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Agglomeration and Industrial Location: An Econometric Analysis of Japanese-Affiliated Manufacturing Establishments in Automotive-Related Industries*

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This paper examines the role of a particular type of agglomeration, the co-location of backward- and forward-linked manufacturing enterprises, in the process of industrial location. It does so by an econometric analysis of Japanese-affiliated manufacturing establishments in automotive-related industries. We advance the hypothesis that proximity to Japanese-affiliated automotive assemblers is the major consideration in the choice of location by Japanese-affiliated automotive suppliers and related manufacturing establishments. We develop econometric models to test this hypothesis in light of a series of measures of agglomeration and other area characteristics such as manufacturing density, unionization, wages, minority concentration, and taxes. The empirical findings confirm this hypothesis. Japanese automotive-related manufacturing establishments reveal a preference for locations in close proximity to Japanese automotive assemblers, with larger populations, a higher manufacturing density, a more educated work force, and better transportation. Furthermore, in contrast to the prevailing literature, Japanese automotive-related manufacturing establishments are found to prefer locations with higher wages and higher concentrations of minorities.

I. INTRODUCTION

Since Marshall [35], economists and geographers have noted the presence of agglomeration or localization economies, a form of external scale economy, in the location and organization of industrial activity (Thompson [39], Walker [43]). Broadly defined, agglomeration refers to the positive

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externalities and economies of scale and scope associated with regional concentration of economic activities, and co-location of related production facilities. Kaldor [28] defined agglomeration as "the existence of increasing returns of scale in processing activities. . . . These are not just the economies of large scale production but the cumulative advantages accruing from the growth of industry itself—the development of skill and know how; the opportunities for easy communication of ideas and experience; the opportunity of ever increasing differentiation of processes and of specialization in human activities." Beeson [11] notes the relationship between agglomeration and productivity growth. Krugman [30, 31] has made a strong case for agglomeration and concentration of industrial activity based on increasing returns and simple pecuniary externalities (also see David and Rosenbloom [17]). Arthur [5, 6] has argued that locational clusters are likely outcomes, given increasing returns, historical cumulation or "path dependence," and locational "lock in." Jaffe [26] has shown the productivity effects that come from geographic proximity.

This article explores the role of a special kind of agglomeration economy—the co-location of backward- and forward-linked manufacturing enterprises—in the process of industrial location. It does so by examining the role of proximity of end-users and suppliers in the location of Japanese-affiliated automotive-related establishments in the United States. The central hypothesis is that location in close proximity to Japanese automotive assembly establishments in the United States is a key determinant of the location of Japanese-affiliated manufacturing establishments in automotive-related industries. This agglomeration preference derives from the underlying organizational and production structure of the Japanese manufacturing system, which favors an agglomerated production complex based upon close proximity between assemblers and their component parts suppliers (Aoki [2–4]; Asanuma [7–9]; Dore [18]). We thus conceptualize industrial location as a constrained choice process which is influenced by the organization of production at the firm and inter-firm levels.

The research presented here tests this hypothesis by implementing econometric models of the industrial location of Japanese-affiliated manufacturing establishments in the automotive-related industries, including automotive component parts, steel production, finishing and processing, and rubber and tire manufacturing. The models are designed to test this hypothesis in light of a series of measures of agglomeration and other location factors, such as manufacturing density, unionization, wages, minority concentration, and tax rates, at various geographic scales. The empirical results confirm the hypothesis that agglomeration, or more specifically co-location of end-users and suppliers, is significant in the location of Japanese-affiliated automotive-related manufacturing establishments. The empirical results add to our understanding of other eco-

nomic and demographic factors which affect the location of Japanese-affiliated manufacturing establishments.

II. CONCEPTS, HYPOTHESES, AND VARIABLES

Our approach builds on the prevailing approaches to location modeling, which offer empirical estimates of industrial location as a function of selected area characteristics (Coughlin *et al.* [15]; Luger and Shetty [32]; Bartik [10]; Woodward [45]). Econometric models treat the location decisions as a form of revealed preference for the locational attributes of a given area. Bartik's [10] research on manufacturing branch plants found greater land area, lower wages, a lower rate of unionization, and better highway access to be area characteristics that are positively related to manufacturing plant location. Luger and Shetty's [32] research on foreign direct investment found that foreign manufacturing establishments prefer areas with a relatively high manufacturing density and low wages. Glickman and Woodward [22] found that foreign manufacturers in the United States serve regional markets, and that the effect of market pull outweighed other factors in the growth of foreign affiliate employment. Coughlin *et al.* [15] found that the number of foreign direct-manufacturing establishments (at the state level) is related to greater land area, lower wages, higher personal incomes, higher unemployment, lower taxes, transportation infrastructure, higher manufacturing intensity, and higher state expenditures on business promotion.

While the literature largely conceptualizes industrial location as a process of unconstrained "environmental scanning" and location choice, we conceptualize the location process as a constrained optimization problem, where the constraint is the economic benefits of agglomeration, in particular, the proximity requirement for just-in-time production. As noted above, our central hypothesis is that the imperatives to suppliers to choose locations in close proximity to the "hub" assembly establishments exert a strong positive influence on the location of Japanese-affiliated automotive manufacturing establishments.

Dependent Variable

The dependent variable in the models is the number of Japanese-affiliated automotive-related manufacturing establishments in a given county. This includes Japanese-affiliated manufacturing establishments in the automotive component parts supply, steel production, finishing and processing, and rubber and tire sectors. The location decisions of Japanese-affiliated automotive assembly establishments are not included in the dependent variable. These assembly establishments represent the focal point or hub of the agglomeration and create the demand pull which draws other automotive-related establishments into the agglomeration.

Indeed, our analysis of the start-up dates for Japanese automotive-related establishments in the United States indicates that other automotive-related establishments have largely followed the initial location decisions of Japanese-affiliated automotive assemblers. The location of Japanese automotive-assemblers informs the construction of key independent variables in the model.

The dependent variable is constructed from a comprehensive database on the location of Japanese automotive-related manufacturing establishments compiled by Florida and Kenney [19, 20]. The database includes information on more than 400 Japanese automotive-related establishments including 315 automotive component parts suppliers, 69 steel establishments, and 20 rubber and tire establishments. These automotive-related establishments are concentrated in the following states: Ohio (76), Indiana (50), Michigan (49), Kentucky (45), Tennessee (36), Illinois (32), and California (25). Each of these states is also home to at least one Japanese-affiliated automotive assembly plant. Note that Texas is the next highest state with 11 Japanese-affiliated automotive-related establishments.

The database is based upon information from the Japan Economic Institute, U.S. Department of Commerce, Japanese External Trade Research Organization (JETRO), trade journal, industry, and other sources, and a mail survey of state development agencies. This database represents the entire population of Japanese automotive-related manufacturers and is arguably the most complete dataset on Japanese manufacturing establishments in automotive-related industries. The majority of Japanese automotive-related manufacturing establishments in the data represent new establishment start-ups. However, a non-trivial number are the result of acquisitions, or are joint ventures with U.S. companies. The models are run both for the location decisions of all Japanese-affiliated manufacturing establishments (ESTAB) and for new establishments (NEWESTAB) which more accurately capture new location choices.

Independent Variables

The independent variables in the models include agglomeration measures, e.g., proximity to Japanese-affiliated assembly establishments, and a range of socioeconomic and policy variables which the literature suggests are important to industrial location decisions, such as manufacturing employment, unionization, education, population size, population density, minority concentration, transportation access, and tax rate variables (see Table 1).

The literature on Japanese manufacturing in the United States suggests that Japanese manufacturing establishments tend to locate in rural, "green-field" sites, avoid unions, and avoid areas with significant minority populations. Yoshida [46] found that the locaton of Japanese manufactur-

ing establishments in the United States was most strongly affected by labor quality, market access, and unionization. Glickman and Woodward [22] found that foreign manufacturing establishments are attracted to the Sunbelt states. Cole and Deskins [14] found that Japanese automotive establishments tend to locate in areas with lower minority concentrations than comparable U.S.-owned assembly establishments and that the percentage of minority employees in Japanese automotive establishments was on average significantly less than the minority share in the surrounding labor market. Glickman *et al.* [23] found that labor costs, transportation, access to markets, and quality of life variables were the most important factors in the location decisions of foreign-affiliated manufacturing establishments in the United States.

Agglomeration. The literature on Japanese industrial organization suggests that agglomeration is a defining element in the organization and effectiveness of Japanese firms and industries. Both the economics and geography literatures suggest that spatial agglomeration plays a significantly greater role in the industrial location and site selection of Japanese manufacturing establishments than in U.S. establishments in similar industries (Aoki [3, 4]; Sheard [38]; Florida and Kenney [20]). Aoki [3] emphasized the role of the just-in-time system of supply and delivery which is based upon geographic proximity, tight customer–supplier linkages, and long-term, interactive business relationships in Japanese industrial organization. Building upon Williamson [44], Dore [18] contrasted the "relational contracting" of Japanese industry to the pure price contracts found in U.S. industry.

Research by Aoki [3], Asanuma [7–9], and others (Odaka *et al.* [36]; Sako [37]) suggests that the tightly clustered just-in-time supplier structure creates significant production efficiencies by reducing both the real and transactional costs related to transportation, communication, and information transfer between and among establishments. Recent research indicates that Japanese automotive manufacturers in the United States are recreating just-in-time production agglomerations similar to those found in Japan (Mair *et al.* [34]). Survey research by Florida and Kenney [19, 20] found that proximity to customers was the main factor in the location decisions of Japanese automotive component parts suppliers in the United States, followed by transportation, labor skills and attitudes, unionization, and labor costs.

The variable used in the present paper to capture the effect of proximity between end users and suppliers is MINDIST, measured as the straight-line distance of a given county to the nearest Japanese automotive assembly plant (transplant assemblers). Straight-line distance measures are used due to difficulty obtaining the actual highway distances. The predicted sign

for this variable's coefficient is negative, representing the increased costs associated with greater distance as well as the diminishing benefits of co-location.

A secondary measure of the effect of co-location is the proximity to "Big Three" automotive assemblers. While the primary market for Japanese-affiliated, automotive-related manufacturers is presumed to be the Japanese automotive assembly establishments, the domestic assembly plants of GM, Ford, and Chrysler represent an additional potential market. Thus, while the effect is likely to be less important, proximity to Big Three assembly plants is expected to have a positive effect on the location of Japanese automotive-related manufacturers. The variable used to capture this effect is the number of Big Three assembly plants within 250 miles of a given county (BIG3).

Manufacturing density. Previous research (Coughlin *et al.* [15]; Luger and Shetty [32]; Woodward [45]) has found that manufacturing density (the percentage of the population employed in manufacturing establishments) is positively related to the industrial location of foreign direct investment at the state level. The existing manufacturing base provides an important "infrastructure" which is attractive to new plant start-ups. Manufacturing density is seen to attract foreign establishments in that it provides a base of manufacturing suppliers, vendors, technology, and skills required for advanced industrial production.

We include a manufacturing intensity variable (MANUF), measured as the percentage of a county's labor force that is employed in manufacturing industries. Higher specialization in manufacturing is expected to convey benefits to Japanese manufacturing establishments, in the form of specialized business services, human capital, and institutional structures. Thus, the expected sign on the coefficient for this variable is negative.

Urbanization. Urbanization effects have been an important component of the debate on industrial location, with no real consensus emerging. On one hand, urbanization economies can yield positive external benefits to establishments located in urbanized areas in the form of economies of scope, spillovers, better developed infrastructure, and specialized business services. On the other hand, increasing urbanization often leads to higher factor costs associated with brown-field sites, higher wages, higher levels of unionization, and greater social problems. The conventional wisdom and much of the literature on Japanese investment hold that Japanese establishments have a preference for rural, green-field locations that yield lower factor costs and more docile, malleable labor forces. However, the information-intensive nature of the Japanese production system seems ideally suited to exploit urbanization economies. Hence, the net effect of urbanization remains open to question.

There are two components to our measure of urbanization. The first is county population size (POP). This reflects the increasing returns to scale argument of agglomeration advantages. Population size is related to the industrial location process in that it is a proxy measure for the size of the labor pool. The second measure is county population density (DENSITY), which represents the geographic concentration of population. Population density reflects the degree of urbanization or concentration of population within the county.

Transportation. Industrial geography has traditionally suggested that transportation access to raw materials and to markets is the central element in the location process (see Walker [43] for a review). Recent conceptual and empirical research suggests that the importance of transportation has diminished due to the rise of new industries and new transportation and communication technologies, and the attendant globalization of economic activity (Glickman and Woodward [21]). However, the literature on Japanese industry suggests that transportation plays a significant role in the just-in-time production system, which emphasizes frequent deliveries and communication between suppliers and end users (Aoki [3]; Asanuma [7–9]; Sheard [38]). Previous research on the location of Japanese automotive assemblers and automotive component parts suppliers further indicates that they tend to cluster near major interstate highways, (Mair *et al.* [34]).

The measure of transportation utilized in the model (TRANS) is a dummy variable indicating whether or not a county is served by an interstate highway. We expect that locations with access to major interstate highways will be more attractive as sites for Japanese-affiliated manufacturing establishments. Furthermore, ground transportation is expected to play a more significant role in industries with heavy or bulky products—those industries in which transportation costs are a higher percentage of total product cost—than in industries whose products are lighter and easier to transport.

Labor market conditions. Labor market factors, specifically wage rates or labor costs, degree of unionization, and labor skills, are viewed as central factors in the location decisions of manufacturing establishments. The conceptual literature suggests that profit-maximizing establishments make a trade-off between lower cost, e.g., low-wage, non-union areas, and the available labor skills and human capital (Walker [43]). The empirical literature on both U.S.-owned and foreign manufacturing establishments indicates that higher wage levels are negatively associated with the location of new manufacturing establishments (Bartik [10]; Luger and Shetty [32]; Coughlin *et al.* [15]). However, the literature on Japanese industrial organization indicates that Japanese establishments offer high wages both

to ensure labor force stability and to develop higher levels of human capital (Aoki [2–4]; Kenney and Florida [29]). Thus, in contrast to the findings of the previous empirical literature, we would not necessarily expect to find a negative relationship between wage rates and the industrial location of Japanese manufacturers in the United States. To test this effect, we include a wage rate variable (WAGE), which is measured as the average annual wage for production workers in manufacturing industries.

Industrial location research is nearly unanimous in suggesting that profit-maximizing establishments avoid highly unionized areas. Unions are associated with higher wages and/or higher costs, and impose rigid work rules which impede management flexibility. To capture the effect of unionization on the industrial location of Japanese-affiliated manufacturing establishments, we use county-level counts of the number of automotive-related union locals present in that county (UNION). This includes locals in the United Auto Workers, United Steel Workers, and the United Rubber Workers. We would prefer to have county-level unionization percentages, but these data were not available. Since Japanese establishments are presumed to be union avoiders, the expected sign for this variable is negative.

The conceptual literature on industrial location suggests that labor skills and/or human capital levels are an important factor in firm-level location decisions (Walker [43]). The literature on U.S. and Japanese management and industrial organization further suggests that labor skills, particularly intellectual capabilities, matter in the Japanese production system in which workers are the source of continuous incremental improvement. We expect the human capital levels of the work force to be positively related to the location of Japanese-affiliated manufacturing establishments. We include the percentage of the population with a high school degree or above (EDUCATE) as a measure for human capital/labor skill.

Minority population. It has been widely asserted that Japanese manufacturing establishments in the United States avoid areas with large minority populations, specifically minority population density. Cole and Deskins [14] studied the relationship between the Japanese automotive manufacturers and minorities in the population, specifically the percentage of black residents, and found that Japanese automotive establishments tend to locate in areas with lower minority populations than U.S. establishments in the same industry. Woodward [45] similarly found that Japanese manufacturing establishments tend to avoid areas with high population densities of African-Americans. However, Kenney and Florida [29] suggest that Japanese automotive-related manufacturing establishments have reduced their minority avoidance over time. The percentage minority population of the county (MINORITY) is included to directly

measure the impact of an alleged bias against locations with high minority populations on the part of Japanese automotive-related firms.

Taxes. There is a considerable debate in the literature over the effect of government policy on industrial location. The conceptual, survey-based, and case study literatures suggest that government policies (in the form of industrial incentives or tax reductions) have at best a minimal effect on industrial location. The empirical literature on the location of both U.S.- and foreign-owned manufacturing establishments provides limited evidence that government incentives and tax rates are related to the industrial location decisions of manufacturing establishments. However, the entire literature notes the difficulty of accurately measuring such government policy variables and of testing their effect on location (see Coughlin *et al.* [15] for a good discussion). Clearly, government policy variables have mixed effects. On the one hand, higher taxes represent increased costs for the firm. On the other hand, higher tax locales may provide increased services, education, or infrastructure that supports manufacturing enterprises. Here, we simply note that the evidence on the effect of taxes on manufacturing is mixed (Woodward [45]).

We utilize local taxes per capita (TAX) as a simple measure of the effect of local government tax policy. Note that taxes per capita do not perfectly reflect the cost of taxation on business. This measure includes both the personal and property taxes paid by residents of a given county. However, we believe that this variable is a reasonable proxy, especially in light of the Byzantine structure of state corporate taxes, which renders them very difficult to compare across regions.

III. MODEL SPECIFICATION AND ESTIMATION

The basic, underlying equation for the model is specified as follows:

$$\begin{aligned}\text{ESTAB/NEWESTAB} &= \beta 0 + \beta 1\,\text{MINDIST} + \beta 2\,\text{BIG3} + \beta 3\,\text{MANUF} + \beta 4\,\text{POP} \\ &\quad + \beta 5\,\text{DENSITY} + \beta 6\,\text{TRANS} + \beta 7\,\text{WAGE} + \beta 8\,\text{UNION} \\ &\quad + \beta 9\,\text{EDUCATE} + \beta 10\,\text{MINORITY} + \beta 11\,\text{TAX} + \varepsilon.\end{aligned}$$

This model is estimated for all U.S. counties and is also implemented with the geographic scope constrained to a broadly defined agglomerated production complex composed of counties within 250 miles of at least one automotive-related manufacturing establishment to better determine the main factors which affect location within the hypothesized agglomeration.

The model is run both for total Japanese manufacturing establishments (ESTAB) and for new manufacturing establishments (NEWESTAB).

Numerous modeling approaches have been used to analyze industrial location. Recently, the trend has been toward ordered or conditional logit models, which compare a given area to others in the defined choice set (see Coughlin *et al.* [15]; Woodward [45]). However, we believe Tobit offers some distinct advantages over ordered logit for modeling industrial location, and thus we initially employ Tobit estimation techniques to model the industrial location process of Japanese-affiliated automotive-related manufacturers. Because of the nature of establishment counts, with many zero counts observed in the data, the dependent variables can be characterized as limited dependent variables, specifically censored dependent variables. Ordered logit models are incapable of incorporating locations which receive no establishments, because this essentially requires taking the natural log of zero. As a consequence, areas with no establishments are discarded from the dataset. We believe that this amounts to throwing away good information—there are, after all, good reasons that some areas do not attract new manufacturing establishments, and ignoring these counties introduces selection bias to the estimates. We treat the data as a censored dependent variable and use the Tobit estimation procedure,[1] which allows us to use the information embodied in those counties receiving no establishment.

Because the nature of the dependent variable is that of counts, we also model the data as a Poisson model. In addition, this allowed us to test the sensitivity of our results to the estimation procedure. The Poisson model treats the data as being derived from a Poisson distribution, with mean and variance equal to λ. The model is parameterized such that $\ln(\lambda) = \beta X$, so that both mean and variance equal $e^{\beta X}$ (see Maddala [33]).

The Poisson model imposes the restriction that the variance of Y is equal to its mean (λ). Using the negative binomial option relaxes this constraint, specifying that $\ln(\lambda) = \beta X + \varepsilon$, where ε is gamma distributed. This allows the variance to exceed the mean (overdispersion in the data). We re-estimated the equations using the negative binomial (see Table 1).

IV. EMPIRICAL RESULTS

The results of the models are summarized in Table 2. Six variations of the model (Tobit, Poisson, and negative binomial for both total and new

[1]This Tobit estimation was carried out using LIMDEP version 6.0. The iteration algorithm utilized was D/F/P. D/F/P was found to be the most convenient algorithm for our model. (For a complete treatment of limited dependent variable models see also Amemiya [1] and Maddala [33].)

TABLE 1
Data Summary

Variable	Mean	Expected sign	Source
Total establishments (ESTAB) Number of investments, both new and acquisitions	0.114		Authors' database
New establishments (NEWESTAB) Number of investments in new establishments	0.073		Authors' database
Distance to closest Japanese assembler (MINDIST) Distance expressed in 100's of miles	4.86	−	Atlas GIS, author's construction
Proximity to Big 3 (BIG3) Number of Big 3 assemblers within 250 miles of a county	3.32	+	Ward's Automotive, authors' compilation
Manufacturing intensity (MANUF) Percentage of work force in manufacturing industries	24.0	+	"City and County Databook," 1988 [40]
Population (POP) Total persons residing in a county (10,000)	76.7	+	"City and County Databook," 1988 [40]
Population density (DENSITY) In hundred persons per square mile	2.26	−	"City and County Databook," 1988 [40]
Highway access (TRANS) 1 = served by interstate, 0 = not served	0.317	+	Atlas GIS, authors' construction
Manufacturing wages (WAGE) Average yearly wages per employee ($1000)	10.6	?	"City and County Databook," 1988 [40]
Unions (UNION) Number of locals in auto, steel, or rubber	1.20	−	Registry of Reporting Labor Organizations
Education (EDUCATE) Percentage of population completing high school	59.2	+	"City and County Databook," 1988 [40]
Minority density (MINORITY) Percentage of population that is non-white	6.00	?	"City and County Databook," 1988 [40]
Taxes (TAX) Local tax burden per capita ($100)	3.51	?	"City and County Databook," 1988 [40]

TABLE 2
Results of the County-Level Models for All Counties in the United States

Variable (units)	Total establishments (n = 3112)			New establishments (n = 3112)		
	Tobit	Poisson	Negative binomial	Tobit	Poisson	Negative binomial
INTERCEPT	−8.36**	−5.92**	−5.74**	−7.96**	−5.88**	−5.91**
	(8.27)	(11.43)	(6.97)	(7.14)	(9.27)	(5.63)
MINDIST (100 miles)	−0.330**	−0.243**	−0.227**	−0.418**	−0.375**	−0.325**
	(5.88)	(7.67)	(10.55)	(5.91)	(7.56)	(11.59)
BIG3 (count)	0.073**	0.050**	0.044**	0.082**	0.046**	0.063**
	(2.48)	(3.82)	(2.33)	(2.62)	(2.82)	(2.54)
POP (10,000 persons)	0.26**	0.09**	0.19**	0.26**	0.12**	0.29**
	(8.03)	(11.76)	(6.32)	(7.44)	(10.02)	(7.06)
TRANS (1 or 0)	1.07**	0.998**	0.883**	1.30**	1.19**	1.14**
	(4.57)	(7.60)	(5.04)	(4.95)	(6.95)	(5.28)
DENSITY (100 persons)	−0.0001	−0.00006	−0.0001	−0.002	−0.0001	−0.0003
	(1.58)	(1.28)	(0.94)	(1.42)	(1.33)	(0.99)
MANUF (percent)	0.025**	0.015**	0.020**	0.014	0.012**	0.014
	(2.88)	(3.26)	(2.76)	(1.50)	(2.13)	(1.47)
EDUCATE (percent)	0.039**	0.035**	0.031**	0.044**	0.039**	0.036**
	(2.54)	(4.22)	(2.20)	(2.56)	(3.66)	(1.97)
MINORITY (percent)	0.033**	0.024**	0.019**	0.022**	0.019**	0.012
	(3.69)	(4.91)	(2.37)	(2.08)	(2.93)	(1.09)
WAGE (1000 dollars)	0.089**	0.072**	0.065**	0.116**	0.084**	0.103**
	(3.49)	(5.40)	(3.19)	(3.701)	(4.87)	(3.11)
UNION (count)	0.008	−0.012**	−0.011	−0.030	−0.025**	−0.045*
	(0.46)	(2.01)	(0.60)	(1.51)	(2.58)	(1.88)
TAX (100 dollars)	−0.06	−0.06	−0.07	−0.38**	0.23**	−0.45**
	(0.65)	(1.26)	(0.94)	(2.94)	(3.37)	(3.21)
α (negative binomial only)			2.59			2.70
			(5.63)			(4.31)
-Log likelihood	835.5	858.4	789.3	594.97	596.09	553.05
Restricted -log likelihood	1051.5	1298.7	976.4	773.37	903.45	718.95
Likelihood ratio	432	880.6	374.2	356.8	614.0	331.8
P (reject $\beta = 0$)	0.999	0.999	0.999	0.999	0.999	0.999

Note. T ratios are in parentheses under each coefficient.
*Significant at the 0.10 level.
**Significant at the 0.05 level.

establishment) were estimated.[2] Interestingly, the signs of the coefficients estimated in the Poisson model and the negative binomial model are identical to those of the Tobit model estimates in all statistically significant cases. The magnitudes of the coefficient estimates were remarkably consistent across estimation techniques. This, combined with the near unanimity of the signs and statistical significance of the coefficient estimates, leads us to conclude that our results are robust, and not merely a result of our functional form.

The coefficient estimates for the minimum distance to a Japanese-affiliated automotive-related assembly plant variable (MINDIST) are all negative and are statistically significant at the 0.01 level. These findings indicate that the proximity of Japanese-affiliated assembly plants is an important element in the location decision of Japanese-affiliated manufacturing establishments in automotive-related industries. Once Japanese establishments decide to locate in the United States, they locate in clustered production complexes, in order to capitalize on lower transaction costs and technological and information spillovers, and to achieve spatial and organizational integration between customer and supplier establishments.

Proximity to U.S.-owned automotive assemblers (BIG3) has a positive and significant coefficient in each of the six cases. These results indicate that, although the Japanese automotive suppliers primarily locate to be close to Japanese automotive assemblers, the presence of potential additional business in the form of Big Three assemblers also plays a role in the location decision of Japanese affiliated automotive-related establishments.

Population size (POP) shows a positive, statistically significant coefficient in all of the equations. The coefficients for the population density variable (DENSITY) are negative and not significant in all of the equations. These results suggest that Japanese firms seek out more populous areas, which may or may not be in more densely populated counties, contradicting the conventional wisdom that the Japanese-affiliated manufacturers prefer rural, green-field locations.

The coefficient for highway access (TRANS) is positive and significant in all cases. This is not a surprising result, given that good transportation is required to serve major customers on a just-in-time basis, particularly in the industrial sectors associated with automobile production.

[2]Note that the coefficients resulting from Tobit represent the expectation of $Y^*|X$, not of $Y|X$, where Y is the actual (positive) number of establishments and Y^* the predicted number, which may be negative. However, it can be shown that the appropriate transformations are straightforward to calculate, and these results were calculated. The transformations do not substantially affect the qualitative results. All of these models performed quite well, and the findings are rather robust to changes in the specification of the variables.

Turning to the labor market variables, the percentage of the work force in manufacturing (MANUF) has a positive and statistically significant coefficient in each of the model specifications dealing with total Japanese-affiliated establishments. However, only one of the new establishment cases, the Poisson case, shows a coefficient that is significant at the 0.05 level. These results indicate that a county's manufacturing intensity has a positive effect on its desirability as a location for Japanese automotive-related establishment.

The educational attainment variable (EDUCATE), our measure of human capital, has a positive coefficient and is statistically significant for at least the 0.05 level in all of the equations. Given the nature of the Japanese production system, with its high degree of emphasis on tapping the intellectual capabilities as well as the physical skill of its labor force, and the emphasis on quality, it is to be expected that higher levels of educational attainment are associated with higher levels of Japanese-affiliated automotive establishment locations.

The minority concentration variable (MINORITY) has a positive coefficient in all of the equations for both total establishments and for new establishments and is significant at the 0.05 level in five of the six cases. This contradicts the notion that Japanese manufacturing establishments locate in areas with relatively lower minority concentrations. This finding, while interesting and potentially important, cannot speak to the actual hiring practices of these establishments. Its insight is limited to refuting the notion that Japanese manufacturers systematically choose to avoid areas with higher minority populations.

The coefficients for the manufacturing wages variable (WAGE) are positive and statistically significant at the 0.01 level in all cases. While traditional location theory predicts that establishments will locate in low-wage areas to minimize costs, Japanese automotive-related manufacturers are locating in areas that are characterized by higher wages. One explanation is that Japanese firms are willing to pay higher wages in exchange for more highly skilled labor. Another possibility is that our measure of human capital (EDUCATE) does not capture the full effect, and the wage variable is picking up the residual effect of more highly skilled labor.

The results for the unionization variable (UNION) are mixed. The coefficients are negative in all cases, except in the Tobit equation for total establishments—a coefficient that is not statistically significant. In the five cases with negative coefficients, two of the three new establishment cases feature coefficient estimates that are significant at the 0.10 level, but only the Poisson models produced a coefficient for the UNION variable that was statistically significant at the 0.05 level. (See Table 2). These results indicate that the presence of unions in a county is a deterrent for new

establishments of Japanese-affiliated manufacturers, but plays only a slight role for total Japanese-affiliated manufacturing establishments.

The results for the tax rate variable (TAX) are mixed. The coefficients are negative in all cases. However, for the total establishment equations, the coefficient estimates are not statistically significant at even the 0.10 level. In all three of the new establishment models, the coefficients are negative and significant at the 0.01 level. These results suggest that while taxes have an impact on the location of new establishments, they play little or no role in acquisition decisions.

Four additional specifications of the model, each using an alternative measure of proximity or agglomeration, were estimated. In these alternate specifications, the coefficients for each of these four measures had the expected sign and were statistically significant for at least the 0.05 level. These results further support our hypothesis that the location of Japanese establishments in automotive-related industries is influenced strongly by a desire to locate in close proximity to the Japanese assemblers. In addition, all coefficient estimates for the other independent variables were of the same sign and statistical significance as the consensus of the models presented in Table 2, with remarkably similar magnitudes. This leads us to conclude that our results are robust and not sensitive to the functional form chosen for the models or the specification of the proximity variable.

The model results presented above estimate the relationship between county characteristics and the location of Japanese establishment. Given that such a high percentage (over three-fourths) of all establishments were located within a region defined by a 250-mile radius around each of the Japanese assemblers in and around the industrial Midwest, the model was also estimated for automotive-related establishments located in counties within a 250-mile radius of any Japanese-affiliated automotive assemblers (Table 3). The objective was to isolate the factors which effect location within the broadly defined agglomerated production complex. This results in a sample of 971 counties, a significant reduction from the 3113 total counties in the model presented previously. The results from these models provide additional support for the main hypothesis that proximity matters in the location of Japanese-affiliated manufacturing establishments in automotive-related industries. Coefficient estimates for the independent variables were of the same sign and significance as the models for all U.S. counties.

V. CONCLUSION

We began by outlining a conceptual model of the location process of Japanese automotive-related manufacturing establishments which emphasizes the role of agglomeration in industrial location. Following Krugman [30, 31], Arthur [6], and others (David and Rosenbloom [17]; Walker [43]),

TABLE 3
Model Results for Counties within the Transplant Complex[a]

Variable (units)	Total establishments (n = 971)			New establishments (n = 971)		
	Tobit	Poisson	Negative binomial	Tobit	Poisson	Negative binomial
Intercept	−6.36**	−4.69**	−4.87**	−5.34**	−4.10**	−4.10**
	(5.50)	(7.31)	(5.13)	(4.81)	(5.61)	(2.16)
MINDIST (100 miles)	−1.94**	−1.36**	−1.40**	−1.94**	−1.58**	−1.58**
	(7.82)	(11.04)	(8.05)	(7.40)	(10.02)	(3.53)
BIG3 (count)	−.008	−.006	.0004	−.009	−.0004	−.0007
	(0.25)	(0.39)	(0.02)	(0.27)	(0.02)	(0.01)
POP (10,000 persons)	.25**	.05**	.08	.26**	.08**	.04
	(3.30)	(2.70)	(1.36)	(3.25)	(3.47)	(0.01)
TRANS (1 or 0)	.588**	.640**	.570**	.712**	.756**	.756**
	(2.10)	(4.05)	(2.76)	(2.54)	(3.99)	(1.98)
DENSITY (100 persons)	.00005	.0002	.0001	−.0002	.00002	0.098**
	(0.14)	(1.18)	(0.40)	(0.41)	(0.06)	(4.71)
MANUF (percent)	.024**	.016**	.018**	.011	.012**	.012
	(2.47)	(2.88)	(2.30)	(1.19)	(1.92)	(0.75)
EDUCATE (percent)	.0744**	.0569**	.0584**	.063**	.046**	.046
	(3.75)	(5.40)	(3.69)	(3.21)	(3.75)	(1.21)
MINORITY (percent)	.055**	.032**	.036**	.048**	.034**	.033
	(3.81)	(3.94)	(3.08)	(3.14)	(3.50)	(0.67)
WAGE (percent)	.102**	.064**	.073**	.091**	.064**	.063
	(3.28)	(3.99)	(2.78)	(2.95)	(.31)	(0.63)
UNION (percent)	.001	−.005	−.001	−.045*	−.023*	−.025
	(0.05)	(0.55)	(0.08)	(1.72)	(1.68)	(0.13)
TAX (100 dollars)	−.388**	−.25**	−.33**	−.31**	−.36**	−.21**
	(2.65)	(3.57)	(2.81)	(2.32)	(3.18)	(6.37)
α (negative binomial only)			1.003			.075
			(3.97)			(6.37)
-Log likelihood	518.5	498.95	474.41	424.1	392.96	379.3
-ln likelihood (all 0 β's)	654.8	765.99	605.1	531.04	572.22	486
Likelihood ratio	273.0	534.1	261.4	213.8	358.5	213.4
P (reject β = 0)	0.999	0.999	0.999	0.999	0.999	0.999

Note. T ratios appear in parentheses under each coefficient.

[a]Being "within the complex" is defined as all counties within 250 miles of at least one transplant assembler.

*Significant at the 0.10 level.

**Significant at the 0.05 level.

we suggested that agglomeration would exert a strong influence upon industrial location. We advanced the hypothesis that agglomeration is a significant factor in the industrial location of Japanese-affiliated manufacturing establishments. The empirical results of the model strongly confirm this hypothesis. The results are consistent across all permutations of geography, there is a high level of accord in the equations using different proximity measures, and the findings are the same using the Tobit, Poisson, or negative binomial functional form. Thus, the empirical findings with regard to the major hypothesis are robust.

A number of additional findings flow from our analysis. In addition to preferring areas in relatively close proximity to Japanese automotive assembly establishments, Japanese automotive-related manufacturers prefer locations with large populations, high manufacturing density, and high wages. These findings support some beliefs, but contradict others contained in the conventional wisdom reported in the literature on industrial location. The most significant findings concern the role of wages, unions, and minority concentrations in the locational choices of Japanese-affiliated manufacturers. The empirical findings unambiguously indicate that these Japanese-affiliated manufacturing establishments tend to locate in higher wage locations. This stands in sharp contrast to the low-wage hypothesis of the extant literature. We believe the higher wage orientation of these Japanese manufacturing establishments reflects a trade-off in favor of higher human capital and greater labor force stability. While the literature portrays Japanese manufacturers as union avoiders, our results are mixed. We find that new Japanese manufacturing start-ups in automotive-related industries prefer less unionized locations, but that this effect is not substantial in the cases including acquisitions as well as new establishments. Furthermore, our empirical results contradict the view that Japanese-affiliated manufacturing establishments in automotive-related industries avoid minority areas. In fact, the results of the models indicate that Japanese-affiliated automotive manufacturers tend to locate in areas with higher concentrations of minority group members.

At a more general level, these findings strongly support the role of agglomeration in industrial organization and economic activity (David and Rosenbloom [17]; Arthur [6]). Our research thus provides a clear illustration of the interplay of economic and geographic phenomenon. We hope that our modest effort will stimulate additional empirical research at the intersection of these two fields.

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