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Modeling the Performance of US Direct Investment in Japan: Some Empirical Estimates

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Foreign firms' direct investments in Japan increased from about $930 million in 1984 to $2.2 billion in 1987, and are still increasing at a rapid rate. Most of these investments come from the United States and Europe. In this paper a short-run model for the performance of a foreign parent firm's subsidiary in Japan is presented. The model is based on theories presented by Hymer, Caves, Buckley and Casson, among others, and consists of two equations: one for profitability and the other for growth. Duality is used to relate a parent firm's activities to its subsidiary firm's profitability. The model is estimated using data for US firms' subsidiaries in the Japanese chemical industry. We find that for jointly owned subsidiaries (joint ventures), imports from US parent firms and the R&D spending by both US and Japanese parent firms are major determinants of profitability and growth. US firms' fully owned subsidiaries, however, exhibit considerably different profit and growth behavior than their jointly owned counterparts. Because of the small sample sizes used, it is not possible to ascertain the sources of the observed differences.

INTRODUCTION

Foreign firms' direct investments in Japan increased from about $930 million in 1984 to over $2.2 billion in 1987,[1] and are still increasing at a rapid rate. Of the 1375 foreign-affiliated firms that were established during the 1979–88 period, 51.2% and 41.7% have, respectively, North American (mostly US) and European parent firms (see Table 1).

Foreign firms' subsidiaries are large relative to domestic Japanese firms. About 34% of foreign firms' subsidiaries in Japan are capitalized at more than 100 million yen, while 99% of all Japanese firms are capitalized at less than 100 million yen. Many of the 230 foreign firms' subsidiaries that are capitalized at more than 1 billion yen are found in the chemical and pharmaceutical industries. (See Table 2 for the size and age distributions of these subsidiaries.)

About 45.8% of these subsidiaries are fully owned by foreign parent firms. The distribution of the share of the foreign (i.e. non-Japanese) ownership for the joint ventures between foreign and Japanese parent firms is such that the share exceeds 50% for 17.4% of the joint ventures, the share exactly equals 50% for 23.3% of the joint ventures, and the share is less than 50% for the remaining 13.5%.[2]

One characteristic of these foreign firms' subsidiaries in Japan is that their propensity to import is very high[3] (Table 3). A government policy encouraging foreign direct investment in Japan may lead to a partial solution to Japan's chronic foreign trade imbalance problem, provided that the high propensity to import of these subsidiaries is consistent with their parent firms' profit maximization. How imported goods from parent firms affect the performance of their subsidiaries will be discussed later in this paper. (Saxonhouse, 1983, discusses policy issues as related to Japan's comparative advantage and gives numerical estimates for country-specific idiosyncrasies.)

In this paper we consider a short-run model for the performance of foreign firms' subsidiaries in Japan. We are particularly interested in modeling how foreign parent firms' investment in research and development (R&D) and ability to transfer to their subsidiaries certain specialized intermediate goods, among other market power-generating factors, contribute to the performance of their subsidiary firms in Japan. Such a model might help potential foreign and Japanese parent firms assess

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Table 1. Numbers of Foreign Parent Firms by Industry and by Nationality[a]

		Manufacturing				Non-manufacturing						
	All industries	Chemicals/ pharmaceutical	Machinery	Electric Machinery/ electronics	All manuf.	Chemicals	Wholesale machinery	Electrical/ electronics	Finance/ insurance	Information	Service	All non-manuf.
N. America	705 (51.2)[b]	112	57	71	365 (61.2)[b]	33	44	24	76	29	27	339 (43.5)[b]
USA	684 (49.7)	112	57	71	356 (59.7)	33	44	24	70	28	27	328 (42.1)
Europe	573 (41.7)	102	41	18	227 (38.1)	49	51	24	81	10	21	346 (44.4)
W. Germany	158 (11.5)	35	14	5	72 (12.1)	15	20	7	15	0	3	86 (11.0)
UK	125 (9.1)	18	5	3	40 (6.7)	8	11	1	33	5	7	85 (10.9)
France	84 (6.1)	17	0	2	29 (4.9)	14	0	3	13	2	4	55 (7.1)
Holland	48 (3.5)	12	1	5	21 (3.5)	3	0	3	5	3	0	27 (3.5)
Switzerland	73 (5.3)	13	7	1	24 (4.0)	2	10	5	10	0	4	49 (6.3)
Sweden	32 (2.3)	1	7	1	18 (3.0)	3	5	1	0	0	2	14 (1.8)
Asia	62 (4.5)	0	0	0	2 (0.3)	1	3	3	24	0	0	60 (7.7)
Hong Kong	18 (1.3)	0	0	0	2 (0.3)	0	1	0	6	0	0	16 (2.1)
Other	36 (2.6)	2	0	0	2 (0.3)	0	1	0	9	1	2	34 (4.4)
Total	1375 (100)	216	98	89	596 (100)	83	99	51	190	40	50	779 (100)

Source: Toyo Keizai Shimposha (1989, p. 96).
[a] Japanese subsidiaries of these firms were established during 1979–88.
[b] Numbers in parentheses are percentage figures.

Table 2. Foreign Firms' Subsidiaries by Industry, Capitalization and Year of Establishment

		Manufacturing				Non-manufacturing						
	All industries	Chemicals/ pharmaceuticals	Machinery	Electric machinery/ electronics	All manuf.	Chemicals	Wholesale machinery	Electrical/ electronics	Finance/ insurance	Information	Service	All non-manuf.
Capitalization												
<10M	577 (21.2)[a]	18	18	11	88 (9.7)	44	67	43	10	30	98	489 (27.0)
10M–50M[c]	804 (29.6)	39	39	23	181 (20.0)	62	112	48	18	36	78	623 (34.4)
50M–100M	410 (15.1)	39	31	26	147 (16.2)	27	44	27	7	18	25	263 (14.5)
100M–500M	573 (21.1)	73	55	38	252 (27.8)	38	59	22	34	29	20	321 (17.7)
500M–1B	122 (4.5)	28	14	4	76 (8.4)	6	4	3	6	1	3	46 (2.5)
1B+	231 (8.5)	82	8	22	162 (17.9)	9	6	5	17	5	5	69 (3.8)
Total	2717 (100)[b]	279	165	124	906 (100)	186	292	148	92	119	229	1811 (100)
Year of establishment												
<1969	541 (18.8)	115	46	27	286 (31.3)	34	54	14	23	7	34	255 (12.9)
1970–74	466 (15.5)	49	37	20	176 (19.3)	28	48	17	35	10	29	270 (13.7)
1975–9	421 (14.6)	32	20	13	109 (11.9)	32	10	26	24	12	35	312 (15.8)
1980–84	704 (24.4)	44	24	33	168 (18.4)	43	72	41	39	35	73	536 (27.2)
1985+	772 (26.8)	43	38	31	174 (19.1)	49	74	52	106	59	64	598 (30.4)
Total	2884 (100)[b]	283	165	124	913 (100)	186	258	150	227	123	235	1971 (100)

Source: Toyo Keizai Shimposha (1989, p. 96).
[a] Numbers in parentheses are percentage figures.
[b] Totals are not the same because relevant data are missing for some firms.
[c] Ranges are given in million (M) or billion (B) yen.

Table 3. Subsidiaries' Sales, Export and Import by Industry

	Sales[a]	Export (parent firm)[a,b]	Export (%) (parent firm %)[b]	Materials procured[a]	Import (Parent firm)[a,c]	Import (%) (Parent firm %)[c]
All industries	10 193 910	1 157 816	11.4	6 119 042	2 813 266	46.0
		(651 644)	(6.4)		(1 607 272)	(26.3)
Manufacturing	7 137 928	773 476	10.8	3 723 537	2 096 725	56.3
		(574 794)	(8.1)		(1 167 560)	(31.4)
Mfg excl.	4 196 266	717 318	17.1	1 977 416	825 691	41.8
Petroleum		(524 865)	(12.5)		(686 295)	(34.7)
Foods	183 948	119	0.1	89 764	26 006	29.0
		(52)	(0.0)		(4 501)	(5.0)
Textile	14 527	3 869	26.6	6 693	1 029	15.4
		(3 617)	(24.9)		(887)	(13.3)
Pulp/paper	31 101	1 039	3.3	13 299	7 549	56.8
		(0)	(0.0)		(2 769)	(20.8)
Chemicals	980 066	78 543	8.0	597 519	174 934	29.3
		(38 754)	(4.0)		(149 921)	(25.1)
Pharmaceuticals	568 431	20 911	3.7	242 912	160 558	66.1
		(9 770)	(1.7)		(123 701)	(50.9)
Petroleum	2 941 662	56 158	1.9	1 746 121	1 271 034	72.8
		(49 929)	(1.7)		(481 265)	(27.6)
Rubber	55 534	2 954	5.3	35 576	19 003	53.4
		(502)	(0.9)		(16 727)	(47.0)
Pottery/	23 916	2536	10.6	16 526	4 842	29.3
ceramics		(64)	(0.3)		(2 694)	(16.3)
Non-ferrous	80 570	53 376	66.2	48 673	5 279	10.8
metals		(29)	(0.0)		(435)	(0.9)
General	487 494	148 977	30.6	267 965	69 133	25.8
machinery		(110 243)	(22.6)		(54 609)	(20.4)
Electric	1 458 990	376 877	25.8	475 235	276 833	58.3
machinery		(340 398)	(23.3)		(264 369)	(55.6)
Transport	142 193	13 751	9.7	88 724	41 509	46.8
machinery		(10 606)	(7.5)		(40 482)	(45.6)
Precision	66 348	10 442	15.7	37 736	20 934	55.5
		(9 877)	(14.9)		(19 736)	(52.3)
Non-mfg	2 803 091	352 482	12.6	2 256 440	706 388	31.3
		(64 279)	(2.3)		(434 564)	(19.3)

Source: Ministry of International Trade and Industry 1987 Survey on Foreign-Affiliated Companies in Japan, as compiled in Toyo Keizai Shimposha (1989, p. 113). The sample consists of 1052 firms which are owned 50% or more by foreign parent firms and responded to the MITI survey (response rate = 46.8%).
[a] Figures in these columns are in million yen.
[b] Amounts or percentage exported to the foreign parent firm.
[c] Amounts or percentage imported from the foreign parent firm.

the profitability and growth prospects of proposed joint ventures. It may also be useful in government planning for forecasting taxable revenues from these subsidiaries. The dual approach underlying our econometric specification may also prove to be useful for deriving subsidiaries' factor demand equations for employment, capital equipment and other tangible and intangible goods including intermediate goods (imports from parent firms, for example and R&D spending).

The model will be estimated using data for US firms' subsidiary firms in the Japanese chemical industry. The Japanese chemical industry has a number of well-established subsidiaries of US and European firms for which accounting and other data are available. Many of these subsidiary firms, with their average age of 19 years, may be viewed as having been successful in pursuing their parent firms' global, long-term strategies[4] in the growing Japanese market. Their before-tax profitability and growth rates in sales revenue in the samples used in this study both exceed those of Japanese and the US parent companies (see variables $JV-PR$, $FP-PR$, $JP-PR$, $JV-GR$, $FP-GR$, $FP-GR$ and JP

$-GR$ in Table A2.1).[5] Explaining empirically the profit and growth behavior of these subsidiaries in a data sample of firms selected on the basis of their successful survival in Japan may be of interest to potential foreign parent firms contemplating direct investment in Japan. Unlike the Japanese automobile, electronics or machinery industries, the Japanese chemical industry has not been competitive in the world market due to the high technological levels maintained by the US and European firms and the relatively high costs in Japan of operations and raw materials, among other factors. The following statistics illustrate this point.

The production index for the chemical industry rose from 100 for 1982 (III, the third quarter) to 115 in 1986 (I), which is attributed to a minor increase in the domestic demand. At the same time, the production indices for electric and precision machineries, for example, rose from 100 to 170 and 160, respectively, reflecting a substantial increase in exports (Economic Planning Agency, 1986, p. 66). Chemical products are the only category of major manufactured goods for which Japan registered a trade deficit of \$400 million[6] in 1985 (Economic Planning Agency, 1986, p. 131). Foreign firms in this industry enjoy a considerable comparative advantage, and the level of their subsidiaries' performance may provide an upper bound on the performance of foreign firms' subsidiaries in other industries.

The model to be estimated consists of two equations: one for a subsidiary's profitability and the other for its growth. While profitability, compared against potential cutoff levels in foreign and Japanese parent firms' capital budgeting, provides the justification for a subsidiary's existence, growth often reflects the parent firms' long-term strategies to achieve larger market shares and the associated economic rents in the long run. It is therefore likely that profitability and growth, at least in the short run, describe different aspects of a subsidiary's behavior.[7]

The organization of the rest of the paper is as follows. In the next section, after a brief review of the Hymer–Caves approach to foreign direct investment, the econometric specification of a short-run (restricted) profit function for a subsidiary firm is discussed. The dual approach to modeling firm behavior is used to relate factors identified by the Hymer–Caves approach as possible determinants of foreign direct investment to a subsidiary's profit function. Then the econometric specification of a growth equation is discussed. In the third section, empirical results are presented for the equations describing the profit and growth behavior of subsidiary firms. The paper ends with conclusions in the final section.

AN ECONOMETRIC MODEL FOR THE PERFORMANCE OF A SUBSIDIARY FIRM

The performance of a subsidiary firm depends on, among other things, various activities it conducts in the host country. The host country governments at various levels, as well as the government of the country of origin of the foreign parent firm, are interested in knowing the levels of the host-country variables associated with a subsidiary's production activities such as employment, investment in plant and equipment, procurement of local materials and services, and expenditure on R&D. Often the interests of the governments of the country of origin for the parent firm and the host country for a subsidiary are perceived to conflict. To understand how a subsidiary determines its production activities, it is essential to understand why firms are motivated to invest abroad.

Hymer (1960, 1976, p. 33) argues that an important reason for a firm to control an enterprise in a foreign country is that 'Some firms have advantages in a particular activity, and they may find it profitable to exploit these advantages by establishing foreign operations'. Extending Hymer's theory, Caves (1971) put forward the hypothesis (sometimes called the Hymer–Caves theory) that firms invest abroad to capitalize on the ownership of such firm-specific assets as production processes, products, managerial abilities and R&D capabilities, provided that firms are able to transfer these assets at zero (or very low) marginal cost to foreign operations.[8]

Specification for Short-run Profitability

Suppose the operations of foreign firms' subsidiaries, fully or jointly owned with domestic firms, are determined by the conditions faced by the parent firms as well as the local conditions encountered by the subsidiaries. A subsidiary firm makes autonomous decisions given the exogenous prices for external goods and services traded in domestic markets and the transfer prices for the goods and services traded internally between a subsidiary and its parent firms.[9] Parent firms are believed to determine the transfer prices for internally traded goods and services in a way that is consistent with firm profit maximization. The internally traded goods and services are assumed to include those derived from the parent firms' tangible and intangible assets. A subsidiary firm purchases goods and services from external markets as well as goods from its parent firms, and it produces and sells its products in domestic markets. There may also be some internally traded goods and services produced and sold by a subsidiary to the parent firms. This framework for modeling the subsidiary–parent firms' relationships using duality is presented in Appendix 1.

A subsidiary's short-run profit function is negatively related to optimal transfer prices set by its parent firms. Since the efficiency with which the goods and services are produced from the parent firms' tangible and intangible assets tends to lower the transfer prices, the net result is that the subsidiary's profit function is positively related to the efficiency in the parent firms' production of goods and services derived from their tangible and intangible assets. This hypothesis is tested empirically in the next section. (Under certain assumptions this scenario is possible. See Eqns (A1.16)–(A1.21) in Appendix 1, for example.)

Specification for Short-run Growth

Hymer (1960, 1976, p. 33) cites as another main reason for a firm to invest abroad that 'It is sometimes profitable to control enterprises in more than one country to remove competition between them'. This highlights the relationship between a firm's long-run profit and its market share in a global market. Firms' long-term strategies to capture market shares in a global market and the associated economic rents could lead to a stable allocation over time of firm resources to investment in foreign subsidiaries.[10] Such growth may also be necessary to achieve economies of scale in production as well as innovative activity. On the latter, Schumpeter (1947) argues, for example, that firm size is essential to the success of innovative activity, since large, monopoly firms can provide sufficient resources to complete the processes of innovation while taking advantage of scale economies in production and innovation. Spencer and Brander (1983) also point out that process R&D could be strategically used to enhance market share.[11] Our hypothesis is that there is a stable relationship between a subsidiary firm's short-run growth performance and the amounts a subsidiary receives of the services and goods derived from the parent firm's tangible and intangible assets. In our empirical specification, which will be tested in the next section, the dependent variable that measures a subsidiary's short-run growth performance is the percentage growth rate in its sales revenue. It is assumed to be a function of factors including the characteristics of the parent firms and a subsidiary.

In our model, macroeconomic and institutional factors including the tax environment and the exchange rate are ignored, since it is assumed that these variables affect the operations of all subsidiaries in the chemical industry in the same manner. These factors may prove to be important, however, in explaining the variation in foreign subsidiaries' performances in different industries. We do not discuss how firms make a choice between joint ventures and fully owned subsidiaries in this paper either. This issue is of practical importance, but has attracted little empirical research. The empirical approach presented in this paper may be useful in identifying some of the characteristics of subsidiaries that determine the type of foreign ownership. (See, for example, Harrigan, 1984; Franko, 1989; Osborn and Baughn, 1987; Tsurumi, 1984, pp. 313–26.[12])

EMPIRICAL RESULTS

Short-run Profitability

To estimate a subsidiary's profit function empirically, the subsidiary's before-tax profit-to-sales ratio ($JV-PR$) is regressed on the following market-power generating factors of its parent firms: the share of the materials used by the subsidiary for its production that are imported ($JV-IMP$),[13] the foreign parent firm's R&D-to-sales ratio ($FP-RD$), export-to-sales ratio ($FP-EXP$), share of ownership ($FP-SHARE$) and sales ($FP-S$), and the Japanese parent firm's R&D-to-sales ratio ($JP-RD$), sales ($JP-S$) and sales per worker ($JP-S/W$). In addition, the subsidiary's sales ($JV-S$), its sales per worker ($JP-S/W$) and growth rate lagged one year ($JV-GR(-1)$) were also used as regressors.

Sales variables, $FP-S$ and $JP-S$, are included to see if they capture parent firms' market power, while $JV-S$ is included to see if the subsidiary's profitability decreases with its size, as is often the case for firms.[14] Sales per worker variables, $FP-S/W$, $JP-S/W$ and $JV-S/W$, are included to capture negative size effects and/or positive productivity effects. (Therefore their net effects may be positive or negative.) The subsidiary's lagged growth rate ($JV-GR(-1)$) is included to see if it has any impact on the short-run profitability. The regression equation to be estimated has the following form:

$$\begin{aligned}JV-PR=f_{\mathrm{p}}(&\overset{(+)}{JV-IMP},\ \overset{(+)}{FP-EXP},\ \overset{(+)}{JP-EXP},\ \overset{(+)}{FP-RD},\ \overset{(+)}{JP-RD},\ \overset{(+)}{FP-SHARE},\\ &\overset{(?)}{JV-S/W},\ \overset{(?)}{FP-S/W},\ \overset{(?)}{JP-S/W},\ \overset{(-)}{JV-S},\ \overset{(+)}{FP-S},\ \overset{(+)}{JP-S},\ \overset{(?)}{JV-GR(-1)})\end{aligned} \tag{1}$$

The expected signs for the estimated coefficients are given above the regressors in Eqn (1).

Relevant information necessary to estimate Eqn (1) exists for a relatively small number of subsidiary firms. Using pooled data for a sample of 12 jointly owned and eight fully owned subsidiaries of US firms over the period of 1984–8, Eqn (1) was estimated using ordinary least squares. The regression results are presented in Table 4. (See Appendix 2 for a detailed description of the data used.)

From columns 1 and 2 of Table 4 the subsidiary's import-share variable ($JV-IMP$) and the parent firms' R&D variables ($FP-RD$) and ($JP-RD$) have statistically significant and positive coefficients, as expected. Sales and sales per worker variables are generally not significant. (The coefficient estimates for $JP-S$ are not reported in Table 4 since they were not significant in any regression.) The subsidiary's lagged growth rate variable is not important, indicating that growth contributes little to profitability in the short run.

Since the flows of the services and intermediate goods derived from the parent firms' intangible and tangible assets are slow to change over time, they may be viewed as fixed effects in our econometric specification. It is interesting to see how much of these fixed effects can be captured by the subsidiary's lagged profit variable.[15] Columns 3 and 4 in Table 4 show regression results with lagged profit variable ($JV-PR(-1)$) included in the estimated equation. The lagged profit variable makes almost all the other explanatory variables insignificant. (The only exception is $JV-IMP$, which remains slightly significant after the inclusion of the lagged profit variable.) The lagged profit variable has a coefficient close to one, indicating that the profit process may be viewed as approximating a random walk process.[16]

An econometric issue of interest here is how the estimated parameter values change in response to alternative equation specifications.[17] Columns 5–10 present estimation results when the explanatory variables related to the US or to the Japanese parent firm, or both, are missing. When the variables related to the Japanese parent firm are omitted, $FP-RD$ seems to pick up the effects of both parent firms' R&D. This phenomenon disappears when the lagged profit variable is entered. When the variables related to the US parent firm are missing, the US parent firm's share of ownership, $FP-SHARE$, appears to become a proxy for the missing effects. This is particularly true when only those variables related to the joint venture are included. Again, this phenomenon disappears when lagged profit is entered in the regression.

Estimation results for fully owned subsidiaries of US firms are given in columns 11–13 in Table 4. A primary difference between the results for joint ventures and for fully owned subsidiaries is that the profitability of the latter seems to depend less on $JV-IMP$ but more on the US parent firm's export position, $FP-EXP$, than is the case for the former. Another difference lies in a much lower estimate of the first-order autocorrelation coefficient of the profit process for a fully owned than for a jointly owned subsidiary. This implies that a fully owned subsidiary's profit process is not a random walk.

Short-run Growth

In order to realize their growth potential, jointly owned subsidiaries take advantage of the domestic marketing capabilities of the Japanese parent firms, as well as the foreign parent firms' technology, established brand names and market power in the global market. Japanese parent firm's growth rate ($JP-GR$) and R&D-to-sales ratio, $JP-RD$, as well as the subsidiary's import ratio ($JV-IMP$), US parent firm's export- and R&D-to-sales ratios

Table 4. Profit Function Estimates[a]

	Jointly owned firms[b]										Fully owned firms[c]		
	(JV, FP, JP)[d]	(JV, FP, JP)	(JV, FP, JP)	(JV, FP, JP)	(JV, FP)	(JV, FP)	(JV, JP)	(JV, JP)	(JV)	(JV)	(JV, FP)	(JV, FP)	(JV)
$JV-IMP$	0.21831***[f]	0.23306***	0.04503	0.04187*	0.24524***	0.04114	0.21747***	0.04299	0.22424***	0.04261**	0.09828**	0.05532	0.06909
	(6.42)[e]	(6.77)	(1.16)	(1.54)	(6.44)	(1.21)	(6.62)	(1.24)	(6.86)	(1.70)	(1.99)	(1.24)	(1.22)
$FP-EXP$	−0.01955	−0.00395	0.00328	0.01165	—	—	—	—	—	—	0.06562**	0.06565**	—
	(0.30)	(0.08)	(0.07)	(0.49)							(1.66)	(1.75)	
$JP-EXP$	—	—	—	—	—	—	−0.06285	0.02918	—	—	—	—	—
							(0.85)	(0.52)					
$FP-RD$	0.61079	0.63936**	0.12569	0.12789	1.2237**	0.15040	—	—	—	—	0.32147	0.48234	—
	(1.22)	(2.20)	(0.32)	(0.55)	(2.51)	(0.44)					(0.31)	(0.52)	
$JP-RD$	1.0861***	1.0177***	0.13845	0.08988	—	—	1.0818***	0.07655	—	—	—	—	—
	(5.12)	(6.19)	(0.59)	(0.55)			(5.53)	(0.45)					
$FP-SHARE$	0.05321	—	0.01322	—	0.12059	0.00841	0.15275*	0.01768	0.29660***	0.02354	—	—	—
	(0.43)		(0.11)		(0.72)	(0.07)	(1.39)	(0.19)	(2.69)	(0.28)			
$JV-S/W$	−0.000048	—	−0.000045	—	0.000005	−0.000002	−0.000139	−0.000082	−0.000005	−0.000000	−0.000765*	−0.000615*	−0.000258
	(0.42)		(0.59)		(0.19)	(0.17)	(1.08)	(1.07)	(0.63)	(0.58)	(1.56)	(1.31)	(0.51)
$FP-S/W$	—	—	—	—	0.017333	0.007351	—	—	—	—	—	—	—
					(0.18)	(0.16)							
$JP-S/W$	0.000150	—	0.000085	—	—	—	0.000283	0.000148	—	—	—	—	—
	(0.81)		(0.76)				(1.25)	(1.13)					
$JV-S$	—	—	—	—	—	—	—	—	−0.000002**	−0.000000	—	—	−0.000000
									(2.39)	(0.84)			(0.52)
$FP-S$	−0.0000010*	—	−0.0000002	—	—	—	—	—	—	—	—	—	—
	(1.33)		(0.39)										
$FP-PR$	—	—	—	—	0.03548	−0.02877	—	—	—	—	0.10312	0.04889	—
					(0.07)	0.12)					(0.41)	(0.19)	
$JP-PR$	—	—	—	—	—	—	0.40787	0.13040	—	—	—	—	—
							(1.20)	(0.68)					
$JV-GR(-1)$	0.00351	−0.03156	0.01593	0.01043	—	—	—	—	0.02684	0.01016	—	—	0.00155
	(0.05)	(0.40)	(0.45)	(0.34)					(0.38)	(0.26)			(0.02)
$JV-PR(-1)$	—	—	0.92062***	0.95269***	—	0.98031***	—	0.95205***	—	0.96447***	—	0.31186***	0.30504*
			(7.02)	(8.59)		(11.46)		(7.50)		(12.42)		(2.75)	(1.29)
Constant	−0.05028	−0.03200	−0.01372	−0.00848	−0.07376	−0.00554	−0.11074**	−0.02147	−0.08257*	−0.00285	0.05082***	0.03156**	0.06449***
	(1.05)	(1.04)	(0.28)	(0.52)	(1.04)	(0.12)	(1.94)	(0.52)	(1.29)	(0.07)	(3.36)	(1.83)	(3.07)
R^2	0.843	0.812	0.937	0.936	0.708	0.936	0.827	0.937	0.725	0.937	0.512	0.562	0.400

[a] The dependent variable for the regression results reported here is the ratio of a subsidiary firm's before-tax income to its sales revenue, denoted by $JV-PR$ in Table A2.1. JV, FP and JP refer to the variables defined for a jointly or fully owned subsidiary firm, its foreign (i.e. US) parent firm and its Japanese parent firm, respectively. The definitions of the explanatory variables used are: IMP = import share in the cost of materials purchased; EXP = export-to-sales ratio; RD = R&D expenditure-to-sales ratio; $SHARE$ = share of the ownership of a joint venture; S/W = sales revenue (S) per worker; S = sales revenue measured in million dollars for a US parent firm and in million yen for subsidiary and Japanese parent firms; PR = before-tax profit-to-sales ratio; $GR(-1) = GR$ lagged one year; $PR(-1) = PR$ lagged one year. See Table A2.1 for further details and for the numbers of firms and pooled observations.

[b] These results are for jointly owned firms.

[c] These results are for fully owned subsidiaries of foreign firms.

[d] (JV, FP, JP) means that the regression reported in this column contains as regressors the variables related to a joint venture (JV), the foreign parent firm (FP) and the Japanese (JP). The same interpretation applies to other columns.

[e] Numbers in parentheses are t-ratios calculated using White (1980)'s heteroskedasticity-corrected standard errors.

[f] Coefficient estimates with asterisks are significant at an 80% level (*), at a 90% level (**) and at a 99% level (***), respectively, based on normal probabilities.

($FP-EXP$ and $FP-RD$) and sales ($FP-S$) are used to capture these effects. In addition, the subsidiary's age measured in years and age squared (AGE and AGE^2), size measured in sales ($JV-S$) and sales per worker ($JV-S/W$) are used to capture the age, size and productivity effects. The regression equation to be estimated and the expected signs for the estimated coefficients are the following:

$$\begin{aligned} JV-GR = f_g\ (&\overset{(+)}{AGE},\ \overset{(-)}{AGE^2},\ \overset{(?)}{FP-GR},\ \overset{(+)}{JP-GR},\ \overset{(+)}{JV-IMP},\ \overset{(+)}{FP-EXP},\ \overset{(?)}{JP-EXP},\\ &\overset{(?)}{JV-PR},\ \overset{(?)}{JP-PR},\ \overset{(+)}{FP-RD},\ \overset{(+)}{JP-RD},\ \overset{(?)}{FP-SHARE},\ \overset{(?)}{JV-S/W},\ \overset{(?)}{JP-S/W},\\ &\overset{(?)}{JV-S},\ \overset{(+)}{FP-S},\ \overset{(?)}{JP-S}) \end{aligned} \tag{2}$$

Ordinary-least-squares estimation results are presented in columns 1–5 of Table 5 for joint ventures and in columns 6 and 7 for fully owned subsidiaries. The Japanese parent firm's growth rate and R&D activities ($JP-GR$ and $JP-RD$), as well as the US parent firm's export share, sales and R&D variables ($FP-EXP$, $FP-S$ and $FP-RD$) and the subsidiary's import-share variable ($JV-IMP$) are all statistically significant and have strong, positive effects, as expected, on the joint venture's growth rate. (Our findings with respect to domestic growth ($JP-GR$) are consistent with Gorecki, 1976, who, using Canadian data, found that industry growth has a strong positive impact on foreign entrants.) The US parent firm's growth rate ($FP-GR$) was also entered in the regression but found to be insignificant. While the subsidiary's sales revenue ($JV-S$) has a significant, negative coefficient, indicating that smaller firms are more likely to grow in proportional terms, the labor productivity reflected in the subsidiary's sales revenue per worker ($JV-S/W$) seems to have a positive impact on growth. The subsidiary's profitability variable ($JV-PR$) has a negative sign but is only slightly significant.[18]

Specifications for joint ventures' growth with and without the variables related to the US parent firm, Japanese parent firm, or both, lead to considerably different estimated parameter values. For example, when the variables related to the US parent firm are omitted, the US parent firm's share of ownership variable ($FP-SHARE$) becomes positive and significant, indicating it acts as a proxy for the US parent firm's omitted variables. When only the variables related to the joint venture are used as regressors, none of them turn out to be significant.[19] For the subsidiaries fully owned by US parent firms, we find that the R&D and sales revenue variables ($FP-RD$ and $FP-S$) have significant, positive effects but the subsidiary's import share ($JV-IMP$) has a negative effect on the subsidiary's growth rate. It is possible that considerable estimation biases result when only the subsidiary-related variables are used to explain its growth.

CONCLUSIONS

The short-run performance of a subsidiary of a US multinational firm has been modeled in terms of its profitability and growth. Empirical equations have been estimated for jointly and fully owned subsidiaries in the chemical industry. Both US and Japanese parent firms' R&D activities[20] seem to promote their subsidiary firms' profitability and growth. Imported materials also contribute positively to joint ventures' profitability and growth as well as fully owned subsidiaries' profitability. The Japanese government's import promotion policy might be particularly effective if more joint ventures are set up, since joint ventures tend to import more from abroad and parent firms' profit and growth objectives seem consistent with joint ventures' increased imports.[21] The factors causing high profitability appear to be fairly stable over time, and the profit process for a jointly owned firm behaves almost like a random walk. It would be interesting to see if these empirical findings and policy suggestions hold for most (if not all) of the Japanese manufacturing industries.

There are considerable differences in profit and growth behavior between jointly and fully owned firms. This is seen, for example, by comparing the estimation results for jointly owned firms using only the explanatory variables related to the US parent firm and its subsidiary firm with the estimation results for fully owned subsidiaries (columns 5 and 6 versus columns 11 and 12 in Table 4 for profitability and column 3 versus column 6 in Table 5 for growth). It is not clear if these observed differences

Table 5. Factors Affecting Growth in Sales Revenue[a]

			Jointly owned firms[b]			Fully owned firms[c]	
	(JV, FP, JP)[d]	(JV, FP, JP)	(JV, FP)	(JV, JP)	(JV)	(JV, FP)	(JV)
$JV-AGE$	0.02872	0.04080**	0.04611**	−0.01130	−0.00903	0.06145	−0.07439**
	(1.25)[e]	(1.71)	(1.9)	(0.48)	(0.37)	(0.75)	(1.99)
$JV-AGE^2$	−0.00081*[f]	−0.00108*	−0.00122**	0.00049	0.00024	−0.001471	0.00205**
	(1.30)	(1.63)	(1.87)	(0.72)	(0.36)	(0.76)	(1.99)
$FP-GR$	−0.04771	—	—	—	—	—	—
	(0.72)						
$JP-GR$	0.27825***	0.32610***	—	0.42010***	—	—	—
	(3.24)	(4.43)		(4.50)			
$JV-IMP$	0.17361**	0.15316**	0.09552	0.27288**	0.06694	−0.92441**	−0.16407
	(2.08)	(1.67)	(1.12)	(2.38)	(0.75)	(2.16)	(1.19)
$FP-EXP$	0.66373***	0.55952***	0.60503***	—	—	0.20610	—
	(3.84)	(3.63)	(4.41)			(0.62)	
$JP-EXP$	−0.15507	—	—	−1.9311***	—	—	—
	(1.00)			(2.94)			
$JV-PR$	−0.53234**	−0.45575*	0.17238	−1.6931***	−0.00642	0.07473	−0.7147*
	(1.67)	(1.46)	(0.60)	(2.91)	(0.02)	(0.12)	(1.50)
$JP-PR$	—	—	—	−1.2308*	—	—	—
				(1.61)			
$FP-RD$	1.9623**	2.3384***	1.9599**	—	—	4.8376***	—
	(2.54)	(4.42)	(2.51)			(2.60)	
$JP-RD$	1.1889***	1.0559**	—	1.1606*	—	—	—
	(2.69)	(2.37)		(1.58)			
$FP-SHARE$	−0.08552	—	—	0.54816**	0.09560	—	—
	(0.52)			(2.24)	(0.33)		
$JV-S/W$	0.00064	0.00009**	0.00004	0.00027	0.00001	0.00331**	−0.00208*
	(1.14)	(2.36)	(1.14)	(0.50)	(0.52)	(2.19)	(1.57)
$JP-S/W$	—	—	—	−0.00115*	—	—	—
				(1.33)			
$JV-S$	−0.000009***	−0.000009***	−0.000109***	−0.000005**	−0.000001	−0.000015***	−0.000011**
	(3.95)	(3.59)	(4.43)	(2.24)	(0.67)	(3.38)	(1.91)
$FP-S$	0.000009***	0.000008***	0.000009***	—	—	0.000066**	—
	(7.90)	(6.72)	(7.79)			(4.09)	
$JP-S$	—	—	—	0.0000002***	—	—	—
				(2.98)			
Constant	−0.50137**	−0.67048***	−0.67931***	0.00609	0.05534	−0.64072	0.85805***
	(2.10)	(3.08)	(3.00)	(0.03)	(0.21)	(0.70)	(2.62)
R^2	0.730	0.708	0.552	0.530	0.137	0.680	0.497

[a] The dependent variable for the regression results reported here is a subsidiary firm's rate of growth in sales revenue, i.e. $[\{JV-S(t+1)\}-\{JV-S(t)\}]/\{JV-S(t)\}$. JV, FP and JP refer to the variables defined for a jointly or fully owned subsidiary firm, its foreign (i.e. US) parent firm and its Japanese parent firm, respectively. The definitions of the explanatory variables used are: AGE = age of a firm; $AGE^2 = AGE$ squared; GR = growth rate in sales revenue (S), i.e. $\{S(t+1)-S(t)\}/S(t)$; IMP = import share in the cost of materials purchased; EXP = export-to-sales ratio; PR = before-tax profit-to-sales ratio; RD = R&D expenditure-to-sales ratio; $SHARE$ = share of the ownership of a joint venture; S/W = sales revenue (S) per worker; S = sales revenue measured in million dollars for a US parent firm and in million yen for subsidiary and Japanese parent firms. See Table A2.1 for further details and for numbers of firms and pooled observations.

[b] These results are for jointly owned firms.

[c] These results are for fully owned subsidiaries of foreign firms.

[d] (JV, FP, JP) means that the regression reported in this column contains as regressors the variables related to a joint venture (JV), the foreign parent firm (FP) and the Japanese parent firm (JP). The same interpretation applies to other columns.

[e] Numbers in parentheses are t-ratios calculated using White (1980)'s heteroskedasticity-corrected standard errors.

[f] Coefficient estimates with asterisks are significant at an 80% level (*), at a 90% level (**) and at a 99% level (***), respectively, based on normal probabilities.

reflect the true difference in behavior due to different ownership arrangements[22] or the small sample sizes used. By estimating similar equations for industries other than the chemical industry we may be able to resolve this issue empirically. Such an extension of the present work is under way.

APPENDIX 1: DUAL APPROACH TO MODELING A JOINTLY OWNED FIRM

In this appendix a model underlying our econometric specification for a jointly owned firm's short-run profitability is presented. It is assumed that a subsidiary firm makes autonomous decisions given the exogenous prices for external goods and services traded in domestic markets and the transfer prices for goods and services traded internally between a subsidiary and its parent firms. The model will then be used to analyze the effects on a subsidiary's profitability and R&D investment decisions of market and other economic conditions faced by both the parent and subsidiary firms.

Suppose foreign and domestic (i.e. Japanese) parent firms (FP and JP) jointly own a subsidiary firm (JV). The FP owns 100α% ($0<\alpha<1$) of the JV. We denote by n_i-dimensional vectors, x^i, the inputs and outputs of each parent firm, and the corresponding price vectors are denoted by p^i ($i=1$ for FP, $i=2$ for JP), where positive (negative) elements of x^i represent outputs (inputs). In addition to externally traded goods, FP and JP also produce and/or consume internally traded goods denoted by m_i-dimensional vectors, y^i, and that are traded between JV and FP ($i=1$) and between JV and JP ($i=2$). The elements of y^i represent, for example, services and goods derived from the tangible and intangible assets owned by parent firms, including intermediate goods, technical knowhow and management services. (A single-parent firm's fully owned subsidiary firms can be modeled using the approach presented in Nakamura *et al.*, 1988.)

Suppose that the n_0-dimensional externally traded goods vector x^0 with price vector p^0 and the internally traded input goods vectors y^{0i} characterize the JV's production, where the internally traded goods are traded between JV and FP ($i=1$) and between JV and JP ($i=2$). Short-run profit maximization problems for parent firms are given by the following expressions:

The FP's problem: Given y^{02} which is optimal to the JP,

$$\max_{x^0,x^1,y^1,y^{01}} \{p^1x^1+\alpha p^0x^0:\ y^1 \geqslant y^{01}, (x^1, y^1, A)\varepsilon T^1, (x^0, y^{01}, y^{02}, C)\varepsilon T^0\} \quad \text{(A1.1a)}$$

and

The JP's problem: Given y^{01} which is optimal to the FP,

$$\max_{x^0,x^2,y^2,y^{02}} \{p^2x^2+(1-\alpha)p^0x^0:\ y^2 \geqslant y^{02}, (x^2, y^2, B)\varepsilon T^2, (x^0, y^{01}, y^{02}, C)\varepsilon T^0\} \quad \text{(A1.1b)}$$

where T^i are the technology sets of the JV ($i=0$), the FP ($i=1$) and the JP ($i=2$) which are assumed to be closed and convex in the relevant x and y variables. The fixed vectors A, B and C represent the factors of production and specific external circumstances that can be viewed as fixed in the short run. Internal transactions do not affect the firms' net profits and hence do not appear in the profit expressions in Eqns (A1.1a) and (A1.1b).

The optimal solution to the FP's optimization problem given in Eqn (A1.1a) can be written using the Lagrangean

$$\begin{aligned} L_1 &= p^1x^1+\alpha p^0x^0+q^1(\alpha y^1-\alpha y^{01})-\alpha q^2y^{02} \\ &= p^1x^1+\alpha q^1y^1+\alpha\{p^0x^0-q^1y^{01}\}-\alpha q^2y^{02} \end{aligned} \quad \text{(A1.2)}$$

as the following saddle-point problem (see, for example, Mangasarian, 1969, p. 117):

$$\begin{aligned} &\max_{x^0,x^1,y^1,y^{01}} \{p^1x^1+\alpha p^0x^0: y^1 \geqslant y^{01}, (x^1, y^1, A)\varepsilon T^1, (x^0, y^{01}, y^{02}, C)\varepsilon T^0\} \\ &= \operatorname*{Min}_{q^1\geqslant 0} \max_{x^0,x^1,y^1,y^{01}} \{L_1\} \\ &= \operatorname*{Min}_{q^1\geqslant 0} [\pi^1(p^1, \alpha q^1)+\pi_1^0(\alpha p^0, \alpha q^1; \alpha q^2 y^{02})] \\ &= \operatorname*{Min}_{q^1\geqslant 0} [\pi^1(p^1, \alpha q^1)+\alpha\pi_1^0(p^0, q^1; q^2 y^{02})] \end{aligned}$$

where αq^1 is the non-negative Lagrange multiplier vector providing the optimal transfer price of y^1; y^{02} and q^2 are the JP's optimal intermediate goods vector and its transfer price, respectively; and π^1 and π_1^0 are defined by

$$\pi^1(p^1, \alpha q^1)=\max_{x^1,y^1} \{p^1x^1+\alpha q^1y^1:(x^1, y^1, A)\varepsilon T^1\} \quad \text{(A1.3)}$$

and

$$\pi_1^0(p^0, q^1; q^2y^{02}) = \max_{x^0, y^{01}} \{p^0x^0 - q^1y^{01} - q^2y^{02}: (x^0, y^{01}, y^{02}, C)\varepsilon T^0\} \quad \text{(A1.4)}$$

Similarly, using the following Lagrangean, with a non-negative Lagrange multiplier $(1-\alpha)q^2$,

$$L_2 = p^2x^2 + (1-\alpha)q^2y^2 + (1-\alpha)\{p^0x^0 - q^2y^{02}\} - (1-\alpha)q^1y^{01}$$

we have, at the JP's optimality, that

$$\begin{aligned} &\operatorname*{Min}_{q^2\geqslant 0} \max_{x^0,x^2,y^2,y^{02}} \{L^2\} \\ &= \operatorname*{Min}_{q^2\geqslant 0} [\pi^2(p^2, (1-\alpha)q^2) + \pi_2^0[(1-\alpha)p^0, (1-\alpha)q^2; (1-\alpha)q^1y^{01})] \\ &= \operatorname*{Min}_{q^2\geqslant 0} [\pi^2(p^2, (1-\alpha)q^2) + (1-\alpha)\pi_2^0(p^0, q^2; q^1y^{01})] \end{aligned}$$

where π^2 and π_2^0 are given by

$$\pi^2(p^2, (1-\alpha)q^2) = \max_{x^2, y^2} \{p^2x^2 + (1-\alpha)q^2y^2: (x^2, y^2, B)\varepsilon T^2\} \quad \text{(A1.5)}$$

and

$$\pi_2^0(p^0, q^2; q^1y^{01}) = \max_{x^0, y^{02}} \{p^0x^0 - q^2y^{02} - q^1y^{01}: (x^0, y^{01}, y^{02}, C)\varepsilon T^0\} \quad \text{(A1.6)}$$

We assume that the parent firms agree to accept their respective optimal transfer prices for internally traded goods so that

$$\pi^0(p^0, q^1, q^2) = \pi_1^0(p^0, q^1; q^2y^{02}) = \pi_2^0(p^0, q^2; q^1y^{01}) \quad \text{(A1.7)}$$

The π^i are short-run (restricted) profit functions for the FP ($i=1$), the JP ($i=2$) and the JV ($i=0$), and are convex in the respective price variables p and q.[23]

Assuming appropriate differentiability, the parent firms' optimization and duality imply[24] that, for the FP,

$$\{\partial\pi^1/\partial(\alpha q^1)\} + \{\partial\pi^0/\partial(\alpha q^1)\} = 0 \quad \text{(A1.8a)}$$

$$y^1 = \{\partial\pi^1/\partial(\alpha q^1)\},\ -y^{01} = \partial\pi^0/\partial(\alpha q^1) \quad \text{(A1.8b)}$$

and

$$q^1(y^1 - y^{01}) = 0 \quad \text{(complementary slackness)} \quad \text{(A1.8c)}$$

If the optimal transfer price, q^1, is positive, then Eqn (A1.8c) implies the market for internal goods y^1 is cleared; i.e. $y^1 = y^{01}$ which is satisfied by Eqn (A1.8a). The convexity of π^1 and π^0 in q^1 implies that the supply curve is upward sloping so that $(\partial y^1/\partial(\alpha q^1)) = (\partial^2\pi^1/\partial(\alpha q^1)^2) > 0$, while the demand curve is downward sloping so that $(\partial y^{01}/\partial(\alpha q^1)) = -(\partial^2\pi^0/\partial(\alpha q^1)^2) < 0$. Similar conditions for the JP are:

$$\{\partial\pi^2/\partial((1-\alpha)q^2)\} + \{\partial\pi^0/\partial((1-\alpha)q^2)\} = 0 \quad \text{(A1.9a)}$$

$$y^2 = \{\partial\pi^2/\partial((1-\alpha)q^2)\},\quad -y^{02} = \{\partial\pi^0/\partial((1-\alpha)q^2)\} \quad \text{(A1.9b)}$$

and

$$q^2(y^2 - y^{02}) = 0 \quad \text{(complementary slackness)} \quad \text{(A1.9c)}$$

If the FP sells to the JV as internally traded goods the goods and services derived from its tangible and intangible assets, the FP's market power is likely to be reflected in the relatively low transfer prices it charges the JV. (Transfer prices are not, in general, observable.) Since the JV's profit function is a decreasing function of these transfer prices, the net result is that the JV's profit function is an increasing function of the FP's market power-generating tangible and intangible assets. The same circumstance may hold for the JV and the JP.

As an example of this approach, suppose that the technology sets are given by:

$$\begin{aligned} T^1 = [(x_1^1, x_2^1, x_3^1, y_1^1, y_2^1): x_2^1 &\leqslant \{(x_1^1)^{1/2} + (y_1^1)^{1/2}\}A_1,\ y_1^1 + y_2^1 \leqslant (x_3^1)^{1/2}A_2] \quad \text{for FP} \\ T^2 = [(x_1^2, x_2^2, x_3^2, y_1^2, y_2^2): x_2^2 &\leqslant \{(x_1^2)^{1/2} + (y_1^2)^{1/2}\}B_1,\ y_1^2 + y_2^2 \leqslant (x_3^2)^{1/2}B_2] \quad \text{for JP} \end{aligned}$$

and

$$T^0 = [(x_1^0, x_2^0, y_2^1, y_2^2: x_2^0 \leqslant \{(x_1^0)^{1/2} + (y_2^1)^{1/2} + (y_2^2)^{1/2}\}C_1] \quad \text{for JV}$$

Using x_3^i purchased from external markets, the two parent firms produce intermediate goods to be used partly for the parent firms' production (y_1^i) and partly for the JV's production (y_2^i) ($i=1,2$). The parent firms produce x_2^i to sell in external markets using as inputs the external goods x_1^i and the intermediate goods y_1^i. The JV produces x_2^0 using external good x_1^0 and internal goods y_2^i purchased from the parent firm i ($i=1,2$). Scalars A_1, A_2, B_1, B_2 and C_1 represent factors such as technologies, fixed capital stocks and business environments that affect the firms' production but are slow to change and hence can be assumed to be constant. For simplicity, all variables in this example, x_1^i, x_2^i, x_3^i, y_1^i, y_2^i, x_1^0 and x_2^0 ($i=1,2$), are assumed to be scalar and non-negative.

The FP's profit maximization is characterized by the Lagrangean

$$\begin{aligned} L_F = {} & p_2^1 x_2^1 - p_1^1 x_1^1 + \alpha q^1 y_2^1 - p_3^1 x_3^1 \\ & + \lambda_1[\{(x_1^1)^{1/2} + (y_1^1)^{1/2}\}A_1 - x_2^1] \\ & + \lambda_2[(x_3^1)^{1/2}A_2 - (y_1^1 + y_2^1)] \end{aligned} \quad \text{(A1.10)}$$

It is shown that $\lambda_1 = p_2^1$, $\lambda_2 = \alpha q^1$ and that the optimal production quantities are:

$$x_1^1 = (1/4)(p_2^1/p_1^1)^2 A_1^2 \quad \text{(A1.11a)}$$

$$x_2^1 = (1/2)(p_2^1/p_1^1)A_1^2 + (1/2)(p_2^1/(\alpha q^1))A_1^2 \quad \text{(A1.11b)}$$

$$x_3^1 = (1/4)(\alpha q^1/p_3^1)^2 A_2^2 \quad \text{(A1.11c)}$$

$$y_1^1 = (1/4)(p_2^1/(\alpha q^1))^2 A_1^2 \quad \text{(A1.11d)}$$

and

$$y_2^1 = (1/2)(\alpha q^1/p_3^1)A_2^2 - (1/4)(p_2^1/(\alpha q^1))^2 A_1^2 \quad \text{(A.11e)}$$

The FP's profit function is given by

$$\begin{aligned} \pi^1(p_1^1, p_2^1, p_3^1, \alpha q^1) = {} & (1/4)A_1^2(p_2^1)^2 \\ & \times \{(1/p_1^1) + (1/(\alpha q^1))\} \\ & + (1/4)A_2^2(\alpha q^1)^2(1/p_3^1) \end{aligned} \quad \text{(A1.12)}$$

The first term in Eqn (A1.12) represents profit from the production and sale of x_2^1, while the second term represents profit from the internal sales of y^1 to the JV.

Similar expressions for x_1^2, x_2^2, x_3^2, y_1^2, and y_2^2 can also be derived for the JP. The profit function for the JP is given by

$$\begin{aligned} \pi^2(p_1^2, p_2^2, p_3^2, (1-\alpha)q^2) = {} & (1/4)B_1^2(p_2^2)^2\{(1/p_1^2) \\ & + (1/(1-\alpha)q^2)\} + \{(1/4)B_2^2 \\ & \times ((1-\alpha)q^2)^2(1/p_3^2)\} \end{aligned} \quad \text{(A1.13)}$$

The JV's optimization problem is characterized by the Lagrangean

$$\begin{aligned} L_{JV} = {} & p_2^0 x_2^0 - p_1^0 x_1^0 - q^1 y_2^1 - q^2 y_2^2 \\ & + \lambda[\{(x_1^0)^{1/2} + (y_2^1)^{1/2} + (y_2^2)^{1/2}\}C_1 - x_2^0] \end{aligned} \quad \text{(A1.14)}$$

It is shown that $\lambda = p_2^0$ and that the optimal production quantities are:

$$x_1^0 = (1/4)(p_2^0/p_1^0)^2 C_1^2 \quad \text{(A1.15a)}$$

$$x_2^0 = (1/2)(p_0^2)\{(1/p_1^0) + (1/q^1) + (1/q^2)\}C_1 \quad \text{(A1.15b)}$$

$$y_2^1 = (1/4)(p_2^0/q^1)^2 C_1^2 \quad \text{(A1.15c)}$$

and

$$y_2^2 = (1/4)(p_2^0/q^2)^2 C_1^2 \quad \text{(A1.15d)}$$

The JV's profit function is found to be

$$\begin{aligned} \pi^0(p_1^0, p_2^0, q^1, q^2) = {} & (1/4)(p_2^0)^2\{(1/p_1^0) \\ & + (1/q^1) + (1/q^2)\}C_1^2 \end{aligned} \quad \text{(A1.16)}$$

The optimal transfer price q^1 is determined by solving the FP's consolidated profit maximization problem:

$$\min_{q^1 \geqslant 0} (\pi^1 + \alpha\pi^0)$$

It is shown to be

$$\begin{aligned} q^{1*} = {} & (1/\alpha)[1/2(p_3^1)\{(A_1/A_2)^2(p_2^1)^2 \\ & + \alpha^2(C_1/A_2)^2(p_2^0)^2\}]^{1/3} \end{aligned} \quad \text{(A1.17)}$$

Similarly, the optimal q^2 is obtained by solving the JP's consolidated profit maximization problem:

$$\min_{q^2 \geqslant 0} (\pi^2 + (1-\alpha)\pi^0)$$

It is shown to be

$$\begin{aligned} q^{2*} = {} & (1/(1-\alpha))[1/2(p_3^2)\{(B_1/B^2)^2(p_2^2)^2 \\ & + (1-\alpha)^2(C_1/B_2)^2(p_2^0)^2\}]^{1/3} \end{aligned} \quad \text{(A1.18)}$$

Consider a scenario in which the FP can efficiently produce intermediate goods including technical knowhow and managerial and R&D capabilities (i.e. A_2 is very large), but operates in a weak or declining domestic market (i.e. $p_2^1 \simeq 0$ or $A_1 \simeq 0$, or both). The JV operates in a growing market where the FP's technology can be fully utilized; i.e. p_2^0 is high and C_1 is relatively large. Then Eqn (A1.17) implies that

$$\bar{q}^{1*} \simeq (1/\alpha)[(1/2)(p_3^1)\{\alpha^2(C_1/A_2)^2(p_2^0)^2\}]^{1/3} \quad \text{(A1.19)}$$

In this scenario the JP cannot utilize the FP's technology by itself, so $B_1 = 0$. The UP, however, can efficiently provide valuable tangible and intangible inputs into the JV's production; i.e. B_2 is large.

Then Eqn (A1.18) becomes

$$\bar{q}^{2*} \simeq (1/(1-\alpha))[(1/2)(p_3^2)\{(1-\alpha)^2 \times (C_1/B_2)^2(p_2^0)^2\}]^{1/3} \qquad \text{(A1.20)}$$

Substituting $\bar{q}^{1*}$ and $\bar{q}^{2*}$ into $\pi^0(p_1^0, p_2^0, q^1, q^2)$ in Eqn (A1.16), we get

$$\pi^0 \simeq (1/4)\{(p_2^0)^2/(p_1^0)\}C_1^2 + (\alpha/128)^{1/3}(p_2^0)^{4/3}(p_3^1)^{-1/3}(C_1)^{4/3}(A_2)^{2/3} + \{(1-\alpha)/128\}^{1/3}(p_2^0)^{4/3}(p_3^2)^{-1/3} \times (C_1)^{4/3}(B_2)^{2/3} \qquad \text{(A1.21)}$$

which is an increasing function of p_2^0, A_2, B_2 and C_1 and a decreasing function of p_3^1, p_3^2 and p_1^0. Identification of the effects of these variables on the JV's profit function may be possible using the specification in Eqn (A1.21).

Hladik (1985) considers the determinants of the incidence of a JV's investment in R&D. Our model can provide relevant econometric specifications as follows. Suppose x_2^0 denotes an output from a JV's R&D activities whose technology is given by T^0. Then the optimal supply of these R&D activities is given by Eqn (A1.15b). Suppose the FP operates in a competitive, technology-oriented industry so that the transfer price (q^1) the FP charges is a decreasing function of the levels of the R&D activities of the FP and of the industry in which the FP operates. (These variables are labeled as USRDS and INDRD in Hladik.) Similarly, suppose that the transfer price (q^2) the JP charges is a decreasing function of the levels of the JP's technical competence and international activity (Hladik's *FTECH* and *FPARTNER*). Suppose further that a JV's production environment is characterized by C_1, which is an increasing function of the host country's population, per capita gross domestic product and government interest in promoting R&D activities (Hladik's *POP*, *GDPC* and *GOVT*). Combining these effects affecting q^1, q^2 and C_1 in Eqn (A1.15b), we find that a JV's supply of R&D activities (reflected in x_2^0) increases with *USRDS*, *INDRD*, *FTECH*, *FPARTNER*, *POP*, *GOPC* and *GOVT*, among other factors. Probit estimation results in Hladik (1985, p. 69, Table 5–3) are generally consistent with these predictions. (The only exception is that the coefficient of *USRDS* is not statistically significant.)

The dual approach given in this appendix provides a convenient framework for modeling interactions between parent and jointly owned firms. The government of a JV's host country is interested in a JV's demands for local employment and investment in R&D activities and in plant and equipment, as well as in the tax revenues to be collected from a JV. For these purposes, the derived demand equations and the profit function for a JV provide a basis for econometric analyses. In contrast, the government of origin of the foreign parent firm may be interested in measuring the losses of employment and investment in R&D and in plant and equipment, as well as losses of tax revenues due to the FP's foreign direct investment. Derived factor demand and supply equations as well as a profit function such as Eqns (A1.11a–c) and (A1.12) for the FP may be useful for econometric analyses.

APPENDIX 2: DATA

Data for the period 1984–8 for subsidiaries in the chemical industry that are jointly or fully owned by US parent firms were primarily collected from Toyo Keizai Shimposha (1989), which contains information on large subsidiary firms with at least 20% foreign ownership as well as on smaller subsidiary firms with at least 49% foreign ownership and a capitalization of at least 50 million yen. Data for Japanese parent firms were collected from Nihon Keizai Shimbunsha (1988) and Toyo Keizai Shimposha (various years), while data for US parent firms were collected from various issues of *Value Line Investment Survey: Ratings and Reports* and *Moody's Industrial Manual*. Information for a subsidiary is usually available only for a fraction of the period 1984–8. It is matched with information for its parent firm(s).

The following are the definitions of the variables (with their units of measurement in parentheses). AGE = the age of a subsidiary (years); $JV-GR$, $FP-GR$, $JP-GR$ = growth rates (measured as (sales $(t+1)$ − sales (t))/sales (t)) for the sales revenues of subsidiary firms (JV), US parent firms (FP) and Japanese parent firms (JP), respectively; $JV-IMP$ = the JV's share of import in the materials procured; $FP-EXP$, $JP-EXP$ = the FP's and the JP's shares of export in their respective sales; $JV-PR$, $FP-PR$, $JP-PR$ = the before-tax income divided by sales revenue; $FP-RD$, $JP-RD$ = the R&D spending divided by sales revenue; $FP-SHARE$ = the FP's share of JV ownership; $JV-S/W$, $FP-S/W$, $JP-S/W$ = the sales revenue divided by the number of workers; $JV-S$, $FP-S$,

$JP-S$ = the sales revenues for JV's (million (M) yen), for FP's (M dollars) and for JP's (M yen), respectively; $FP-GR(-1)$, $JP-GR(-1)$, $JV-PR(-1)=FP-GR$, $JP-GR$ and $JV-PR$ lagged one year, respectively. The means and standard deviations for these variables are given in Table A2.1. The variables $JV-IMP$, $FP-EXP$, $JP-EXP$, $FP-RD$, $JP-RD$ and $FP-SHARE$ are assigned the values observed for the last year of the period for which JV data are available, and hence do not vary over time. This is done partly because these variables change their values relatively slowly over time and partly because relevant information is often not available every year for most firms. The JP-related variables are not based on consolidated financial statements while figures for US parent firms are based on consolidated statements reflecting the figures for both the parent and relevant subsidiary firms.

Only those JV firms for which all relevant information is available were included in the data samples used for estimation. Each firm included in the sample has at least two years of data so that the growth rate ($JV-GR$) can be calculated for the growth regression and the lagged profit ($JV-PR(-1)$) can be included in the profit function regression. Let $\{X_{it},\ t=1, 2, \ldots, T_i,\ i=1, 2, \ldots, I\}$ denote data for firm i for year t. T_i differs from one firm to another. The profit and growth samples described in Table A2.1 contain data on $\{X_{it}, t$

Table A2.1 Characteristics of Data Samples[a]

	Jointly owned firms		Fully owned firms	
	Profit sample	Growth sample	Profit sample	Growth sample
$JV-AGE$	19.9 (6.0)	18.9 (6.1)	19.8 (5.9)	18.5 (6.5)
$JV-AGE^2$	433.4 (228.0)	392.2 (217.7)	424.7 (251.7)	373.7 (220.9)
$JV-GR$	—	0.025 (0.095)	—	0.071 (0.127)
$FP-GR$	—	0.077 (0.142)	—	0.030 (0.144)
$JP-GR$	—	0.028 (0.129)	—	—
$JV-IMP$	0.211 (0.271)	***[b]	0.237 (0.247)	***[b]
$FP-EXP$	0.401 (0.177)	***[b]	0.424 (0.167)	***[b]
$JP-EXP$	0.124 (0.087)	***[b]	—	—
$JV-PR$	0.090 (0.097)	0.079 (0.086)	0.089 (0.036)	0.072 (0.033)
$FP-PR$	0.055 (0.023)	0.054 (0.023)	0.052 (0.037)	0.053 (0.038)
$JP-PR$	0.037 (0.027)	0.031 (0.029)	—	—
$FP-RD$	0.036 (0.020)	***[b]	0.027 (0.019)	***[b]
$JP-RD$	0.051 (0.037)	***[b]	—	—
$FP-SHARE$	0.516 (0.083)	***[b]	—	—
$JV-S/W$	147.9 (390.6)	144.9 (378.0)	34.5 (25.2)	33.9 (27.9)
$FP-S/W$	0.185 (0.142)	0.172 (0.116)	0.115 (0.047)	0.110 (0.040)
$JP-S/W$	118.5 (229.1)	121.2 (248.6)	—	—
$JV-S$	14 270 (11 263)	14 194 (11 576)	8032 (7683)	8263 (9417)
$FP-S$	13 655 (14 250)	12 542 (12 850)	1847 (1891)	1950 (2085)
$JP-S$	867 030 (94 9690)	829 990 (93 5470)	—	—
$JV-GR(-1)$	0.025 (0.095)	—	0.071 (0.127)	—
$FP-GR(-1)$	0.077 (0.142)	—	0.030 (0.144)	—
$JP-GR(-1)$	0.028 (0.129)	—	—	—
$JV-PR(-1)$	0.079 (0.086)	—	0.072 (0.033)	—
No. of firms	12	12	8	8
No. of pooled observations	37	37	20	20

Variables definitions: JV, FP and JP refer to the variables defined for a jointly or fully owned subsidiary firm, its foreign (i.e. US) parent firm and its Japanese parent firm, respectively; AGE = age of a firm; $AGE^2 = AGE$ squared; GR = growth rate in sales revenue (S), i.e. $\{S(t+1)-S(t)\}/S(t)$; IMP = import share in the cost of materials purchased; EXP = export-to-sales ratio; PR = before-tax profit-to-sales ratio; RD = R&D expenditure-to-sales ratio; $SHARE$ = share of the ownership of a joint venture; S/W = sales revenue (S) per worker; S = sales revenue measured in million dollars for a US parent firm and in million yen for subsidiary and Japanese parent firms; $GR(-1)=GR$ lagged one year; $PR(-1)=PR$ lagged one year.

[a] See text for the data source and further definitions of these variables. Numbers in parentheses are standard deviations.

[b] The figures for these variables are identical to those reported in the preceding columns to the left.

$=2, 3, \ldots, T_i,\ \ i=1, 2, \ \ldots, I\}$ and $\{X_{it},\ t=1, 2, \ldots, T_i-1,\ \ i=1, 2, \ldots, I\}$, respectively. Thus for firm i for which relevant information exists for T^i years, data for the last T^i-1 years are included in the profit sample while data for the first T^i-1 years are included in the growth sample. The numbers of firms are $I=12$ (jointly owned) and $I=8$ (fully owned). The following are the firms included in the samples and their parent firms. *Jointly owned*: Asahi-Penn Chemical Co. (FP = PPG Industries, Inc., JP = Asahi Glass Co.); Ube Cycon, Ltd (General Electric Co., Ube Industries); Showa Cabot K. K. (CabotCorp., Showa Denko K. K.); Du Pont-Showa Denko Co. (Du Pont de Numours & Co., Showa Denko K. K.); 3M Health Care Ltd.[25] (Minnesota Mining & Mfg Co.; Sumitomo 3M); Sumitomo Naugatuck Co. (Dow Chemical Co., Sumitomo Chemical Co.); Toshiba Silicone Co. (General Electric Co., Toshiba Corp.); Nissan Ferro Electronics Co. (Ferro Corp, Nissan Chemical Industries Ltd.); Nippon Engelhard, Ltd (Engelhard Corp., Sumitomo Metal Mining Co.); Mitsui-Cyanamid Ltd (American Cyanamid Co., Mitsui Toatsu Chemicals, Inc.); Lucidol Yoshitomi, Ltd (Pennwalt Corp., Yoshitomi Pharmaceutical Industries, Ltd); Union Showa K. K. (Union Carbide Corp., Showa Denko K. K.). *Fully owned*: IFF Japan Ltd (International Flavors & Fragrances, Inc.); Avon Products Co.[26] (Avon Products, Inc.); Grace Japan K. K. (W. R. Grace & Co.); Nippon Du Bois Co. (Chemed Corp.); H. B. Fuller Japan Co. (Fuller Co.); Nippon Lubrizol Industries Corp. (Lubrizol Corp.); Loctite (Japan) Corp. (Loctite Corp.); Max Factor K. K. (Revlon Group Inc.).

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NOTES

1. There is an imbalance in the flow of direct investment between Japan and overseas. Japan's foreign direct investments increased from about \$10 billion in 1984 to over \$30 billion in 1987.
2. These statistics do not contain those joint ventures that have been dissolved, are dormant or are not active. The distribution of the foreign share of ownership of joint ventures was affected, at least in the past, by government policies. The 1950 Law Concerning Foreign Investment permitted foreign firms to own at most 49% of Japanese firms. The law was changed in 1973 to allow foreigners to obtain 100% ownership subject to certain exceptions. (See, for example, Krause and Sekiguchi, 1976, and Ito and Kiyono, 1988, pp. 163–9). There is no doubt that Japanese government policies on foreign ownership played a role in the development of Japanese technology. On the relationship between foreign ownership and technology, Ozawa (1987, p. 175) notes: 'The government's policy of acquiring technology through licensing as much as possible, however, necessarily required adaptive R, D & E on the part of technology-importing Japanese firms for the very reason that foreign firms were hindered from providing "ready-made" technologies via direct investment . . . the government's insistence on licensing created the "learning by doing" effect on R, D & E and generated technological momentum in Japanese industry.' On the Canadian policy towards inward foreign direct investment, Globerman (1987, p. 210) notes: 'The most contentious policy debate in Canada has surrounded the appropriate treatment of inward FDI. This contention has been excerbated by the absence of strong and persuasive evidence regarding the impacts of inward FDI on the efficiency and competitiveness of the Canadian economy.' See also Globerman (1979). Averyt (1986) discusses Canadian and Japanese foreign investment screening.
3. The foreign firms' subsidiaries for which statistics are reported in Table 3 account for 3.3% of Japan's aggregate export in 1986 but 10.3% of Japan's aggregate import. US multinational firms do export more than other US firms. (See Lipsey and Weiss, 1981, 1984.)
4. For firms' strategies and transfer pricing see, for example, Tsurumi (1984, pp. 262–8), Rugman and Eden (1985, pp. 1–10) and Diewert (1985). Caves (1982, p. 246) notes: ' . . . Large firms generally are not in a position to keep two sets of books . . . transfer prices directly affect decentralized decisions in the large firm—for example, whether some component should be secured from a corporate sibling or bought on the open market. The transfer price serves as a "shadow price' ' within the company to guide its own resource-allocation decisions . . . . the MNE (multinational enterprise) hoping to confuse the tax collector runs some danger of confusing itself and demoralizing subsidiaries required to report low profits.' Caves (1982, p. 247) states, however, that large MNEs, lacking arm's-length bases for setting transfer prices, 'can justify the overhead expense of a complicated cost-based system of transfer pricing capable of compromise among administrative and tax-avoidance objectives . . . . ' Overall, the companies do heed tax considerations and some other government fiscal incentives, but they also manage

transfer prices for internal-control objectives. Yunker (1982, p. 40) also notes that active manipulation of transfer prices for enhancement of corporate goals faces obstacles in the legal and regulatory environment and in the general variability and unpredictability of the business environment.

5. This is consistent with MITI's findings that foreign-affiliated firms in Japan are considerably more profitable than domestic Japanese firms. For example, the average ordinary (before-tax) profit-to-sales ratios for manufacturing in 1986 are 5.7% for firms owned at least half by foreign firms and 2.8% for all firms, respectively (Toyo Keizai Shimposha, 1989, p. 112). Direct investment in Japan has been profitable for US firms. Aggregate income from US firms' investment in Japanese manufacturing (excluding petroleum industries) as a fraction of total investment averaged 14.7% over 1983–5, compared to 10.6% for the European Communities, 19.8% for Asia/Pacific excluding Japan and 9.6% for the world (Economic Planning Agency, 1988, calculated from various issues of the Survey of Current Business). In this regard, Hirschey (1982, p. 345) also states that 'Estimation results for a sample of large US multinationals reveal superior valuation effects due to returns from foreign as opposed to domestic operations .... Such findings are also consistent with previous suggestions that firms develop markets abroad to exploit economic rent opportunities.'
6. The net trade balance figures (export minus import, in billion dollars) are: automobiles (33.8), iron/steel (12.2), VCR (8.4), office equipment (6.2), chemicals (−0.4), scientific/optical/precision equipment (5.9), textiles (2.4), ships (5.7), auto-parts (5) and semiconductor/electronics parts (3.8). The factors that have affected the historical development of the Japanese chemical industry include the technology gap between them and the European and US competitors, the oil shocks and the supply of energy and raw materials, the cost of investment in anti-pollution equipment, and environmental issues and competition from newly industrialized countries.
7. The same thing may be said of a parent firm's behavior. The short-run variation in profitability cannot have much impact on the allocation of the resources that must be done based on a firm's strategic objectives. Conversely, growth in the short run does not necessarily increase short-run profitability. A firm realizes its economic rents only when a stable, large market share (or some other strategic advantage) has been established.
8. Buckley (1985), Casson (1987) and Buckley and Casson (1976) put forward the internalization theory to explain multinational firms' behavior: 'One aspect is the internalization of a market where an arm's length contractual relationship is replaced by unified ownership. The other concerns the internalization of an externality where a market is created where none existed before' (Buckley, 1985, p. 9). A detailed historical development of various economic theories of multinational firms is found in Buckley (1985). Morck and Yeung (1989), using Tobin's q, provide some empirical evidence consistent with the internalization theory.
9. We define transfer prices broadly in this paper so that they overlap with, for example, royalties and management and licensing fees. See, for instance, Abdullah (1987, pp. 153–6) for various forms of intercorporate transfer of funds used by multinational firms.
10. For empirical evidence concerning a market share and associated economic rents, see Mueller (1986, p. 103) and Nakamura (1988). Tsurumi (1982) notes that Japanese firms view market share as deferred and compounded profit returns. See also Jatusripitak *et al.* (1985) and Ryans (1988).
11. See Yoshioka (1989, p. 41) for empirical evidence on scale economies in production found in the Japanese chemical industry; Saxonhouse and Wright (1984) illustrate, from a historical perspective, how such process R&D in the cotton-spinning industry in the 1920s led Japan to take charge of large segments of the world textile market; Link (1980) provides empirical evidence that firm size is a prerequisite for successful innovative activity for the US chemicals and allied products industry; see also Arc and Audretsch (1987) and Audretsch and Yamawaki (1988).
12. Foreign direct investment can occur regardless of the level of economic development of the country of the parent firm's origin (see, for example Diaz-Allejandro, 1977). Beamish (1985) also observes that joint ventures in developed countries are more stable than those in developing ones.
13. It is assumed here that most of the subsidiary's imported goods come from its foreign parent firm. (See the row for 'Chemicals' in Table 3.)
14. This is sometimes attributed to the inefficiency in a large firm's decision-making mechanism due to agency costs, among other causes. (See, for example, Mueller, 1986, p. 138; Shapiro, 1980, p. 57).
15. Treating fixed effects using the lagged dependent variable within a micro-data environment is discussed in Nakamura and Nakamura (1985a, b).
16. References are found in Nakamura and Nakamura (1985c), who discuss modeling US and Japanese firms' dividend decisions assuming that the firms' earnings are described by random walk processes. See also Fuller (1976, p. 371) for demonstrating that random walk processes and first-order autoregressive processes with the autoregressive coefficients greater than 0.9 are difficult to distinguish.
17. There are some *a priori* reasons to believe that specifications involving relevant information on a subsidiary as well as its parent firms would be preferred.
18. There is no clear-cut empirical relationship to be expected between the short-run profitability and growth. See, for example, Shapiro (1980, p. 118) and Radice (1971).
19. This is because a very large fraction of the variation in the dependent variable is unexplained.
20. Japanese parent firms spend larger fractions of their sales on R&D ($JP-RD=0.051$ in Table A2.1) than their US counterparts ($FP-RD=0.036$), resulting in lower before-tax profitability for Japanese firms (JP

$-PR=0.037$, $FP-PR=0.055$). But the sum of the R&D-to-sales and before-tax profit-to-sales ratios is about the same for both countries ($JP-RD+JP-PR=0.088$ for Japan and $RP-RD+FP-PR=0.091$ for the United States).

21. Table A2.1 indicates that both joint ventures and fully owned subsidiaries import similar fractions of total materials procured, but since joint ventures are considerably larger than fully owned subsidiaries, the actual amounts of import are much larger for joint ventures than for fully owned subsidiaries.
22. For example, fully owned subsidiaries and their parent firms may have more opportunities to reduce taxes payable by manipulations with transfer prices and accounting profit than jointly owned subsidiaries and their parent firms.
23. See, for example, Lasdon (1970, p. 412) or Varian (1984, pp. 44–46).
24. See, for example, Diewert (1974) or Varian (1984, pp. 52, 54).
25. Sumitomo 3M is owned by Minnesota Mining & Mfg (50%), NEC Corp. (25%) and Sumitomo Electric Industries Ltd (25%). NEC, the larger of the two Japanese parent firms, is assumed to be the 3M Health Care's JP.
26. Treated as fully owned by Avon Products, Inc., which owns 60% of Avon Products Company's shares with the rest of the shares floating with no major institutional investors.

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