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A Model of Intraurban Employment Location

An Application to Bogota, Colombia

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A Model of Intraurban Employment Location: An Application to Bogota, Colombia[1]

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A micro model is formulated to study the location behavior of manufacturing firms in urban areas. A bid-rent function is derived from the profit function and captures the firms' locational equilibrium situations. The theoretical model is extended to a multinomial logit specification and estimated using establishment survey results for Bogota, Colombia. The survey included information on (1) attributes of the establishment such as plant space, and (2) attributes of the plant site such as access to markets. The estimated model is capable of predicting the location choices of different types of firms.

1. INTRODUCTION

The work reported here is part of a World Bank urban study project. In this paper a theoretical model of employment location is formulated and extended to an empirical specification in the multinomial logit framework.

In the descriptive phase of the study, the employment location patterns of Bogota, Colombia, and their changes were extensively analyzed using industrial directory data. The analysis, performed in terms of births, deaths, and relocation of firms, revealed a high degree of employment location dynamics: both the birth and relocation rates were high and evidence of spatial decentralization of manufacturing employment was strong (Lee [9]).

Although researchers have drawn attention to the need for modeling employment location behavior, the gap in this area remains unattended in the literature. The analytical work reported in the present paper is an

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attempt to model the location behavior of the firm and to explain observed patterns of employment location. For this purpose, a survey of manufacturing establishments was conducted in Bogota, a rapidly growing city comparable to such United States cities as Phoenix and Houston. This paper presents estimation results based on the survey. The model is presented in the next section, the survey is then briefly described, and finally, the estimated results are reported.

2. A MODEL OF EMPLOYMENT LOCATION

Consider T types of manufacturing firms in an urban area. The firm maximizes profits as a price taker in both product and factor markets. The firm uses a set of variable and fixed inputs to produce an output. The problem is to determine the optimum combination of inputs, including the lot size and the plant location, to attain locational equilibrium profits in an urban area.

Consider a production function in the general form

$$Q = f(L, X; Z) \tag{1}$$

where Q is the output, L the lot size, X a vector of other inputs such as labor, and plant and equipment; Z a vector of site characteristics that are independent of lot size and can be considered as "local public goods"[2] such as the quality of public utility services, accessibility to markets, and amenities of the zone of plant location.

The profit of the firm is

$$\Pi = pf(L, X; Z) - RL - wX \tag{2}$$

where Π is the profit, p the output price, R land rent per unit, w other input prices, such as wage rate, and price of capital input.

From the first-order conditions for profit maximization, one obtains the following demand equations for variable inputs:

$$\frac{\partial f}{\partial L} = \frac{R}{p} \tag{3}$$

$$\frac{\partial f}{\partial X} = \frac{w}{p}. \tag{4}$$

Solving (3) and (4) for the optimal input quantities L^* and X^*, and substituting them into (2), the "profit function," based on the duality

[2] Burstein [1] included this variable in the household utility function of her housing demand study.

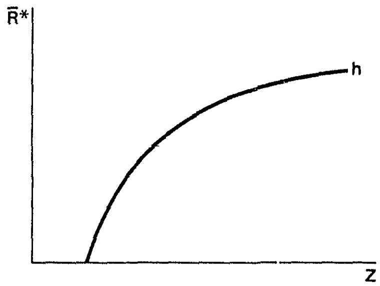

FIG. 1. The firm's bid-rent function.

theorem,[3] is obtained as

$$\begin{aligned}\Pi^* &= pf(L^*, X^*; Z) - RL^* - wX^* \\ &= \Pi^*(p, R, w; Z).\end{aligned} \tag{5}$$

Let t be the unit transport cost for shipment of output; then $p - t$ is the factory price of output. Using p as the numeraire and introducing the location subscript (u), (5) becomes

$$\bar{\Pi}^*(u) = g[1 - \bar{t}(u), \bar{R}(u), \bar{w}(u); Z(u)] \tag{6}$$

where $\bar{\Pi}$, $\bar{t}$, $\bar{R}$, and $\bar{w}$ are values normalized by p; u refers to the distance to the product market.

In locational equilibrium, for a given u every firm should have the same profit, and there is no incentive for any firm to relocate. An equilibrium rent profile must satisfy

$$\bar{\Pi}^*(u) = g[1 - \bar{t}(u), \bar{R}(u), \bar{w}(u); Z(u)] = \text{const.}^4 \tag{7}$$

As with residential location, a useful interpretation of this formulation of firm location choice is in terms of the bid-rent function of the firm, giving the price for site with characteristics Z that yields profit $\bar{\Pi}^*$. Let $\bar{R}^*(u)$ denote the bid rent, then (as in Fig. 1)

$$\bar{R}^*(u) = h[1 - \bar{t}(u), \bar{w}(u); Z(u); \bar{\Pi}^*(u)]. \tag{8}$$

For convenience, suppose the unit transport cost is site invariant within an urban area and include it as an element in the constant term. Also

[3]For the duality relations between the production function and the profit function, see Diewert [2] and Lau and Yotopoulos [6].

[4]Solow [12] shows an equilibrium rent profile of households in an urban area.

suppress $\overline{\Pi}^*(u)$ which is constant. Hence (8) can be written

$$\bar{R}^*(u) = h[\bar{w}(u);\, Z(u)] \tag{9}$$

where

$$\frac{\partial \bar{R}^*}{\partial \bar{w}} < 0; \qquad \frac{\partial \bar{R}^*}{\partial Z} > 0. \tag{10}$$

For illustration, consider the case of labor input. As the labor–land ratio increases the marginal product of land increases relative to that of labor, and the relative price of land with respect to labor also rises. This argument supports the empirically observed rent gradient in an urban area in the sense that as the distance to the CBD becomes shorter, the intensity of a variable input such as labor increases and the land rent rises.[5] In other words, producers respond to input price differentials over space to obtain optimal input combinations including lot size. Also the value of land increases as desirable site characteristics, such as public service provision and accessibility, are improved.

Since $\bar{w}$ is the input price vector normalized by output price, (4) can be rewritten as

$$\frac{\partial f}{\partial X}(u) = \bar{w}(u). \tag{11}$$

Substituting (11) into (9), we have the bid-rent function expressed in terms of firm characteristics $\partial f/\partial X$ and site characteristics Z.

For expository reasons, rewrite (9) as

$$\bar{R}^*(u) = h[x(u),\, Z(u)], \tag{12}$$

where $x(u)[= (\partial f/\partial X)(u)]$ now represents a vector of firm characteristics, namely input combinations, which in turn depend on technology characterized, for example, by type of production process and building structure. As mentioned earlier $Z(u)$ is a vector of site characteristics.

Now suppose that there are T types of firms defined by x and S types of sites defined by Z. Let N_t be the number of type t firms in the market.

Then using (12), the bid rent for a site with characteristics Z by the nth firm of type t is given by

$$\bar{R}^*_{tn} = h_{tn}(Z_n), \qquad n \in N_t. \tag{13}$$

[5]A measure of the land price gradient using the survey data used in this study resulted in the following: ln land price $= 8.029 - \underset{(3.17)}{0.1126}$ distance, $R^2 = 0.1093$, which can be written as land price $= 3069e - 0.1126$ distance.

Note that we have now suppressed the vector $x(u)$ that is used to define the firm type t. For example, all firms of type t are similar in terms of output, input combination and technology, that is, they have an identical production function.

Following Ellickson's [3, 4] work on residential location, we can interpret this model in terms of predicting the probability of a certain type of firm t to locate at a site with a specified set of characteristics Z.

The stochastic version of (13) is

$$\bar{R}^*_{tn} = h_{tn}(Z_n) + e_{tn}, \qquad n \in N_t. \tag{14}$$

where e_{tn} is a random disturbance term reflecting unaccounted variations of firm characteristics of type t.

Since a given site is occupied by the firm with the highest bid, the relevant variable for determining the probability that a given site is occupied by a firm type t is the maximum bid given by firms of type t.

$$\bar{R}^{\max}_t = \max_n(\bar{R}_{tn}) = h_t(Z) + e_t, \qquad t \in T \tag{15}$$

where

$$e_t = \max_n(e_{tn}), \qquad n \in N_t.$$

If the e_t are identically and independently distributed Weibull,[6] the specification of a logit model follows, namely, the probability that a firm of type t occupies a site with characteristics Z takes the logit specification[7]

$$p(t \mid Z) = \frac{\exp[h_t(Z)]}{\sum_{t' \in T} \exp[h_{t'}(Z)]}. \tag{16}$$

The above discussion shows that the basic theoretical approach used in the study of residential location can provide a useful analytical framework for the study of employment location.[8] The optimizing behavior of the firm is postulated as location specific, that is, the choice by the firm of a specific site is part of the production decision; furthermore, the location specific

[6]For example, the maximum value of an identically and independently distributed normal variate has the Weibull distribution.

[7]Ellickson [3, 4] derived this variation of the logit model in his residential location study.

[8]Theoretical and empirical work is rare in this area; Mills [10] and Solow [12] offer basic micro foundations; the work by Hoover and Vernon [5], Struyk and James [13], and Schmenner [11], although descriptive, serves as the empirical bases in the field.

equilibrium position of individual firms is extended to the "locational equilibrium" situation of all firms in an urban area. The theoretical model is easily extended to the stochastic specification of the model in an estimable form.

3. THE DATA

The sample of 126 establishments was drawn for the survey from DANE's 2629 distinct firm records in the industrial directory files covering 1970–1975,[9] stratified by the following four categories: (1) location history, that is, stationary firms, movers, and births[10]; (2) the zone system defined by 38 *comunas*; (3) the type of industry defined by 3-digit SIC codes; and (4) firm size by employment.

To minimize the sampling cost while having sufficient observations for econometric estimation, we chose the textile industry and the fabricated-metal industry as the two main industries to be studied. Both industries had a large share of manufacturing establishments in Bogota. The homogeneity of firms in each industry group makes it possible to test behavioral hypotheses with sufficient degrees of freedom. We added as a third group, however, the "other industries" category with which to do mainly descriptive studies about establishments in various other types of industries.

The second consideration given in the sampling process was to oversample large firms so that the number of jobs included in the sample could be maximized. Finally, an attempt was made to cover a wide geographic area in such a way that spatial analyses could be possible, including the estimation of the rent and wage gradients. Our target sample size was 120 with about equal shares of establishments among the three types of location history.

The realized sample of 126 establishments consists of 58 stationary firms, 50 movers (including two firms that moved to Bogota from outside) and 18 births (see Table 1). The newly established firms were mostly small (Table 3). The sample coverage across zones was satisfactory; with 27 *comunas* covered, the spread was fairly even over the 3 Rings that have high manufacturing employment densities (see Table 1 and Fig. 2). On the other hand, only a small number of establishments was selected from Ring 1 (CBD) and Ring 6 (3 residential *comunas* in the north).

[9]The original DANE (National Statistics Department) files had 3388 records for the 6-year period. To maintain consistency in coverage over the period, however, firms with less than 10 employees or those that appeared in the directory for only one year were not included in our master file. The basic structure of the industrial directory data was documented in Lee [7].

[10]Stationary firms are defined as those that appeared in all six annual directories with the same address; births are those that appeared for the first time in any year during 1971–1975; movers are those that relocated within Bogota during 1971–1975. An analysis of the employment location patterns by this classification of establishments was done in Lee [9].

TABLE 1
Sample Composition: Zone by Firm Type

Zone	Stationary	Birth	Mover within Bogota	Mover from outside	Total
Ring 1	0	2	2	0	4
	0.00	50.00	50.00	0.00	100.00
	0.00	11.11	4.17	0.00	3.17
Ring 2	7	3	5	0	15
	46.67	20.00	33.33	0.00	100.00
	12.07	16.67	10.42	0.00	11.90
Ring 3	17	6	13	1	37
	45.95	16.22	35.14	2.70	100.00
	29.31	33.33	27.08	50.00	29.37
Ring 4	16	3	13	1	33
	48.48	9.09	39.39	3.03	100.00
	27.59	16.67	27.08	50.00	26.19
Ring 5	16	4	12	0	32
	50.00	12.50	37.50	0.00	100.00
	27.59	22.22	25.00	0.00	25.40
Ring 6	2	0	3	0	5
	40.00	0.00	60.00	0.00	100.00
	3.45	0.00	6.25	0.00	3.97
Total	58	18	48	2	126
	46.03	14.29	38.10	1.59	100.00
	100.00	100.00	100.00	100.00	100.00

Source. The City Study Establishment Survey.

In some cases the 4-way stratification severely limited the possibility of drawing sample establishments from a specific population category. For example, not enough textile firms were located in certain *comunas.* Therefore, sample establishments were also selected from two other industry categories that are closely related to the two main industries; namely, the textile industry was supplemented by the apparel industry, and the fabricated-metal industry by the nonelectric machinery industry. As shown in Table 2, the final sample has fairly even shares among the three industry groups: about 35% each for the two main industry groups and 30% for the "other" category.

In Table 3, we see that the average size of stationary firms in the sample is almost five times larger than the average size of births, and more than

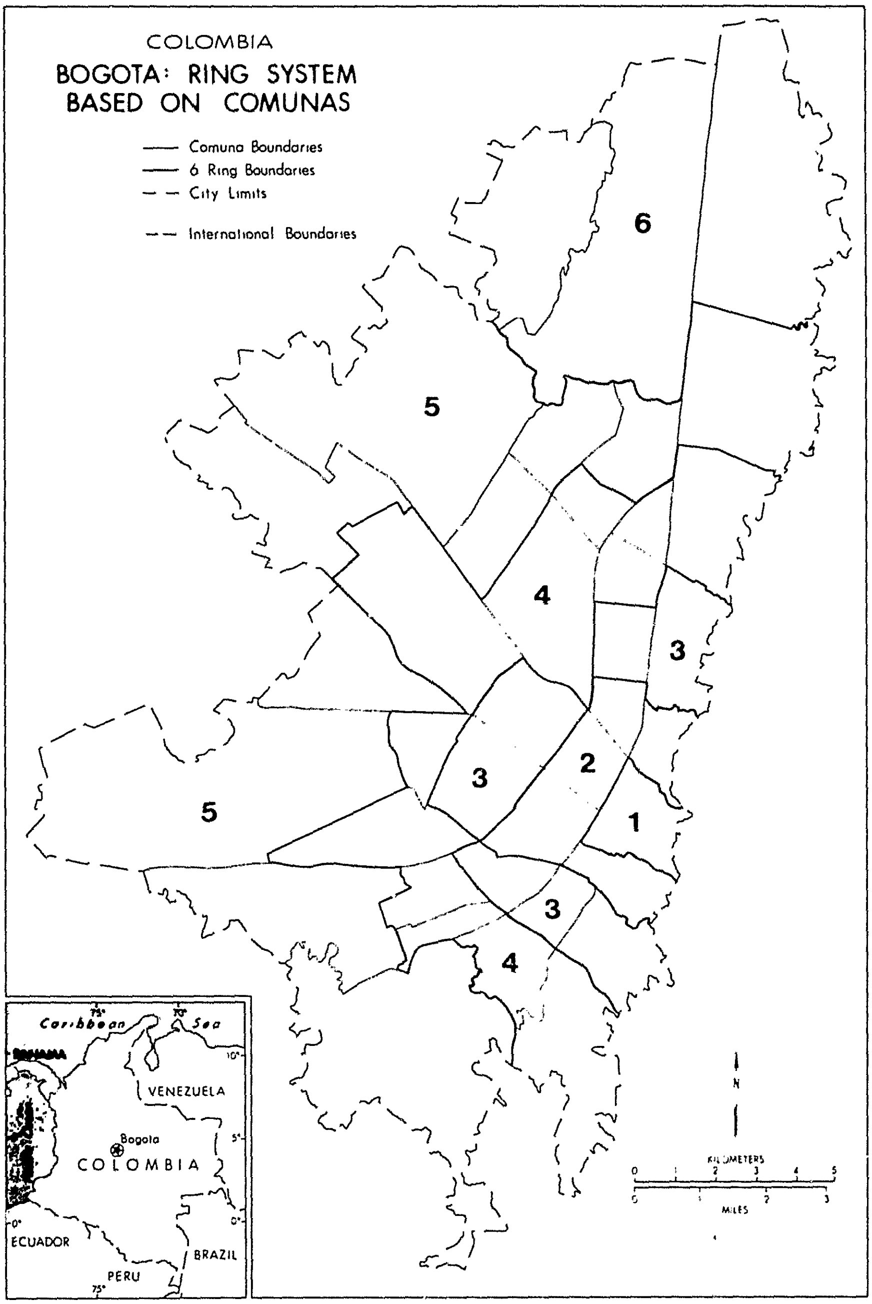
COLOMBIA
BOGOTA: RING SYSTEM BASED ON COMUNAS
Comuna Boundaries
6 Ring Boundaries
City Limits
International Boundaries
6
5
4
3
3
2
1
5
3
4
Caribbean Sea
VENEZUELA
Bogota
COLOMBIA
ECUADOR
BRAZIL
PERU
N
KILOMETERS
MILES

FIGURE 2

TABLE 2
Sample Composition: Zone by Industry

Zone	Textiles	Apparel	Fabricated metal	Nonelectric machinery	Other	Total
Ring 1	1	1	1	0	1	4
	25.00	25.00	25.00	0.00	25.00	100.00
	3.03	10.00	2.86	0.00	2.56	3.17
Ring 2	3	1	4	1	6	15
	20.00	6.67	26.67	6.67	40.00	100.00
	9.09	10.00	11.43	11.11	15.38	11.90
Ring 3	6	6	13	4	8	37
	16.22	16.22	35.14	10.81	21.62	100.00
	18.18	60.00	37.14	44.44	20.51	29.37
Ring 4	12	1	9	2	9	33
	36.36	3.03	27.27	6.06	27.27	100.00
	36.36	10.00	25.71	22.22	23.08	26.19
Ring 5	10	1	6	2	13	32
	31.25	3.13	18.75	6.25	40.63	100.00
	30.30	10.00	17.14	22.22	33.33	25.40
Ring 6	1	0	2	0	2	5
	20.00	0.00	40.00	0.00	40.00	100.00
	3.03	0.00	5.71	0.00	5.13	3.97
Total	33	10	35	9	39	126
	26.19	7.94	27.78	7.14	30.95	100.00
	100.00	100.00	100.00	100.00	100.00	100.00

Source. The City Study Establishment Survey.

twice that of movers. This resulted from the oversampling of large firms; the sample average firm size of 135 persons is about twice as large as the average firm size of the establishments in the population.[11]

4. SELECTED ESTIMATION RESULTS

We now turn to the estimation of the multinomial logit model (16). Estimation is based on the Bogota establishment survey results and other secondary data sources. Although the survey questionnaire was designed to take no more than 1 hour to complete, it was comprehensive in coverage to include plant characteristics, employment composition, transport access, proximity to markets, local public services, and the respondent's evaluation

[11]According to the industrial directory file of 1975, the average firm size of 1829 establishments with 10 or more employees was 65 persons.

TABLE 3

Sample Composition: Firm Type by Size

Firm type	Employment size[a] (1,4)	(5,9)	(10,19)	(20 49)	(50,99)	(100 or more)	Total
Stationary	0	1	8	13	4	32	58
	0.00	1.72	13.79	22.41	6.90	55.17	100.00
	0.00	25.00	38.10	34.21	23.53	72.73	46.03
	—	6.00	16.25	33.54	81.75	324.72	194.66
Birth	1	2	3	9	1	2	18
	5.56	11.11	16.67	50.00	5.56	11.11	100.00
	50.00	50.00	14.29	23.68	5.88	4.55	14.29
	3.00	6.00	13.00	26.56	63.00	174.00	39.11
Mover	1	1	10	16	12	10	50
	2.00	2.00	20.00	32.00	24.00	20.00	100.00
	50.00	25.00	47.52	42.11	70.59	22.73	39.68
	3.00	7.00	13.50	31.94	78.75	335.60	99.14
Total	2	4	21	38	17	44	126
	1.59	3.17	16.67	30.16	13.49	34.92	100.00
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	3.00	6.25	14.48	31.21	78.53	320.34	134.53

Source. The City Study Establishment Survey.

[a]The bottom number in each group is the mean employment size of firms in that group.

of the plant location. Particular attention was given to the characteristics of movers[12] and the factors that influence location decisions.

In (16) specification of the dependent variable requires a stratification of firms by type according to the vector of firm characteristics x; the independent variables are the site characteristics Z. The survey instrument contains a number of candidate variables for the stratification of firms to define the dependent variable: variables related to output such as product type and annual sales; variables related to technology such as type of production process and building structure; and variables associated with inputs, for instance, plant space, lot size, and the number of production workers. The site characteristics to be used as independent variables include those associated with accessibility to various types of markets (product, material inputs, and labor), and those related with the quality of local public services.

Of the 126 firms in the sample, 87 are in the textile and the fabricated metal industries, the two major industries included in the study. We report here estimated results obtained with the specifications shown in Table 4.

[12]Detailed analysis of movers appears in Lee [8].

TABLE 4
Stratification of Dependent Variable

Group	Industry	Floor space	Number of Observations
1	SIC 321 and 322	Less than 1000 m^2	17
2	SIC 321 and 322	1000 m^2 or more	26
3	SIC 381 and 382	Less than 1000 m^2	27
4	SIC 381 and 382	1000 m^2 or more	17
Total			87

Note: SIC 321, textile; SIC 322, apparel; SIC 381, fabricated metal; and SIC 382, nonelectric machinery.

For the dependent variable, the 87 firms in the two major industries are grouped into two plant sizes according to floor space. The independent variables are in the following categories: access to the local markets for output and material inputs measured by the proportion of output sold and inputs bought in Bogota, proximity to residential areas of production and administrative workers, an index of the quality of local public services measured by the frequency of electricity interruption, the extent of agglomeration economies measured by the employment-location quotient of individual industries in the zone of location, and the intensity of economic activities and the degree of congestions measured by the population density in the zone of location. The distance to the CBD is included as a measure of accessibility to the city center.

Ideally, stratification for the dependent variable should be achieved by more than the 2-way (and 4-cell) classification used here. The small sample size, however, limits such possibilities. Therefore, we include two firm type stratification variables on the right-hand side of the equation, specifically, the year of initial operation at the present location that discriminates old mature establishments against new ones and recent movers, and the ownership dummy variable to distinguish renters from owners.

All independent variables entered the model as "group-specific"[13] except for the location-quotient variable and the ownership dummy variable; the former being specified as "generic" within the same industry group, and the latter within the same size group. In the estimation of this multinomial logit formulation, Group 4 was used as the reference group. Therefore, the estimated logit coefficients of group-specific variables should be interpreted as relative differences with respect to the reference group. Hence, the signs of the coefficients do not necessarily mean the direction of causation; they

[13]This expression is equivalent to "alternative-specific" in the multinomial-logit literature.

only reflect the relative orders of magnitudes of individual coefficients with respect to the reference group for a given independent variable.

Table 5 reports the estimated logit coefficients and *t* statistics that are the test of difference between the coefficients of a particular group with respect to those of the reference group. In Table 5, Group 4 (large metal-fabricating firms) was set as the reference group. The *t* tests indicate that the differences of coefficients are significant between two size groups (large as against small), and are more robust within the same industry (Group 4 vs Group 3). None of the coefficients of Group 2 (large textile firms) was statistically significant. The likelihood ratio index of 0.29 indicates that the overall goodness of fit is good. These patterns held true in the estimation of alternative model specifications with lot size and employment variables in place of the floor space variable.

To interpret the estimated logit coefficients the elasticities of probabilities are calculated at sample means and reported in Table 6. This parameter measures the percentage change in the probability of being in the *i*th group with respect to 1% change in a given independent variable for that group. In Table 6 we first observe that Group 3 (small metal-fabricating firms) has the highest elasticity values for most of the variables; compared with the other two, however, this group is least sensitive to the electricity interruption rate ELECINT and the location quotient LOCQT. The most important variable that influences the probability of being in Group 3 is the measure of access to the local input markets INPUTBT, followed by the measure of access to the local product markets PRODSOLD. Local market orientation is very important for this group.

For Group 1 (small textile firms), the measure of access to the local input markets is also the most important variable, followed by proximity to production workers' residential areas WKSOUTH. The weakest variable in this case is distance from the CBD, which implies that small textile firms tend to locate near the CBD compared with the other 2 groups. As distance from the CBD increases, the probability of being in Group 2 is three times higher than that of being in Group 1. However, small metal-fabricating firms tend to locate farther from the CBD than do textile firms of both size groups.

In the case of large textile establishments (Group 2), it is interesting to find that the most important variable is the location quotient LOCQT, followed by the electricity interruption rate ELECINT, and the proximity to the residential areas of administrative workers ADMNORTH. For this group of large firms, the measure of access to local markets and the proximity to production workers' residential areas are rather unimportant. Large textile firms tend to be more export-oriented and use capital-intensive production facilities. Also, the fact that large firms have less likelihood of locating in a densely populated area POPDENS is consistent with the finding that they tend to locate farther from the CBD.

TABLE 5

Logit Estimation of Firm Location Choice: Dependent Variable, Industry and Floor Space[a]

	CONSTANT[a]	PRODSOLD	INPUTBT	DISTCBD	WKSOUTH	ADMNORTH	ELECINT	POPDENS	LOCQT	YRINOP	RENTER
Coefficients											
Group 1	−15.680	0.011	0.019	0.012	0.014	−0.010	0.501	0.008	0.749	0.159	2.069
Group 2	−2.128	0.008	−0.010	0.032	0.003	−0.016	0.448	0.002		0.033	—
Group 3	−12.880	0.028	0.027	0.151	0.022	−0.020	0.115	0.012	0.738	0.095	2.069
Group 4[b]	—	—	—	—	—	—	—	—	—	—	—
t Statistics											
Group 1	2.09**	0.74	1.39	0.07	0.80	0.64	1.05	1.11	1.69*	1.63*	2.67**
Group 2	0.57	0.60	0.89	0.21	0.20	1.12	1.11	0.35		0.60	—
Group 3	2.07**	1.83*	2.05**	0.92	1.33	1.40	0.24	1.89*	1.71*	1.20	2.67**
Group 4	—	—	—	—	—	—	—	—		—	—

Percent correctly predicted:	54.02	Number of observations:	Group 1 = 17
Likelihood ratio index:	0.2903		Group 2 = 26
Likelihood ratio statistic:	70.02		Group 3 = 27
			Group 4 = 17

Source. The City Study Establishment Survey.

[a] Definitions of variables are given in the Appendix.

[b] Group 4 is used as the base.

*Significant at the 5% level.

**Significant at the 2.5% level.

TABLE 6

Elasticities of Probability: Logit Estimation of Location Choice

Industry groups by floor space	PRODSOLD	INPUTBT	DISTCBD	WKSOUTH	ADMNORTH	ELECINT	POPDENS	LOCQT	YRINOP	RENTER	Share
Group 1	0.515	1.182	0.052	0.808	−0.496	0.711	0.794	0.544	9.264	1.665	0.1954
Group 2	0.272	−0.293	0.155	0.128	−0.538	0.556	0.124	0.722	1.585	—	0.2989
Group 3	1.367	1.455	0.584	1.120	−0.689	0.123	1.233	0.468	4.630	1.467	0.3103
Group 4	—	—	—	—	—	—	—	—	—	—	0.1954

Source. The City Study Establishment Survey.

Notes. For definitions of dependent and independent variables, see the Appendix.

The elasticity of probability is defined as $e_{ij} = (1 - p_i)b_{ij}\overline{X}_{ij}$, where p_i is the share of ith group, b_{ij} the jth logit coefficient of the ith group, and $\overline{X}_{ij}$ the sample mean of the jth independent variable for the ith group.

It should be noted that the logit coefficients reported in Table 5 are the differences with respect to the coefficients of the base group. Therefore, the values of elasticities in this table are the results based on $(b_{ij} - b_j^*)$ instead of b_{ij}, where b_j^* is the coefficient of the base group.

With such a small sample and a large number of independent variables, the above results look promising. When the model was specified with lot size and employment size as the stratifying variable (in place of the floor space), the estimation results were quite similar to those reported here.

5. CONCLUDING REMARKS

This paper presents an abstract but empirically tractable model of employment location; it shows that the basic theoretical approach used in the housing literature can provide a useful analytical framework for the study of employment location. The results of the establishment survey conducted in Bogota are used to test a multinomial logit specification of bid-rent function following the approach used by Ellickson [4] in his housing study.

The estimation of the model was performed with a 2-way stratification of dependent variable by the use of industry type and floor space, each having two categories. Independent variables included were measures of access to the output and input markets, indexes of concentration of economic activities, and a quality index of public utili. services. Even though the sample size was not large, the goodness of fit was satisfactory, and the estimated model was capable of predicting, in probability terms, which types of firms are likely to occupy a site with those characteristics specified by the explanatory variables.

The predicted location patterns resulting from the model are consistent with those expected *a priori*. For small firms the accessibilities to the local input and output markets are most important; the benefits of accessibility to the central area tend to compensate for the high land rent and congestion costs in the high density area. On the other hand, large establishments, which are more export-oriented and require more plant space with modern production technology, tend to locate in outer areas where more space is available at lower cost. The estimated results also show that for large firms, the quality of public utility services is very important, and that the proximity to the residential areas is more important to administrative workers than to production workers.

Separate regression results[14] (using the same data set) indicate a strong relationship between the intensity of input (labor and capital) use and land price; given a well shaped (monocentric) rent gradient in Bogota,[15] these results support the hypothesis that the firms respond to the substitutability of land with respect to other inputs over space, and this evidence is consistent with the predictions obtained from the logit specification in this paper. The patterns of employment location in Bogota are by no means

[14] Reported in the earlier version of this paper presented at the Denver meetings of the Econometric Society.

[15] See footnote 5, and also Villamizar [14].

random; they are quite similar to those observed for large cities in the United States.

APPENDIX: DEFINITIONS OF VARIABLES IN TABLE 5

Dependent Variable

See Table 4

Independent Variables

CONSTANT	Group specific constants
PRODSOLD	Percent of products sold in Bogota
INPUTBT	Percent of inputs bought in Bogota
DISTCBD	Airline distance (km) from the CBD (the center of *comuna* 31) to the establishment location (the center of the *comuna* where the establishment is located)
WKSOUTH	Percent of production workers living in the south
ADMNORTH	Percent of administrative workers living in the north
ELECINT	Frequency of electricity interruption; (1, never; 2, once a week; 3, twice a week; 4, more than twice a week)
POPDENS	Population per hectare of the *comuna* where the establishment is located
LOCQT	Location quotient defined as *comuna j*'s share of industry *i* relative to its share of total manufacturing employment (Separate values are used for the two industry groups.)
YRINOP	Year of initial operation at the present location
RENTER	Ownership dummy: 1 if renter, 0 if owner. (Assigned to establishments with floor space of less than 1000 m^2 in both industry groups.)

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