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ABSTRACT

Using a unique database on all Japanese manufacturing plants in the United States, we examine the relationship between plant size and growth for these foreign-owned plants. These plants average sizes are three times larger than comparable U.S. plants and experienced 30 percent growth from 1987 through 1990, while U.S. average plant sizes declined over the same period. Our estimates strongly reject Gibrat's Law for these plants, and suggest that smaller plants grow faster. We also find learning affects plant-level growth. Newer 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.

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1. Introduction

In the early 1930s, Robert Gibrat developed the hypothesis that the distribution of plant sizes in manufacturing are log normal, and showed this using data on 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;1987b), 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 U.S. firms, while the studies by Dunne et al. examine U.S. 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 Jovanovic's (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

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

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 (such as 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 (1996) 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, even after controlling for 4-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 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 U.S. manufacturing has nearly quadrupled over the period from 1977 to 1994, growing from 3.7 percent to 13.4 percent (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 U.S. published by the Japan Economic Institute. 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 U.S. firms previously examined. In particular, they have average sizes that are substantially larger than U.S. domestic-owned plants in the same 4-digit SIC industry and averaged 30 percent 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 U.S. 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 U.S. 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.

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[2] In comparison, employee growth across all manufacturing plants in the U.S. declined from 1987-92 by eight percent.

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 three years old and has a three-year growth rate of thirty percent. Our estimates imply that a six-year-old plant's three-year growth rate is only twenty percent. 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 effects. We find joint venture partnering with U.S. 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.

Finally, we 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 percent three-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.

2. Size and growth of Japanese manufacturing subsidiaries 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 subsidiary plants located in the United States using a data set established and published by the Japan Economic Institute beginning in 1980 and updated semiannually through 1990. These data were collected through surveys of all known Japanese plants in the United States and include information on 1) subsidiary 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 4-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 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 U.S. 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 U.S. 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

[3] The data are published in *Japan's Expanding U.S. Manufacturing Presence*. Washington, DC: Japan Economic Institute (JEI), various issues. 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.

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

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 U.S. plant size, and growth rates of Japanese affiliate plants from 1987 through 1990 by 2-digit manufacturing SIC industries. Throughout this paper, we only consider majority-owned affiliates.[5] Japanese plants are represented in almost every industry, with large numbers 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 U.S. industry counterparts. In fact, the ratio of 1987 employees in a Japanese plant to that of a U.S. 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 U.S. firms: the average Japanese plant has 179.8 employees, while the average U.S. plant has 51.4 employees. While this is a very large difference, it is similar to the size difference between all U.S. foreign subsidiaries and counterpart U.S.-owned plants. Howenstine and Zeile (1992) show that the 1987 ratio of average employee levels in all foreign-owned plants to all U.S. plants in the United States is

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[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.

slightly over three (160.9 average employees for U.S. foreign subsidiaries versus 51.4 for all U.S. plants).

While employee sizes of Japanese subsidiary plants relative to U.S. 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 percent 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 percent in a number of industries, with an average growth rate of 30 percent across all manufacturing sectors.

This growth pattern in Japanese subsidiaries, as with size, is quite different from U.S. 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 percent decrease. Negative growth rates in U.S. plant size is 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 U.S. trend. It also contrasts with average growth in plant employees for all foreign-owned establishments, which was 4.7 percent from 1987-1990 (160.9 employees per plant in 1987 to 168.4 employees).[7]

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

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 percent) 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 U.S. 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 six years of plant life.

3. Determinants of plant growth

We next turn to 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 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. After examining this question, the latter part of this section then examines the effect of learning on plant-level growth for these Japanese-owned affiliates. This is an important issue for our sample as well, since foreign-owned plants likely face steep learning curves across a number of dimensions when operating in foreign markets.

We begin our examination of growth in Japanese affiliates by testing a common form of Gibrat's law[8]:

$$\text{Growth Rate} = \alpha + \beta_1 \text{Log(Plant Size)} + \varepsilon \qquad \textbf{(1)}$$

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, and ε is a classical error term. If Gibrat's Law holds, then β_1 should equal zero. Table 3 gives summary statistics of growth rates and logarithm of plant sizes for our sample of Japanese majority-owned affiliates. Our choice to focus on growth from 1987 to 1990 was motivated by data considerations. First, our data set ends in 1990, which was the last year the Japan Economic Institute collected and published these

[8] Our specification follows Hall (1987) and Acs and Audretsch (1990). 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.

data.[9] 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.

Column 1 of table 4 reports our results from testing equation (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. The coefficient on the log of firm size is -0.072 and statistically significant at the 95 percent confidence level. The magnitude of the deviation from Gibrat's Law is quite large as well. The point estimate suggests that if we double the size of the plant, it's 3-year growth rate falls by about 5 percentage points. This is substantial, even for our sample where the average growth rate is 30 percent from 1987 to 1990.

Hall (1987) includes industry fixed-effects and finds they are statistically significant in her sample, while Evans (1987a) finds significant differences in the relationship between growth and firm size across manufacturing industries. Our sample spans a wide array of manufacturing industries, so column 2 of table 4 reports results from testing equation (1) when we include industry fixed effects.[10] An F-test ($F[16,673]=3.65$) rejects the null hypothesis that the effect of industry controls is insignificant at the one percent significance level. Controlling for industry effects also has a significant impact on the relationship between plant size and growth, as the

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[9] 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.

[10] Industry controls were defined by 2 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.

coefficient on the logarithm of plant size doubles.

Another 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 percent) exited from our sample, as noted above. 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.[11]

A final 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, Yamawaki (1993), Kogut and Chang (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 U.S. technology. To examine whether these issues impact our estimated relationship between plant size and growth, we split our sample and report separate estimates for greenfield and acquired plants in columns 3 and 4 of table 4. Although there are comparable numbers of observations for both investment types, the negative correlation between plant size and growth is

[11] Quadratic terms were also important in the studies by Hall (1987) and Evans (1987b). F-tests rejected inclusion of quadratic terms in all our specifications reported here.

estimated much more precisely for greenfield plants than acquired ones. However, statistically one cannot reject that the estimates are the same.

3.1. The effect of firm age

Evans (1987a;b) introduced consideration of firm age in the examination of firm growth and size. His studies find a significant inverse relationship between age and firm growth across a wide variety of sample firms. 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 may be a particularly 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 U.S. 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. A 1993 *Wall Street Journal* article details a number of such difficulties between German managers and U.S. workers:

> "Manfred Baumann, the chief engineer for Baker Material Handling [a German subsidiary in South Carolina], recalls that his workers once left a critical component out of the final blueprints for a product; it turned out they had assumed there would be built-in opportunities for fixing mistakes and lapses. 'I've learned I have to give them more detailed instruction than I have to give in Germany,' he says." (WSJ, May 4, 1993, p. A1;1)[12]

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 U.S. puts them in a market far from their own suppliers in Japan, and close to potential U.S. suppliers that were not accustomed to this system. Numerous Japanese auto part's firms eventually located in the U.S., however, a couple years after the initial auto plants began operations. These issues suggest that the learning process may be even more important for understanding growth of foreign affiliate plants than domestic plants. In fact, 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.

We begin our exploration of learning on growth in our sample of Japanese manufacturing affiliates by following Evans (1987a;b) and including plant age in our specification:

$$\text{Growth Rate} = \alpha + \beta_1 \text{Log(Plant Size)} + \beta_2 \text{Log(Plant Age)} + \varepsilon \qquad \textbf{(2)}$$

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[12] The article also discusses two other examples of cultural miscommunication. One day the German managers at Baker Material Handling thought they had a labor problem when many workers called in sick. They subsequently learned it was the opening of hunting season. The article also describes the negative effect on U.S. worker morale of German managers keeping their office doors closed, as is custom in Germany to conserve heat, and the subsequent steps taken by the managers to change this policy.

where Plant Age is measured in years. Evan's specifications often include quadratic terms for 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.[13] Summary statistics for the logarithm of plant age can be found in table 3. Column 1 of table 5 reports estimates using equation (2) specification on our full sample of Japanese manufacturing affiliates. Controlling for plant size, there is a significant inverse relationship between plant age and growth. Doubling the age of the plant means a 10 percentage point drop in the plant's 3-year growth rate from 1987 to 1990.

The strength of our point estimates on plant age above are surprising in some respects, 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 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. Because of these concerns, we next estimate equation (2) using separate samples of greenfield and acquired observations in our sample, which are reported in columns 2 and 3 of table 5. As expected, the estimated effect of the logarithm of plant age variable 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

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[13] 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 percent confidence level. Like Evans(1987b), we find significant multicollinearity problems with these quadratic terms and logarithm of plant size and plant age as well.

that the coefficients on log of plant age are statistically identical at the 99 percent significance level.

3.2. 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 plausible proxies for plant-level learning that we draw on from our sample data. In this section we briefly explore the role of joint ventures on learning. In our sample, 22 percent of the greenfield observations are joint ventures, and almost half of these are with a U.S. firm as partner. Joint ventures may have an impact on plant-level learning and growth. In particular, firms may decide to partner with another firm, particularly a U.S. 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 would suggest that joint ventures would experience lower growth and/or the effect of plant age on growth would not be as pronounced. To test both of these potential effects, we include a dummy variable that takes the value of "1" if the plant is a joint venture with a U.S. firm, and an interaction term with this dummy variable and the logarithm of plant age. We control for the effect of U.S. joint ventures only, since our results for all joint ventures are qualitatively identical, but weaker. This is expected, since a Japanese firm will likely learn more about their efficiencies in the U.S. market by partnering with a U.S. firm than with another foreign firm. Column 4 of table 5 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. Thus, joint ventures are unlikely to be a significant way for plants to learn more quickly.

3.3. Evidence of firm-level learning and plant growth

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 U.S. market makes future investments in the U.S. 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, 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 equation (1) 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 6 reports estimates for this subsample of 1986-87 plants using equation

[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), Chang and Kogut (1993), Hennart and Park (1994), and Belderbos (1997).

(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 U.S. plants established by the parent firm as a proxy for previous experience in the U.S. market and expect a negative correlation. As column 2 of table 6 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 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.

3.4. The role of automobile-related plants

An important motivation for investment of many Japanese plants during our sample 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 percent of our observations are ones that we can classify 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 three-year growth rate from 1987-90 in our sample drops from 30 percent to17 percent. The average growth rate of the automobile-related firms over this period was more than 100 percent! Therefore, although we have included 2-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 equation (1) and include a dummy variable that takes the value of "1" if the plant is automobile-related and a variable that interacts this dummy with the other variable of interest, the logarithm of plant size. Column 1 of table 7 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 equation (1). The implication of these estimates is the deviation from Gibrat's Law is substantial for automobile-related firms, as evidenced by the interaction term. In fact, the effect of plant size on plant growth is much more 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.

A similar story is true when we add a dummy variable for automobile plants and interaction terms when estimating equation (2). These results are reported in column 2 of table 7. As with plant size, the effect of plant age on plant growth is much more significant for automobile-related firms. However, these observations are 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 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 3 of table 7 presents results when we augment our specification in column 2 of table 6 with a dummy variable for automobile-related plants and an interaction term between that dummy and the number of previous U.S. 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 U.S. 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 U.S. plants is significantly negative at the 90 percent confidence level. The results suggest that an additional plant 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 strongly 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 U.S. 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 U.S. 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 U.S. protection during our sample.

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 domestically-owned plants, yet there has little or no examination of growth patterns of foreign-owned plants. Our sample of Japanese plants are much larger, grow much faster, and exit less often than domestic plants, yet our estimates suggest that plant size and age have proportionally similar effects on plant growth to those found by previous studies of mainly domestic firms and plants. Even for this unique data set, 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 U.S. investment experience by the

Japanese parent firm, are substantial, particularly for the automobile-related firms.

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.

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Table 1. Japanese majority-owned affiliate plant sizes for 1987, average U.S. plant size for 1987, and 1987-90 growth rates of Japanese majority-owned affiliate plants by 2-digit manufacturing SIC industries.

SIC	Industry Description	Number of Plants	Average Plant Size, 1987 (employees)	Employee Growth, 1987-90 (in percent)	U.S. 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

Table 2. 1987-90 Employee Growth of Japanese Subsidiaries, by Age.		
Age (in Years)	**Number of Plants**	**1987-90 Growth Rate (Percent)**
1-3	356	42.4
4-6	91	35.5
7-9	107	8.7
10+	134	4.9
Total	688	28.9

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

Table 4. Plant size and growth for Japanese majority-owned plants in U.S. manufacturing industries.[a]				
	Dependent Variable: Firm Growth Rate, 1987-1990			
Regressors	**(1) Full Sample**	**(2) Full Sample**	**(3) Greenfield**	**(4) Acquired**
Constant	0.613*** (0.181)	0.793*** (0.232)	0.817*** (0.278)	0.556 (0.372)
Logarithm of 1987 Plant Size (measured in employees)	- 0.072** (0.035)	- 0.145*** (0.047)	- 0.147*** (0.056)	- 0.106 (0.078)
Industry Dummies	No	Yes	Yes	Yes
F-Test	5.24**	3.79***	2.16***	2.09***
R^2	0.01	0.06	0.05	0.05
Observations	692	692	391	301

[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 2-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. In addition, SIC 26 was left out for the sample with only acquired plants because there were no observations. Robust White standard errors are reported in parentheses, and ***, **, and * indicate statistical significance at the 1, 5, and 10 percent significance levels respectively.

Table 5. Determinants of Japanese majority-owned plant growth in U.S. manufacturing industries, 1987-1990.[a]

	Dependent Variable: Firm Growth Rate, 1987-1990			
Regressors	**(1) Full Sample**	**(2) Acquired**	**(3) Greenfield**	**(4) Greenfield**
Constant	0.954*** (0.241)	0.564 (0.369)	1.087*** (0.300)	1.002*** (0.292)
Logarithm of 1987 plant size (measured in employees)	- 0.130*** (0.046)	- 0.102 (0.080)	- 0.114** (0.054)	- 0.111** (0.054)
Logarithm of plant age	- 0.146*** (0.032)	- 0.037 (0.031)	- 0.221*** (0.053)	- 0.179*** (0.051)
Dummy variable for joint venture with U.S. firm				0.495 (0.400)
Dummy variable for joint venture with U.S. firm q 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 2-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, and ***, **, and * indicate statistical significance at the 1, 5, and 10 percent significance levels respectively.

Table 6. Determinants of Japanese majority-owned plant growth in U.S. manufacturing industries, 1987-1990.[a]

	Dependent Variable: Firm Growth Rate, 1987-1990	
Regressors	**(1) 1986-87 Plants**	**(2) 1986-87 Plants**
Constant	0.717** (0.348)	0.712** (0.347)
Logarithm of 1987 plant size (measured in employees)	- 0.144* (0.076)	- 0.141* (0.076)
Number of previous affiliates in the United States		- 0.007 (0.006)
Industry Dummies	Yes	Yes
F-Test	1.80**	1.71**
R^2	0.10	0.10
Observations	298	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 2-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, and ***, **, and * indicate statistical significance at the 1, 5, and 10 percent significance levels respectively.

Table 7. Determinants of Japanese majority-owned plant growth in U.S. manufacturing industries, 1986-1987.[a]

	Dependent Variable: Firm Growth Rate, 1987-1990		
Regressors	**(1) Full Sample**	**(2) Full Sample**	**(3) Plants, 1986-87**
Constant	0.551*** (0.348)	0.606*** (0.202)	0.996*** (0.381)
Logarithm of 1987 plant size (measured in employees)	- 0.088** (0.076)	- 0.081** (0.039)	- 0.207** (0.084)
Logarithm of plant age		- 0.054** (0.025)	
Automobile-related plant	3.389*** (1.068)	3.292*** (1.058)	1.479*** (0.425)
Automobile-related plant q Logarithm of 1987 plant size	- 0.518*** (0.188)	- 0.476*** (0.185)	
Automobile-related plant q Logarithm of plant age		- 0.276** (0.136)	
Number of previous affiliates in the United States			- 0.000 (0.005)
Automobile-related plant q Number of previous affiliates in the United States			- 0.249* (0.135)
Industry Dummies	Yes	Yes	Yes
F-Test	9.29***	8.93***	3.86***
R^2	0.21	0.22	0.22
Observations	692	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 2-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, and ***, **, and * indicate statistical significance at the 1, 5, and 10 percent significance levels respectively.