0617
R&D	0.1745	0.2317
BRANDS	-0.3894	0.5172
SCI	23.6461*	2.6851
PRIMARY	24.9326*	1.7011

Note: * indicates significance at the 1 percent level.

both positive and significant. This suggests that *POA* is positively related to the level of ownership of partner firms.

In the next section we consider the effects of *POA*'s on *PCM*'s.

V. Determinants of PCM

In this section, we consider second stage optimization, where for given s_{ij}'s (determined in the first stage) each firm chooses profit maximizing production quantities. Assuming a closed economy (no exports or imports), the conjectural variations model estimated by Alley (1997) is

$$PCM_i = a_1 POA + a_2 MS_i POA, \tag{8}$$

where $a_1 = \dfrac{\alpha}{\eta}$, $a_2 = \dfrac{1-\alpha}{\eta}$, and $a_3 = -\alpha$. *a* and *h* respectively stand for the conjectural variation elasticity and the price elasticity of demand,[9] $\dfrac{dx_j}{dx_i} = \alpha \dfrac{x_j}{x_i}$ and $\eta = -\dfrac{p}{x_i}\dfrac{dx_i}{dp}$. Equation (8) is not complete, but as a first approximation, we employ equation (9).

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[9] For a model with imports included, see footnote (14) of Alley (1997).

$$PCM_i = a_1 POA + a_2 MS_i POA + a_3 DGR \qquad\qquad (9)$$

where *DGR* stands for the real rate of economic growth in GDP. Since equation (9) is considered as an approximation, we are not interested in estimating *a* or *h*. Rather, we are interested in examining the qualitative effects of shareholder activities already determined in first-stage optimization. Furthermore, to examine the effects of foreign ownership on *PCM* we include a dummy variable, *FOREIGN*, in the regression.[10] The results are summarized in Table 3.

Table 3. Parameter Estimates

	Coefficient	Standard error
POA	1.9952 *	0.4900
MSPOA	-0.3312 *	0.0973
DGR	0.5143	1.2109
FOREIGN	13.0029 **	7.0899

Notes: * and ** indicate significance at the 1 and 10 percent levels, respectively

The estimated coefficients for *POA* and *MS_iPOA* in Table 3 are significant. While the coefficient of *POA* is positive, the coefficient of *MS_iPOA* is negative. This suggests that entering into a *POA* increases price-cost margins (2% higher). However, this effect decreases as the market share of the firm increases inferring that *POA* are more advantageous for smaller firms. Consistent with the findings of Yamawaki (1989) and Alley (1997) *DGR* is not significant suggesting that domestic growth does not have an impact on *PCM*. Lastly, the coefficient for *FOREIGN* is positive and significant. This suggests that entering into a *POA* with a foreign firm increases the profitability of Japanese automobile manufactures on average.[11]

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[10] *FOREIGN* = 1 when the partner firm is foreign.

[11] An anonymous referee suggested that the results reported in Tables 1, 2 and 3 may be influenced by the success of Nissan during the period under examination. To check the

VI. Concluding Remarks

In this paper we presented a model that determines *POA*s endogenously. We then examined the determinants of *POA*s in the Japanese automobile industry empirically, with the intent of pointing out some of the behavior differences between foreign and domestic firms. We found that technology transfers and/or technology accumulation through *POA*s both directly and/or indirectly induce behavioral differences. While both foreign and domestic firms appear to be interested in the profitability of a *POA*, the former appear to be more interested in short-term profitability and the latter in long-term profitability. Both foreign and domestic firms are interested in specific technologies, as reflected in the negative effect of *BRANDS*. Further, foreign and domestic firms appear to examine product mix closely when exploring potential *POA*s. In the domestic case this may indicate an interest in partner firms that produce products of a similar nature, thus allowing for cost reduction through parts standardization. On the other hand, in the foreign case, interest seems to be directed toward gaining access to the extant technologies associated with a particular vehicle class rather than potential technologies that may be developed through *R&D* activities. Finally, majority share holdings of one third or more were found to have a positive and significant effect on *POA*'s.

Data Appendix

The data for 11 Japanese automobile manufacturers from 1990 to 2000 were collected from a number of sources. The number of automobiles in each size class manufactured by each company were taken from the *Automotive Years HandBook*. Data for *POA, PCM, ER, R&D,* and *BRANDS* are published in the *General Report on Securities* and Japan's domestic growth rate is available from *International Financial Statistics*.

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robustness of our results, all regression models were estimated without the data for Nissan. While there were minimal changes in the size of estimated coefficients, no sign changes occurred suggesting that the presented results are consistent.

Table A1. Firms Included in the Data Set

Japanese firm	Partner firms	Ownership share
Toyota	---	---
Nissan	Renault^F	36.82
Honda	---	---
Mitsubishi	Daimler Chrysler^F	36.01
Subaru	GM^F	24.39
Mazda	Ford^F	33.39
Suzuki	GM^F	21.00
Daihatsu	Toyota^D	52.42
Isuzu	GM^F	49.00
Hino	Toyota^D	33.80
Nissan Diesel	Nissan and Renault^{DF}	45.00

Note: Ownership share is the percentage of the Japanese firm's stock held by the partner firm in the year 2000. ^{D} and ^{F}, respectively, indicate domestic and foreign partners.

Table A.1. shows the Japanese firms included in the data set along with their partner firms. The ownership shares are presented for the year 2000, however, there is some variation in these over the data set. For the most part ownership shares are increasing and the partner firm does not change during the period under examination. Subaru is an exception where the partner firm was Nissan from 1990 to 1999 but became GM in 2000.[12]

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[12] As a referee pointed out, Hino and Nissan Diesel respectively specialize in the production of buses and trucks. From the point of view of technology transfers, it may be better to separate passenger cars and trucks. In reality, however, many Japanese automakers, such as Toyota, Isuzu and Suzuki, produce both passenger cars and trucks. Furthermore, some of the major automobile manufacturers, such as Toyota and Nissan, form groups and exchange engineers each other. In addition, an executive of one firm may sit on the board of directors of another firm within the same group. See Alley(1997) for more detail on the structure of cross-holdings of stock in the Japanese automobile industry.

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