TECHNOLOGICAL CAPABILITIES AND JAPANESE FOREIGN DIRECT INVESTMENT IN THE UNITED STATES

Bruce Kogut and Sea Jin Chang*

Abstract—This article examines the effect of relative technological capabilities on Japanese direct investment into the United States by looking simultaneously at industry conditions in the two markets. A negative binomial regression model is specified to estimate the effects of R & D capability and industry structure on a count measure of Japanese entries across 297 industries. The results indicate that Japanese direct investment in the United States is drawn to industries intensive in R & D expenditures summed across both countries; voluntary restraints on Japanese exports encourage direct investment. When the entries are disaggregated by mode (e.g., new plant or acquisition), there is a significant indication that joint ventures are used for the sourcing and sharing of U.S. technological capabilities.

THERE is an on-going policy concern in the United States over the loss of the resident technological capabilities due to foreign direct investment. Popular attention has focused particularly on Japanese investments in high technology industries. Yet, little analysis has been given to whether these investments reflect the extension of Japanese firm advantages through foreign direct investment as opposed to the targeting of American technology.

These issues are also of interest to the broadening of theoretical and empirical studies on the relationship of R & D expenditures to foreign direct investment. Home technological capability has been found in numerous empirical studies to correlate significantly with outward exports and foreign direct investment.[1] The explanation for

dynamic comparative advantage and industry rivalry. R & D expenditures lead to the creation of valuable rent-yielding and intangible assets, such as the knowledge involving new product and process technologies. Home oligopolistic rivalry not only promotes the creation of these technologies, but leads to eventual investments in overseas markets.[2]

Frequently neglected in the empirical studies on the determinants of foreign direct investment are the conditions of the foreign market. This neglect is particularly important to identifying whether foreign direct investment is motivated by the home technological advantage or by the desire to source technology in the foreign market. Because of the high correlation of the industry distribution of R & D expenditures among countries, the positive relationship between home R & D and outward direct investment cannot itself distinguish between these two distinct motives.

For example, due to the paucity of non-American data on R & D expenditures, most empirical studies on foreign investment into the United States have relied on American industry data, assuming a high correlation of R & D expenditures among countries. But the positive relationship between U.S. R & D expenditures and foreign entry raises, in fact, a paradox that for-

The importance of distinguishing between the relative technological capabilities of the source and recipient countries has recently been raised by the studies of Audretsch and Yamawaki (1988) and Yamawaki and Audretsch (1988) on the determinants of Japanese exports to the American market. In their work, Japanese exports have been shown to be sensitive to competitive conditions in the home and foreign market. Relative Japanese advantage in R & D is a significant determinant of exports to the American market.

The following article addresses the question of capability on Japanese foreign direct investment into the United States. Two industry measures of technological capability are examined: R & D expenditures for each country and innovation frequency (though data for the latter exist only for the United States). These variables, along with other determinants of foreign direct investment, are then regressed against a count measure of the number of Japanese entries in 297 United States industries. Because the dependent variable is a count of entries, a negative binomial regression is specified, with heterogeneity being captured by an error term. The count measure allows for a lower level of aggregation (4-digit SIC) than previous studies and for the elimination of censoring bias if an industry has not evidenced an entry.

I. Industry Influences on Foreign Entry

There is little theoretical controversy over the importance of the role of the competitive conditions of the foreign market in the theory of foreign direct investment. The incorporation of the effects of the competitive nature of the foreign market on inward direct investment poses, however, complications to the traditional explanation stressing intangible assets of the firm and oligopolistic rivalry of the home market. These

the positive effect of tariffs on inward investment flows.[5]

Common sense notwithstanding, the high degree of flows of foreign direct investment among developed countries suggest that location advantages in factor costs are not pivotal. In fact, Swedenborg (1979) found that the country distribution of Swedish outward investment flows are correlated with high wages. One possible explanation for this anomaly derives from Caves' (1971) explanation that foreign direct investment stems from the public good character of the rent-yield-

production to adapt products to the foreign market. Alternatively, Swedenborg's result could represent a confounding of horizontal and vertical investment. Vertical direct investment need not be restricted to raw material and low-cost labor sites, but also can occur for the sourcing of the technical capabilities (as embodied in skilled and professional workers) from foreign countries. Both Dunning (1988) and Cantwell (1989) hypothesize, with empirical support, that countries leading in technology will draw foreign direct investment.

The second complication posed by incorporating competitive conditions of the target country in the theory of foreign direct investment is that the foreign market may itself be oligopolistic. In the 1960s, when the overwhelming proportion of the world's foreign direct investment flows was American, the interaction between national oligopolies did not seem very consequential. Hence, the emphasis by Vernon (1966) solely on the influence of home rivalry in new product and process technologies on foreign direct investment was reasonable and supported by considerable empirical evidence.[6] Subsequent empirical work, especially of Flowers (1976) and Graham (1978), and the theoretical model of cross-hauling invest-

TABLE 1.—JAPANESE ENTRY INTO 2-DIGIT SIC INDUSTRIES

SIC Code	Industry Group	Entry Count	Value (million $)
20	Food and kindred products	73	1298
21	Tobacco products	0	0
22	Textile mill products	13	130
23	Apparel and related products	7	40
24	Lumber and related products	10	0
25	Furniture and fixture	8	37
26	Paper and allied products	9	174
27	Printing and publishing	9	166
28	Chemical and allied products	100	2382
29	Petroleum and coal products	2	−18
30	Rubber and plastics, n.e.c.	29	804
31	Leather and leather products	2	0
32	Stone, clay, and glass products	22	205
33	Primary metal industries	72	2195
34	Fabricated metal products	48	434
35	Machinery, except electrical	133	3210
36	Electric and electronic equipment	209	2334
37	Transportation equipment	114	3111
38	Instruments and related products	49	1389
39	Miscellaneous manufacturing	29	335
	Total	938	18,226

Note: The amount of Japanese investment in the United States is calculated for 1980–88. The entry count is for 1976–87.

tition (sometimes abetted by governments) is driven by investments in R & D.[7]

Though R & D influences jointly exports and outward direct investment, there is a subtle difference. By Vernon's product cycle argument, foreign direct investment should occur in industries that are maturing and, hence, declining in R & D expenditures. Similar implications are to be found in Dornbusch, Fischer, and Samuelson's (1977) Ricardian analysis of trade, where differences in relative productivity among two countries result in each country specializing in the industries where it maintains a relative technical advantage. Productivity gains localized to a few export industries force the marginal industries to withdraw from the market. Two implicit alternatives are for home firms to transfer production to the foreign market if they are at a home location disadvantage but otherwise maintain a competitive position in the foreign market, or to increase investments in R & D expenditures in order to renew the technological base of export or import-competing industries.

In summary, there exists three issues of theoretical and policy importance that are currently unsettled: whether foreign direct investments into the United States respond to conditions of the home or foreign market structure; whether they are motivated by the exploitation of home technological advantage or by the sourcing of the U.S. locational advantages in technology; and whether exports is the preferred mode in those industries where home technological capabilities are relatively advantaged. The first two of these issues are examined below by looking jointly at the influence of Japanese and U.S. industry factors on Japanese direct investments in the United States; the last issue is only addressed by joint inference from our and other studies' results.

II. Empirical Model

Measurement of Foreign Entry

Sorting out explanations for these issues has always been difficult because foreign direct investment figures are prone to substantial measurement errors. (R & D measurement has also been a stumbling block, as discussed below.) Balance of payment records neglect the investment portion derived from local debt or the capitalized contribution of intangibles, such as technology or goodwill. Foreign sales in a country have been a

[7] See Brander and Spencer (1983, 1985), as well as the empirical treatment by Scherer (1988).

preferred measurement, but are also vulnerable to error by neglecting local content in the value-added. Like R & D expenditures, most available data on foreign direct investment or foreign sales tend to be aggregated to the 3 or 2 digit SIC levels.

We employ a novel measure in the analysis below, that is, a count of the number of entries in each 4-digit industry made by Japanese firms between 1976 and 1987. (See the appendix on data sources.) An entry count has the methodological advantage in providing a disaggregated measurement of foreign direct investment, thus allowing for a more refined determination of the influence of industry variables. Table 1 provides the industry breakdown of Japanese entries into the United States and the value of these investments as provided by balance of payments statistics. (We give only the entry count and value for manufacturing industries; minority investment positions are excluded.[8]) The correlation between these two series is 0.89.

Variable Measurement

A major problem in analyzing the relative influence of industry and country variations in R & D expenditures on foreign entry is the paucity of data. When available, the data are highly aggregated. In addition, problems of collinearity are unavoidable, because industry R & D expenditures are correlated across countries.

Audretsch and Yamawaki (1988) and Yamawaki and Audretsch (1988) address these problems by using multiple measures of technological intensity, in addition to looking at the raw differences in industry R & D expenditures between the two countries. We follow this approach by gathering information on R & D expenditures as a percentage of sales and (for the United States only) on innovation frequencies. This latter measure is a count of the number of innovations reported at the four-digit industry level.[9] These measures have been used successfully in previous applied work.[10] All three variables (*Japan R & D*, *U.S. R & D*, and *Innovation Frequency*) are expected to be positively related to Japanese entry.

The drawback of the R & D expenditures is the high correlation between the U.S. and Japanese series. We addressed this problem by both summing and subtracting the two countries' expenditures.[11] The R & D sum provides a measure of the overall effect of R & D on entry; it captures the dimension of international rivalry in R & D, as well as its properties as an intangible and, thus, internationally transferable asset. The R & D difference serves to indicate whether entry is motivated by a home (i.e., Japanese) technological capability or by the desire to source U.S. technology. The two variables are weakly correlated with each other.[12]

The remaining variables are designed to capture other conditions of rivalry in Japan and the United States, as well as barriers to entry into the United States. Following Hymer (1976), Knickerbocker (1973), and others, we use the industry concentration ratio as an index of rivalry (*U.S. 8-Firm Concentration* and *Japan 8-Firm Concentration*).[13] Because intermediate levels of concentration have been found empirically to lead to oligopolistic instability, 8-firm concentration indices for Japan and the United States were used. (Regression results with 4-firm concentration rates are similar, as to be expected given the high correlation between the two indices.)

As foreign entry shares many of the characteristics of entry into new product markets, we can rely on the results of the recent literature on entry to identify additional variables that influence foreign investment. One variable characterizing the attractiveness of an industry for entry is shipment growth (*Shipment Growth*).[14] A growing industry permits entry without necessarily displacing encumbents. Industry advertising and marketing expenditures (*US Advertising*) have, however,

[8] Because a few industries (especially auto-related) experienced an inordinately large number of entries, the regressions reported below were reestimated without them; no change in the results were found.

[9] See Acs and Audretsch (1987) for a description.

[10] See Audretsch and Yamawaki (1988) and Yamawaki and Audretsch (1988). An alternative strategy of using company data is provided by Goto and Suzuki (1989), but this information is available only for a fraction of the cases.

[11] We thank Paul Rosenbaum for this suggestion.

[12] Since the U.S. and Japanese R & D series are not identical in their aggregation, we also built the same sum and difference measures using the National Science Foundation R & D data, which aggregated similarly to the Japanese series. None of the results reported below were changed.

[13] Similar findings for the degree of concentration and outward U.S. direct investment were found by Baldwin (1979) and Pugel (1978) and by Caves, Porter, and Spence (1980) for U.S. investment in Canada.

[14] See Gorecki (1975), Duetsch (1984), and Khemani and Shapiro (1986). Shapiro (1983) also confirms this finding for foreign entry into Canada.

TABLE 2.—DATA DESCRIPTIONS AND PREDICTED SIGNS FOR INDEPENDENT VARIABLES

Variable	Definition	Predicted Sign
Japan R & D	Japanese R & D expenditure/sales, (%) eleven years average for 1976–85	+
U.S. R & D	U.S. R & D expenditure/sales (%) 1977	+
R & D Sum	Japanese R & D expenditure + U.S. R & D expenditure	+
R & D Difference	Japanese R & D expenditure − U.S. R & D expenditure	−
Innovation Frequency	Number of new innovations, collected by Small Business Administration, 1982	+
Japan R & D Growth	Average growth rate of Japanese R & D expenditure/sales, 1975–85	−
Japan 8-Firm Concentration	8-firm concentration ratio (%), 1982	+
U.S. 8-Firm Concentration	8-firm concentration ratio (%), 1982	−
Shipment	Eleven years average value of industry shipment, 1975–85	+
Shipment Growth	Average growth rate of industry shipment, 1975–85	+
Import	Import/Shipment (%), eleven years average 1975–85	+
U.S. Advertising	Advertising expense/sales (%), 1977	−
Export Restriction	Dummy variable noting the existence of quota and voluntary restraints for Japanese export	+

been usually found to deter entry.[15] While advertising levels have been found to be correlated with outward flows of foreign direct investment, they should deter inward entry. To these two variables, we add the degree of import penetration (*Import*); industries with high penetration of imports should also be easier to enter by local operations. To control for industry size effects, we include shipments volume (*Shipment*) as a right-hand variable. Finally, in line with the findings of Horst (1972) that import tariffs encourage inward investment, a dummy variable indicating quotas (*Export Restriction*) is constructed.

The above arguments and variable definitions are given in table 2. (Sources for the data are given in the appendix.) Descriptive statistics are given in table 3. The correlation matrix of the variables (not reported here) indicates a substantial degree of collinearity exists for the Japanese and U.S. R & D expenditure variables. A low correlation between innovation frequency and Japanese R & D expenditures suggests one avenue to compare the relative effects of Japanese [illegible] U.S. technological investments without de-

grading the standard errors. Some caution in interpretation is required, however, for, as discussed below, innovation frequency and R & D expenditures are imperfect substitutes for each other.

Sample Size

The Department of Commerce listing of foreign entries indicates 938 Japanese entries occurred in 218 industries in the period of 1976 through 1987; the remaining 245 industries, as identified by the U.S. Standard Industrial Classification, did not experience a Japanese entry during the period. Entries only into wholesale and retail distribution are not classified in the manufacturing industries and are not included in the analysis; industries experiencing no entries are included. Unfortunately, matching Japanese industry concentration data to the U.S. industries left 122 U.S. industries without a match; an additional 34 industries were lost due to missing values of other variables. We eliminated these industries in the runs. (Including these industries

TABLE 3.—DESCRIPTIVE STATISTICS AND CORRELATION MATRIX

Variable	Mean	Standard Deviation	Lowest	Highest
(1) *Entry Count*	2.78	6.74	0.00	72.00
(2) *Japan R & D*	1.72	1.14	0.20	5.70
(3) *U.S. R & D*	1.35	1.46	0.00	10.20
(4) *R & D Sum*	3.07	2.29	0.40	15.90
(5) *R & D Difference*	0.36	1.25	−6.76	3.98
(6) *Innovation Frequency*	11.44	56.78	0.00	860.00
(7) *Japan R & D Growth*	0.05	0.02	−0.01	0.12
(8) *Japan 8-Firm Concentration*	76.04	19.26	17.50	100.00
(9) *U.S. 8-Firm Concentration*	54.27	22.70	5.00	100.00
(10) *Import*	0.12	0.27	0.00	2.98
(11) *Shipment*	5,503.90	14,689.00	65.34	209,924.27
(12) *Shipment Growth*	0.02	0.05	−0.15	0.41
(13) *U.S. Advertising*	1.62	2.39	0.00	20.20
(14) *Export Restriction*	0.03	0.17	0.00	1.00

Note: $N = 297$.

dustries accounted for 88% of all manufacturing entries.

Model Specification

The use of a count of foreign entries presents econometric and measurement issues similar in the study of patents. We follow the approach of Hausman, Hall, and Griliches (1984) on patent counts by specifying a Poisson regression to model the probability that the number of entries will occur n times (with $n = 0, 1, 2, \ldots$) as follows:

$$\text{Prob}(Y = yj) = e^{-\lambda j}\lambda_j^{Yj}/Y_j! \qquad (1)$$

with Y_j being the count of relationships for the entries of the jth industry. To incorporate exogenous variables, lambda can be made a function of the covariates:

$$\lambda_j = \exp(\Sigma B_i X_{ij}), \qquad (2)$$

where B's are the coefficients, X's are the covariates (with $X1$ set to one), i indicates the ith variable, and j is the jth industry. The exponential function ensures non-negativity.

The Poisson distribution contains the strong assumption that the mean and variance are equal to lambda. Based on an OLS regression, an estimate of the Breusch-Pagan statistic for heteroscedasticity was found to be highly significant. Since some of the (heteroscedastic) variation can be attributed to the large differences in shipment volume across industries, we calculated the Goldfeld-Quandt statistic, which indicated significant differences in variances due to industry size.

To eliminate some of this variation, the initial Poisson regression (using the same variables given in column 3 of table 4) was weighted by shipment volume (*Shipment*). As a heuristic diagnostic (described in Cameron and Trivedi (1986)), the squared residual (i.e. $(y_j - \lambda_j)^2$) was calculated from this initial regression and then regressed on the predicted count (λ_j). The coefficient of 0.02 is significant at less than 0.001, indicating substantial overdispersion.

To address the persisting problem of heteroscedasticity, we incorporate explicitly the disturbance of industry heterogeneity by specifying a compound distribution through an addition of an error term. Equation (2) now becomes

$$\lambda_j = \exp(\Sigma B_i X_{ij})\exp(u_j); \qquad (3)$$

λ_j is no longer determined but is itself a random variable. As u_j is unobserved, it is integrated out of the expression by specifying a gamma distribution for the error term, whereupon the now compound Poisson reduces to the negative binomial model (Johnson and Kotz, 1970). Only the scale of the distribution is permitted to vary as a function of the covariates, with the variance of Yj parameterized to equal $(1 + \alpha)E(Yj)$, that is, a

TABLE 4.—NEGATIVE BINOMIAL REGRESSION ESTIMATES ON ENTRY COUNTS

	Equations				
Variable Name	(1)	(2)	(3)	(4)	(5)
Intercept	0.36	1.22	0.57	0.58	0.58
	(0.90)	(3.12)[a]	(1.41)	(1.44)	(1.43)
Japan R & D	0.47		0.26		
	(6.04)[a]		(2.67)[a]		
U.S. R & D		0.29	0.20		
		(6.39)[a]	(3.69)[a]		
R & D Sum				0.23	0.22
				(5.78)[a]	(5.35)[a]
R & D Difference				0.02	0.04
				(0.36)	(0.60)
Innovation Frequency					0.48×10^{-3}
					(0.17)
Japan R & D Growth	−14.27	−23.06	−16.03	−16.17	−16.21
	(−2.30)[b]	(−4.06)[a]	(−2.70)[a]	(−2.72)[a]	(−2.74)[a]
Japan R & Firm	0.02	0.02	0.02	0.02	0.02
Import	0.16	0.41	0.25	0.25	0.25
	(0.25)	(0.62)	(0.40)	(0.40)	(0.40)
Shipment	-0.54×10^{-5}	-0.47×10^{-5}	-0.49×10^{-5}	-0.49×10^{-5}	-0.49×10^{-5}
	(−1.04)	(−0.89)	(−1.01)	(−1.01)	(−0.99)
Shipment Growth	4.56	1.18	1.90	1.86	1.24
	(3.11)[a]	(0.39)	(1.18)	(1.15)	(0.66)
U.S. Advertising	−0.03	−0.04	−0.04	−0.04	−0.03
	(−0.72)	(−1.17)	(−0.39)	(−0.86)	(−0.82)
Export Restriction	2.58	3.02	2.84	2.85	2.83
	(6.99)[a]	(8.99)[a]	(8.43)[a]	(8.46)[a]	(8.26)[a]
α	0.72	0.70	0.65	0.65	0.65
	(7.73)[a]	(7.58)[a]	(7.47)[a]	(7.48)[a]	(7.11)[a]
Log-Likelihood	−714.84	−712.10	−707.08	−707.12	−707.01

Note: t-statistics are in parentheses.
[a] $p < 0.01$.
[b] $p < 0.05$.

constant variance-mean ratio.[16] Given this specification, it becomes straightforward to account for overdispersion.[17] The parameter estimate of α provides a measure of contribution of intrinsic randomness or (as is more probable) heterogeneity caused by omitted variable bias. One likely source of heterogeneity is the omission of the effects of time. Given the availability of a single panel for most of the variables, the data were pooled over time and analyzed by cross-section. Using 1981 and 1985 as breakpoints (which closely correspond to obvious disturbances caused by changes in the value of the dollar/yen exchange rate), the data were partitioned into three samples. No important differences were found in the estimates of the coefficients.

III. Statistical Results

In the results described below, we report only the negative binomial regression estimates. The Poisson estimations tend to give substantially higher t-statistics; there are few cases where a variable that is significant under the negative binomial specification is not also significant under the Poisson. All tests are two-tailed. We discuss first the R & D results across all the regressions and then turn to the other estimates.

In table 4, the first two columns report the results when R & D expenditures for Japanese and the United States are separately entered. The findings indicate strongly that the number of

[16] We verified the specification against an alternative by running the diagnostic recommended by Cameron and Trivedi (1986) to regress the squared residual (divided by the predicted count) on a constant and the predicted count. The fit is positive and only significant for the intercept, supporting the constant variance-mean parameterization.

[17] Greene's statistical package (LIMDEP) provides this test as a standard feature.

entries is related to Japanese and U.S. R & D expenditures, at least when they are separately entered. Interestingly, growth in Japanese R & D expenditures depresses the tendency to enter the United States. As explained further below, this result implies that in industries where Japanese corporations are increasing their technological capabilities, foreign direct investment in the United States is relatively less prevalent. The next regression, reported in column 3, enters U.S. and Japanese R & D expenditures simultaneously. Despite their collinearity, both variables are estimated to be positively and significantly related to entry.

Because of possible contamination of the standard errors due to collinearity, other specifications were explored. As explained earlier, we summed the Japanese and U.S. R & D expenditures (*R & D Sum*), as well as subtracted the U.S. expenditure from the Japanese (*R & D Difference*). The results, given in column 4, indicate that entry is more likely in high R & D expenditure industries; the relative technological advantage of either country does not itself appear to influence the likelihood. The finding points to the importance of the intangibility and transferability of R & D assets, as well as to international rivalry in high technology industries.

In column 5, *Innovation Frequency* is added to the regression. Though positive, its coefficient is not significant. This result is somewhat surprising given a relatively large bivariate correlation (0.4) between *Innovation Frequency* and entry. (Inspection of the correlation table suggested that this correlation is potentially spurious due to the multicollinearity of *Innovation Frequency*, *Shipment Growth*, and *U.S. R & D*.)

The coefficient signs and significance levels of the other variables are fairly robust over the

auto-related industries were outliers in entries and also were characterized by export restrictions, we reestimated the regression in their absence. The results remained largely the same. The imposition of voluntary export restraints promotes Japanese entry into the United States through foreign direct investment. (A coefficient of 2.8 implies that entry should increase by 16, a significant amount!)

The estimates to the remaining variables are not impressive. High important penetration (*Import*) and domestic growth in shipments (*Shipment Growth*) are very weakly related to foreign entry. The coefficient to U.S. advertising and marketing expenditures is negative, indicating that entry is deterred, but the result is not significant. The absolute volume of shipments is also not significantly related to entry.

In all of the regressions, the estimates for unexplained heterogeneity (α) are highly significant. Clearly, there is a significant proportion of interindustry variation in entry that is not being explained by the included variables. One possibility is that investment motivations differ by the mode of entries (i.e., acquisition, new plant, or joint venture), which vary in frequency across industries. We address this issue below.

Discussion

The regression analysis strongly confirms the traditional findings that foreign direct investment is related to the intensity of industry R & D expenditures. In fact, the strong correlation to both U.S. and Japanese R & D expenditures indicate substantial competition in technological intensive

Japanese firms are proportionately expanding most rapidly their technological capabilities.

When analyzed in conjunction with Yamawaki and Audretsch's (1988) positive finding between exports and Japanese expenditures relative to the United States, the results on R & D point to the speculation that growth in Japanese R & D capa-

It is of some considerable policy interest that export restrictions promote foreign entry, with a significance of less than 0.001. In light of Yamawaki's (1986) finding that quotas decrease Japanese exports, the effect of export restrictions is to discourage exports and increase foreign entry into the United States. This result is not

cause exports persist as the optimal mode. Both modes require a domestic technological capability to be viable. But the switch point from exports to foreign direct investments appears to be driven by dynamic changes in comparative advantage in maintaining and developing the technological capability of export industries.

An examination of the data provides further insight into the analysis. Among the fast growing R & D industries are sectors which are known to be facing considerable import competition in Japan and which are difficult to transplant, e.g., metals (zinc, aluminum, iron and steel) and petroleum refining. The slowest R & D growth industries include television and radio, transportation (exclusive of aircraft), and chemicals. This pattern suggests the immobility of production in import-competing industries stimulates R & D expenditures; the causal path between the feasibility and desireability to shift production offshore and R & D expenditures is likely to flow in both directions. The data are consistent with the broad arguments of Vernon (1966) and Dornbusch, Fischer, and Samuelson (1977), but they also give the important reminder of the endogeneity of R & D and productivity expenditures.

Though not significant, *U.S. Advertising* is negatively signed, consistent with the literature on entry.[18] As the usual finding is that domestic advertising is associated with outward foreign direct investment flows, this negative relationship between advertising and inward entries suggests a potential qualification to past empirical work. In particular, one can speculate that advertising advantages are harder to transport across borders because it is not product embodied and is often tailored to national cultures (Caves, 1982). In addition, entry is deterred by the presence of encumbent brands.

cymakers is dubious.

In summary, the statistical analysis generally confirmed the expected relationships between the independent variables and the count frequency of Japanese investment entry into U.S. manufacturing industries. The surprising findings that entries are less likely from Japanese industries showing growing technological capabilities can be reconciled with recent theories of export and production hysteresis, where production from marginally-viable industries are shifted to foreign sites (Kogut and Kulatilaka (1990)). Yet, the alternative explanation that Japanese investments are promoted to source the technological advantages resident in the United States is equally consistent with the results.

IV. Entry by New Plants, Acquisition, or Joint Venture

Some insight into the relative merits of these arguments can be gleaned by partitioning the data by mode of entry.[19] In table 5, the regression results are provided for each entry mode. Columns 1 to 3 are the negative binomial regression estimates for entry with both Japan and U.S. R & D expenditures included; columns 4 to 6 give the estimates with the R & D expenditures summed and subtracted.

The results given in columns 1 to 3 indicate important differences from the results in table 4 and substantial variation across mode of entry. Of most importance, Japanese R & D expenditures have no significant influence on entry into the United States by acquisition or joint venture. For new plants, the effect of Japanese R & D investment is to increase the likelihood of entry. U.S. R & D expenditures are associated with higher entry rates by all three modes, but especially by

[18] See Shapiro and Khemani (1987).

[19] Because of its small sample size, entry by plant expansion is not examined.

TABLE 5.—NEGATIVE BINOMIAL REGRESSION ESTIMATES BY TYPE OF ENTRY

	Acquisition	Joint Venture	New Plant	Acquisition	Joint Venture	New Plant
Intercept	−0.14	−0.94	−0.50	−0.10	−0.91	−0.50
	(−0.20)	(−1.50)	(−0.88)	(−0.15)	(−1.44)	(−0.88)
Japan R & D	0.05	−0.11	0.41			
	(0.44)	(−0.82)	(3.00)[a]			
U.S. R & D	0.18	0.34	0.20			
	(2.56)[b]	(3.92)[a]	(2.87)[a]			
R & D Sum				0.10	0.11	0.31
				(1.95)[c]	(2.12)[b]	(5.87)[a]
R & D Difference				0.03	−0.25	0.08
				(0.35)	(−2.34)[b]	(0.81)
Innovation				0.003	−0.001	−0.001
Frequency				(1.04)	(−0.24)	(−0.26)
Japan R & D	−14.80	−2.08	−21.99	−13.50	−2.26	−22.25
Growth	(−1.89)[c]	(−0.27)	(−2.43)[b]	(−1.91)[c]	(−0.29)	(−2.48)[b]
Japan 8-Firm	0.02	0.02	0.02	0.02	0.02	0.02
Concentration	(3.13)[a]	(2.69)[a]	(3.20)[a]	(2.94)[a]	(2.70)[a]	(3.28)[a]
U.S. 8-Firm	−0.03	−0.01	−0.02	−0.03	−0.01	−0.02
Concentration	(−5.18)[a]	(−2.54)[b]	(−2.77)[a]	(−4.85)[a]	(−2.58)[a]	(−2.90)[a]
Import	0.57	−0.88	−0.19	0.71	−0.87	−0.20
	(0.61)	(−0.96)	(−0.24)	(0.85)	(−0.95)	(−0.25)
Shipment	-0.28×10^{-5}	-0.94×10^{-5}	0.12×10^{-5}	-0.30×10^{-5}	-0.95×10^{-5}	0.12×10^{-5}
	(−0.46)	(−1.33)	(0.20)	(−0.47)	(−1.25)	(0.20)
Shipment	2.75	−3.64	1.52	−0.69	−3.19	2.51
Growth	(1.54)	(−1.75)[c]	(0.80)	(−0.28)	(−1.35)	(1.06)
U.S. Advertising	0.02	−0.21	−0.05	0.03	−0.22	−0.05
	(0.47)	(−2.75)[a]	(−0.77)	(0.74)	(−2.78)[a]	(−0.82)
Export	1.67	3.33	2.69	1.53	3.37	2.71
Restriction	(4.74)[a]	(8.40)[a]	(7.56)[a]	(4.09)[a]	(7.79)[a]	(7.53)[a]
α	0.62	0.32	0.83	0.56	0.33	0.82
	(3.25)[a]	(2.98)[a]	(5.54)[a]	(3.22)[a]	(2.73)[a]	(5.35)[a]
Log-Likelihood	−394.46	−330.94	−518.71	−391.36	−330.60	−518.61

Note: t-statistics are in parentheses.
[a] $p < 0.01$.
[b] $p < 0.05$.
[c] $p < 0.10$.

joint ventures. These results suggest the use of cooperative ventures to source, or benefit from, U.S. technological capabilities in industries where the United States, but not Japan, are intensive in R & D expenditures. But it should be noted that the effect of the growth in Japanese R & D expenditures is to dissuade entry, no matter by what mode.

The remaining variables present some interesting contrasts. Acquisitions are strongly favored when the investment is from a concentrated Japanese industry but into a low concentrated U.S. industry. This relationship suggests that home rivalry might spill over into a rush to invest by acquisition. Sparsity of American targets appears to discourage acquisitions, presumably because the likelihood of a takeover is captured in the valuation of share prices.

Joint ventures favor industries where advertising expenditures are low. This finding reinforces the explanation that joint ventures are oriented towards technological sourcing. All three modes are stimulated by the existence of export restraints.

Columns 4 to 6 report the estimates by replacing each country's R & D expenditure by the variables *R & D Sum*, *R & D Difference*, and *Innovation Frequency*. The results point to a striking difference. Unlike the other entry modes, joint ventures clearly favor industries where the United States has greater R & D expenditures. The results for entry by new plants resemble the findings for the overall sample, as given in table 4. Acquisitions are insensitive to differences in R & D expenditures and are only weakly related to the total expenditures in both countries.

The difference between new plants and the other two modes is echoed in the other results. Joint ventures are shown again to be less likely in high advertising expenditure industries. A posi-

tive but modest effect is evident for acquisitions; the effect is insignificant but it raises the speculation that acquisitions are also used for brand label and distribution channel access. The importance of home (i.e., Japanese) market concentra-

rect investments in new plants predominate in high R & D expenditure industries, but are not sensitive to a relative technological advantage in either market.

These issues are important to the on-going

measure of U.S. concentration indicates, however, that foreign market structure (and, possibly, the lack of acquisition targets) is an important deterrent to entry.

In summary, the results on entry mode choice provide an interesting blend of support for a Ricardian investment model of the product cycle and technological sourcing explanations.[20] Entries by new plants occur in industries where the total R & D expenditures are high and where Japanese R & D expenditures are not growing quickly. As predicted by Vernon's product cycle explanation or by recent arguments of direct in-

contention in the popular press that foreign investments drain American technology. With the recent strengthening of the oversight provisions of the interagency Committee on Foreign Investment in the United States, the executive branch has the authority to block foreign acquisitions in violation of national security interests. Many of these interests have been defined as the safeguarding of U.S. technological strengths.

The results of this paper do not indicate that Japanese acquisitions are more frequent in high-technology industries. In fact, the entry count of acquisitions is related only with weak significance

Audretsch, David, and Hideki Yamawaki, "R & D Rivalry, Industrial Policy and U.S. Japanese Trade," this REVIEW 70 (Aug. 1988), 438–447.

Baldwin, Robert E., "Determinants of Trade and Foreign Investment: Further Evidence," this REVIEW 61 (Feb. 1979), 40–48.

Brander, James A., and Paul R. Krugman, "A 'Reciprocal Dumping' Model of International Trade," *Journal of International Economics* 15 (1983), 313–321.

Brander, James A., and Barbara Spencer, "International R & D Rivalry and Industrial Strategy," *Review of Economic Studies* 50 (Oct. 1983), 707–722.

_____, "Export Subsidies and International Market Share Rivalry," *Journal of International Economics* 18 (Feb. 1985), 83–100.

Cameron, A. Colin, and Pravin Trivedi, "Econometric Models Based on Count Data: Comparisons and Applications of Some Estimators," *Journal of Applied Econometrics* 1 (Jan. 1986), 29–53.

Cantwell, John, *Technical Innovations in Multinational Corporations* (London: Basil Blackwell Inc., 1989).

Caves, Richard, "International Corporations: The Industrial Economics of Foreign Investment," *Economica* (Feb. 1971).

_____, *Multinational Enterprise and Economic Analysis* (New York: Cambridge University Press, 1982).

Caves, Richard, Michael E. Porter, and A. Michael Spence, with John T. Scott, *Competition in the Open Economy: A Model Applied to Canada* (Cambridge: Harvard University Press, 1980).

Deardorff, A., "Testing Trade Theories and Predicting Trade Flows," in R. W. Jones and P. B. Kenen (eds.), *Handbook of International Economics* (Amsterdam: Elsevier Science Publishers, B.V., 1984).

Dornbusch, Rudiger, Stanley Fischer, and Paul Samuelson, "Comparative Advantage, Trade, and Payments in a Ricardian Model," *American Economic Review* 67 (1977), 823–839.

Deutsch, Larry, "Entry and the Extent of Multiplant Operations," *Journal of Industrial Economics* 32 (1984) 477–487.

Dunning, John H., "Explaining the International Direct Investment Position of Countries," *Weltwirtschaftlisches Archiv* (1981), 30–64.

_____, *Multinationals, Technology, and Competitiveness* (Bos-

the Patents–R & D Relationship," *Econometrica* 52 (July 1984), 909–938.

Highfield, Robert, and Robert Smiley, "New Business Starts and Economic Activity: An Empirical Investigation," *International Journal of Industrial Organizations* 5 (1987), 51–66.

Horst, Thomas, "The Industrial Composition of U.S. Exports and Subsidiary Sales to the Canadian Market," *American Economic Review* (Mar. 1972), 37–45.

Hymer, Stephen, *International Operations of National Firms: A Study of Direct Foreign Investment* (Cambridge: MIT Press, 1976).

Johnson, Norman, and Samuel Kotz, *Discrete Distributions* (Boston: Houghton Mifflin, 1970).

Kessides, Ioannis, "Advertising, Sunk Costs, and Barriers to Entry," this REVIEW 68 (Feb. 1986), 84–95.

Khemani, R. S., and D. Shapiro, "The Determinants of New Plant Entry in Canada," *Applied Economics* 18 (1986), 1243–1257.

Kindleberger, Charles P., *American Business Abroad: Six Lectures on Direct Investment* (New Haven: Yale University Press, 1969).

Kogut, Bruce, "Joint Ventures and the Option to Expand and Acquire," *Management Science* 37 (1991), 19–33.

Kogut, Bruce, and Nalin Kulatilaka, "Direct Investment, Hysteresis, and Real Exchange Volatility," Working Paper, Reginald H. Jones Center for Corporate Strategy, The Wharton School (1990).

Knickerbocker, Federick, *Oligopolistic Reaction and Multinational Enterprise* (Boston: Division of Research, Graduate School of Business Administration, Harvard University, 1973).

Magee, Stephen, "Information and the Multinational Corporation: An Appropriability Theory of Direct Foreign Investment," in Jagdish Bhagwuti (ed.), *The New International Economic Order* (Cambridge: MIT Press, 1976), 317–340.

McClain, David, "Foreign Direct Investment in the United States: Old Currents, 'New Waves,' and the Theory of Direct Investment," in C. Kindleberger and D. Audretsch (eds.), *The Multinational Corporation of the 1980's* (Cambridge, MA: MIT Press, 1983).

Pugel, Thomas, *The Industry Determinants of Foreign Direct Investment into the United States* (New York: Division of Research, Graduate School of Business Administra-

Wells, Louis (ed.), *The Product Life Cycle and International Trade* (Graduate School of Business, Harvard University, 1972).

Yamawaki, Hideki, "Exports, Foreign Market Structure and Profitability in Japanese and U.S. Manufacturing," this REVIEW 68 (Nov. 1986), 618–627.

Yamawaki, Hideki, and David B. Audretsch, "Import Share Under International Oligopoly with Differentiated Products: Japanese Imports in U.S. Manufacturing," this REVIEW 70 (Nov. 1988), 569–579.

DATA APPENDIX

Since the entries are counted at the 4-digit SIC level, most of the independent variables were collected also at the 4-digit level, except for Japanese R & D expenditures and its growth rate. *ENTRY COUNT* was constructed by calculating total numbers of Japanese firms' entries into the U.S. manufacturing industries during the period 1976–87. The raw data on the Japanese entries into the United States were collected by the International Trade Administration at the Department of Commerce, as published annually in *Foreign Direct Investment in the United States*, Department of Commerce, ITA. *JAPAN R & D* was constructed from the *Kagaku Gizyuitsu Kenkyou Chousha Houkou* (Research Report on Science and Technology), based on the survey by Statistics Bureau, Office of Prime Minister, Japan. *JAPAN R & D* is for 1975–85 and is SIC aggregated to the equivalent 2 or 3 digit level. *JAPAN R & D GROWTH* is computed as the average of annual growth rates of *JAPAN R & D*. *JAPAN CONCENTRATION* are 8-firm concentration ratios, constructed from *Syuyou Sangyoni Okeru Seisan Syouchyoudo to Herfindahl Index no Syui* (Trends in Production-based Concentration Ratios and Herfindahl Indices for Major Industries), Report #12-87-001, 262-00-A, Fair Trade Commission, Japan, 1987. The matching of Japanese industry concentration data to the U.S. industries left 122 out of 454 4-digit SIC manufacturing industries without a match.

U.S. R & D and *U.S. ADVERTISING* are constructed from the Federal Trade Commission Line of Business Report for 1977. *SHIPMENT*, eleven years' average value of industry shipment, 1975–85, was obtained from unpublished reports from the Department of Commerce. *SHIPMENT GROWTH* is the average of annual growth rates of *SHIPMENT*. *IMPORT* is import value divided by industry shipment, eleven year average 1975–85, from the same source as *SHIPMENT*. *US CONCENTRATION* are 8-firm concentration ratios for 1982, as listed in the *1982 Census of Manufacturing*, Department of Commerce. *INNOVATION FREQUENCY* measures the numbers of new innovations for each industry, which are collected by Small Business Administration for 1982. *EXPORT RESTRICTION* is a dummy variable noting the existence of U.S. quota or voluntary export restraints by Japanese companies. Those industries include steel industries (3312, 3313, 3315, 3316, and 3317), television and radios (3651), semiconductors (3674), automobiles and parts (3711 and 3714). Textile industries were not included in the sample because of the missing data in other variables.