A COUNTY-LEVEL MODEL OF MANUFACTURING PLANT RECRUITMENT WITH IMPROVED INDUSTRIAL SITE QUALITY MEASUREMENT

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Abstract

Empirical analysis of manufacturing plant location requires the use of a single industrial site quality measure. Under hedonic price theory, the price of industrial sites can be explained by their quality characteristics. The estimated site price is included with ten other location factors in an ordered, categorical logit model of plant attraction to Georgia counties. The results inform public decisionmakers of the relative impact of site location factors and how changes in location factors can alter the probability of attracting a manufacturing plant.

Key words: hedonic price, industrial site, manufacturing location, ordered categorical logit model, spatial profit maximization

Analysis of the factors that attract manufacturing firms to communities continues to stir the interest of researchers. This interest is spurred by a resurgence in community-controlled economic development programs that focus on industry recruitment as a primary development strategy. While southern states have been quite successful in attracting manufacturing investment through the 1980s (Conway), specific communities lack the ability to assess their locational advantages in a structured, analytical sense. This article presents the results of a Georgia county-level location study conducted to help county leadership assess their potential for attracting an industrial plant. The results also suggest which local investments can be made in a community to improve its probability of attracting a firm. This analysis introduces an innovation in measuring industrial site quality, which has been a significant location factor in earlier research (Smith, Deaton, and Kelch; Kriesel, Deaton, and Johnson). Hedonic price analysis is used to estimate values for industrial sites, and this estimated price is included in the location model as a measure of site quality.

THEORETICAL FRAMEWORK

The conceptual basis for research in industrial plant location lies in the classical tradition of Alfred Weber's location theory, as modified by Tord Polander, Edgar Hoover, and Melvin Greenhut (Smith). Industrial location is conceptualized as a two-stage location process that has come to be known as spatial profit maximization. In the first stage, a footloose firm selects the region with factor supplies and product market access that would be consistent with the firm's location objectives. Once this regional decision has been made, a specific site within that area is selected according to the firm's minimum cost of production criteria. Within this secondary decision level, some location factors, such as a community's geographic situation or climate, are fixed. However, another set of factors, such as infrastructure development and worker training, is subject to community alteration. Selection of a site within the region, therefore, can be influenced by public policy.

The seminal study which explicitly examined the impact of community attributes on plant location was conducted by Wallace and Ruttan. Their study of plant locations in southern Indiana examined the factors that plant managers indicated influenced firms' location decisions. The analysis supported the hypothesis that community action can influence plant location decisions. Furthermore, Wallace and Ruttan compared the community's position to that of a monopolist (or an oligopolist in the case of communities competing for a firm) and the firm's position to that of a monopsonist. From this, they suggested that bargaining would implicitly arise to determine the terms of the location transaction.

More recent research (Sulaiman and Hushak; Kuehn, Braschler, and Shonkwiler; Smith, Deaton, and Kelch; McNamara, Kriesel, and Deaton; Kriesel, Deaton and Johnson) regressed measures of plant locations against location factors, some of which are controlled by the community. These studies also support the hypothesis that location decisions can be influenced by community action.

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SPECIFICATION OF THE LOCATION MODEL

Within the spatial profit maximization model, community action impacts the location decision at the secondary search level where firms seek the cost-minimizing site. In this stage of the location process, firms seek the location that will minimize costs, or maximize firm profits. The model suggests that firms compare expected profitability associated with all potential sites in a region to identify the profit maximizing site for plant location. Location factors that influence this process include agglomeration economies, industrial site quality, transportation facilities, fire protection rating, taxes, and labor cost, quantity, and quality. These are location factors which apply to all types of manufacturing firms. In mathematical terms, location theory hypothesizes that:

(1) $SS_i = f(L_i, C_i, A_i)$

where SS_i = manufacturing site selection in community i, L_i = a vector of market labor characteristics in community i, C_i = a vector of community characteristics in community i, and A_i = a vector of agglomeration economies in community i.

The bargaining process posited by Wallace and Ruttan establishes the definition of the unit of observation, i.e., it must be able to act as an independent bargaining agent in its negotiations with firms. Georgia counties meet this requirement because they wield more power at the sub-state level than other entities, e.g., planning districts and municipalities. Certain independent variables may take on more than one value in a county, as in the case of multiple fire districts. In these cases, spatial profit maximization implies that firms will respond to the single most favorable value within a county, so that value is used in the empirical analysis.

The left hand side of the model, manufacturing site selection in county i, is measured in a probabilistic choice context. Four ordered response categories, described in the following data section, are defined by the number of plants attracted to a county over a given period of time, and the j^{th} category is:

$SS_i = 1$ if the county attracts j plants,

and $SS_i = 0$ otherwise.

Estimation of an ordered, multiple-category logit model is a departure from previous research (Debertin, Pagoulatos, and Smith; Kriesel, Deaton, and Johnson) which used the binary logit model, where the dependent variable was '1' if a community had attracted one or more plants, and '0' otherwise. This binary model is appropriate for many counties, but for some counties (especially those in metropolitan areas) the probability of attracting at least one plant approaches one. As mentioned in the introduction, a goal of this research is to generate information on how a county can alter a location factor and improve its predicted probability of attracting a plant. However, if a county's baseline probability is one, then the model cannot provide further information on attraction.

The ordered categorical model avoids this shortcoming by estimating the probability of each county attracting the number of plants in the j^{th} category. At the highest category, for four of more plants, no county's baseline probability approaches one. The SAS routine PROC LOGIST estimates beta coefficients for the location factors plus a set of intercepts, each of which corresponds to a particular response category (Harrell). Then, the probability of a county attracting j plants is:

(2) $\Pr(\text{Category } j) = (1 + \exp(-a_j - BX))^{-1}$,

where X is a vector of location factors, B is a vector of estimated coefficients, and the intercept a_j corresponds to category j. The next section presents the empirical location model, followed by a section that describes an innovation in measuring an important, controllable location factor, industrial site quality.

DATA AND THE EMPIRICAL MODEL

Data for 158 Georgia counties were used to specify the empirical location model. The dependent variable, number of new plant announcements in a county during the 1986-1988 period, was defined over four categories: (1) counties that attracted one plant (N=36), (2) those with two plants (N=23), (3) those with three plants (N=13), and (4) those with four or more plants (N=19). Sixty-seven counties attracted no plants (Georgia Department of Industry and Trade). Five of the eleven location factors are subject to the counties' control. When data sources permitted, the practice of previous research (Smith, Deaton, and Kelch) was adopted by measuring location factors in the same year that plant locations begin, 1986. All of the location factors are described below.

Measures that describe the cost, availability, and quality factors in the local labor market have been shown to be important location determinants in earlier research (Smith, Deaton, Kelch; Sulaiman and Hushak; Kuehn, Braschler, and Shonkwiler; McNamara, Kriesel, and Deaton). This study included three labor measures. The 1986 unemployment rate, UMEMP, is a measure for labor availability (Georgia Department of Labor). A higher unemployment rate is an indicator of labor availability and, thus, is hypothesized to have a positive association with plant location. The average weekly wage rate, WAGE, is included in the model as a labor cost measure. This variable is hypothesized to have a negative association with location decisions, if the productivity of labor is held constant (Georgia Department of Labor). SCHOOL, the percentage of students who complete high school, is included in the model as a measure for the level of human capital entering the labor force, or for quality of available labor. A higher percentage of students completing high school is hypothesized to be associated with availability of skilled/productive workers. This measure, therefore, should have a positive association with location decisions. The only available data was for 1987 (Georgia Department of Education).

Agglomeration measures describe the cost advantages that accrue to firms that locate in areas with concentrations of other firms (Richardson). This study measures agglomeration by the number of manufacturing employees in a county in 1986, WORKERS. This measure was hypothesized to have a positive influence on locations reflecting the agglomeration economies associated with a firm's locating in a community where there is relatively more manufacturing activity. Also, the WORKERS variable is related to labor availability (Georgia Department of Labor).

Transportation is an important location factor in both decision stages of the spatial profit maximization process. The firm first determines its optimal location within a transportation network, and then is concerned with access to transportation routes within this optimal region (Smith). In Georgia, the primary transportation modes are truck, rail, and air. With one exception, every county has a railroad through it, and access to airports is accounted for in the industrial site quality measure. The remaining access measure is for shipping over interstate highways. This is measured by the mileage of interstate highway, MILES, within a county. This measure is hypothesized to have a positive influence on firm locations, reflecting lower transportation costs associated with access to an interstate highway.

Previous studies have included measures of local taxation as a location measure, but the results have been varied (Walker and Calzonetti). A recent survey article by Newman and Sullivan showed that a definitive test of tax effects on location must meet a set of strict conditions. However, a strict test is not the subject of this article. Rather, these assumptions are made: if communities are equally efficient in providing public services, and if firms are not fully benefitted by the services (e.g. welfare-related expenditures), then firms will view a local tax increase as an ambiguous benefit and tax effects in a location model should be negative. The county's effective tax rate, TAX, is included in the model. Only 1988 data are available. TAX is measured by the dollars paid per one thousand dollars of real and personal property owned (Georgia Department of Industry and Trade).

Communities are observed to be more or less receptive to new industries (Kriesel, Deaton, and Johnson). The best measure of community eagerness for new industry would quantify the effort expended in attracting new firms, but this measure is unavailable. FREEPORT, a 0-1 dummy variable, was included in the model to indicate whether or not a locality had passed, prior to 1987, a local referendum to exempt manufacturers from inventory taxes. This measure should be a clear indication that the majority of citizens felt receptive to new business at the time the referendum was conducted. It also describes a tax effect. FREEPORT is hypothesized to have a positive impact on firm location (Georgia Department of Industry and Trade).

The county fire protection rating in 1986, FPR, ranges from 1 (best) to 10 (worst) and it determines firms' insurance rates. For counties with more than one fire district, the best system was chosen to represent the county. The variable was hypothesized to have a negative impact on location decisions, as a higher number suggests a higher insurance cost (Insurance Services Office).

In the rural South there has been controversy as to whether predominately black communities are handicapped in industrial recruitment. The percentage of black population may influence locations for several reasons. First, firms may recognize the impact that historic barriers to education have had on blacks' accumulation of human capital. Second, blacks are reputed to have a higher propensity to unionize. And third, business firms may be practicing discrimination. These communities may need to adjust their economic development strategies if there is evidence that relocating firms avoid them. A variable, RACE, for the 1986 percentage of the county's population that is black is included with a hypothesized negative influence *(County-City Data Book)*.

COLLEGE, the distance from the county center to a city with a four-year college and student population of at least 2000 students, was included in the model as a quality of life measure. It was hypothesized that amenities associated with the presence of colleges of this size or larger would have a positive impact on local quality of life. This measure, distance in miles, was hypothesized to have a negative impact on location decisions. In Georgia and surrounding states, the large colleges are often located in metropolitan areas, so this variable also measures agglomeration effects and access to the regional airports in MSAs

(1987, Rand-McNally Commercial Atlas and Marketing Guide).

The estimated per acre price for industrial sties, PRICE, was included in the model as a site quality measure. The development of industrial site quality measures is discussed in the following section, and the results of the hedonic model are presented in the Appendix. The location variables are defined in Table 1, with their means and standard deviations.

Industrial Site Quality

In a discussion of the role of industrial sites in the location decision, Deaton notes that the site represents a bundle of factors including land, infrastructure, and its location. He says that operationalizing site quality measurement must overcome two concerns. First, communities sometimes have more than one site with differing characteristics, all of which cannot be included in the location model. However, firms seeking industrial sites are interested in meeting their specific requirements for water, sewer, electric services, etc., and they would want a single site that provides access to all of the needed services. Therefore, the site with more of the needed service attributes should be included in the empirical model.

Table 1: Definitions and Summary Statistics of Location Variables

Variable	Mean	Std. Dev.
Non-controlled Location Variables		
WAGE: the county's average weekly manufacturing wage ($)	268.92	88.72
UNEMP: the unemployment rate (%)	8.16	2.52
WORKERS: the number of manufacturing employees	3,463.88	6,410.41
MILES: mileage of interstate highway in the county	7.49	11.94
RACE: the percentage of black residents	28.12	17.36
COLLEGE: distance from county's center to a city with more than 2,000 college students	26.64	18.06
Community-Controlled Variables		
SCHOOL: the percentage of students who complete high school	61.49	0.11
FPR: fire protection rating, 1=highest, 10 = lowest	6.13	1.65
FREEPORT: dummy variable for passage inventory tax exemption 1 = yes, 0 = no	0.61	0.49
TAX: the county's effective tax rate per $1,000 of property($)	8.68	2.51
PRICE: the predicted per-acre price of the county's best industrial site ($)	9,072.63	16,662.22

Deaton's second concern is with the problem of entering industrial site characteristics separately as independent variables in a location model. Ideally, the estimated location model will yield information on the industrial site's *net* influence. The task is difficult because financially sound communities tend to have well-developed sites. For example, at least two important site characteristics, water and sewer utilities, are strongly determined by the community's infrastructure capability. Therefore, inclusion of site characteristics in a location model may yield information about the community's ability to provide characteristics, rather than the characteristics themselves. Added to this difficulty is the empirical problem of evaluating a potentially large number of site characteristics.

Two studies (Smith, Deaton, and Kelch; Kriesel, Deaton, and Johnson) used an industrial site index as a site quality measure. The measure was computed from data on sites' water, sewer, rail service, and size attributes. Each site was given a score, based on the proportion of settled sites it exceeded in quality on all of the four factors divided by the total number of settled sites.

While site indices used in prior research provide insight into the importance of industrial site quality in manufacturing location, two problems are associated with their use. First, the measures can accommodate only a limited number of quality factors. The choice of which ones to include is arbitrary, and therefore may not reflect the attributes that are critical in the location decision process. Second, empirical results based on an index are of limited policy value because of the difficulty in determining which factor, at the margin, would have the greatest impact on a community's probability of attracting a firm.

A hedonic pricing model is used in this research to estimate a site quality measure. In hedonic theory, the price of a heterogeneous good is a function of attributes that describe its quality. An estimated price, therefore, should be a direct reflection of the potential value of site quality characteristics. The estimated price measure has two advantages over measures used in prior research. First, a greater number of site attributes can be incorporated into computation of the site quality measure. Second, marginal changes in specific site attributes can be evaluated to examine (1) their impact on the selling price of the site, and (2) their impact on a community's probability of attracting a manufacturing plant. Finally, use of the estimated, rather than actual, price increases the sample size. This is because many communities regard their site's price as negotiable, and did not report any price. The hedonic model is described briefly in the Appendix.

STATISTICAL RESULTS FOR THE LOCATION MODEL

An ordered, categorical logit model was used to estimate the probability of a community attracting a manufacturing plant. Table 2 presented the ordered logit analysis results for three specifications of the location model. Model 1 contains the full set of eleven variables, and the chi-square statistic is highly significant at 61.58 with 11 degrees of freedom. The one-tail null hypothesis is rejected for five of the location factors at the 0.05 level of significance. These variables are FREEPORT, MILES, RACE, FPR, and UNEMP. Each coefficient has the hypothesized sign, except for WAGE and SCHOOL. Unexpected signs can be caused by multicollinearity among the independent variables, and matrix of correlation coefficients was examined for evidence of pairwise combinations.

The WORKERS variable was correlated with four other variables at a rate greater than 0.5, so WORKERS was dropped from Model 2. The results are similar to Model 1's, with the model's chi-square at 59.44, except that the null hypothesis on the PRICE variable is rejected. Under OLS estimation, multicollinearity leads to inflation of an estimate's standard error, and it increases the likelihood of a type-2 error. This seems to be the case for the PRICE variable in Model 1. The WAGE variable was correlated with three other variables, and the effects of its exclusion are reported in Model 3. The PRICE variable has become insignificant again, and the incorrect sign for the SCHOOL variable remains. The model's chi-square has increased to 61.56.

UNEMP, the local unemployment rate, was included in the model as a measure of labor availability. This measure was significant, supporting the hypothesis that local labor availability influences location decisions. MILES, the mileage of interstate highway in the county, was also positively associated with plant location decisions. RACE, however, the percentage of black residents, is negatively associated with plant location. The results for these three variables, UNEMP, RACE, and MILES, provide communities with some insight into probability of their attracting a manufacturing firm. These variables, however, do not measure location factors that community leadership can directly impact.

The other three variables in the model that were statistically significant, FREEPORT, FPR, and PRICE, represent location factors that can be controlled or influenced by community leadership. FREEPORT, passage of a referendum to exempt firms from local inventory taxes, had a significant impact on location. This result suggests that Georgia communities that enact Freeport ordinances will in-

Table 2: Maximum Likelihood Results of the Ordered, Categorical Location Model

	Model 1		Model 2		Model 3	
Variable	BETA	STD ERROR	BETA	STD ERROR	BETA	STD ERROR
UNEMP	0.2429	0.0759*	0.2554	0.0757*	0.2417	0.0754
WAGE	0.0003	0.0022	0.0008	0.0022	-	-
WORKERS	0.0001	0.0001	-	-	0.0001	0.0001
MILES	0.0425	0.0175*	0.0457	0.0172*	0.0429	0.3476*
RACE	- 0.0227	0.0113*	- 0.0245	0.0113*	- 0.0226	0.0113*
COLLEGE	- 0.0034	0.0095	- 0.0043	0.0095	- 0.0035	0.0095
SCHOOL	- 0.3759	1.4812	- 0.6573	1.4828	- 0.3469	1.4676
FPR	- 0.2787	0.1384*	- 0.3700	0.1233*	- 0.2843	0.1333*
FREEPORT	0.6525	0.3491*	0.6127	0.3476*	0.6483	0.3476*
TAX	- 0.0577	0.0732	- 0.0681	0.0729	- 0.0563	0.0725
PRICE	0.0001	0.0001	0.0001	0.0001*	0.0001	0.0001

[a] The categorical dependent variables are: CATEGORY 1: one plant locates (n=36), CATEGORY 2: two plants locate (n=23), CATEGORY 3: three plants locate (n=13),CATEGORY 4: more than three plants locate (n=19). The remaining 67 counties attracted no plants.

[b] N=158, Model 1 chi-square=61.56 with 11 d.f.

*Indicates rejection of the one-tail hypothesis test at the 0.05 level of significance.

crease their probability of attracting a manufacturing firm. FPR, the local fire protection rating, also had the hypothesized association with location decisions. This suggests that actions within a community to lower the fire protection rating (a low value is a better rating) will have a positive impact on firm location decisions. The third locally controlled variable, PRICE, is the estimated price of the local industrial site. This variable can be influenced by a variety of local actions to improve specific site attributes.

CONCLUSIONS

The research suggests that community leadership can take three types of actions to influence their community's probability of attracting a manufacturing plant. Investments that improve a community's fire protection rating or increase the value (estimated price) of industrial land increase the community's probability of attracting a firm. Passage of local Freeport ordinance, a tax reducing action, also will increase a community's probability of attracting a firm.

Noncontrolled factors also are shown to influence firms' location decisions. The local unemployment rate, percentage of black residents, and the mileage of an interstate highway within the community each influence a community's probability of attracting a manufacturing firm. Community leadership's ability to influence state policies that affect labor availability, labor quality, or interstate highway access may also influence the community's probability of attracting new manufacturing investment. Leaders in communities that do not have available labor and are not linked to the state interstate highway system should be cautious about investing in an industrial recruitment program without assessing the impact that nonlocally controlled factors have on limiting recruitment efforts.

The results of this study are consistent with those of earlier studies (Smith, Deaton, and Kelch; Sulaiman and Hushak; Kuehn, Braschler, and Shonkwiler; McNamara, Kriesel and Deaton; Walker and Calzonetti) that have indicated that locally controlled location factors such as fire protection rating and industrial sites are important determinants of firm location. This research adds to the earlier work by providing a method for targeting industrial site investments to site attributes that will have the greatest impact on a community's probability of attracting manufacturing investment.

These research results have been incorporated into an extension program on industrial recruitment. The program gives local leaders information on how industrial recruitment can fit into an overall program of economic development. Probability plots can be made from the estimated equation for any of the independent variables. If increasing location probability is a goal of the leadership, comparing the plots for location factors that they can invest in, e.g., site quality versus fire protection, yields information on which investment will be more cost effective. In making the choice between investing in industry-specific location inducements and more general improvements, an important consideration is that the community will receive a payoff from the industrial site only if it indeed attracts a plant, whereas improvements to items such as fire protection yield benefits even if no new plants are attracted. The graphical analysis sometimes shows that industrial recruitment is a poor development strategy for some counties that have distinct locational disadvantages.

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APPENDIX: THE HEDONIC MODEL FOR INDUSTRIAL SITES

The theory of hedonic pricing suggests that the price of a heterogeneous good is determined by the characteristics that reflect its quality. Therefore, the price should be a valid site quality indicator. A full development and discussion of the model is found in Kriesel and McNamara.

In this hedonic model, price is a function of lot size (SIZE), distance from an interstate highway (DINTER), water main diameter size (WATER), sewer diameter size (SEWER), fire protection rating for the site (FPRI), gas main diameter size (GAS), and distance to local air service (AIR). The hedonic model also included county characteristics that contribute to a site's productivity. These characteristics are: percent of adult population who graduated from high school (GRADS), the number of manufacturing firms in the community (PLANTS), size of the civilian labor force (LABOR), and a dummy variable for whether the county is in a metropolitan area (MSA). Data on industrial site prices and attributes were obtained from Oglethorpe Power, a Georgia utility, for all Georgia industrial sites registered with the utility. Use of the seller's asking price is consistent with other hedonic studies that use prices from a multiple listing service (e.g. Dinan and Miranowski). In the study, 329 industrial sites in 93 counties were used for the analysis.

Table 3 reports the ordinary least squares results of the hedonic model, estimated with the double logarithmic functional form. An R-square, adjusted for degrees of freedom, of 0.64 was obtained. Of the twelve independent variables, the one-tailed hypothesis test was rejected for seven, at the 0.05 significance level. All variables have their expected signs

Table 3: OLS Estimation of the Hedonic Model[a]

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR
INTERCEP	- 2.163	1.445
SIZE	- 0.218	0.033*
DINTER	- 0.172	0.042*
WATER	0.056	0.052
SEWER	0.033	0.056
FPRI	- 0.081	0.138
GAS	0.099	0.072
AIR	- 0.112	0.054*
GRADS	1.552	0.305*
PLANTS	0.123	0.062*
LABOR	0.468	0.076*
MSA	0.295	0.142*

[a] N=329, R-squared adjusted for degrees of freedom = 0.64, F=53.68.

* Indicates rejection of the one-tail hypothesis test at the 0.05 significance level.