FIRM-SPECIFIC STRATEGIC ADVANTAGES AND FOREIGN DIRECT INVESTMENT BEHAVIOR OF FIRMS: THE CASE OF JAPANESE SEMICONDUCTOR FIRMS

Yui Kimura*
International University of Japan

Abstract. We examine the effects of firm-specific strategic advantages on the FDI behavior of Japanese semiconductor firms. We investigate the strategic advantages necessary for undertaking FDI in this industry, and show that these advantages are systematically associated with the variation in FDI behavior. We identify technological innovation, a broad product line, and vertical linkages with downstream businesses as sources of such strategic advantages. We also show that size of the firm influences its decision to go international.

The questions of determinants of foreign direct investment (FDI) were approached initially from several different perspectives, but the different strands of research have converged through synthesis to a view that is now known as the "eclectic" approach [Buckley and Casson 1976; Dunning 1977]. This approach has prompted extensive empirical investigations [Lall 1980; Pugel 1981; Swendenborg 1979; Dunning 1980].

Most of these empirical studies, however, substituted industry for the firm as a unit of observation, using industry data that aggregated all the firms in an industry. They explained why certain industries tend to be more prevalent than others in FDI, but they provide no clues as to why some firms are more likely than others to operate multinationally within these industries. Horst [1972] and Swendenborg [1979] attempted using firm-level data to explain the variations in FDI activities among firms after accounting for the variations across industries. They were, however, unable to isolate the factors explaining the intra-industry variation other than firm size and the firm's experience in multinational operations.

The purpose of this paper is to provide an explanation for intra-industry variation in FDI behavior among firms, and to present a piece of empirical

*Dr. Yui Kimura is currently an associate professor of business administration at the Graduate School of International Management, International University of Japan, where he teaches managerial economics, industry and competitive strategy analysis, and international business. Professor Kimura's areas of research interest include competitive strategies of Japanese firms in the global markets and the foreign direct investment behavior of Japanese firms. He received his Ph.D. from New York University.

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evidence. Underlying our approach is the premise that firms within an industry may differ in their strategic advantages that allow them to compete with indigenous firms in host country markets.

Specific strategic advantages necessary to compete effectively differ from industry to industry. A close examination of intra-industry variation in FDI behavior thus requires one to focus on possible sources of strategic advantages that are relevant to an industry or a small set of homogeneous industries. In this study, we focus on several of those possible sources of strategic advantages in a specific industry context—within the Japanese semiconductor industry.

Statistical studies of intra-industry interfirm variations in FDI behavior face a number of limitations, due to problems in firm-level data and statistical methods of analysis. This study is not an exception, and it does not escape some of those limitations. Thus, in this paper, we do not intend to present a definitive statistical work on the Japanese semiconductor industry. Rather, it is intended as a contribution enunciating a new avenue of analysis on FDI and suggesting a new way to estimate its testable implications.

With individual firms as a unit of observation, our approach allows us to sharply focus on, and define specific sources of firm-level strategic advantages that prompt firms to undertake FDI. The firm-level focus enables one to relate intra-industry variation in FDI behavior to the recent industrial organization and competitive strategy literature on intra-industry interfirm competitive asymmetry. Our approach moves us closer to the outlooks of industrial organization and competitive strategy researchers, and this perspective generates rich analysis and testable implications.

In this paper, we first describe briefly the FDI activities of major Japanese semiconductor firms. Second, we develop an analytical framework for explaining the variation in the FDI activities. Then, we identify possible sources of strategic advantages that are likely to motivate the firms to go abroad, and propose several testable hypotheses. Finally, we define the variables, specify the empirical model, and report the results of our empirical investigation.

FDI BY THE JAPANESE SEMICONDUCTOR FIRMS

Table 1 summarizes the FDI activities of Japanese semiconductor firms in terms of the dates of establishment, the locations, and the production activities at these locations as of 1985.

In the table, some distinct patterns of their FDI behavior can be discerned. First, the degree and the extent of FDI activities seem to differ considerably across the firms in this industry. Some firms, notably NEC, Hitachi, and Toshiba, have substantial foreign production while some others remain limited FDI investors. Second, the locations of FDI activities of these firms also differ. The former group of firms are engaged in foreign production in both advanced and newly industrializing economies (NIEs) whereas Matsushita and Tokyo Sanyo conduct assembly operation only in NIEs.

TABLE 1
Foreign Direct Investment by the Japanese Semiconductor Firms

Firm	Country	Year Established	Information
NEC	Singapore	1976	Assembly and testing of discrete devices and linear ICS.
	Malaysia	1976	Assembly and testing of discrete devices and linear ICS.
	U.S.	1978	Integrated production of VLSI memory ICs, and gate arrays.
	U.K.	1982	Assembly and testing of VLSI memory ICs.
	Ireland	1976	Assembly and testing of VLSI memory ICs.
Hitachi	Malaysia	1973	Assembly and testing of linear ICs.
	U.S.	1979	Assembly and testing of memory ICs.
	West Germany	1980	Assembly and testing of memory ICs.
Toshiba	Malaysia	1975	Production of discrete devices and assembly and testing of ICs.
	Korea	1969	Production of discrete devices and assembly and testing of ICs.
	Mexico	1966	Production of semiconductor (discrete) devices.
	U.S.	1980	Integrated production of gate arrays and assembly and testing of memory ICs.
	West Germany	1984	Assembly and testing of VLSI memory ICs.
Mitsubishi	U.S.	1985	Assembly and testing of VLSI memory ICs.
Fujitsu	U.S.	1979	Assembly and testing of VLSI memory ICs.
	Ireland	1981	Assembly and testing of VLSI memory ICs.
Matsushita	Singapore	1979	Production of discrete devices and assembly and testing of linear ICs.
Tokyo Sanyo	Korea	1973	Production of discrete devices and assembly and testing of linear ICs.
	Taiwan	1974	Production of discrete devices and assembly and testing of linear ICs.

Sources: Yano Economic Research Institute (1983, 1985), Toyo Keizai (1985), and Nikkei Electronics (August 1983)

Moreover, the semiconductor devices manufactured at these locations differ. Integrated circuits based on advanced semiconductor technologies and largely used for computers and telecommunications equipment, such as MOS memory ICs, are made solely at the locations in the advanced countries, but linear ICs and discrete devices are produced only at the locations in NIEs.

ANALYTICAL FRAMEWORK

These observed variations in FDI behavior among the Japanese semiconductor firms lead to questions about the sources of these variations. The key to this analysis is the hypothesis that the firms may differ in their strategic advantages, and hence in their possession of internationally-mobile intangible assets on which they rest.

According to the eclectic theory of FDI [Buckley and Casson 1976; Dunning 1977; Teece 1981], for the firm to undertake foreign production, it must possess some kind of strategic advantage that more than offsets the cost of operating in countries alien to the firm and from a distance. Such strategic advantages are based on a special class of assets held by the firm, with some unique characteristics. First, the firm must be able to transfer these assets from the home country location to foreign locations at a low incremental cost, without reducing their revenue-generating productivity at the original location. Second, the sale or lease of these assets to an independent party must involve substantial transaction cost, so that the firm decides that it may be able to appropriate the stream of rent arising from these assets more completely by internalizing them than by selling or leasing them.

Such assets are intangible assets, particularly various kinds of knowledge and know-how for new products and production processes, for developing and carrying out marketing programs, and for managing these economic (value) activities. The knowledge and know-how tend to be internationally mobile, and the arm's-length transactions in these assets tend to be subject to high transaction costs and to a high degree of uncertainty. The firm holding these assets may decide to internalize them, and put them to use in foreign locations when it finds that they can be utilized more profitably in these locations due to relative factor costs, tariffs, taxes, transportation cost, and market size [Buckley and Casson 1976; Rugman 1980; Swedenborg 1979; Caves 1982; Pugel 1982; Teece 1981].

Strategic assets, however, may *not* be distributed uniformly across firms within an industry. Firms acquire and accumulate strategic assets over time, and the configuration of asset bundles may differ considerably across firms within an industry, depending on their initial and subsequent strategic choices [Caves and Porter 1977; Caves 1984; Porter 1985]. An implication of this is that these firms may be left with differential bundles of strategic assets, rendering them specific to firms rather than to the entire industry. The differential strategic assets held by firms may delineate them in strategy and in their ability to compete. Within an industry, some firms may possess superior, internationally-mobile strategic assets in their bundles, providing the basis for strong strategic advantages to overcome those disadvantages faced in operating overseas and to compete effectively with indigenous firms. Other firms may lack such advantages. Then, the firms with such strong strategic advantages may undertake FDI whereas those firms lacking the advantages may remain home-bound or service foreign markets in other modes.

Moreover, locational conditions appropriate for using these heterogeneous firm-specific strategic assets may differ even within an industry. When put to use, these assets must be complemented with specific input factors available in the locations where they are used. The specific input factors required for a particular type of these heterogeneous strategic assets may vary, and the countries in the world are not uniformly endowed with these specific factors. Also, the size and the nature of demand for the products and services that embody these assets may differ from location to location, as do the trade policies and taxes.

Some of those locational factors may have influenced the Japanese firms' decision to undertake FDI in certain locations in advanced countries and NIEs. FDI by the Japanese semiconductor firms in advanced countries, particularly in the U.S., were motivated to service the rapidly growing, large market (the computer and telecommunications equipment industries), and were spurred by the threat of the imminent protectionist trade policy of these countries [*Nikkei Electronics* 1986].

FDI in NIEs may have different underlying locational influences. As the concentration of the timing of these investments in the late 1960s and early 1970s (see Table 1) suggests, they may have been undertaken in response to off-shore assembly operations by the U.S. semiconductor firms in NIEs. In those years, the threat of imports from those off-shore operations by the U.S. firms was real to the Japanese semiconductor firms [The Ministry of International Trade and Industry, the Japanese Government 1970]. Another locational factor, perhaps more significant in recent years, may be those firms' motivation to locate the final stage of production closer to end-users in those locations and serve them well. Casual evidence suggests that these production subsidiaries perform assembly operations not only for re-export to the Japanese parents, but also for local consumption [The Ministry of International Trade and Industry, the Japanese Government 1985]. Local end-users include the subsidiaries of the firm's own consumer electronics division and other multinational consumer electronics firms, as well as indigenous firms.

THE EMPIRICAL MODEL AND VARIABLES

This analysis motivates a model that relates the variation in the FDI behavior among firms within an industry to the variation in their strategic advantages based on internationally-mobile strategic assets, and to the variation in the locational conditions specific to the locations where FDI is undertaken. We subject this hypothesized relationship to empirical test. In doing so, we focus on the influences of the variations across firms in their strategic advantages. As seen in Table 1, production FDI by the Japanese semiconductor firms is concentrated into only a few locations in the world, and this is not likely to provide variations sufficient to capture the locational influences on the FDI behavior in this industry. However, we are able to investigate them indirectly. As argued earlier, the strategic advantages required for undertaking FDI in different geographic locations may differ even within an industry, and the FDI determinants may differ according to the broad geographic regions where it is located. We thus examine the determinants of FDI in advanced countries and NIEs separately.

We use a pooled set of the firm-level data on FDI activities and strategic advantages from NEC, Hitachi, Toshiba, Mitsubishi, Fujitsu, Oki, Matsushita, Tokyo Sanyo and Sharp for the five-year period, 1978-1982.[1] These nine firms are the largest semiconductor firms in Japan, and a set of systematic data is available only for these nine firms and for this period. The sources of data and the definitions of variables are presented in the Appendix.

The use of pooled data potentially creates some problems. Replication of data-points through pooling across time may not allow sufficient cross-sectional variations. It may also potentially introduce autocorrelation in our estimated model. We have, however, only five time-series data-points in our sample. The sample is too small to test and correct statistically potential autocorrelation. Thus, we should note that the estimation of our model on this sample faces considerable limitations, and that the results reported in the later section should be regarded as highly tentative.

It should also be noted that among these nine firms, Oki and Sharp had no production FDI, and that some other firms did not engage in production FDI in either advanced countries or NIEs during the period covered. These non-FDI investor firms are included in the sample because we are interested in investigating not only the effects of strategic advantages on the size of FDI activities of those firms already engaged in FDI but also their effects on the firm's decision on whether or not to undertake FDI. For this purpose observations with no FDI activities are retained in the sample.

In estimating the model on this sample we will employ the tobit form of regression analysis (one-tail truncated regression). When the distribution of the dependent variable is truncated, OLS estimates are biased and inefficient. Tobit corrects these deficiencies of OLS estimates. Thus, in our estimation, we will use the tobit maximum likelihood (ML) estimator.

FDI Variables

According to our analysis, we generally expect that the firms with superior strategic advantages tend to engage in larger size FDI activities than the firms that are less favorably positioned in the strategic advantages.

We estimate this hypothesized relationship for production FDI in two different geographic locations: FDI activities in advanced countries and those in NIEs. We thus introduce two different measures of the size of the firm's FDI activities:

FDIAD The measure of size of the firm's FDI activities in advanced countries.

FDIDV The measure of size of the firms's FDI activities in NIEs.

These measures of the size of the firm's FDI activities are constructed as the annual balance of the cumulative capital paid into its semiconductor production subsidiaries in the geographic regions as defined.[2]

Explanatory Variables

The theory of FDI and the literature on the semiconductor industry point to several possible sources of strategic advantages that may motivate firms to engage in FDI activities. These advantages are based on the firm's leadership in semiconductor technologies, the broad scope of its semiconductor product line, and the systems knowledge and know-how shared with downstream final systems equipment businesses within the firm. Also, the size of the firm's semiconductor operation seems to play a role in its decision to undertake FDI activities.

Technological innovation: Strategic advantages based on technological innovation derive from its ability to delineate the firms as technological leaders and followers, opening a gap between these two groups of firms. The gap gives leader firms a transient monopoly over an innovation and constrains follower firms' ability to differentiate product and to reduce cost vis-a-vis leader firms. It may also increase capital requirements for R&D [Kamien and Schwartz 1982; Porter 1983]. It may also be sustained by first-mover advantages based on learning curves, switching and search cost [Spence 1981; Schmalensee 1982; Flaherty 1983]. All this suggests that technological innovation may indeed be a powerful source of competitive asymmetry, and that the variation across firms in their technological position may provide an explanation for the variation in their FDI activities.

Semiconductor technology has two salient features. It consists of heterogeneous, distinct design and process technologies for diverse device-applications. These distinct technologies tend to be device-specific. While most semiconductor technologies are specific to narrow device areas, certain technologies, particularly metal oxide semiconductor (MOS)-based VLSI memory technology, tend to be less device-specific.[3]

The heterogeneity and device-specificity of technology suggest that firms may choose strategically to focus on a certain technology-product area. The end-user industries of specific semiconductor devices vary, ranging from the consumer electronics industry for bipolar linear devices to the computer industry for bipolar logic and MOS memory devices. The firm's choice of technological area focus thus tends to define its product focus and target end-user industries.

For foreign production, this implies that the firm's FDI activities may differ in the locations, types of production activities, and the semiconductor devices produced according to its technology-product area focus and its leadership in those technologies. Locational conditions differ in end-user demands, relative factor costs, technological infrastructure and so on. In advanced countries, particularly the U.S., the demand centers on those devices for computer and telecommunications, applications, such as bipolar logic and MOS memory devices. On the other hand, the end-users in NIEs are largely the consumer electronics industry whose demand concentrates on bipolar linear devices. These locations also differ in the technological infrastructure. All this leads to suggest that the firm's leadership in MOS memory, microprocessor, or bipolar digital technologies allows expansion of its FDI activities in advanced country markets while the leadership in bipolar linear technology tends to drive the firm toward FDI activities in NIEs.

Varying device-specificity of technologies suggests that the leadership in the less device-specific technology (e.g., MOS-based VLSI memory technology) may carry over to other device areas at an incremental cost and risk lower than the cost and risk of independent originial R&D in those other areas, allowing the leader firm the strong competitive base in broad product areas. This strategic advantage may be easily extended to foreign locations as well, and those broad technology-based firms are likely to engage in FDI activities for a broad array of devices in diverse geographic locations. We may, then, hypothesize that the firms with leadership in MOS memory technology tend to engage in FDI activities not only in advanced countries but also in NIEs while those firms lagging in this technology may be limited to FDI only in NIEs.

To test these hypotheses, we construct measures of firms' technological leadership in four distinct seminconductor technologies, drawing on the data in Sakuma [1983]. The data allow identification of a specific innovation in a particular year with the firm that introduced the innovation, and with a specific area of four broadly defined, distinct technology areas for the period 1975-1982. This list of innovations includes only those leading-edge innovations that are likely to open a considerable gap. Innovations afford leader firms a transcient monopoly over follower firms while they maintain the leadership. To account for the time period during which the firm's leadership is sustained, and the time lag between the introduction of innovations and market impact, these measures are constructed by cumulating the firm's annual count of innovations in a specific technology area over the last three years and by lagging this cumulative count a year.[4] Thus:

INMME The leadership measure of the firm in the MOS memory technology area.

INMCR The leadership measure of the firm in the MOS-based microprocessor technology area.

INBDG The leadership measure of the firm in the bipolar digital technology area.

INBLN The leadership measure of the firm in the bipolar linear (analog) technology area.

Breadth of product line: The firm's breadth of product line may influence its competitive position in foreign markets and FDI behavior through economies of scope [Baumol, Panzar and Willig 1982; Teece 1980] and differentiation advantage associated with a broad product line. The strategic advantage based on scope economies may result at the foreign subsidiary level or permeate through its entire multinational system, in either case affecting its FDI behavior.

Cost savings due to the R&D activities common to different semiconductor technology areas are likely to influence the firm's competitiveness throughout its multinational system. The knowledge and know-how gained in such R&D activities may carry over at a low incremental cost not only across product areas but also across national borders within the firm.

Cost savings may occur also at the foreign subsidiary level. In a foreign production location, the same process equipment can be shared across products that are based on the same process technology. Similarly, a firm with a broad product line may be able to attain a lower unit cost in marketing activities in a foreign location by selling a package of multiple devices rather than a single product.

Moreover, firms that offer a broad product line may be able to achieve a differentiation advantage associated with multiple products. In the semiconductor industry, this advantage may derive from the end-users' needs for multiple, functionally different yet complementary and technically compatible semiconductor devices in systems integration.

These strategic advantages may facilitate firms' penetration in foreign markets, and increase the size of their FDI activities. To capture this influence, we introduce:

PRSCP The measure of the firm's breadth of product line in its integrated circuit business.

Vertical linkages with downstream systems businesses: These Japanese semiconductor firms are partially vertically integrated with their own downstream systems equipment businesses in their domestic operations [Kimura 1986]. These tapered vertical linkages may affect the competitive positions of firms in foreign locations.

These firms' vertical linkages are likely to affect their FDI behavior through economies attained in R&D for systems integration technology that links semiconductor device design and systems application, and through product differentiation based on the knowledge of systems integration. The strategic advantages derive from the fact that the IC devices increasingly incorporate subsystems on the chips, and that chip manufacturers are increasingly required to possess the knowledge in systems integration in each downstream area. Integrated firms should be able to eliminate the duplication in R&D at at the two stages. They also may be able to differentiate—due to their knowledge of systems integration—their IC devices from those of unintegrated chip makers, offering devices that better meet the systems integration needs of final systems manufacturers. The knowledge and know-how in systems integration can also be readily transferred to and put to use in foreign locations. These hypotheses are tested using the following variables. To account for the differences in the types of semiconductor devices in particular systems applications areas, we introduce two separate measures:

*VTEC*1 The measure of the degree of the vertical linkages of the firm's semiconductor operation with its own businesses in the area of computers and telecommunications equipment.

*VHOM*1 The measure of the degree of the vertical linkages of the firm's semiconductor operation with its own businesses in the area of consumer electronics.

These measures are constructed as the proportion of sales of a distinct group of final systems products that tend to use certain types of semiconductor devices to total sales of these two broad product groups, multiplied by the ratio of captive consumption to the value of total semiconductor production. These variables thus measure the degree of vertical linkage between the semiconductor operation and one of the two broad groups of final systems products. Moreover, the firm's sale proportion of a group of systems products may, we would argue, proxy the depth of its systems knowledge and know-how in the product area that affect its capability of systems integration in chip design.

We expect that the firm's FDI activities in developed countries should be positively related to *VTEC1* and unrelated to *VHOM1*, reflecting the demand pattern and the types of devices produced in these locations. We predict the opposite relationship for FDI activities in NIEs.

Firm size and diversification: The last set of variables in our specified model pertain to the size of the firm's domestic semiconductor operation and the degree of its diversification. Unlike the early proponents of oligopolistic theory of FDI [Hymer 1960; Horst 1972], we will follow Swendenborg's [1979] analysis. We hypothesize that the same strategic advantages, particularly those based on technologies, that make the firm large at home tend to make it large abroad, and that firm size may be merely a reflection of these strategic advantages.

Given the strategic advantages, the larger the firm grows relative to the domestic market, the less profitable it would be to increase its domestic share relative to expanding to foreign markets or to diversification. Foreign market penetration and diversification in the domestic markets, then, become alternatives for the growth of the firm [Swendenborg 1979].

A foreign market can be serviced via export or FDI, and the choice of the production location hinges on the relative cost that is determined by such factors as tariffs, taxes, and input factor prices. However, the size of the firm's domestic operation may also affect the cost and influence its choice to undertake FDI if production is subject to substantial economies of scale. With substantial production economies present, it will likely service foreign markets via export until MES is exhausted in its domestic plant, and perhaps wait to commence production in a foreign location until the sales volume in the location reaches MES.

While firm size tends to reflect the firm's strategic advantages other than size, it may thus play its own role in influencing the firm's decision to undertake FDI. To account for this influence, we include in our model:

LDMSA The natural log of the firm's domestic merchant sales of semiconductors.

The last variable is a measure of the firm's diversification. As argued in the preceding paragraph, the degree of diversification should be negatively related to the firm's FDI activities. Thus, we introduce:

DIVSF The measure of the degree of the firm's diversification.

This is a proxy measure of the degree of the firm's diversification, and it is a count of the Japan SIC 3-digit industries in which each firm operated during the time period under investigation. The Herfindahl types of measures are more desirable, but the line-of-business sales of each firm are not available.

THE EMPIRICAL RESULTS

The results of our empirical estimation of the model are shown in Tables 2 and 3. Tables 2 and 3 show respectively the correlation coefficients among variables used in our test and the results of our estimation using tobit. As discussed earlier, the model is estimated using one-tail truncated regression, or tobit, and the estimates are maximum likelihood estimates.

Overall, the results seem more or less consistent with our hypotheses. Both equations performed reasonably well.[5] They suggest that the hypothesized strategic advantages are often important influences on the firm's FDI behavior in this industry. Though our results seem supportive of our hypotheses, a word of caution is in order. As discussed earlier, our analysis suffers serious limitations, and these results must be seen as highly tentative, hence their interpretation requires caution. We now examine the results more closely focusing on those hypothesized influences.

Technological innovation: As hypothesized, the technological leadership measures are often significant determinants of the size of FDI activities. Particularly, the firm's leadership in the MOS memory and bipolar digital technologies seems to have a pervasive influence on the firm's FDI activities. *INMME* has positive significant coefficients in both equations, while the coefficient of *INBDG* is positive and significant in the *FDIAD* equation. The coefficients of *INMCR* and *INBLN*, however, are statistically insignificant in both equations.

These results are consistent with our hypotheses for the *FDIAD* equation. We argued earlier that the major market for semiconductors in advanced countries is for the devices for computers and telecommunications applications, such as MOS memory and bipolar logic devices, and that the firm must possess strategic advantages in those technologies, but not in bipolar linear technology, to undertake FDI in those locations. The bipolar linear technology is not appropriate technology for the market, and does not provide a basis for strategic advantage for competing with indigenous firms. The insignificant coefficient of *INMCR* in the *FDIAD* equation is somewhat puzzling. It may suggest a technological lag the Japanese leader firms face vis-a-vis indigenous (read U.S.) firms and their inability to compete effectively in this technology/product area.

The results of the *FDIDV* equation are, however, inconsistent with our predictions. Given the focus of the Japanese semiconductor FDI on production of bipolar linear devices in NIEs, and given the product-specificity of semiconductor technology, we expected that *INBLN* is positively related to *FDIDV* while other technological leadership measures are unrelated. The negative insignificant coefficient of *INBLN* suggests that the technological

TABLE 2
Correlation Coefficients among Dependent and Explanatory Variables

	INMME	*INMCR*	*INBDG*	*INBLN*	*PRSCP*	*VTEC1*	*VHOM1*	*LDMSA*	*DIVSF*
INMME	1.000								
INMCR	0.219	1.000							
INBDG	-0.119	-0.032	1.000						
INBLN	0.101	0.445	-0.145	1.000					
PRSCP	0.561	0.234	0.027	0.055	1.000				
VTEC1	0.556	0.093	0.276	-0.051	0.131	1.000			
VHOM1	-0.467	0.025	-0.286	0.211	-0.653	-0.317	1.000		
LDMSA	0.507	0.442	-0.199	0.245	0.759	0.143	-0.325	1.000	
DIVSF	-0.052	-0.104	-0.359	0.081	0.418	-0.515	0.196	0.344	1.000
FDIAD	0.604	0.489	0.227	0.255	0.622	0.505	-0.477	0.679	-0.196
FDIDV	0.388	0.691	0.090	0.284	0.419	0.165	-0.253	0.546	-0.172

TABLE 3
Truncated Regression (Tobit) Analysis Explaining Size of FDI Activities

Independent Variables	Dependent Variables	
	FDIAD	*FDIDV*
Const	-19.340	-10.766
	(-3.843)	(-3.376)
INMME	0.453[b]	0.782[c]
	(2.239)	(1.698)
INMCR	0.264	1.222
	(0.723)	(1.510)
INBDG	1.964[a]	2.866
	(2.660)	(1.601)
INBLN	0.865	-1.461
	(0.951)	(-0.981)
PRSCP	0.696[a]	0.329
	(2.591)	(0.801)
VTEC1	6.528[c]	-23.451[a]
	(1.895)	(-4.258)
VHOM1	7.164	8.609
	(0.779)	(1.227)
LDMSA	2.142[a]	4.147[a]
	(3.376)	(3.433)
DIVSF	-0.078	-0.303[a]
	(-1.456)	(-3.056)

Notes: 1. Figures in parentheses are *t*-values. The significance of the regression coefficients is tested using a two-tail test.
a. Coefficient is significant at 99% level.
b. Coefficient is significant at 95% level.
c. Coefficient is significant at 90% level.
2. Number of observations: 45

leadership is not a major factor for undertaking FDI. For undertaking FDI in NIEs, other factors, such as vertical linkages and locational factors, may be more important determinants.

This result may indicate that the firms have undertaken FDI in NIEs not mainly for exploiting their strategic advantage in bipolar linear technology, but for other reasons. The timing of these FDI, concentrated in the late 1960s and early 1970s, shows that they may have been the strategic response to achieve the labor cost parity with the off-shore production by U.S. semiconductor firms in those countries. At these locations, the Japanese firms have performed only the labor-intensive assembly stage of production. Also, the positive relationship with the vertical linkage with consumer electronics may indicate that these FDI served as a captive or stable source of semiconductor devices for the firm's own or its buyers' consumer electronics subsidiaries in NIEs.

The positive relationship between *INMME* and *FDIDV* is also inconsistent. This result suggests that the knowledge and know-how gained in R&D in MOS memory might carry over to bipolar linear devices, a product area that is technologically remote from MOS memory. Knowledge in MOS memory may not carry over directly, but it may facilitate better design compatibility of linear devices with related MOS products used in systems integration, and improve the firm's competitiveness in foreign markets.

Breadth of product line and vertical linkages: In both equations the coefficient of *PRSCP* is correctly signed, and it is statistically significant in explaining the size of FDI activities in advanced countries.

This result supports our contention that the firm's segment scope may influence the size of its FDI activities in an industry. The influence derives from economies of scope attainable in various activities throughout the firm's entire multinational system or at a subsidiary level, and from product differentiation advantage associated with multiple products. Although we are unable to decompose the influence of *PRSCP* into those arising from economies of scope and those from differentiation, *PRSCP* seems to be capturing these influences.

The high significance of these influences on FDI activities in advanced countries may reflect the nature of the demand for semiconductors in those locations. The demand is largely for the chips for computers and telecommunications systems in those locations, and a system requires in integration a broad array of functionally different, yet technically complementary and compatible IC devices. This may offer firms an opportunity to exploit potential scope economies in R&D, production, and marketing, and an opportunity to differentitate their products from those of competitors. This may explain the strong influence of *PRSCP* on the size of FDI activities in advanced countries.

The vertical linkage measures, *VTEC1* and *VHOM1*, show the pattern of results consistent with our predictions. As predicted, *FDIAD* equation has positive, significant and positive, but insignificant coefficients on *VTEC1* and *VHOM1* respectively. In the *FDIDV* equation, *VHOM1* has a positive coefficient as predicted, but it is statistically insignificant. We expected a stronger positive effect of *VHOM1* for this equation. The coefficient of *VTEC1* is negative, and significant. We hypothesized no influence of *VTEC1* on *FDIDV*, but this result should not be surprising. Those firms that are vertically integrated with computer and telecommunications equipment business tend to have strategic advantages in MOS memory and bipolar logic technologies and systems integration know-how in these systems equipment. In resource allocation for FDI activities, they may face a choice of locations of their FDI, and decide to locate their FDI in advanced countries where they are able to exploit their strategic advantages. This may result in the negative, significant effect of *VTEC1* on *FDIDV.*

Firm size and diversification: The results show that the firm's domestic size is the persistent, powerful influence on the size of FDI activities in both locations. The coefficient on *LDMSA* is positive, and statistically highly significant. These results suggest that the larger the domestic size of the firm, the larger the size of its FDI activities, and this seems consistent with the finding of Horst [1972].

However, our results differ from those of Horst. In our results firm size is only one of the several factors that explain the intra-industry interfirm variations in the size of FDI activities. Moreover, as Table 2 shows, firm size is collinear with strategic advantage measures *INMME* and *PRSCP,* suggesting that firm size may be a surrogate of these strategic advantages. The relatively high correlation between firm size and strategic advantage measures may provide a confirmation of Swendenborg's hypothesis. However, despite the relatively high collinearity, firm size and those strategic advantage measures are all significant in explaining the size of FDI activities. Thus it seems that firm size has its own influence on FDI size independently from those of strategic advantages. As we suggested earlier, the firm may first exhaust economies of scale at home locations and build up foreign sales through export to the level of MES before it undertakes FDI. Firm size is, then, an important element in the firm's decision to stay home or to go abroad, and the influence of firm size on the size of FDI activities may fade once it becomes a foreign investor.

A comparison of the results of our tobit analysis with the OLS regressions based on the sample that includes only those firms that are already FDI investors seems to support this conjecture. Our tobit sample includes all nine firms, both FDI investors and non-investors, and *LDMSA* has a strong influence on FDI size. However, in the OLS regressions based on the investor firm sample, the influence of firm size fades considerably.

The last factor included in our analysis is the degree of the firm's diversification. Our hypothesis was that it has a negative impact on the size of FDI activities as diversification is an alternative to FDI in growth of the firm. Our results strongly support this. The coefficient of *DIVSF* is correctly signed in both equations, and significant in the *FDIDV* equation. This is consistent with our hypothesis, and also with the results of Swendenborg [1979].

CONCLUSIONS

This paper examined the sources of variations in the firm's FDI activities in the Japanese semiconductor industry. We started this paper with the premise that the firm may differ in economically important aspects other than size within an industry, and argued that the variations across firms in the internationally-transferable strategic advantages give rise to variations in the firm's FDI behavior. Several hypotheses have been developed and tested concerning the specific strategic advantages that are likely to give rise to variations in the firm's FDI behavior in the semiconductor industry.

Our results show that the firm's technological lead in particular semiconductor technology areas drives it to engaging in FDI particularly in the advanced countries. They suggest that the strategic advantages associated with broad breadth of product line and partially internalized vertical linkages may transfer to foreign locations and have some effects on the size of the firm's FDI activities. They also imply that the firm's domestic size in part reflects the strategic advantages that are also important to make it large in foreign locations, and also that it itself plays its own role in influencing the firm's decision to go overseas. Our results also suggest that domestic diversification is an alternative to FDI in the growth of the firm.

Although the results of this study are by and large consistent with theory, they should be regarded as highly tentative and need caution in interpretation. This study focuses entirely on a single industry. The data are limited. The measurement is crude. The sample used was also too small to examine and correct for potential autocorrelation over time. These are the limitations inherent in dealing with oligopolistic industries in which multinational direct investment is prevalent. We must acknowledge these serious limitations of this study.

Granted that this paper suffers these limitations, it still presents a piece of modest empirical evidence. Perhaps more important, it points to a new, interesting avenue of research that may lead to rich analyses of the firm's FDI behavior within an industry and their testable implications. This study shows that we are able to define more or less precisely firm-specific strategic advantages, and that they often influence significantly the firms' multinational FDI behavior. It suggests that the focus on the broad industry characteristics alone is not sufficient for furthering our understanding of firms' behavior. To further our knowledge, we must delve into the complexities and richness of firms' characteristics, so as to identify specific sources of strategic advantages and to disentangle their influences that underlie the firms' varied multinational FDI behavior within an industry. Clearly, this requires us to overcome the sorts of limitations that this paper suffers, but we hope that researchers will develop ingenious approaches to pursue research in the direction this paper suggests.

APPENDIX

Definitions of Variables and Sources of Data

Explanatory Variables

1. The firm's technological leadership

   Following variables are constructed as a sum of the firm's annual count of innovations and new product introductions in each of the four technology areas, as defined below, in the years $t-1$, $t-2$, $t-3$, where $t=1978$, 1979, 1980, 1981, and 1982. [Source: A. Sakuma, Nihon Kigyo no Kenkyu Kaihatsu [Research and Development of the Japanese Firms], *Business Review* 30 (1983)]

INMME Leadership in MOS memory technology.
INMCR Leadership in MOS-based microprocessor technology.
INBDG Leadership in bipolar digital technology.
INBLN Leadership in bipolar linear technology.

2. The firm's breadth of product line.

PRSCP An annual count of IC product categories, as defined in the Yano Economic Research Institute surveys (nineteen categories in total), in which a firm produced and sole microdevices in a year during the years from 1978 through 1982. [Source: Yano Economic Research Institute, *Semiconductor/Microelectronics Industry in Japan*, 1982 and *1984 nen-ban Handotai Shijo no Chuki Yosoku.*]

3. The measures of the degree of the firm's vertical linkage

$$VTEC1\ DVTEC \times RTCAP$$

$$VHOM1\ DVHOM \times RTCAP$$

where,

DVTEC Firm's annual sales in computer and telecommunications equipment,
DVTEC Firm's annual sales in computer and telecommunications equipment, divided by its annual sales in computers, telecommunications equipment and consumer electronics equipment in the five years from 1978 through 1982.
DVHOM Firm's annual sales in consumer electronics equipment, divided by its annual sales in computers, telecommunication equipment and consumer electronics equipment in the five years from 1978 through 1982.

[Source for above two variables: *Yukashoken Hokokusho* of NEC Corporation; Hitachi, Ltd.; Toshiba Corporation; Mitsubishi Electric Corporation; Fujitsu Ltd.; Oki Electric Industry Co., Ltd.; Matsushita Electronic Industrial Co., Ltd.; Tokyo Sanyo Electric Co., Ltd; Sanyo Electric Co., Ltd.; and Sharp Corporation, for 1978-1982.].

RTCAP The ratio of the values of a firm's captive consumption of semiconductor devices to the values of its total production, for 1980 and 1982. The 1982 ratio is used for 1981 and 1982, and the 1980 ratio for 1978, 1970, and 1980. [Source: Yano Economic Research Institute, *Semiconductor/Microelectronics Industry in Japan*, 1982 and *1984 nen-ban Handotai Shijo no Chuki Yosoku*, 1983 (Tokyo, Japan: Yano Economic Research Institute).].

4. The measure of the firm's domestic size
   - *LDMSA* Natural log of the firms domestic merchant sales of semiconductors in the year *t*, where *t*=1978, 1979, 1980, 1981, and 1982. [Source: Yano Economic Research Institute, *Semiconductor/Microelectronic Industry in Japan*, 1982, and *1984 nen-ban Handotai shijo no Chuki Yosoku*, 1983.]
5. The measure of the degree of the firm's diversification of domestic operations
   - *DIVSF* The count of the three-digit Japan SIC industries other than the semiconductor industry in which the firm produced in the year *t*, where *t*=1978, 1979, 1980, 1981, and 1982. [Source: *Yukashoken Hokokusho* of NEC Corp.; Hitachi, Ltd.; Toshiba Corporation; Mitsubishi Electric Corporation; Fujitsu Ltd.; Oki Electric Industry Co., Ltd.; Matsushita Electric Industrial Co., Ltd.; Tokyo Sanyo Electric Co., Ltd.; and Sharp Corporation, for 1978-1982.]

Dependent Variables

The measure of the size of the firm's FDI activities in the defined locations is the cumulative amount of capital (in millions of yen) paid into all the semiconductor production subsidiaries in the locations as defined as of the year *t*, where *t* = 1978, 1979, 1980, 1981, and 1982. [Sources: *Yukashoken Hokokusho* of NEC Corporation; Fujitsu Ltd.; Oki Electric Industry Co., Ltd.; Matsushita Electric Industrial Co., Ltd.; Tokyo Sanyo Electric Co., Ltd.; Sanyo Electric Co., Ltd.; and Sharp Corporation, for 1978-1982. Toko Kezai, ed., *Japanese Multinationals: Facts and Figures 1983*, 1983. Nikkei Electronics, *Microdevices*, 1983 and June 1985.]

- *FDIAD* The measure of the size of the firm's FDI activities in the semiconductor industry in the advanced countries.
- *FDIDV* The measure of the size of the firm's FDI activities in the semiconductor industry in the NICs.

NOTES

1. These nine firms control about 90% of the industry's total production. See Seno-o [1983].

2. As a measure of the size of the firm's FDI activities, total sales or total assets of its foreign subsidiaries are desirable as they reflect the size of FDI activities more accurately. These data, however, are not available.

3. Parrillo [1983], *Nikkei Electronics* [February 10, 1986] and *Nikkei Electronics* [February 1986].

4. For a more detailed discussion, see Kimura [1986], chap. 5. The cumulative lag structure is based on the observation that it took about three years for follower firms to catch up with leader firms in the MOS memory technology area during the period covered in the analysis. Since more than 60% of the innovations covered in the analysis are related to the MOS technology, it was assumed that a similar intertemporal gap existed in other technology areas as well. The one-year lag is rather arbitrary. Some new innovations seem to have had a more immediate market impact, but some others

reqired a longer lead time. Various structures of time period of sustaining leadership and lags were attempted in the preliminary research, and this specification performed best.

5. There is no good measure of overall goodness of fit in the tobit model due to its statistical properties, and we are forced to use a less formal measure. Our results suggest that 67% and 53% of the estimated values fall within the 10% range of the actual values for *FDIAD* and *FDIDV* respectively.

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