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Size and growth of Japanese plants in the United States

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Abstract

Using a unique database on Japanese manufacturing plants in the United States, we examine for the first time the relationship between plant size and growth for foreign-owned affiliate plants. Japanese manufacturing affiliates are three times larger on average than comparable US plants and experienced 30% growth from 1987 through 1990. Despite this, our estimates strongly reject Gibrat's Law for these plants and suggest smaller plants grow faster. We also find younger plants grow quicker and previous investments by the parent firm mean slower growth, particularly for automobile-related plants. Both are consistent with inexperienced firms growing faster as they learn. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

In the early 1930s, Robert Gibrat developed the hypothesis that the distribution of plant sizes in manufacturing is log normal, and showed this using data on

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French manufacturing establishments (Sutton, 1997). By the 1960s, several studies had examined the implication of Gibrat's Law that firm growth should be independent of firm size. These studies often yielded mixed results, but certainly no convincing rejection of Gibrat's Law.[1] More recently, Hall (1987), Evans (1987a,b), and Dunne et al. (1988, 1989) have reexamined the relationship when correcting for potential sources of statistical bias, including sample selection bias from exiting firms, heteroscedasticity, and the role of age on firm growth. The studies by Hall and Evans examine data on US firms, while the studies by Dunne and coworkers examine US plants, yet they come to similar conclusions. The proportional rate of growth of a firm (or plant) conditional on survival is decreasing in size and age. The relationship between firm growth (and survival) and age is seen as consistent with the Jovanovic (1982) theory that firms learn about their abilities over time.

To date, no one has examined these issues with respect to foreign-owned affiliate plants in a host country, though theory and empirical evidence suggests that foreign-owned plants may behave quite differently from domestic-owned ones across a number of dimensions. The industrial organization view of multinational firms is that they are multinational precisely because of firm-specific advantages that give them incentives to grow and set up plants across multiple locations. These ideas were formalized in the ownership–location–internalization framework of Dunning (1981) and features of this have been more formally incorporated into general equilibrium trade and multinational firm models summarized in Markusen (1995). These models postulate that multinational firms differ from domestic firms in that they develop firm-specific assets (technologies, patents, management skills, advertising skills, etc.) which can then be applied across multiple plants. This means that multinational plants are necessarily different from domestic plants both in the home country of the parent firm, as well as in the host country, which may translate into different growth dynamics.

There is also a growing body of empirical evidence that confirms that plants of multinational firms have quite different plant characteristics than those of domestically-owned firms. Howenstine and Zeile (1992, 1994) and Doms and Jensen (1998) find significant differences between foreign-owned and domestic-owned manufacturing plants. In particular, foreign-owned plants in the United States tend to be larger, more capital-intensive, more productive and pay higher wages than domestic-owned ones (particularly those that are not affiliates of US-based multinational firms), even after controlling for four-digit Standard Industrial Classification (SIC) industry, state, and plant age. Globerman et al. (1994) obtain similar results using data on foreign affiliates in Canada.

Despite this, no one has looked at the growth of foreign-owned affiliates, even

[1] See Sutton (1997) for a review of these earlier studies.

though the share of production by foreign-owned affiliates has been growing rapidly for many countries over the last few decades. For example, the share of foreign-affiliate employment in US manufacturing has nearly quadrupled over the period from 1977 to 1994, growing from 3.7 to 13.4% (Blonigen and Slaughter, 1999). Is the relationship between firm growth and firm size for these foreign-owned affiliates similar to that found for domestic plants?

We use data on all Japanese-owned manufacturing plants in the United States as a first step toward examining these issues. In particular, we use a relatively unexploited data base on Japanese plants in the US published by the Japan Economic Institute (1980–1990). The data were collected in 1980 and updated semiannually until 1990, allowing us to track growth in employee size of individual plants. These data are of particular interest because in the mid- and late-1980s the United States experienced a substantial wave of Japanese foreign direct investment, with many Japanese firms establishing a plant in the United States for the first time.

We first show that these Japanese manufacturing plants differ substantially from samples of US firms previously examined. In particular, they have average sizes that are substantially larger than US domestic-owned plants in the same four-digit SIC industry and averaged 30% growth rates from 1987 to 1990.[2] Given this sample of relatively large plants with high growth rates, one may not expect smaller plants to grow faster, as found by previous studies of US firms and plants. Yet, when we examine the relationship between firm growth and firm size, we resoundingly reject Gibrat's Law and find that smaller plants grow faster than larger ones. While this general result is consistent with studies of domestic-owned US plants and firms, the magnitude of the effect is relatively quite large. For our sample, a doubling of a plant's size reduces growth by one-third.

Foreign-owned plants present an excellent opportunity to test for learning effects connected with plant growth. These plants face all the learning challenges that any domestic-owned plant would encounter, but must do so in a foreign market as well. As a result, learning effects on growth may be quite substantial for foreign-owned affiliates. Consistent with previous studies, we test for learning effects by estimating the effect of plant age on plant growth. Controlling for plant size, we find that more recent plants grow much quicker than older plants, which is consistent with learning effects. The average plant in our sample is 3 years old and has a 3-year growth rate of 30%. Our estimates imply that a 6-year-old plant's 3-year growth rate is only 20%. Unlike previous studies, we also test whether the presence of joint-venture partners or previous investment by the Japanese parent firm in the United States affects plant growth in a manner consistent with learning

[2] In comparison, employee growth across all manufacturing plants in the US declined from 1987–92 by 8%.

effects. We find joint venture partnering with US firms has no significant impact on growth, but there is weak evidence that previous investment by the parent firm slows growth, which is consistent with learning effects.

We also examine the role of automobile-related investment on our estimates. A substantial amount of investment by Japanese automobile-related firms occurred in the United States during this period due to a voluntary export restraint (VER), and these plants average over 100% 3-year growth rates. While Gibrat's Law is separately rejected for both the automobile-related investments and the non-automobile-related plants, we find that learning effects were much more important for the automobile-related plants.

Finally, we examine and find that industry-specific characteristics lead to significant differences in plant growth levels and deviations from Gibrat's Law for our sample. In particular, we find evidence that plants grow faster in industries where scale economies are important, particularly if the plants start as small operations. This is consistent with previous work on US manufacturing plants in general and is consistent with the notion that firms may pursue strategies to start with a small plant, evaluate the market, and then grow quickly if profit opportunities exist (Caves, 1998).

2. Size and growth of Japanese manufacturing affiliates in the United Sates: A first look at the data

Japanese FDI into the United States, especially in manufacturing, has been substantial in the past two decades. Although Japan's FDI into the United States is recent, by 1990 Japan ranked as the one of the largest source countries for FDI into the United States. In this section, we take a first look at the data on Japanese manufacturing affiliate plants located in the United States using a database established and published by the Japan Economic Institute (1990) beginning in 1980 and updated semiannually through 1990. These data were collected through surveys of all known Japanese manufacturing plants in the United States and include information on (1) affiliate name, (2) plant location, (3) parent firm(s) and their ownership shares, (4) whether the plant was acquired or a new plant (i.e. 'greenfield' investment), (4) product lines and four-digit SIC classification, (5) number of employees, and (6) year the plant was opened or acquired.[3]

To our knowledge there is no similar detailed source of information on

[3] The data are published in *Japan's Expanding US Manufacturing Presence* by the Japan Economic Institute (1990), Washington, DC (various issues 1980–1990). We gratefully thank Keith Head and John Ries at the University of British Columbia for sharing their electronic version of the 1990 update of this database.

employee size of foreign subsidiary plants in the United States for other source countries that is publicly available; hence, we focus on Japanese subsidiaries.[4] Some work examining plant characteristics of foreign affiliates in the United States has used detailed data from surveys conducted by the US Bureau of Economic Analysis (BEA), in conjunction with the Bureau of the Census. However, the database's observations at the plant level are not publicly available for proprietary reasons. Howenstine and Zeile (1994) report a broad array of characteristics of these foreign manufacturing establishments relative to all US establishments using this BEA/Census database and find a number of substantial differences. First, foreign-owned establishments tend to be larger in average plant size (both in terms of employees and value-added per establishment) in general and within specific industries. Second, capital intensity, hourly compensation, and labor productivity seems to be higher in foreign-owned establishments as well. Although, these effects seem to be due to concentration of foreign-owned establishments in capital-intensive, high-wage and productive sectors, not from their foreign ownership per se.

Table 1 reports average Japanese affiliate plant sizes in the United States for 1987, average US plant size for 1987, and growth rates of Japanese affiliate plants from 1987 through 1990 by two-digit manufacturing SIC industries. Throughout this paper, we only consider majority-owned affiliates.[5] Japanese plants are represented in almost every industry, with a large number of plants in SIC 20 (food and kindred products), 28 (chemicals and allied products), 35 (industrial machinery and equipment) and 36 (electronic and other electric equipment).[6] With the exception of SIC 28, the Japanese subsidiary plants are larger than their US industry counterparts. In fact, the ratio of 1987 employees in a Japanese plant to that of a US plant in the same industry ranges from approximately one in SIC 28 to over 6.5 in SIC 32 (stone, clay and glass products). Across the entire sample, Japanese firms are over three times larger than all US firms: the average Japanese plant has 179.8 employees, while the average US plant has 51.4 employees. While this is a very large difference, it is similar to the size difference between all US foreign subsidiaries and counterpart US-owned plants. Howenstine and Zeile

[4] The German American Chamber of Commerce publishes a directory of German subsidiaries in the United States, but reports US employee levels for the firm (not plant), which may cover numerous plants across manufacturing, distribution, retail and service sectors.

[5] Also, there were a number of instances where employee numbers were only listed for a group of plants in the same industry and owned by the same firm (i.e. there were no individual plant employee numbers for these groups). For these observations we assigned the average size and growth across the related firms to each individual observation. Elimination of these observations leads to qualitatively identical results as those reported throughout the paper, including our regression estimates below.

[6] SIC industries 21 (tobacco products), 29 (petroleum and coal products) and 31 (leather and leather products) are not reported because they had only one or zero Japanese plants.

Table 1
Japanese majority-owned affiliate plant sizes for 1987, average US plant size for 1987, and 1987–90 growth rates of Japanese majority-owned affiliate plants by two-digit manufacturing SIC industries

SIC	Industry description	Number of plants	Average plant size 1987 (employees)	Employee growth, 1987–90 (%)	US average plant size 1987 (employees)
20	Food and kindred products	97	102.4	1.2	70.4
22	Textile mill products	13	201.8	8.7	110.8
23	Apparel and other textile products	13	129.7	64.8	46.6
24	Lumber and wood products	7	60.6	0.0	20.5
25	Furniture and fixtures	6	157.6	13.1	43.9
26	Paper and allied products	9	123.9	0.4	97.2
27	Printing and publishing	12	61.2	0.0	24.0
28	Chemicals and allied products	116	67.5	14.4	67.6
30	Rubber and miscellaneous plastics products	41	169.6	45.9	57.0
32	Stone, clay, and glass products	21	210.9	36.8	32.3
33	Primary metal industries	30	539.0	48.7	105.3
34	Fabricated metal products	46	77.2	23.4	40.4
35	Industrial machinery and equipment	98	162.8	23.2	35.4
36	Electronic and other electrical equipment	94	282.2	62.4	98.3
37	Transportation equipment	23	724.1	91.6	173.0
38	Instruments and related products	33	142.0	34.8	96.4
39	Miscellaneous manufacturing industries	28	119.1	17.7	22.6
	All manufacturing	688	179.8	29.0	51.4

(1992) show that the 1987 ratio of average employee levels in all foreign-owned plants to all US plants in the United States is slightly over three (160.9 average employees for US foreign subsidiaries versus 51.4 for all US plants).

While employee sizes of Japanese subsidiary plants relative to US industry averages are high, Table 1 shows that growth rates in these subsidiary plants during 1987–1990 are high as well. Employee growth rates during this period range from no growth in SIC 24 (lumber and wood products) and SIC 27 (printing and publishing) to over 90% in SIC 37 (transportation equipment). The large growth in transportation equipment plants may be exceptional because of the large relocation of Japanese automobile and related automobile parts plants due to the voluntary export restraints in Japanese exports of automobile parts. Our analysis below will specifically address the effect of these automobile-related plants on our general results. Despite the very high growth rates in the automobile-related industries, growth rates exceed 30% in a number of industries, with an average growth rate of 30% across all manufacturing sectors.

This growth pattern in Japanese subsidiaries, as with size, is quite different from US plants in general. Using calculations from the Census of Manufactures, employee growth across manufacturing plants in the United States from 1987–1992 was actually an 8% decrease. Negative growth rates in US plant size is

Table 2
1987–90 employee growth of Japanese subsidiaries, by age

Age (in years)	Number of plants	1987–90 growth rate (%)
1–3	356	42.4
4–6	91	35.5
7–9	107	8.7
10+	134	4.9
Total	688	28.9

apparently a trend since the 1970s, as discussed in Carlsson et al. (1994). Thus, the growth in employee size of Japanese subsidiaries in the United States during this period stands in sharp contrast to this US trend. It also contrasts with average growth in plant employees for all foreign-owned establishments, which was 4.7% from 1987–1990 (160.9 employees per plant in 1987 to 168.4 employees).[7]

A final important observation is that growth in these Japanese plants seems to take place primarily in its early years of operations. Table 2 shows the 1987–1990 employee growth rates of Japanese plants by age. These data show quite clearly that there is very high growth in the initial 6 years of plant life, with subsequent growth rates that are more in line with the average growth rate of all established foreign subsidiaries in the United States (4.7%) mentioned above. In fact, this suggests that one substantial explanation for the high relative growth rate for all Japanese subsidiaries is that so much of Japanese FDI into the United States has been relatively recent.

In summary, consistent with previous research on foreign-owned establishments in the United States, Japanese subsidiaries tend to be quite large in comparison to US plants in the same industry. Howenstine and Zeile (1994) list a number of plausible explanations for this, including the benefits of larger scale are necessary to compensate for the disadvantages foreign investors face when operating in the United States. Despite these generally large plants, we also find high growth rates of the Japanese plants from 1987–90. Finally, the descriptive statistics suggest that a substantial portion of growth in these plants apparently occurs in the first 6 years of plant life.

3. Determinants of plant growth

We next turn to a more formal examination of the relationship between plant size and growth of Japanese affiliate plants in the United States. Our starting point is to test whether Gibrat's Law holds for our data. Gibrat's Law suggests that firm

[7] These figures calculated from data reported in Howenstine and Zeile (1992, 1994).

(or plant) growth should be independent of size, yet many recent studies, including Hall (1987), Kumar (1985), and Acs and Audretsch (1990) find evidence that smaller firms (or plants) grow faster than larger ones. This is an interesting question for our data of Japanese affiliates, which we have shown are much larger on average than domestic-owned plants in the same industry, and yet display very high rates of growth over our sample period.

Our initial specification will control for the plant's age, as well as its size. Beginning with Evans (1987a,b), this has been a standard way to examine the impact of learning on plant- or firm-level growth. Evans' studies find a significant inverse relationship between age and firm growth across a wide variety of sample firms, and he argues that this is consistent with Jovanovic's (1982) theory of innovation and firm growth. In Jovanovic's model firms learn about their true efficiencies over time through a Bayesian learning process, which means there is a convergence of the firm's output level to its optimal state over time. Older firms are presumably closer to convergence and hence, experience less growth, ceteris paribus.

Learning is likely an important issue for foreign affiliate plants, because there may be so many more uncertainties in the marketplace facing a foreign investor, as opposed to a domestic one. There are a number of reasons why this might be true. First, there may be numerous inefficiencies connected with foreign management and corporate structure adapting practices to domestic labor. For example, in the late 1970s Japanese automakers expressed strong concerns that US labor would not be able to adapt and attain production efficiency sufficient to justify locating plants in the United States. Moreover, cultural miscommunications in the workplace exist between foreign managers and domestic workers, which may hinder efficiency in production.[8] Another source of initial production inefficiency for foreign plants may be connected with obtaining material inputs. For example, Japanese automakers are renowned for their use of just-in-time inventory system. However, location in the US puts them in a market far from their own suppliers in Japan, and close to potential US suppliers that were not accustomed to this system.[9] Finally, Kogut and Chang (1996) suggest and provide evidence that initial investments by Japanese firms in the United States serve as 'platforms' for future investments. This suggests that foreign firms understand and plan for the substantial learning that occurs when first entering a country with new investment.

Thus, we begin our examination of the effects of size and age on plant-level

[8] For example, a 1993 *Wall Street Journal* article (WSJ, May 4, 1993, p. A1;1) details a number of such difficulties between German managers and US workers at Baker Material Handling, a German-owned affiliate in South Carolina.

[9] Numerous Japanese auto part's firms eventually located in the US, however, this occurred a couple years after the initial auto plants began operations.

growth in our sample of Japanese manufacturing affiliates by testing a common form of Gibrat's law which includes a plant age term[10]:

$$Growth\ Rate = \alpha + \beta_1 \log(Plant\ Size) + \beta_2 \log(Plant\ Age) + \epsilon \quad (1)$$

where we define *Growth Rate* as the 3-year percentage change in plant-level employees from 1987 to 1990, *Plant Size* as the 1987 plant-level employees, *Plant Age* is measured in years, and ϵ is a classical error term. Table 3 gives summary statistics of growth rates and logarithm of plant sizes and plant ages for our sample of Japanese majority-owned affiliates.

If Gibrat's Law holds, then β_1 in Eq. (1) should equal zero. A negative β_1 indicates that smaller plants grow faster than larger ones, whereas a positive β_1 suggest larger plants grow faster. A negative coefficient on the plant age regressor (β_2) suggests learning is important as it indicates that younger firms grow faster. Evans (1987a,b) specifications often include quadratic terms for the log of plant size and plant age, as well as an interaction term between the two variables, to control for possible nonlinearities. We do not include these terms in our reported results because they are statistically unimportant for our estimates, either jointly or separately.[11]

Before reporting results, we note that our choice to focus on growth from 1987 to 1990 was motivated by data considerations. First, our data set ends in 1990,

Table 3
Summary statistics for key variables

Regressors	Mean	Standard deviation	Minimum	Maximum
Plant employee growth rate, 1987–1990	0.30	1.02	−0.76	12.33
Logarithm of plant employee size	4.34	1.23	1.10	8.47
Logarithm of plant age	1.04	1.05	0.00	4.32

[10] Our specification closely follows Hall (1987) and Acs and Audretsch (1990), with the exception that we include a Plant Age term. Evans (1987a) and Kumar (1985) alternatively specify the dependent variable as the logarithmic growth rate, defined as the log of the end-of-period size minus the log of the initial size. This specification yielded qualitatively similar results in the sense that the elasticity of end-of-period size with respect to initial size is estimated as less than one.

[11] The F-statistic for inclusion of the squared terms of the logarithm of plant size and plant age, and the logarithm of the interaction of plant size and plant age is $F[3,686]=0.47$, which fails to reject the null hypothesis of no statistical significance for these terms at the 95% confidence level. Like Evans (1987b), we find significant multicollinearity problems with these quadratic terms and logarithm of plant size and plant age as well.

which was the last year the Japan Economic Institute collected and published these data.[12] Second, extending our growth period to years earlier than 1987 sacrifices many observations, since a substantial portion of Japanese investment in the United States did not occur until the middle 1980s.

3.1. Results from initial specification

Column 1 of Table 4 reports the estimates of Eq. (1) using our sample of all Japanese manufacturing affiliate plants in the United States as of 1987. We control for heteroscedasticity using White's correction. We also control for industry fixed effects and an F-test ($F[16,673]=3.65$) rejects the null hypothesis that the effect

Table 4
Determinants of Japanese majority-owned plant growth in US manufacturing industries, 1987–1990[a]

Regressors	Dependent variable: Firm growth rate, 1987–1990			
	(1) Full sample	(2) Acquired	(3) Greenfield	(4) Greenfield
Constant	0.954***	0.564	1.087***	1.002***
	(0.241)	(0.369)	(0.300)	(0.292)
Logarithm of 1987 plant size (measured in employees)	−0.130***	−0.102	−0.114**	−0.111**
	(0.046)	(0.080)	(0.054)	(0.054)
Logarithm of plant age	−0.146***	−0.037	−0.221***	−0.179***
	(0.032)	(0.031)	(0.053)	(0.051)
Dummy variable for joint venture with US firm	–	–	–	0.495
				(0.400)
Dummy variable for joint venture with US firm⊗ Logarithm of plant age	–	–	–	−0.354
				(0.229)
Industry dummies	Yes	Yes	Yes	Yes
F-test	4.45***	2.00***	2.87***	2.81***
R^2	0.11	0.11	0.12	0.13
Observations	692	301	391	391

[a] The dependent variable, firm growth rate, is defined as the change in plant-level employees from 1987 to 1990 divided by the plant-level employees in 1987. Industry dummies are defined at the two-digit Standard Industrial Classification (SIC) level and include SIC industries 20, 22–28, 30, and 32–38. There were no observations for SIC 21, 29 or 31, and SIC 39 was left out to avoid perfect multicollinearity of the industry dummies with the constant term. Robust White standard errors are reported in parentheses.

***, ** Indicate statistical significance at the 1 and 5% significance levels, respectively.

[12] Of course, examination of growth patterns of Japanese affiliates in the United States after 1990 would be of great interest. However, when the Japanese economy went into recession in the 1990s, the Japan Economic Institute was apparently affected financially. They collected some data for a new volume in the mid-1990s, but never were able to organize and publish the data.

of industry controls is insignificant at the 1% significance level.[13] In general, we found that controlling for these industry effects has a significant impact on the relationship between plant size and growth, as the coefficient on the logarithm of plant size is twice as large as when the industry controls are not included. Below we will test more specifically for differences in growth and deviations from Gibrat's Law that are related to industry characteristics.

Turning to our coefficients of interest, the coefficient on the log of firm size is −0.130 and statistically significant at the 99% confidence level. The magnitude of the deviation from Gibrat's Law is quite large. The point estimate suggests that if we double the size of the plant, it's 3-year growth rate falls by about nine percentage points. This is substantial, even for our sample where the average growth rate is 30% from 1987 to 1990. Controlling for plant size, there is a significant inverse relationship between plant age and plant growth as well. Doubling the age of the plant means a 10-percentage point drop in the plant's 3-year growth rate from 1987 to 1990. This suggests substantial learning effects for Japanese plants in the United States.

One issue commonly addressed in studies of Gibrat's Law is sample selection bias when exit is not modeled. The above results are obtained from the sample of 692 Japanese manufacturing plants that survived from 1987 to 1990. During that same period, 31 plants (less than 5%) exited from our sample. The obvious way to control for this potential bias is a sample selection correction following that of Hall (1987) and Evans (1987b). However, because of the small number of exits, there is no measurable impact on our coefficients in any of the results we report here when we estimate with a sample selection correction.

A second issue we explore with our initial specification is how the relationship between plant size and growth is affected by whether the plant was acquired or a greenfield establishment. Acquired plants are former domestically-owned plants, and thus, may not give a true indication of growth patterns of foreign-owned plants. In addition, there is evidence that establishment of greenfield operations may be for completely different reasons than for acquisitions, and this may impact the relationship between plant size and growth. For example, Kogut and Chang (1991), Yamawaki (1993), and Blonigen (1997) suggest that acquisitions by Japanese firms in the United States during this time period were largely motivated by Japanese firms' desires to gain access to US technology. The strength of our point estimates on plant age above are particularly surprising because, as constructed, age of *acquired* plants is calculated as the number of years the plant has been owned and controlled by the foreign firm, not years of existence. While

[13] Industry controls were defined by two-digit SIC, excluding SIC 39 (Miscellaneous manufacturing industries) to avoid perfect multicollinearity. In addition, no controls were included for SIC 21 (Tobacco products), SIC 29 (Petroleum and Coal Products), and SIC 31 (Leather and leather products) because there were no observations for those industries.

there must be some learning that occurs after a foreign owner acquires an existing plant, it seems plausible that it would be less than for a greenfield plant, since an acquired plant is more likely to have production, input suppliers, distribution networks, and customers in place.

To examine whether these issues impact our estimated relationship between plant size and plant age on growth, we split our sample and report separate estimates for greenfield and acquired plants in columns 2 and 3 of Table 4. Although there are comparable numbers of observations for both investment types, the negative correlation between plant size and growth is estimated much more precisely for greenfield plants than acquired ones. However, statistically one cannot reject that the estimates are the same. On the other hand, the estimated effect of the logarithm of plant age variable on growth is larger in absolute value with the greenfield sample and much smaller with acquired plants and statistically insignificant. A Wald test rejects the null hypothesis that the coefficients on log of plant age are statistically identical across acquired and greenfield plants at the 99% significance level.

3.2. Further examination of learning effects

3.2.1. The role of joint ventures

While the logarithm of plant age in our regressions is highly significant, and performs as one would expect if it correctly proxies for learning by plants, there are other sources of learning that we can test, given the characteristics of our sample. One factor that may play an important role in learning by foreign-owned affiliates is arrangements to jointly own a plant and produce with another firm. In our sample, 22% of the greenfield observations are joint ventures, and almost half of these are with a US firm as partner. In particular, firms may decide to partner with another firm, particularly a US one, so that the enterprise starts from a better understanding of its own efficiencies. In a sense, it can begin as a more experienced firm. This consideration suggests that Japanese plants that are joint ventures would experience lower growth and/or the effect of plant age on growth would not be as pronounced. On the other hand, a joint venture may be an investment by the Japanese parent firm that facilitates their ability to learn and grow more quickly in the market. This hypothesis is in the spirit of Cohen and Levinthal (1989) which finds that the process of R&D activity by itself (regardless of the innovation it produces) allows a firm to learn and assimilate information more quickly. Joint venture activity may have similar features, allowing these plants to learn and grow quicker. This latter argument, as opposed to the former, does not assume that the foreign partner immediately absorbs the partner's experience and information about the market, which may be more realistic.

To test the effect of joint venture activity, we include a dummy variable that takes the value of '1' if the plant is a joint venture with a US firm, and an interaction term with this dummy variable and the logarithm of plant age. We control for the effect of US joint ventures only, since our results for all joint ventures are qualitatively identical, but weaker statistically. Column 4 of Table 4 reports estimates from this specification, which show that there is no significant differences between joint ventures and other greenfield investment with respect to the effect on plant growth.

3.2.2. Firm-level learning through prior investments

Another potential source of learning for foreign affiliates is through prior investments by the parent firm in the market. Kogut and Chang (1996) find that previous investments by Japanese electronics firms in the US market makes future investments in the US market much more likely.[14] They see this as evidence that prior investments serve as 'platforms' for facilitating future investments. If prior investments make future plants more likely, it may mean these plants start with a better knowledge of their true efficiencies than otherwise would be true, and hence have lower rates of growth, controlling for size and age.

To examine this, we next focus on 1987–90 growth rates of new plants that were established in 1986 and 1987 and explore whether previous investments by the same parent firm mean slower growth rates. We restrict the sample to only new firms to avoid endogeneity bias. In particular, endogeneity bias occurs because older plants in our sample are often prior investment within the same firm to newer plants in our sample. One reasonable way to avoid this is to turn to simple cross-sectional data. However, we include observations from both 1986 and 1987 (rather than just 1987), because there are few instances of 1986 plants preceding 1987 plants for the same firm and this gives us a greater number of observations. Note that since these plants are all essentially new plants, we no longer include plant age as a regressor. Instead, we estimate Eq. (1) without the plant age term using this new sample and include a regressor to take into account previous experience of the plant's parent firm in the United States.

Column 1 of Table 5 reports estimates for this subsample of 1986–87 plants using Eq. (1) as our specification. We begin with this benchmark specification as a robustness check of our initial results with the full sample and find that we get an almost identical point estimate on the effect of plant size on plant growth. The rejection of Gibrat's Law holds. We next include the number of previous US plants established by the parent firm as a proxy for previous experience in the US market and expect a negative correlation. As column 2 of Table 5 reports, previous parent firm plants has the expected sign, but is not statistically significant at standard levels. Even if the coefficient were estimated with precision, it suggests a fairly small effect: even three prior plants by the parent firm would only reduce the

[14] This accords with other studies that found 'experience' effects at the firm level are important in understanding firm FDI entry decisions, including Yu (1990), Kogut and Chang (1991), Hennart and Park (1994), and Belderbos (1997).

Table 5
Determinants of Japanese majority-owned plant growth in US manufacturing industries, 1987–1990[a]

Regressors	Dependent variable: Firm growth rate 1987–1990	
	(1) 1986–87 Plants	(2) 1986–87 Plants
Constant	0.717**	0.712**
	(0.348)	(0.347)
Logarithm of 1987 plant size	−0.144*	−0.141*
(measured in employees)	(0.076)	(0.076)
Number of previous	–	−0.007
affiliates in the United States		(0.006)
Industry dummies	Yes	Yes
F-test	1.80**	1.71**
R^2	0.10	0.10
Observations	298	298

[5] The dependent variable, firm growth rate, is defined as the change in plant-level employees from 1987 to 1990 divided by the plant-level employees in 1987. Industry dummies are defined at the two-digit Standard Industrial Classification (SIC) level and include SIC industries 20, 22–28, 30, and 32–38. There were no observations for SIC 21, 29 or 31, and SIC 39 was left out to avoid perfect multicollinearity of the industry dummies with the constant term. Robust White standard errors are reported in parentheses.

**, * Indicate statistical significance at the 5 and 10% significance levels, respectively.

plant's 1987–90 growth rate by about two percentage points. We tried a variety of alternative measurements of previous experience, including (1) a dummy variable which takes the value of '1' if the parent firm had any previous experience, and (2) the number of prior plant years (not just plants) the parent firm had in the United States. These alternative measures yielded quite similar results. Thus, we find little evidence that prior experience by the parent firm generally affects plant growth of Japanese affiliates in the United States. These results in conjunction with the results we find with plant age, suggest that learning at the plant level, not the firm level, are important for plant-level growth.

3.3. The role of automobile-related plants

An important motivation for investment of many Japanese plants in our sample period was the significant location of automobile and automobile parts plants into the United States, presumably because of the voluntary export restraints on Japanese automobiles to the United States. About 13% of our observations can be classified as automobile-related. These plants had much higher growth rates than the other Japanese plants, as they 'ramped up' production in the United States during this period. In fact, when we eliminate these automobile-related plants, the average 3-year growth rate from 1987–90 in our sample drops from 30 to 17%. The average growth rate of the automobile-related firms over this period was more than 100%! Therefore, although we have included two-digit SIC industry dummies in our regression specifications (which are statistically significant controls), we examine the extent to which the automobile-related plants drive our results.

We first estimate Eq. (1) and include a dummy variable that takes the value of '1' if the plant is automobile-related, as well as interactions of this automobile-related dummy variable and the plant size and plant age variables. Column 1 of Table 6 reports results from this specification. The automobile-related variables are highly significant and the fit of the regression improves substantially from the initial estimation of Eq. (1). One implication of these estimates is that the deviation from Gibrat's Law is substantial for automobile-related firms, as evidenced by the regressor capturing the interaction between automobile-relatedness and plant size. In fact, the effect of plant size on plant growth is much more

Table 6
Determinants of Japanese majority-owned plant growth in US manufacturing industries, 1986–1987[a]

Regressors	Dependent variable: Firm growth rate, 1987–1990	
	(1) Full sample	(2) Plants, 1986–87
Constant	0.606***	0.996***
	(0.202)	(0.381)
Logarithm of 1987 plant size (measured in employees)	−0.081**	−0.207**
	(0.039)	(0.084)
Logarithm of plant age	−0.054**	–
	(0.025)	
Automobile-related plant	3.292***	1.479***
	(1.058)	(0.425)
Automobile-related plant⊗Logarithm of 1987 plant size	−0.476***	–
	(0.185)	
Automobile-related plant⊗Logarithm of plant age	−0.276**	–
	(0.136)	
Number of previous affiliates in the United States		−0.000
		(0.005)
Automobile-related plant⊗Number of previous affiliates in the United States		−0.249*
		(0.135)
Industry dummies	Yes	Yes
F-test	8.93***	3.86***
R^2	0.22	0.22
Observations	692	298

[a] The dependent variable, firm growth rate, is defined as the change in plant-level employees from 1987 to 1990 divided by the plant-level employees in 1987. Industry dummies are defined at the two-digit Standard Industrial Classification (SIC) level and include SIC industries 20, 22–28, 30, and 32–38. There were no observations for SIC 21, 29 or 31, and SIC 39 was left out to avoid perfect multicollinearity of the industry dummies with the constant term. Robust White standard errors are reported in parentheses.

***, **, * Indicate statistical significance at the 1, 5, and 10% significance levels, respectively.

significant for automobile-related firms than for non-automobile-related plants. Importantly though, the automobile-related plants are not driving our rejection of Gibrat's Law. The coefficient on the logarithm of plant size, which is capturing the effect of plant size on plant growth for non-automobile-related plants is still significantly negative, though somewhat smaller.

As with plant size, the effect of plant age on plant growth is also much more significant for automobile-related firms. However, these observations are also not driving the general results, in the sense that plant age still has a significant, though smaller, effect on firm growth for non-automobile-related firms as well. Thus, there is evidence that learning at the plant level (as proxied by age) was even more important for the automobile-related plants during our sample time period than for plants in other industries.

This result on learning carries through when we examine firm-level learning effects from the parent's previous experience in the United States. Column 2 of Table 6 presents results when we augment the specification in column 2 of Table 5 with a dummy variable for automobile-related plants and an interaction term between that dummy and the number of previous US plants by the parent firm. As before, this specification is run using only 1986–87 observations to avoid endogeneity bias between the dependent variable and the number of previous US plants variable. The results suggest that firm-level learning is also much more important for the automobile-related plants, as the interaction between the automobile-related dummy and number of previous US plants is significantly negative at the 90% confidence level. The results suggest that a previous investment by the Japanese firm in the US market reduces growth in an automobile-related plant by about 25 percentage points, but has no impact on non-automobile-related plants.

In summary, our general results are magnified by the automobile-related investment that occurred primarily in the last half of the 1980s. The automobile-related plants display a much larger deviation from Gibrat's Law and their growth rates are much more affected by plant- and firm-level learning effects. However, the effects of plant size and age across the entire sample are not generally affected.

Are these effects common to all products and industries subject to US protection? To investigate this, we performed similar regressions to those in Table 8 for products in (1) textiles and apparel, (2) steel, (3) machine tools, and (4) affirmative US antidumping investigations (including semiconductors and ball bearings among other products). The first three products were subject to voluntary restraint agreements (VRAs) with the United States during this time period, the last variable was defined to apply to any product that was subject to an affirmative antidumping investigation from 1980 through 1987. We find there are no significant effects related to learning effects with any of these products. In addition, the Japanese plants producing textiles/apparel or steel do not differ from other plants in terms of how plant size affects growth. On the other, hand, Gibrat's Law is *not* rejected for plants in machine tools. However, the deviation from

Gibrat's Law for plants involved in antidumping investigations show even larger deviations from Gibrat's Law than other plants, which mirror our results for automobile-related plants. Thus, the automobile-related effects do not seem generalizable to all industries in which Japanese firms were facing US protection during our sample. The next natural step is to examine the more general question of whether deviations from Gibrat's Law vary across industries in a way that is systematic to other observable industry characteristics.

3.4. Industry effects

Recent work by Audretsch (1995a,b), Audretsch and Mahmood (1995), Baldwin and Rafiquzzaman (1995), and others find evidence that industry characteristics can affect survival and growth in important ways.[15] These papers generally show that scale economies, capital intensity, and R&D/innovation activity, affect survival rates and subsequent growth rates of survivors. The evidence suggests that these entry barrier features tend to lead to lower survival rates, but faster growth rates of surviving firms. As Caves (1998) summarizes, these effects are consistent with the hypothesis that firms may purposely start out small in industries with high barriers, examine their returns, and then either exit with a small loss or grow rapidly to reach scale economies and other characteristics of a mature plant in the industry.

Analysis of these effects in our sample Japanese-owned affiliates is intriguing for a number of reasons. First, most of the plants in our sample are quite young, yet initial sizes tend to be large relative to the US industry average. Second, our analysis above for automobile-related plants and other sectors subject to US protection, found quite different deviations from Gibrat's Law which may be related to these industry characteristics. Finally, estimation of Eq. (1) by two-digit SIC industries shows substantial heterogeneity in the effect of initial plant size on plant growth. Table 7 shows the coefficient estimate on plant size from estimation of Eq. (1) on all two-digit SIC manufacturing industries for which we had at least 20 observations. Two industries, SIC 36 and 37, show large deviations from Gibrat's Law, which suggests that small firms in those industries grow substantially faster than large firms. At the same time, three other industries, SIC 20, 32, and 38, show statistically significant deviations from Gibrats Law that imply *larger* plants grow faster. Clearly, the restriction that deviations from Gibrat's Law are identical across industries is rejected.

To test more generally the role industry characteristics play in these differences, we estimate a variation of Eq. (1) that includes the logarithm of industry measures of scale economies, R&D intensity, advertising intensity, and capital intensity, as well as interactions of these four industry variables with the logarithm of plant

[15] A survey of these papers and related work is Caves (1998, pp. 1960–1961).

Table 7
Estimates of plant size on plant growth by two-digit SIC industry[a]

SIC	Industry description	Coefficient on plant size
20	Food and kindred products	0.011**
28	Chemicals and allied products	−0.053
30	Rubber and miscellaneous plastics products	−0.105
32	Stone, clay, and glass products	0.241*
33	Primary metal industries	−0.317
34	Fabricated metal products	0.100
35	Industrial machinery and equipment	0.042
36	Electronic and other electrical equipment	−0.497**
37	Transportation equipment	−0.324*
38	Instruments and related products	0.151*
39	Miscellaneous manufacturing industries	−0.028

[a] Estimates from separate regressions of Eq. (1) by industry. Only two-digit SIC industries with more than 20 observations are reported.

**, * Indicate statistical significance at the 5 and 10% significance levels, respectively, based on robust White standard errors.

size.[16] The industry-characteristic regressors test for independent effects of these characteristics on growth for the sample in general, whereas the interaction terms examine the role of these characteristics in deviations from Gibrat's Law. In other words, one can think of the coefficient on the interaction terms as examining whether these industry characteristics affect growth by small plants differently than growth by larger plants.

Column 1 of Table 8 reports estimates from a specification that includes the logarithm of the industry-specific characteristics, whereas column 2 of Table 8 reports estimates when we also include interactions of these industry characteristics with the logarithm of initial plant size. Column 1 results show that all industry-specific characteristics have an estimated positive coefficient, though only capital intensity is estimated with precision. Positive coefficients on these proxies for entry barriers is consistent with previous work (e.g. Audretsch, 1995a,b; Baldwin and Rafiquzzaman, 1995) showing these factors increase surviving firms' growth.[17]

[16] Our measure of scale economies is the average size of US plants in the associated four-digit industry in 1987 which comes from the *Census of Manufactures*. Following Audretsch (1995a), we construct capital intensity as the average gross assets per employee in the associated four-digit US SIC industry, which also is taken from the *Census of Manufactures*. R&D intensity (R&D expenditures as a percentage of sales) by industry for 1987 comes from data published by the National Science Foundation. Finally, advertising intensity by industry (advertising expenditures as a percentage of sales) comes from the 1977 Census publication.

[17] As discussed above, these previous studies also find that these barriers make survival less likely. Because our sample has few exits, one can think of our sample as one of surviving plants.

Table 8
Determinants of Japanese majority-owned plant growth in US manufacturing industries, 1987–1990[a]

Regressors	Dependent variable: Firm growth rate, 1987–1990	
	(1) Full sample	(2) Full sample
Constant	0.390	−0.935
	(0.280)	(0.697)
Logarithm of 1987 plant size (measured in employees)	−0.149***	0.150
	(0.050)	(0.141)
Logarithm of plant age	−0.160***	−0.167***
	(0.035)	(0.035)
Logarithm of minimum efficient scale	0.085	0.595***
	(0.062)	(0.228)
Logarithm of R&D intensity	0.115	0.661
	(0.167)	(0.600)
Logarithm of advertising intensity	0.010	−0.035
	(0.022)	(0.070)
Logarithm of capital intensity	0.133**	−0.170
	(0.057)	(0.291)
Logarithm of minimum efficient scale⊗	–	−0.117***
Logarithm of 1987 plant size		(0.042)
Logarithm of R&D intensity⊗	–	−0.020
Logarithm of 1987 plant size		(0.017)
Logarithm of advertising intensity⊗	–	0.012
Logarithm of 1987 plant size		(0.016)
Logarithm of capital intensity⊗	–	0.075
Logarithm of 1987 plant size		(0.065)
Industry dummies	Yes	Yes
F-test	3.47***	3.07***
R^2	0.12	0.14
Observations	692	692

[a] The dependent variable, firm growth rate, is defined as the change in plant-level employees from 1987 to 1990 divided by the plant-level employees in 1987. Industry dummies are defined at the two-digit Standard Industrial Classification (SIC) level and include SIC industries 20, 22–28, 30, and 32–38. There were no observations for SIC 21, 29 or 31, and SIC 39 was left out to avoid perfect multicollinearity of the industry dummies with the constant term. Robust White standard errors are reported in parentheses.

***, ** Indicate statistical significance at the 1 and 5% significance levels, respectively.

Column 2 of Table 8 tests whether these industry-specific characteristics are more important for smaller firms' growth by including interaction terms. The negative coefficient on the interaction terms of scale economies and R&D intensity with initial plant size in column 2 of Table 8 support the notion that these factors affect smaller plants' growth to a greater degree. In particular, it suggests that surviving smaller firms in industries with substantial scale economies (and possibly R&D intensity) must grow rapidly relative to larger firms in the industry.

Thus, these results show some support for the notion that industry factors that affect entry and survival, also may have implications for growth dynamics. These conclusions are tempered somewhat by the relative imprecision of our estimates on the industry-specific characteristics and their interactions with initial plant size. In addition, we note that the two-digit industry dummies continue to be highly statistically significant in the regressions reported in Table 8, suggesting that there are many unobserved industry-specific effects that affect plant growth and for which we cannot account. At the very least, this suggests that further analysis in this area would be useful.[18]

4. Conclusion

This paper examines plant growth and the plant size of Japanese manufacturing plants in the United States. Previous studies have found sizeable differences between operating characteristics of foreign affiliates and domestically-owned plants, yet there has been little or no examination of growth patterns of foreign-owned plants. Our sample consists of Japanese-owned manufacturing plants in the United States which are much larger, grow much faster, and exit less often than comparable US domestic-owned plants. Despite this, our estimates suggest that plant size and age have proportionally similar effects on plant growth to those found by previous studies of mainly domestic-owned firms and plants. Even for this unique database, Gibrat's Law does not hold and the evidence suggests that smaller plants grow faster the larger ones. At the same time, we find learning effects, proxied by plant age and previous US investment experience by the Japanese parent firm, are substantial, particularly for the automobile-related firms. Similar to previous work we also find evidence that industry factors (particularly, significant economies of scale) lead us to observe surviving plants growing faster, especially ones that start as relatively small operations.

The growing role of foreign affiliate activity in the United States and other countries makes the analysis of these issues important. The studies in Baldwin et al. (1998) point out that activities of multinational firms are significant and growing in the world economy, yet the available data make it often difficult to assess the economic importance of these firms on home and host countries. While our paper is one step toward some understanding of these issues, there are more steps that need to be taken in these directions.

[18] We also included the four-firm concentration ratio and innovation intensity (the latter variable, defined as innovations per thousand employees, follows Audretsch (1995a,b)) as industry-specific variables which had no significant impact on plant growth in our regressions. These variables were also substantially correlated with our other industry-specific variables, so we do not include them in the regressions we report here.

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