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in the Urban Land Market in Bogota, Colombia
The Role of Quantity Premiums and Discounts**

M. Wilhelm Wagner

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The World Bank
Washington, D.C., U.S.A.

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Washington, D.C. 20433, U.S.A.

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First printing August 1984

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Library of Congress Cataloging in Publication Data

Wagner, M. Wilhelm.

Market prices and assessed values in the urban land market in Bogota, Colombia.

(World Bank staff working papers ; no. 651)

Bibliography: p.

1. Real property--Prices--Colombia--Bogotá. 2. Real property--Valuation--Colombia--Bogotá. 3. Assessment--Colombia--Bogotá. I. Title. II. Series.

HD520.B63W33 1984 333.33'23'098614 84-13212
ISBN 0-8213-0389-9

ABSTRACT

The purpose of this paper is to investigate three related issues concerning the urban land market in Bogota, Colombia. First, an attempt is made to quantify the extent to which land unit prices vary in response to the size of the lots. Second, land value gradients for the city as a whole are estimated to examine the evolution of the land price surface during the 1955-1978 period. Finally, the paper investigates the extent to which cadastral assessments follow market land valuations. This last section also serves to quantify the relationship between land values and the income of the resident population, and, by implication, to infer the distributive effects of those taxes which are based on land valuations.

The analysis indicates that there can be both quantity premiums and discounts in the urban land market at the same time. These scale effects however, are not stable over time but change in response to urban growth. It is found, for example, that land parcels which were offered at a discount in the past, were earning quantity premiums at a later date. Estimation of land price surfaces shows that the differences in land values between the city center and the periphery are declining. This effect is the net result of constant real prices in the center and rising values in outlying areas which are related to the decentralization of population and employment. Comparing market prices with assessed values reveals that the cadastral appraisals have been relatively successful in approximating market values. In addition, it is found that the assessed values are quite sensitive to the income of the resident population. Market values, in contrast, are weakly related to income differences. Consequently, it is argued that taxes on land valuations have been more progressive than if the assessment procedures had replicated the prices that are obtained in the market.

EXTRACTO

La finalidad del presente estudio es analizar tres cuestiones conexas concernientes al mercado de bienes raíces en Bogotá, Colombia. En primer lugar, se intenta cuantificar en qué medida los precios unitarios de la tierra varían en relación con el tamaño de los lotes. En segundo lugar, se calcula la gradiente del valor de la tierra para toda la ciudad, a fin de examinar la evolución de los precios de la tierra durante el periodo de 1955-78. Por último, se analiza en qué medida los avalúos catastrales concuerdan con la valoración de la tierra en el mercado. Esta última sección sirve también para cuantificar las relaciones entre el valor de la tierra y el ingreso de los habitantes urbanos y, como resultado, para deducir los efectos distributivos de los impuestos que se basan en las tasaciones de la tierra.

El análisis indica que en el mercado urbano de bienes raíces puede haber al mismo tiempo primas y descuentos por cantidad. Sin embargo, estos efectos de escala no son estables a través del tiempo, sino que varían en relación con el crecimiento urbano. Por ejemplo, se ha observado que parcelas que en el pasado se ofrecían con una rebaja, posteriormente generaban primas. La estimación de los precios por ubicación muestra que las diferencias en el valor de la tierra entre el centro de la ciudad y la periferia están disminuyendo. Este efecto es el resultado neto del nivel constante de los precios reales en el centro y del creciente valor de las zonas periféricas, debido a la descentralización de la población y el empleo. La comparación de los precios de mercado con los valores tasados revela que las tasaciones catastrales se han aproximado relativamente bien a los precios de mercado. Además, se ha observado que los valores tasados guardan una relación bastante sensible con el nivel de ingresos de los residentes. En contraste, los valores de mercado se relacionan débilmente con las diferencias entre los niveles de ingresos. Por consiguiente, se arguye que los impuestos basados en las tasaciones de la tierra han sido más progresivos de lo que hubieran sido si los procedimientos de tasación hubiesen reproducido los precios que se obtienen en el mercado.

Le présent document porte sur trois questions liées entre elles, concernant le marché des terrains urbains à Bogota (Colombie). Ses auteurs s'efforcent tout d'abord de quantifier la mesure dans laquelle les prix par unité de surface varient en fonction de la superficie des parcelles. Ils estiment ensuite le coefficient de variation de la valeur des terrains pour la ville dans son ensemble, de façon à étudier l'évolution des prix des terrains par surface pendant la période 1955-1978. Enfin, ils examinent dans quelle mesure les évaluations cadastrales suivent les prix du marché. Cette dernière section sert également à quantifier les rapports entre la valeur des terrains et le revenu de la population qui y réside, et, par voie d'implication, à déduire quels effets distributifs ont les impôts fondés sur les évaluations foncières.

Il ressort de l'analyse qu'il peut exister simultanément sur le marché des terrains urbains des primes et des décotes tenant à la quantité. Ces effets d'échelle ne sont toutefois pas stables et changent à mesure que la ville grandit. On a découvert, par exemple, que les grandes parcelles offertes d'abord à un prix inférieur à la normale se vendaient ultérieurement à un prix supérieur à celui des parcelles moins étendues. Les estimations des prix des parcelles en fonction de leur superficie montrent que les différences de valeur entre le centre et la périphérie diminuent. Il s'agit là de l'effet net du maintien des prix réels à un niveau constant dans le centre et de l'augmentation de la valeur des terrains dans les faubourgs liée à la décentralisation de la population et de l'emploi. La comparaison des prix du marché et des évaluations cadastrales montre que celles-ci sont relativement proches de la réalité. En outre, il ressort de l'étude que les évaluations cadastrales sont extrêmement sensibles aux revenus de la population résidente. En revanche, les prix du marché n'ont que de faibles liens avec les différences de revenu. En conséquence, il faut conclure que les impôts sur les plus-values foncières sont plus progressifs qu'ils ne l'auraient été si les procédures d'évaluation avaient abouti aux mêmes prix que ceux obtenus sur le marché.

PREFACE

This paper forms part of a large program of research grouped under the rubric of the "City Study" of Bogota, Colombia, being conducted at the World Bank with the collaboration of Corporacion Centro Regional de Poblacion. The goal of the City Study is to increase our understanding of the workings of five major urban sectors--housing, transport, employment location, labor markets, and the public sector--in order that the impact of policies and projects can be assessed more accurately.

This paper would not have been possible without the help of Guillermo Wiesner who kept meticulous records of vacant lot transactions over the period of analysis, Rakesh Mohan who initiated and supervised the land market work, and Rodrigo Villamizar who organized the task of transferring the data to computer readable form. The author is also grateful to the Cadastral Division of Bogota for providing the land value maps of the city. A special word of thanks goes to Leslie Kramer for calculating the 1980 assessed values from these maps.

The author has benefited from the encouragement, support and comments of Gregory K. Ingram, Johannes F. Linn and other members of the City Study research staff at the World Bank and at the Corporacion Centro Regional de Poblacion in Bogota. Finally, the author wishes to thank Mary Ann Heraud, Maria Elena Edwards and Elfrida O'Rielly-Campbell for typing various versions of the manuscript before the paper could attain its present form.

Other City Study papers dealing with the urban land market include:

1. Guillermo Wiesner, "Cien Años de Desarrollo Historico de los Precios de la Tierra en Bogota", Bogota, Colombia; Corporacion Centro Regional de Poblacion. Working Paper No. 4, 1980; also in Revista Camara de Comercio de Bogota, Nos. 41-42 (December 1980), pp. 171-208.
2. Alan Carroll, "Pirate Subdivisions and the Market for Residential Lots in Bogota," Washington, D.C., World Bank Staff Working Paper No. 435, October 1980
3. Rodrigo Villamizar, "Land Prices in Bogota Between 1955 and 1978: A Descriptive Analysis," Washington, D.C., The World Bank, Urban and Regional Report No. 80-2, April 1980, Also in J. V. Henderson (ed.) Research in Urban Economics, Vol. 2, 1981. (City Study Project Paper No. 7).
4. Rakesh Mohan and Rodrigo Villamizar, "The Evolution of Land Values in the Context of Rapid Urban Growth: A Case Study of Bogota and Cali, Colombia", Washington, D.C., The World Bank, Urban and Regional Report, No. 80-10, 1980, Also in Mathew Cullen and Sharon Woolery, (eds.), World Congress on Land Policy Proceedings, Lexington Books, 1982, pp. 217-254, (City Study Project Paper No. 14).

5. Gregory K. Ingram, "Land in Perspective: Its Role in the Structure of Cities" Washington D.C., The World Bank, Urban and Regional Report No. 80-9, 1980; also in Cullen and Woolery, op.cit. (City Study Project Paper No. 18).

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I. INTRODUCTION

The role of land in the urban economy is multi-dimensional. On the one hand, land is an important input in the construction of residential, commercial and industrial structures as well as in the provision of public investment projects (e.g., streets and parks). Secondly, land can be viewed as a "pure asset" which is held by individuals both as hedge against inflation and for speculative motives. Since capital markets in developing countries are usually not properly functioning, land holdings constitutes one of the few options available for the accumulation of wealth. Finally, land plays a key role in urban fiscal affairs; taxes and charges on real estate not only contribute to the revenue of the municipal government, but also have the potential to influence the distribution of income. Given the importance of land in urban activities, it is therefore necessary to gain a better understanding on the operation of the urban land market. Land prices are key in examining this behavior.

The purpose of this paper is to investigate the spatial and behavioral regularities of the land prices in Bogota, Colombia. Specifically, three related issues are examined: first, an attempt is made to determine the extent to which economies of scale are available in the sale of undeveloped lots. Second, the paper documents the changes in the land price surface over time. Lastly, by combining the information on market prices with cadastral appraisals and income, it is possible to evaluate the assessment procedures of the local authorities, and, by implication, to infer the distributive effects of those taxes which are based on land valuations.

For the purposes of this study, market prices were derived from the records of the long established real estate firm of Wiesner and Cia. Ltd. This data set consists of 6,100 transactions of vacant lots covering the period 1955 to 1978. The information has been transformed in various ways to show the patterns and changes over time of land prices in the city. The assessed values, on the other hand, were obtained from land value maps prepared by the Cadastral Division of Bogota. This information is available for 1976 and 1980.

The analysis indicates that there can be both quantity premiums and discounts in the urban land market at the same time. These scale effects however, are not stable over time but change in response to urban growth. It is found, for example, that land parcels which were offered at a discount in the past, were earning quantity premiums at a later date. Estimation of land price surfaces shows that the differences in land values between the city center and the periphery are declining. This effect is the net result of constant real prices in the center and rising values in outlying areas which are related to the decentralization of population and employment. Comparing market prices with assessed values reveals that the cadastral appraisals have been relatively successful in approximating market values. In addition, it is found that the assessed values are quite sensitive to the income of the resident population. Market values, in contrast, are weakly related to income differences. Consequently, taxes based on land valuations have been more progressive than if the assessment procedures had replicated the prices that are obtained in the market.

The remainder of the paper is divided into four sections. Section II quantifies the scale economies that are available in the sale of vacant parcels. The section following examines the changing spatial patterns of land prices for the city as a whole. Section IV then discusses the relationships between market prices, assessed values and income. The final section restates the major findings and offers some concluding remarks.

II. QUANTITY PREMIUMS AND DISCOUNTS IN THE LAND MARKET

2.1 The Determinants of Land Prices: Analytical Framework

It is not an easy task to estimate the price of land in an urban setting. When we speak about the price of a good, we usually refer to a distribution around some mean, which, in general, is not difficult to find. In a market which is free of distortions, the observed prices of a good cluster closely around the mean and therefore the variability observed is small. The key idea is that the good is homogeneous so that we can state unambiguously its price and trend over time. In the case of land, however, such a simplification is generally not warranted. To speak about land as a homogeneous commodity would clearly be a misrepresentation.

A distinguishing characteristic of the market for land is product differentiation: that is, we are talking about the same generic good but with different component characteristics. Since no two lots are exactly alike, there is substantial variability in their prices. It is not surprising, therefore, that the prices of otherwise seemingly comparable land parcels can vary by orders of magnitudes. An extreme view would be that each lot is unique and that its price is a reflection of that uniqueness. The question to be asked then is what factors account for the wide dispersion of land prices that are observed in urban areas. In this section we concentrate on two of these factors, namely the lots' access characteristics and their size.

Lot Accessibility

The location of the parcels in relation to the overall spatial structure of the city can be expected to be an important determinant of

of land price variation. The essence of the argument lies in the intra-urban distribution of economic activity. Under this view, the concentration of people in a city will enable some firms to realize economies of scale in the production of their output. Other firms who sell their outputs to or who buy their inputs from the firms with scale economies will attempt to economize on their transportation costs by locating near the firms with the scale economies. Similarly, the workers of these firms, who are also the customers of the final product, will find it advantageous to locate near these firms in order to minimize on their commuting costs. Following the argument a step further, additional suppliers and the producers of other consumer goods will locate in a similar manner. In all cases the key issue is proximity to the market place both for inputs and for outputs. As a result, the spatial patterns that emerge are such that some activities cluster more in certain zones than in others. Characteristically, these activities concentrate in or near the center of the city. ^{1/} The population and employment densities of most cities, for example, decline with distance from the city center. ^{2/} Since access to economic opportunities declines with distance, so will the price of land. Competition among the various land users will ensure that vacant plots closer to the city center will be more valuable than similar plots farther away.

^{1/} The center of the city can even be defined as that part of the city that has a concentration of activities.

^{2/} For U.S. cities these patterns are documented by Mills (1972). Evidence for Colombian cities, particularly for Bogota, can be found in Ingram and Carroll (1981), Pachon (1979), Mohan (1980) and Mohan and Villamizar (1980).

Lot Size

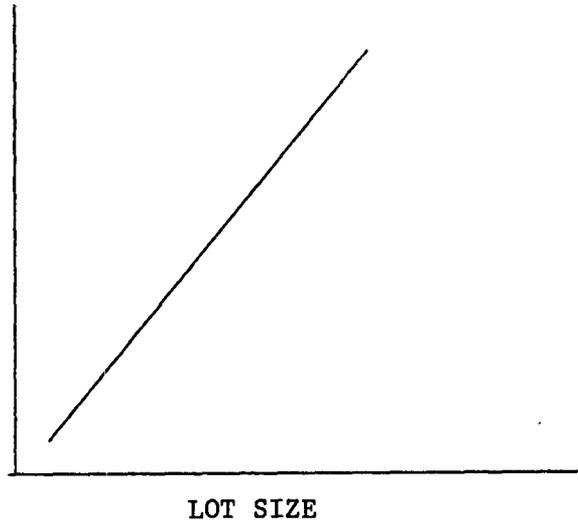
One of the intrinsic properties of parcels which may have an important effect on the price of the lot (or the price per unit area) is its size. If all lots have the same size and are indistinguishable in other respects, it is conceivable that there would be a uniform price. However, if the lots vary in their size while other factors remain constant, it is not entirely clear if the price per unit area will be constant. Figure 1 suggests three possible ways in which land prices can be related to lot size. A positively sloped relation would indicate that prices per unit area rise with the size of the lot, suggesting that quantity premiums accrue to the larger parcels. Alternatively, a declining land price with increasing lot size would reflect the presence of quantity discounts in the sale of land. Between these two cases, a flat curve would indicate that the price of land per unit area is constant regardless of the size of the lot. Although any of the above three possibilities offers a plausible characterization of the effect of size on the price of land, the question that remains unanswered is which situation best depicts the market for land.

Interaction of Location and Size

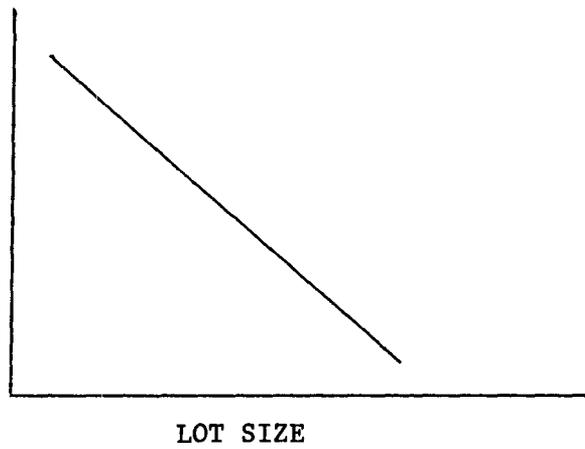
Up to this point, we have considered the location of land parcels and their size in isolation. In fact, it has been argued that these two factors will have independent effects on the valuation of land. However, we should allow for the possibility that the two effects interact to produce the observed variability in market prices. Under this interpretation, we can conceive of situations where both quantity premiums and discounts are being offered in the sale of land depending on the location of the parcels. Figure 1 above suggested three alternative characterizations of the relationship market prices and lot sizes. What is argued now is that all three possibilities can be present in an urban area at the same time!

FIGURE 1: LAND PRICE - LOT SIZE RELATIONSHIP:
THREE ALTERNATIVE FORMULATIONS

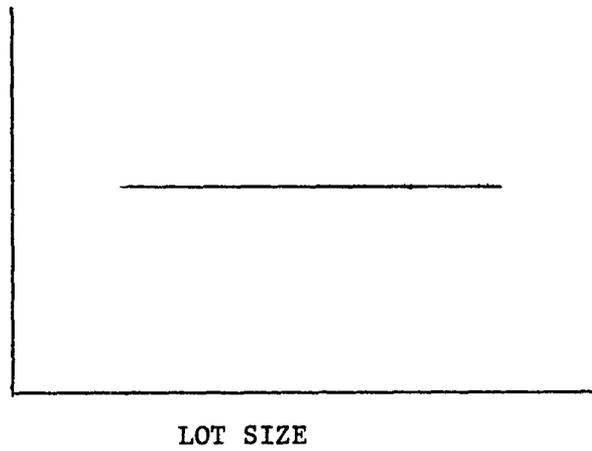
a. LAND PRICE/
UNIT AREA



b. LAND PRICE/
UNIT AREA



c. LAND PRICE/
UNIT AREA



For the sake of argument, consider two groups of lots with identical size distributions. Furthermore, assume that all other factors which affect prices, except for their location, are common to the two groups. While in one group size has a positive impact on prices (Figure 1.a.), in the other, size is inversely related to prices (Figure 1.b.). If the strength of the premiums and discounts is of the same magnitude, the fitted regression line on the two groups would be parallel to the horizontal axis (as in Figure 1.c.) and we would tend to conclude that the size of the lot does not affect prices. The source of the error lies in the combination into one sample of observations from two populations which exhibit totally different behavioral patterns. Had we properly accounted for the location of the two groups, we would have obtained the relationships indicated in Figures 1.a. and 1.b. The point to bear in mind is that the observations in the first group are associated with one set of regression parameters, while the observations in the second group are associated with a different set of regression parameters.

The above hypothetical example is probably not an unrealistic representation of the patterns observed between land prices and lot sizes in urban areas. In a market system, the price of land (or the price of a lot or a part thereof) represents the discounted sum of expected returns.^{1/} These returns, in turn, reflect the development potential of a plot of land in the context of urban space. In the city center, where land is scarce and

^{1/} Mathematically this can be represented by

$$P_0 = \sum \frac{R_t}{(1+r)^t}$$

where P_0 is the price of land at time 0, R_t is the return from it at time t , r is the discount rate. Thus, the price of land today depends on the returns we can expect from it tomorrow.

where few vacant lots remain, we can expect land prices to be positively related to lot size in the manner suggested by Figure 1.a. The reason why the larger empty parcels will command a higher price per unit areas than the smaller parcels is because they are best suited for the construction of structures that are consistent with the types of activity prevailing in the areas. One can also argue that in the city center larger plots may tend to be more valuable on a per unit basis than smaller plots due to the often substantial costs of land assembly. On a larger lot, for example, one can build a bigger building or shopping center than if the lots is small. The size of the smaller parcels, on the other hand, may have quality problems (e.g., too small) which do not allow for the effective utilization of the land. Their expected returns per unit area will be lower than those for the larger lots, and, consequently, so will their prices. In short, it can be conjectured that there are quantity premiums in the sale of land in or near an urban area's central business district (CBD).

The pattern depicted in Figure 1.b. is perhaps characteristic of the conditions prevailing in the urban periphery. Undeveloped land is more readily available, in these parts of the city, than it is in the central core. The prices per unit of the larger lots do not necessarily have to be higher than those of the smaller lots because these properties are not subject to the pressures that exist in the CBD. More important, however, is the fact that sellers might be willing to offer "quantity discounts" to buyers: that is, if there are increasing returns to scale in the sale of land, then some of the cost savings might be passed on to the lot buyers. This could be explained by the subdivision and development costs, including bureaucratic costs, that the landowner must face. In such cases, one expect the price per unit areas to decrease with increasing lot size.

Between these two extremes, the possibilities are endless. The patterns in which land prices and lot sizes behave in different locations within a city will depend on the relative strength of two opposing forces: if vacant land is scarce (such as in the CBD), it is conceivable that prices per unit area will rise with increasing parcel size; in contrast, where vacant land is plentiful (such as in outlying areas), land prices will most likely fall with increasing scale. In the continuum of urban space, we can therefore expect the land price-lot size relationship to be positive in the city center (suggesting quantity premiums) and to become increasingly flatter and even negative (suggesting quantity discounts) as one moves out to the periphery. The important point is that it is perhaps more proper to view the overall urban market for land as consisting of a number of submarkets loosely connected. This land market segmentation is modeled in this paper by the access characteristics of the lots, specifically as regards their distance from the city center.

The Effects of Urban Growth

The discussion so far has been largely set in a static context. It must be recognized, however, that the manner in which land prices are related to lot sizes depends partly on urban growth. Two of the most common and best documented phenomena associated with this growth are the decentralization of the residential population and of employment. The need for land and space by households and by the various economic activities will place heavy strains on the market for land in the affected areas. For the purposes of this study, this "tightness" in the land market will imply a gradual counter-clockwise

rotation of the land price-lot size relationship associated with each location. In some of the city, for example, lot buyers may eventually end up paying premiums for land that was being offered at a discount in the past.

2.2 Equation specification

Having laid down the justification for the influence of lot sizes on land prices, the next step is to estimate the sign and magnitude of the postulated effects. The equation to be fitted to the data is of the general form

$$P = a \cdot S^b$$

where P = price per square meter

S = size of the lot (in square meters)

a, b = parameters to be estimated.

Of special interest here is the parameter b which stands for the size elasticity of prices. As such, it represents the percentage change in the price of land for a percentage increase in the size (area) of the lot. Thus, the estimated coefficient provides an indication as to the extent to which economies of scale are available in the market for land: a significantly positive coefficient will indicate the presence of quantity premiums while a significantly negative coefficient will indicate that quantity discounts are being offered in the sale of land. For statistical estimation the equation is transformed by taking natural logarithms, such that

$$\ln P = \ln a + b \ln S$$

At this stage, it is important to recall the hypotheses raised in the preceding section. There it was argued that the price-size relationship for vacant land parcels may not be constant across the urban area, but may vary depending on the location. In order to control for these differential "size effects" on land prices, a number of shift variables and interaction terms are included in the equation. Specifically,

$$\begin{aligned} \ln P = & a_1 + a_2 \text{ RING2} + a_3 \text{ RING3} + a_4 \text{ RING4} + a_5 \text{ RING5} + \\ & a_6 \text{ RING6} + b_1 \ln S + b_2 \ln \text{SR2} + b_3 \ln \text{SR3} + b_4 \ln \text{SR4} + \\ & b_5 \ln \text{SR5} + b_6 \ln \text{SR6} \end{aligned}$$

where

RING 2 through 6 take the value of 1 if the property is located in RING_i (i = 2, 3, 4, 5, 6).
0 otherwise. ^{1/}

lnSR2 through lnSR6 equal the product of the size of the lot and the dummy variable for its location.

and P and S are the same as before. Thus, the estimated function includes land prices (P) as the dependent variable, lot size (S) as the independent variable, and a set of dummy variables and interaction terms which allow for changes in both the "intercept" and "slope" of the land price-lot size relationship. ^{2/}

^{1/} The map in the Appendix illustrates the rings in which the city has been subdivided. These rings represent semicircles around the traditional center of business activity (ring 1), and roughly standardized for distance.

^{2/} The intercept and slope of the base case are a_1 and b_1 , respectively. The corresponding coefficients for location i ($i > 1$) are $(a_1 + a_i)$ and $(b_1 + b_i)$. The coefficients estimated with this equation are exactly the same as those that will be obtained from separate regressions of P on S for each individual location.

The key idea underlying the equation specification is that each land parcel is imperfectly substitutable, and, hence, non-competing with other parcels at other locations. ^{1/} Stated differently, it is argued that there are really many land markets in an urban area with different conditions obtaining in each. One way to introduce this segmentation is to classify the vacant lots by their access characteristics. In the equation above, lot accessibility is represented by their distance to the center of the city. It is assumed that, if the overall urban land market is properly functioning, the prices of similar lots will not be too different at similar distances from the center. ^{2/} Consequently, the lots lying at a constant radius from the CBD can be said to be relatively substitutable, competing within the same sub-market.

One limitation of this specification is the exclusion of other factors which affect the valuation of land, the most important being: the neighborhood qualities and amenities, the quantity and quality of infrastructure provision, and the topography of the site. Unfortunately, data limitations prevent us from analyzing these additional explanatory concepts in a comprehensive manner. While a more complex specification that allows for these factors might be desirable in order to explain the variability of land prices, the intention of this exercise is not to obtain equations

^{1/} As indicated earlier, an extreme view is that each parcel is unique and that it belongs to a market of its own.

^{2/} On examining land prices in Bogota during the 1955-78 period, Mohan and Villamizar (1980) observe that, while land prices in poor areas have generally been lower than in rich areas, there has been a catching up phenomenon such that the prices of similar land parcels equidistant from the city center are not too dissimilar.

with "best fit" properties, but to demonstrate a sense of the direction and magnitude of the relationships between one particular lot attribute -- size -- and land prices in different locations within an urban area.

2.3. Empirical Analysis

Table 1 presents the regression results of the log-linear specification discussed above. In all cases, the dependent variable is the price per square meter. All prices have been deflated by the consumer price index of white collar workers for Bogota (1955=100). The period of analysis covers the years 1955 to 1978. For ease of presentation, the equations were estimated by pooling the data on three-year intervals.^{1/}

The coefficient of the lot size variable ($\ln S$) and the constant of the equation correspond to the slope and intercept of the price-lot size relationship for land parcels in the CBD (ring 1). To obtain the parameter values of the "size effects" on land prices at the other locations, the coefficient of the dummy variable (RING i) and the interaction term ($\ln SR_i$) of each ring must be added to the intercept and slope of the CBD, the comparator base. Table 2 summarizes the slope parameters associated with each location that result from manipulating the estimated coefficients in this manner. For example, the slope of the price-lot size equation of vacant parcels in ring 2 during the 1973-75 period is calculated by adding the coefficient of $\ln SR_2$ to the coefficient $\ln S$ or $0.3800 - 0.2678 = 0.1122$.

^{1/} The equations were also estimated on a yearly basis, but the results are not included here. In general, the estimated coefficients are consistent with those reported in Table 1.

Table 1: LOG-LINEAR REGRESSION EQUATIONS RELATING LAND PRICES TO LOT SIZES, BOGOTA, 1955-78

	1955-57	1958-60	1961-63	1964-66	1967-69	1970-72	1973-75	1976-78
LN S	-0.1555 (1.79)	-0.1660 (2.87)	0.3577 (5.47)	-0.1481 (2.09)	-0.2290 (3.02)	-0.0849 (0.90)	0.3800 (4.29)	0.0057 (0.06)
RING2	-0.0543 (0.09)	-1.5731 (3.62)	1.4352 (3.20)	-1.3334 (2.59)	-1.4074 (2.52)	-0.8607 (1.30)	1.4336 (2.44)	-1.1234 (1.88)
RING3	-0.8660 (1.56)	-0.7403 (1.86)	2.2367 (5.32)	-0.9771 (1.98)	-1.3808 (2.50)	-0.7019 (1.07)	1.6887 (2.91)	-0.1811 (0.32)
RING4	-0.4326 (0.76)	-0.5266 (1.34)	1.3729 (3.19)	-0.8056 (1.75)	-2.4718 (4.66)	-0.9165 (1.47)	1.2039 (2.14)	-1.6572 (2.89)
RING5	-1.9701 (3.18)	-0.6217 (1.45)	1.9538 (4.53)	-0.5420 (1.19)	-1.5925 (2.84)	-0.2726 (0.44)	2.4655 (4.41)	-0.0126 (0.03)
RING6	-2.9262 (2.69)	-1.7098 (3.14)	2.1594 (3.85)	-0.5717 (0.74)	-1.6940 (2.84)	0.5427 (0.74)	5.4249 (8.30)	1.2766 (2.12)
LSNR2	-0.1397 (1.45)	0.1763 (2.40)	-0.3751 (4.87)	0.1228 (1.39)	0.1246 (1.33)	0.0888 (0.80)	-0.2678 (2.66)	0.1223 (1.23)
LSNR3	-0.0333 (0.35)	-0.0112 (0.17)	-0.5262 (7.36)	0.0208 (0.25)	0.0915 (1.00)	0.0436 (0.40)	-0.3380 (3.38)	-0.0659 (0.70)
LSNR4	-0.1486 (1.57)	-0.0888 (1.35)	-0.4292 (5.78)	-0.0554 (0.71)	0.2469 (2.77)	0.0550 (0.53)	-0.2551 (2.62)	0.1811 (1.89)
LSNR5	-0.0775 (0.77)	-0.2064 (3.02)	-0.6416 (8.72)	-0.1755 (2.30)	0.0259 (0.28)	-0.1198 (1.19)	-0.5516 (5.71)	-0.1389 (1.51)
LSNR6	-0.0113 (0.08)	-0.0902 (1.16)	-0.6893 (8.12)	-0.2461 (2.22)	0.0600 (0.66)	-0.3052 (2.66)	-1.0512 (9.66)	-0.3818 (4.00)
Constant	6.3855	6.2284	3.2450	6.0928	6.5593	5.2681	2.4156	4.8075
R ²	0.5930	0.5913	0.4787	0.5898	0.5068	0.3700	0.3267	0.2800
N	666	895	1058	745	699	593	752	731

SOURCE: City Study data.

Table 2: Elasticities of Land Prices with Respect to Lot Size, Bogota, 1955-78

(Number of Observations in parentheses)

	1955-57	1958-60	1961-63	1964-66	1967-69	1970-72	1973-75	1976-78
CBD	-0.1555 (75)	-0.1660 (91)	0.3577 (123)	-0.1481 (69)	-0.2290 (88)	-0.0849 (47)	0.3800 (55)	0.0057 (38)
Ring 2	-0.2952 (208)	0.0103 (238)	-0.0174 (233)	-0.0253 (134)	-0.1044 (137)	0.0039 (101)	0.1122 (125)	0.1280 (118)
Ring 3	-0.1888 (193)	-0.1772 (242)	-0.1685 (270)	-0.1273 (187)	-0.1375 (149)	-0.0413 (116)	0.0420 (151)	-0.0602 (160)
Ring 4	-0.3041 (134)	-0.2548 (213)	-0.0715 (264)	-0.2035 (200)	0.0179 (176)	-0.0299 (162)	0.1249 (181)	0.1868 (183)
Ring 5	-0.2330 (40)	-0.3724 (72)	-0.2839 (131)	-0.3236 (118)	-0.2031 (103)	-0.2047 (128)	-0.1716 (182)	-0.1332 (179)
Ring 6	-0.1668 (16)	-0.2562 (39)	-0.3316 (37)	-0.3942 (37)	-0.1690 (46)	-0.3901 (39)	-0.6712 (58)	-0.3761 (53)

SOURCE: Table 1.

Considerable care must be exercised when interpreting the results. As Table 1 shows, many of the estimated coefficients are not significantly different from zero according to the standard tests of statistical inference. In the present context, however, it is important to consider what the estimated coefficients and t-ratios of the dummy variables and interaction terms stand for: they measure the departure and significance of that departure respectively from the parameters of the base case (i.e., ring 1). A small value of the coefficients and of their corresponding t-statistics indicates that the "size effects" are not substantially different between the location being analyzed and the CBD. Conversely, if the coefficient is large and statistically significant, it can be concluded that the manner in which lot size affects land prices is materially different between the location in question and the city center. Thus, for some rings there can be a significant correlation between the unit land price and the lot size variables in spite of statistically insignificant results for their corresponding shift and interaction terms.

A striking feature of the results reported in Table 2 is the wide variability exhibited by the estimated coefficients. While in one time period the "size effect" at a certain location is positive, in another location the effect is negative. Furthermore, the influence of lot size on land price for each ring changes in sign and magnitude over time. Amid this apparent instability, three roughly consistent patterns can be observed.

First, looking at each three year period reveals that the coefficients of lot size for the inner rings are generally higher than for the outer rings. This result implies that the quantity premiums (discounts) are higher (lower) in central areas and that these decrease (increase) with distance from the city center. During 1973-75, for example, the "size effects" are (decreasingly) positive between rings 1 and 4, and (increasingly) negative in rings 5 and 6. ^{1/}

A second peculiarity of the results is that the elasticities with respect to lot size are always negative in rings 5 and 6, suggesting the existence of size discounts in peripheral areas throughout the 24 year period. These findings are consistent with estimates from other studies. In an analysis of illegal residential developments in Bogota, Carroll (1980) showed that unit land price decreased with lot size, indicating the presence of "quantity discounts" in the sale of land. The land parcels of which his study was based, however, were mostly located in the urban fringe (i.e., rings 5 and 6 according to the spatial aggregation indicated in the Appendix). Hence, his results are consistent to those reported here which indicate that the prize effects in outlying areas are negative during the 1955-1978 period.

A final regularity clearly indicated in Table 2 is the tendency of the "size effects" to increase over time. With a few exceptions, the elasticity of land prices with respect to lot sizes at each location tends to increase during the observation period. To illustrate: the depressing effect of lot size on land price in the earlier years is less negative (ring 5), not present (ring 1 and 3) and, in some cases, of the opposite sign (rings 2 and 4) in the more recent years. The most notable exception to this pattern is the experience of ring 6 where the inverse relationship has become progressively more negative, suggesting that quantity discounts are more substantial today than in the past. This last result should not be too

surprising since the area enclosed by ring 6 continues to be largely undeveloped. Given the availability of large quantities of vacant land, it is still possible to offer "quantity discounts" in the sale of land. As this area becomes economically more integrated to the rest of the city, one might expect these discounts to diminish, and, eventually, to become negative.

How then can one rationalize these "size effect" regularities, both across the various rings and over time? At this stage, it is important to recall the arguments raised earlier on the expected responses of land prices to lot sizes. There it was stated that the high concentration of economic activities in the CBD makes accessibility valuable. Consequently, this area and its immediate vicinity will exhibit high population and employment densities. Competition among land users (e.g., households and firms) will ensure that land prices reflect the discounted value of future rents. From this simple formulation of urban structure and market behaviour, several interesting propositions for the land price-lot size relationship follow. In central areas where little vacant land remains, the price per unit area for the bigger lots may be higher than for the smaller lots, perhaps because the bigger parcels permit the construction of structures consistent with the economic potential of the zone (e.g., office buildings, department stores), while the smaller parcels may not be suitable for the same purposes. In the least developed parts of the city, on the other hand, sellers may be willing to offer quantity discounts to buyers not only because more vacant parcels

are available, but also because there may be economies of scale in the sale of land so that some of the cost savings are passed on to consumers. This notion of "tightness" in central areas and "looseness" in the periphery is clearly indicated by the results for the 1973-75 and 1976-78 periods: the elasticities of land price with respect to lot size are positive in the inner rings and negative in the outer rings. The patterns exhibited in earlier years, however, do not fit this description since the "size effects" are generally negative. Nevertheless, the results do show a definite regularity: the "size effects" are increasingly negative moving out from the center to the periphery. Thus, it can be argued that if quantity discounts are available throughout the urban area, these will be smaller in the center and will tend to increase with distance.^{1/}

The postulated land price-lot size relationship is not a stable one over time, as would be expected. The gradual increase (decrease) in the premiums (discounts) of each location reflect the response of the land market to urban growth. As mentioned earlier, this growth is generally accompanied by the increased decentralization of the residential population and of employment. As the city expands, land closer to the center gets converted to urban use. Land prices must therefore rise not only to indicate scarcity but also to reflect the increased economic opportunities that become available with the decentralization of urban activity. In this context, the evolution of the land price-lot size relationship is understandable: large

^{1/} Conversely, if premiums are the norm, it is not unreasonable to expect that these will be highest in the center and will tend to decrease with distance.

lots will become increasingly more valuable per unit area than the smaller lots. The arguments follow essentially the same line as those mentioned in the preceding paragraph regarding the cross-sectional evidence.

At this stage one may ask whether the observed "size effects" are due to the omission of other factors which affect the variation of land. Specifically, would the results differ if service provision indicators are taken into account? Probably not in the central areas where all lots are likely to be serviced. In the periphery, on the other hand, the largest lots may lack public utilities which would result in lower unit prices than for smaller residential lots with such services. In this case, the size of the lots merely acts as a proxy for service indicators. While this is a valid argument, the evidence does not support it. The data indicate that over 98 percent of all lots in the sample were serviced by water and electricity while nearly 82 percent had access to roads. Moreover, it is important to note that the lots lacking these services were both large and small and that they did not concentrate in any particular area of the city. Thus, it appears safe to assume that service standards were held constant in the estimation of the size effects.

Overall, the analysis yields coefficients of the expected signs and magnitudes. The correlations of land prices with lot sizes in different locations within the city suggest that the market for vacant land in Bogota is responsive not only to land use patterns (since the "size effects" are highest in central areas and tend to decrease with distance) but also to urban growth (since the "size effects" tend to increase over time). Conformance of the observed regularities across space and time with expectations offers an indication of the efficient functioning of the market for land in Bogota.

III. THE LAND PRICE SURFACE, 1955-78

As was mentioned earlier, distance to the centers of economic activity is an important determinant of land prices in urban areas. In the previous section, this variable (represented by the rings) was used to control for the access characteristics of the vacant lots. The main purpose there, however, was not to explain land price variability over space, but to measure the extent to which quantity premiums and discounts were available in different parts of the city. In this section we describe in greater detail the patterns of land prices within the city and analyze the changes in the land price surface over time.

3.1. The Negative Exponential Function

Characteristically, the price of land in the center of urban areas is higher than in the periphery. In the continuum of urban space, therefore, it is reasonable to expect that market prices will decrease with increasing distance. Most models of urban structure, for example, predict that land rents fall off smoothly and at a decreasing rate as one moves out from the city center. An equation specification which satisfies these conditions is the negative exponential function.^{1/} This function takes the form:

$$P(x) = P(o) e^{-gx}$$

where $P(x)$ is the price of land located at "x" distance from the center, $P(o)$ is the price level at the CBD, e is the base of the natural logarithm

^{1/} This functional form has been widely used to document the spatial distributions of urban activity, especially population and employment densities.

and g is the parameter often termed the gradient. The value of the gradient represents the proportional change in prices given a one unit change in distance. The coefficients to be estimated -- $P(o)$ and g -- are of special interest here since they fix the position and shape of the land price surface. Thus, the negative exponential function can be viewed as a useful descriptive tool for tabulating and comparing land price patterns over time.

3.2. Setting the Data

Before presenting the results, it is important to consider the methodology followed in preparing the data for estimation. As will be shown later, some of the conclusions differ depending on how land prices are calculated.

The data used in this analysis were derived from the data set on lot valuations which was discussed in Section II. A major distinction, however, is that the units of observations are comunas^{1/} and not vacant lots. Simply put, the data were aggregated geographically and a "representative" price was calculated for each location. With the information on hand, it was possible to obtain unit prices for each comuna in two ways: first, by taking the simple arithmetic average of the prices per square meter of the lots in the location; and, second, by weighting the unit prices by each lot's share in the total area covered by the sample. These two procedures can be expressed mathematically as follows:

^{1/} These comunas are geographical partitions of the city and consist of neighborhood groupings. The Maps in Appendix I outline this zone system. Bogota can be divided into 38 comunas.

$$P_c = \frac{\sum_i^N P_i}{N} \quad (\text{arithmetic average})$$

and

$$P_c = \frac{\sum_i^N P_i a_i}{\sum_i^N a_i} \quad (\text{weighted average})$$

where P_c is the average price of land at comuna c; P_i and a_i are the unit price and area respectively of lot i; and N stands for the number of observations (lots) in the comuna.

The estimates obtained with the two methods will differ unless all lots are the same size or there is no price variability in the comuna.^{1/} Given that there is a wide dispersion of lot sizes and unit prices, it is therefore important to determine which method gives a closer approximation to the "true" land prices of the comunas. In this respect, the weighted average probably holds an edge over the arithmetic average. A couple of reasons can be given in support of this contention.

The average prices of each comuna are based on a sample of lots. The precision of the estimates obviously depends on whether these parcels accurately reflect the land in the comuna. Since the larger parcels account for a bigger share of the total land in the comunas, it can be argued that they are more representative of the land in the zone. Hence, their prices should be more important in the determination of average comuna land prices.

^{1/} The two methods will also give the same results if there is only one observation in the comuna.

In Section II it was found that there are quantity premiums and discounts in the sale of land depending on the location. Since these "size effects" are a characteristic of the land market, it would seem desirable to include them in the computation of average comuna prices. An attempt to do so is by weighting the observations by their share in the total area of the sample. Given that the size of the lots determines the quantity premiums and discounts, it appears reasonable to weight their unit prices by their relative sizes. The simple averaging procedure, on the other hand, does not account for these economies of scale (positive or negative) because all the observations are weighted by a constant factor (i.e., 1/N).

3.3. The Estimated Functions

For estimation by ordinary least squares, the negative exponential function was transformed by taking natural logarithms, such that

$$\ln P(x) = \ln P(o) - gD$$

Table 3 summarizes the regression results for the 1955-78 period. The two sets of estimates correspond to the two alternative methods of calculating average comuna land prices that were outlined above. The first three columns are based on data calculated with the weighted procedure, while the last three columns are based on data calculated with the simple arithmetic average. ^{1/} The general result is that the exponential

^{1/} In an earlier paper, Villamizar (1980) used the same information on vacant lots to examine the behavior of land prices in the city. To obtain "average comuna prices" he used the weighted procedure. Given the differences in the treatment of comunas with no observations and in subsequent editing, the results reported in the last three columns of Table 3 do not replicate those appearing in Villamizar's study. In his study, comunas with no observations were imputed an approximate value by interpolation. In the present study, these comunas are excluded from the computations. His reported results are more similar to those obtained here using the arithmetic averages.

TABLE 3: PARAMETER ESTIMATES OF NEGATIVE EXPONENTIAL
LAND PRICE FUNCTIONS FOR BOGOTA: 1955-78

<u>Year</u>	<u>Based on Weighted Averages^{1/}</u>			<u>Based on Unweighted Averages^{2/}</u>		
	<u>Constant</u>	<u>Gradient</u>	<u>R²</u>	<u>Constant</u>	<u>Gradient</u>	<u>R²</u>
1955	4.89	-.234	.464	5.07	-.226	.509
1956	4.79	-.187	.418	4.81	-.163	.369
1957	4.84	-.197	.477	4.99	-.195	.496
1958	4.96	-.227	.449	4.99	-.207	.412
1959	4.99	-.194	.573	5.06	-.180	.620
1960	4.74	-.135	.436	4.92	-.121	.479
1961	4.99	-.204	.564	4.98	-.154	.531
1962	4.91	-.159	.502	4.96	-.146	.456
1963	4.48	-.086	.129	4.65	-.085	.252
1964	5.07	-.162	.505	5.11	-.135	.508
1965	4.87	-.178	.514	5.06	-.162	.572
1966	4.80	-.178	.378	4.87	-.160	.432
1967	5.00	-.147	.501	4.98	-.125	.507
1968	5.12	-.185	.576	5.09	-.156	.568
1969	4.52	-.087	.142	4.76	-.096	.332
1970	4.63	-.109	.303	4.56	-.075	.383
1971	4.93	-.154	.501	4.87	-.118	.398
1972	4.60	-.088	.294	4.48	-.057	.252
1973	4.98	-.133	.386	4.81	-.082	.396
1974	4.77	-.092	.388	4.63	-.057	.250
1975	4.58	-.082	.388	4.38	-.043	.226
1976	4.80	-.108	.354	4.43	-.047	.166
1977	4.77	-.110	.335	4.71	-.075	.336
1978	4.74	-.072	.224	4.50	-.028	.090

All coefficients are statistically significantly different from zero at the 99 confidence level.

1/ Comuna unit prices calculated by weighting lot prices by their relative share in the total area of the comuna.

2/ Comuna unit prices calculated by taking the simple arithmetic average of lot size in the location.

function offers a good approximation to the pattern of land prices within the city. The performance of the equations is relatively good, as measured by the R^2 statistics, and all the estimated parameters are significantly different from zero at the 99 percent confidence level.

One of the most interesting findings clearly indicated in Table 3 is the almost monotonic decrease in the value of the gradient. Since the gradient measures the rate of change of prices with respect to distance, this result implies an overall "flattening" of the land price surface over time: that is, the differences in land prices between the city center and the periphery are declining. This pattern of change is closely related to the decentralization of urban activity in a rapidly growing city since this has the effect of improving the accessibility of distant land to economic opportunities. With the suburbanization of population and employment, the price of land in outlying areas is bid up, and, in the case of Bogota, it appears that the rate of price increases in the periphery has been greater than in the center.

Throughout the period of analysis, the prices of land in or near the CBD have remained the highest. In a sense, this pattern reflects the monocentricity of the city. The data, however, suggest the appearance of secondary business districts. This is indicated by noting that the overall fit of the equation worsens as time passes. During the earlier years, the equations explain around one-half of the log-variance of land prices, while in more recent years, their explanatory power drops to about 20-30 percent. In other words, the land price surface develops

ridges, valleys and small hills as the city expands. These "disturbances" can be interpreted as secondary centers of economic activity which are competing with the traditional CBD and which are developing land price surfaces of their own. ^{1/}

The two sets of estimates reported in Table 3 exhibit similar declining trends in the values of the gradients and in the overall fit of the negative exponential equations. It must be noted, however, that there are significant differences between the results obtained with the weighted data and with the unweighted (or arithmetic average) data. Examining Table 3 in closer detail reveals that the estimates differ in two major respects.

Constants: According to the unweighted data, the constant terms of the equations show a slight tendency to decline over time: in the beginning of the period, the estimates cluster around 5.0, while in later years the estimates fall to about 4.5. Recall that the intercept represents the natural logarithm of the price of land at the city center. Combining this result with the fact that the gradients decline, the temptation is to conclude that the land price surface has flattened over time not only because prices in the periphery have risen, but also because prices in the CBD have absolutely fallen. This conclusion, however, is not supported by the estimates based on the weighted data. If anything, the results show that the average price of land in the CBD has remained relatively constant throughout the 24 year period.

^{1/} For a more detailed analysis on the evolution of land prices along specific city corridors and secondary business districts, see Villamizar (1980) and Mohan and Villamizar (1980).

Gradients: Comparing the land price gradients in the two sets of estimates reveals that the land price surface corresponding to the weighted data is consistently steeper than for the unweighted data. ^{1/} In the earlier part of the period, the differences are small. However, in the more recent years, the differences are quite substantial. From 1970 onwards, for example, the gradients obtained with the weighted data are sometimes twice as large as those obtained with the simple average. From this evidence, it can be conjectured that, if more reliable estimates of comuna prices are obtained by weighting lot unit price by their areas, the use of simple averages will overstate the "flattening" process of the price function over time.

To illustrate the inconsistencies between the two sets of results, the estimated functions for 1955 and 1978 are plotted in Figure 2. According to the unweighted data, the flattening of the land price surface is pervasive as both the intercept and slope experience significant declines during the 24 year period. Such a pattern of change is also indicated when the weighted data are used, but note that the drop in the price level at the CBD is rather small and that the curve remains relatively steep. Overall, the graph clearly indicates that the conclusions on the behavior of the land price surface over time are somewhat different depending on the method used to impute "average" comuna prices.

Figure 2 also shows the manner in which the price surface varies between the two data sets in each year. If the weighted method is the correct procedure to estimate comuna land prices, then it is clear

^{1/} The only year when this is not the case is 1969. The difference between the two estimates, however, is rather small.

ESTIMATED LAND PRICE FUNCTIONS: 1955 AND 1978

(1955 P2909)

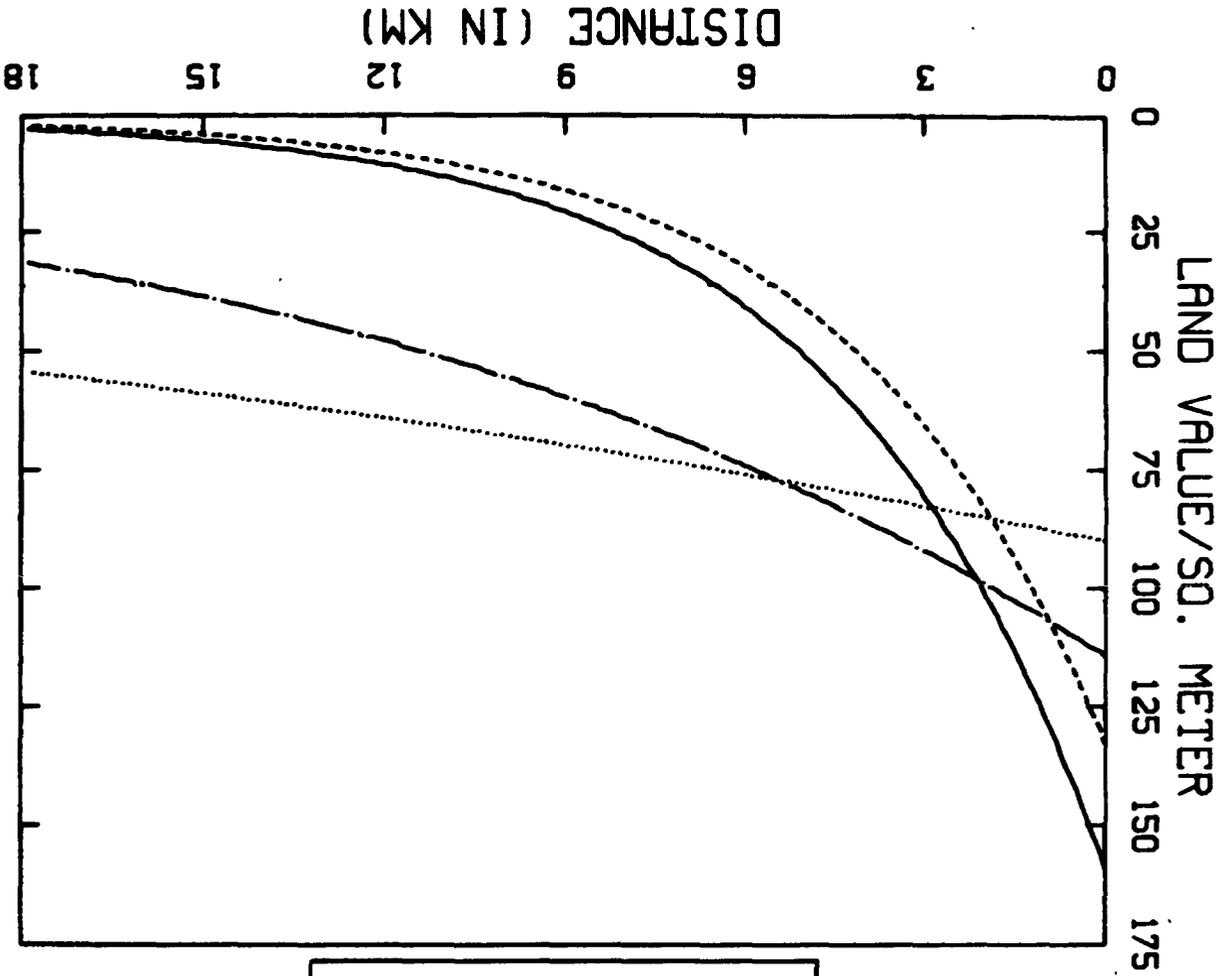
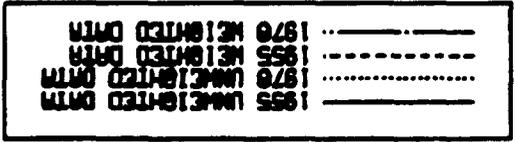


FIGURE 2.

that the unweighted data overstates prices in 1955. In 1978, on the other hand, the unweighted method of price imputation under-predicts prices in central areas and over-predicts prices in the periphery. Although the evidence pertains to the end-point observations, it must be noted that similar results were obtained for the intervening years. ^{1/} Given this, an attempt was made to determine if there is a systematic relationship between the two estimation procedures and distance. Toward this purpose, bivariate regressions for each year were run with the ratio of weighted to unweighted comuna prices (in percent) as the dependent variable, and distance (in kilometers) as the independent variable. The results show that in the 1950s and 1960s the two variables are not significantly related, but that the effect of distance is consistently negative. Moreover, the intercept terms are generally below 100 -- the value that would be obtained if the average land prices at the CBD are the same according to the two methods. After 1970, the signs are again negative, and statistically significant at the 95 confidence level. A typical result of the latter period is the estimated equation for 1978: ^{2/}

$$\begin{array}{l} \text{RATIO} = 117.08 - 2.64 \text{ DISTANCE} \\ \quad \quad \quad (2.41) \end{array} \qquad R^2 = 0.1429$$

These observations are not surprising when examined in light of the results presented in Part II. There it was found the economies of scale in the sale of land varied with distance from the city center.

^{1/} For ease of exposition, these results are not reported here.
^{2/} Where RATIO = Weighted/unweighted comuna averages. t-ratio in parenthesis.

Specifically, the results indicated that quantity discounts were available in the earlier years and that these tended to increase as one moved out to the periphery. In addition, it was found that over time the discounts at each location gradually disappear and eventually become negative. The patterns toward the end of the period, for example, are such that quantity premiums accrue to land in central areas while quantity discounts accrue to land in the periphery. Recall, furthermore, that the weighted procedure outlined above attempts to capture these scale economies whereas the unweighted method does not. Bearing these observations in mind, the estimated relations between the two methods of comuna price imputation and distance now become clear. The presence of quantity discounts in the beginning of the period implies that the weighted averages will be lower than the unweighted figures. Since the size of the discounts tends to increase as one moves out from the city center, the percent deviation between the two methods will also tend to increase with distance, hence the estimated negative coefficients in the equations.^{1/} In the 1970s, quantity premiums in central areas and discounts in the periphery add to the significance of the coefficients: the intercept term rises above 100 and the slope coefficient becomes increasingly negative. This means that the weighted averages are greater than the unweighted estimates in or near the CBD while the opposite being true farther out. The estimated land price functions for 1978 in Figure 2 clearly indicate this pattern.

^{1/} That is, the ratio of weighted to unweighted averages is greater in central areas than in the periphery. For this period, this means that the two methods yield similar estimates near the center but significantly different farther away. Since the unweighted procedure overstates prices to a greater extent in the periphery, the ratio decreases with distance.

The spatial analysis on land prices presented in this section has revealed some interesting regularities. The estimation of negative exponential functions for the 1955-78 period indicate that the land price surface has tended to level-off, suggesting that the prices have become less responsive to distance. The extent to which this "decentralization" process has proceeded, however, depends in large measure on how one obtains "representative" land prices for the city as a whole. Two methods of aggregation were suggested. Although the estimates imply similar patterns of behavior, there are also some significant differences, particularly as regards to the price level at the CBD and the magnitude of the price gradients. An attempt was made to account for the differences between the two methods of price imputation. In this respect, the findings of Part II on scale economies in the sale of land proved extremely valuable. Overall, the results show that the procedure used to calculate "representative" land prices matters, especially when one is drawing inferences on the behavior of the land price surface over time.

IV. THE RELATIONSHIP BETWEEN ASSESSED VALUES, MARKET PRICES AND INCOME

4.1 Motivations for Public Policy

So far this paper has been concerned with the market price of land. The information on vacant lots has allowed us to examine in detail the patterns and trends of land prices in different locations within the city. In this section, our attention turns to determine whether the observed prices are consistent with the assessed land values prepared by the local authorities.^{1/}

Such a study is particularly important in the case of Bogota since property taxes and user charge rates on some public utilities are based on cadastral assessments.^{2/} Consequently, the degree to which these appraisals deviate from "true" market values has very important implications for the formulation, execution, and evaluation of urban land policy. First, eliminating these distortions can correct the allocative inefficiencies which produce, for example, undesirable land use patterns. Second, bringing assessed values "in-line" with actual values can not only improve the

^{1/} The terms "price" and "value" will be used interchangeably throughout as well as the terms "assessment" and "appraisal".

^{2/} Public utilities also charge for the amount consumed, but the rate structure is graduated according to the property values of the users. This type of tariff structure is used in the pricing of water, sewer, telephone, and refuse collection. The major exception is electricity where charges are based on quantity consumed with adjustments for service category (e.g., residential, commercial, industrial) and for time of duty (peak, non-peak hours). A thorough study on public utilities in Bogota is that of Linn 1976b).

revenue performance of the local government in the form of increased property taxes and user charges, but also aid in the cost recovery of public works which are financed by taxes on property owners in proportion to the benefits conferred.^{1/} Finally, the concern for income redistribution can be better served by making allowance for differences in income groups as approximated by differences in "correctly" assessed property values. This last point is very important given the government's explicit objective of affecting the income distribution by pricing practices which result in implicit taxes and subsidies, and which eventually redistribute income. ^{2/}

These considerations, while important for public policy, are not thoroughly examined here since a more comprehensive treatment on these subjects is available elsewhere.^{3/} Instead, the purpose of this section is to investigate the relationships between cadastral values, market prices and income so that we can gain a better understanding of assessment practices in Bogota. First, the quality of land appraisal procedures is evaluated by comparing the assessed values with the actual (or market) values of land in different locations within the city. Then we examine the extent to which

^{1/} It is assumed here that the improvements will reflect in the increased value of the property. These taxes are better known as valorization taxes and are designed to recoup the cost of public infrastructure projects. A detailed review on the valorization system in Bogota is presented in Doebele and Grimes (1977). It should also be mentioned that property taxes constitute the largest source of locally raised taxes. See for reference the studies by Linn.

^{2/} See Linn (1976 a,b) and references cited therein.

^{3/} See Linn (1976 a,b), (1977), (1979), (1980), for a discussion on some of these issues in the Colombian context.

land values are related to income. It is hoped that the evidence presented below can help address more effectively such important policy issues as land use strategies, local revenue capacity and income distribution.

4.2 The Data

Comparison of appraisal and market land values on a comuna basis was possible for 1976 and 1980. The assessed values were derived from land value maps prepared by the Cadastral Division of Bogota. These maps show the variation of land prices within the city by means of price contours.^{1/} Essentially, the procedure consisted in weighting the "representative" prices of subdivisions within each comuna by their share in the total area of the comuna. For 1976, these subdivisions were represented by the area between "iso-value" lines. For 1980, on the other hand, an average land value for each barrio (neighborhood) was calculated, and then the estimates were weighted by the barrios' relative contribution to the total area of the comuna.

The market values that are used in the comparisons are the comuna average prices that were obtained by using the weighted procedures outlined in Part III. These estimates refer to 1976 but represent the moving average for the 1975-77 period.^{2/} This was done in order to abstract from atypical values in any one year and to obtain a more "permanent" measure of the market price of land at each location. In sum, the data set assembled for the present purposes consists of three estimates for each comuna:

^{1/} This system of presentation is analogous to the one used to indicate different elevations in topographic maps.

^{2/} That is, the land prices for each comuna in 1975, 1976 and 1977 were added and the result was divided by 3. This averaging procedure will introduce an upward bias if the growth of land prices is accelerating. The evidence, however, indicates that growth rates are relatively stable. See for reference Villamizar (1980) and Mohan and Villamizar (1980).

the assessed values for 1976 and 1980; and the market values for 1976. These data are expressed in constant pesos (1976 = 100) per square meter. Furthermore, note that a common base (i.e., the 1976 market prices) is used to evaluate the cadastral appraisals in both years.

4.3 Assessment Practices, 1976-80

To summarize the relationship between the cadastral assessments and market prices, bi-variate regressions were run with the 1976 and 1980 assessed values as the dependent variable and the 1976 market values as the independent variable. The results for both linear and log-linear specifications are reported in Table 4. In addition to providing a relatively good fit to the data, the estimated equations indicate that there is a statistically significant positive relation between the two variables. The results for 1976 further reveal that the slope coefficient of the linear specification is not significantly different from unity, the number one would expect if the assessed values were the same as the actual. This implies that the cadastral authorities were quite successful in 1976 in devising a valuation methodology which closely approximated market prices. Such a correspondence is no longer maintained in 1980. Note, however, that the 1980 appraisals are compared with the 1976 and not the 1980 market values due to lack of information on the latter. The results show that the coefficient of the independent variable is smaller than one. Assuming that market values did not change or that land prices grew by the same proportion, this would suggest a tendency for the relation between assessed and market values to deteriorate for more expensive land.

The differences between the assessment procedures in the two years are brought together in Figure 3 which shows graphically the estimated linear functions. For reference, the figure also indicates those points where

TABLE 4: RELATIONSHIPS BETWEEN ASSESSED AND MARKET VALUES, 1976-80

Dependent Variable = Assessed Values (per square meter)

	<u>Linear Specification</u>		<u>Log-Linear Specification</u>	
	<u>1976</u>	<u>1980</u>	<u>1976</u>	<u>1980</u>
Market values (per square meter)	1.08 (0.05)	0.72 (0.07)	1.03 (0.10)	0.97 (0.14)
Constant	-87.12 (53.48)	222.65 (82.19)	-0.31 (0.71)	0.12 (0.92)
R ²	0.9337	0.7240	0.7157	0.5700

Numbers in parentheses represent the standard errors of the regression coefficients.

ASSESSED AND MARKET VALUES COMPARED (1976-1980)
(1976 PESOS)

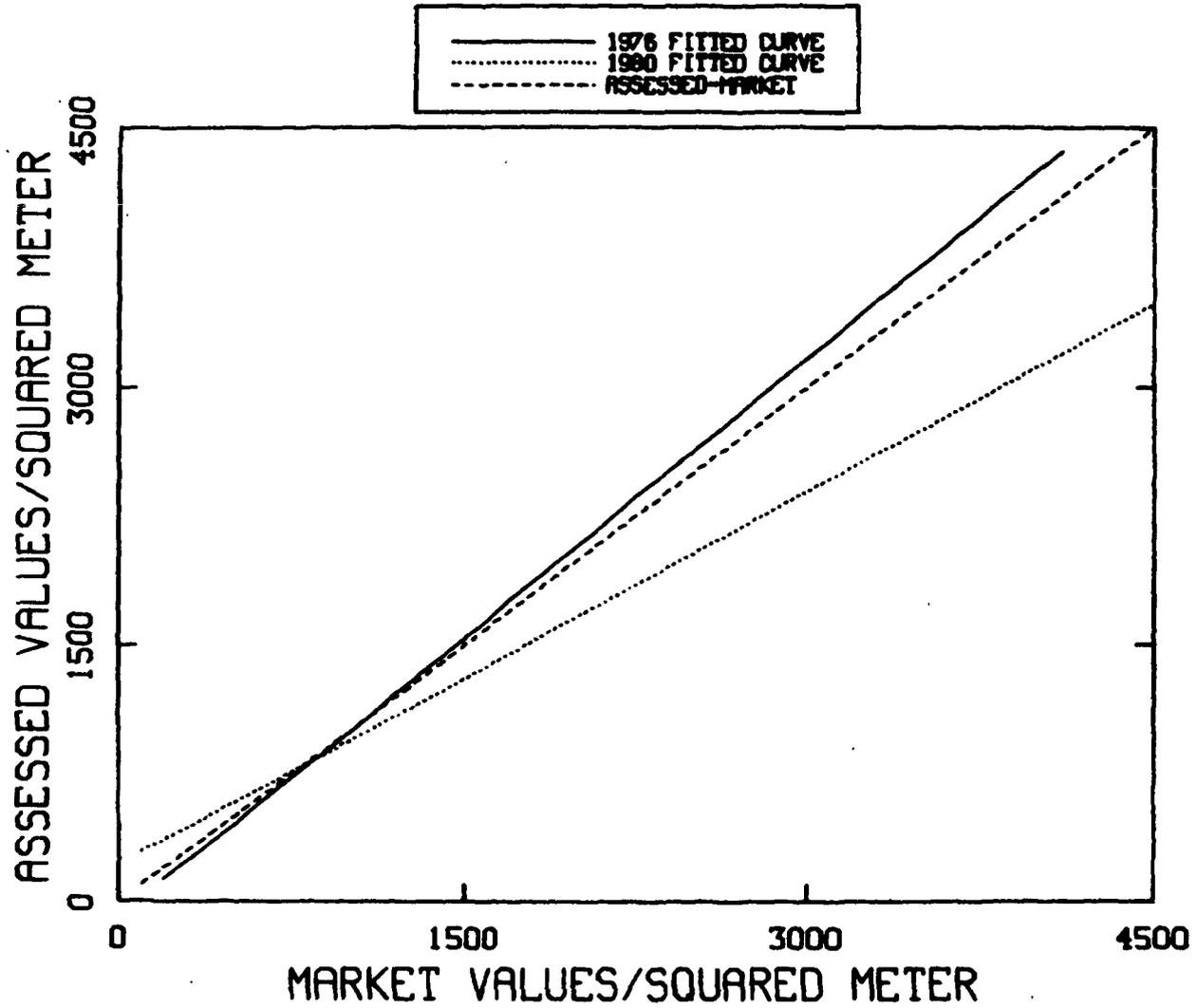


FIGURE 3.

the assessed values equal the market values.^{1/} The near-coincidence of the 1976 curve with the main diagonal is clear as well as the general under-assessment of more expensive land in 1980. The tilt of the 1980 curve relative to the 1976 curve may also be due to the more rapid growth in the appraisals of low-value areas, a result which parallels our earlier finding of market prices rising faster in the periphery.

Interestingly, the regression coefficients in logarithmic form presented in Table 4 show that the average elasticities of the cadastral appraisals with respect to market prices are not significantly different from unity in both years. This means that proportional differences between the actual prices of land among the comunas are reflected by the same percentage in their assessed values. Given that the cadastral appraisals for high-valued land in 1980 were generally lower than the market prices (as shown in Figure 3), this result further implies that land in these comunas was undervalued by the same proportion.

The quality of the land appraisal procedures in each comuna can be determined more precisely by calculating the effective assessment ratio (i.e., the assessed value expressed as a percent of the market value) in each year. This information is provided graphically in Maps 1 and 2. The figures on the top of the maps roughly indicate the magnitudes corresponding to each symbol. Note that the darker shades represent higher assessment ratios.

As can be seen in Maps 1 and 2, the highest over-valuation of land occurred in the northern suburbs of the city in both years. This probably reflects the local authorities interest not only in constraining the growth of the city in this direction, but also in limiting speculative land investments in the area.^{2/} In contrast, the remaining comunas in the periphery

^{1/} This line corresponds to the legal assessment ratio of 100%: that is, when all properties are appraised at full market value.

^{2/} There is widespread belief that land prices in this part of the city have risen the fastest. However, the evidence presented by Villamizar (1980) seems to contradict this general impression.



MAP 1: ASSESSMENT RATIOS BY COMUNA, 1976



MAP 2: ASSESSMENT RATIOS BY COMUNA, 1980

exhibited a shortfall of assessed values from market values during the period. This was also true for land to the south and west of the CBD. It is of interest to note that it is in these areas where most low income households live.^{1/}

In spite of the similarities between the assessment practices in the two years, there are also some important differences. These are represented more clearly in Map 3 which shows the 1980 assessed values as a percent of the 1976 assessed values. Again, the darker shades represent those situations where the ratio is highest. As indicated in the map, the largest relative increases in the assessed values took place in the comunas to the immediate west and south of the CBD; in the industrial and residential districts to the west of the city; and in the extreme north. The subareas lying between these three locations also experienced increases in their appraisal values but to a lesser extent. Moreover, it appears that the revaluation of land during the period did not alter the assessed values of land in peripheral locations to the south and west of the city. Interestingly, the comunas in the eastern edge of the city, including the CBD and the rich residential neighborhoods, exhibited relative declines in their cadastral appraisals. Given that the market prices of land in these locations have generally been the highest, this result partly explains the apparent undervaluation of land in 1980 indicated in Figure 3.

^{1/} The relationships between assessment practices and the household income of the resident population are discussed later in the paper.



0.34	0.50	0.65	0.80	0.95	1.11	1.26	1.42	1.57	1.72
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To measure more systematically the changes in the assessment procedures over space, negative exponential functions were estimated for the city as a whole. The results are presented and graphed in Figure 4. When looked in this way, it appears on average that the assessed values in both years were lower than the actual values. The absolute size of the discrepancy, however, tended to decrease with distance from the city center so that the assessed values and market prices were not too different in the periphery.

The spatial patterns implied by the cadastral appraisals in the two years are remarkably consistent. As figure 4 shows, the estimated land price surfaces almost coincide over the entire range, perhaps with the 1980 curve lying above the 1976 curve. Since all prices are constant 1976 pesos, the evidence suggests that the re-valuation of land by the local authorities during the 1976-80 period was not only quite effective in accounting for inflation, but also partially successful in bringing the assessed values more in line with market values. Note, in particular, that the three price surfaces almost coincide in the periphery. In Part III it was found that land prices in these locations were rising the fastest. Thus it would appear that the assessment procedures were quite successful in adjusting to these market price increases.

4.4. Assessment Practices and Income, 1976-80

As mentioned earlier, the assessment procedures have potentially serious implications for urban land policy. In Bogota, their importance stems from the fact that property taxes and user charges on some public utilities are based on cadastral assessments. From the standpoint of equity, these pricing practices take on an added significance since they may result in implicit

ASSESSED AND MARKET LAND VALUE GRADIENTS COMPARED

(1978 P2909)

- - - - - 1978 MARKET VALUES
 1980 ASSESSED VALUES
 _____ 1976 ASSESSED VALUES

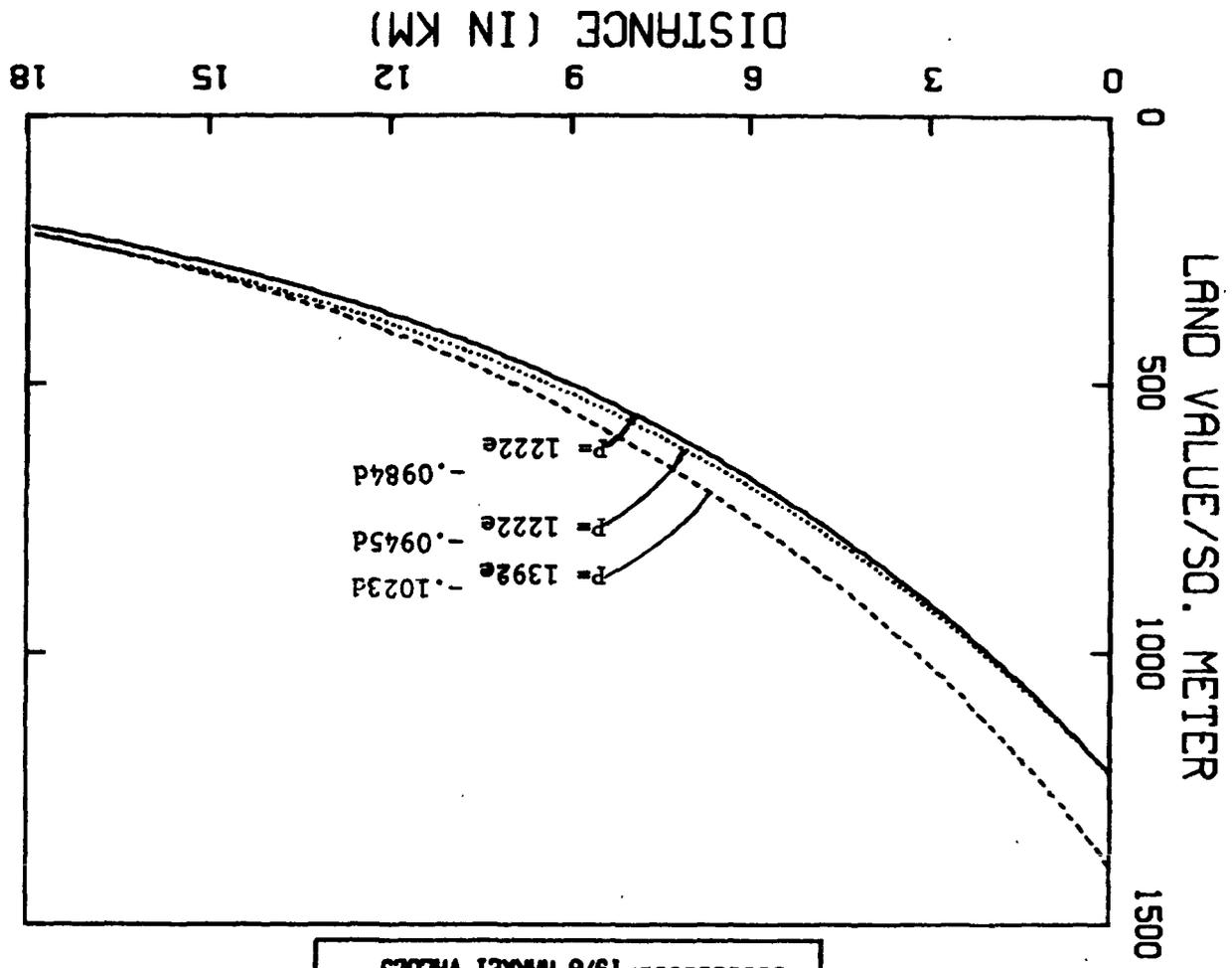


FIGURE 4.

taxes and subsidies which can effectively redistribute income. Having recognized the potential for improving the income distribution, an objective of the local authorities has been to link the tariff structures progressively to the assessed property values. The underlying assumption is that differences in property values are probably good approximations for differences in income groups. This section examines the extent to which this assumption is supported by the data for land values only. More generally, it attempts to shed some light on the redistributive impact of assessment practices by noting the relationships between land values, assessment ratios and income.

At the outset it is important to consider the limitations of the analysis. First, the discussion is in terms of land valuations which, strictly speaking, are only part of the taxable real estate in Bogota. Specifically, the appraisals used for the purposes of taxation not only include the value of the land itself, but also the capital value of the structures and the improvements on the property. It is assumed here that the conclusions remain unaffected even when property values are narrowly defined as being equivalent to land values. ^{1/}A second difficulty is that the results are based entirely on averages. This simplification smooths out the wide variability that is observed in practice.

In order to investigate the relationship between land values and income, the information on the comunas was first aggregated geographically and an average figure was calculated for each variable. Tables 5 and 6 display the results of these computations. The system of rings groups comunas into semicircles around the city center. The second pattern of aggregation

^{1/} Linn (1977) observed in selected departamentos (States) and cities in Colombia that the assessed land values on average amounted to approximately 40 percent of total property value.

referred to as "radial sectors", divides the city into pie slices which emanate from the center. The maps in the Appendix provide a graphical description of these two zone systems.

The average land values at each location were estimated by weighting the unit prices of the comunas in proportion to their share in the total area of the ring (or sector).^{1/} Hence, the assessment ratios indicated in the tables are equivalent to the total assessed value of the comunas in the group being considered divided by their total market value. Note that the 1976 market values were used as a common base throughout. The income figures were derived from the 1978 World Bank-DANE household survey and represent the average monthly household income of the resident population.

As Table 5 indicates, both assessed values and market values exhibited similar spatial patterns. In all cases, unit land prices were highest in the city center (ring 1) and declined (exponentially) with distance. It must be noted, however, that there was some variability between the market prices and the cadastral appraisals corresponding to each ring. These differences are brought more clearly by the assessment ratios for the two years. In 1976, for example, land in or near the center was over-assessed, whereas in 1980, land in these locations was under-assessed. The opposite was true for land in rings 3 and 4. For the city as a whole, the ratio increased slightly from 93% in 1976 to 97% in 1980. Recall that

^{1/} This weighted average should be distinguished from the arithmetic average, the calculation of which involves adding the unit prices of the comunas and dividing by the number of observations in the ring or sector.

the 1976 market values are used as the base in both years. Hence the 1980 assessment ratios must be viewed with caution. The disregard for the growth of market prices during the intervening period introduces an upward bias to the 1980 ratios. To correct for this, the 1976 land price estimate (Col\$ 621) was extrapolated to 1980 using the average annual growth rate of land prices over the 1955-78 period.^{1/} Having done so, the assessment ratio for the city as a whole decreases to about 82 percent. Based on these estimates, one is led to conclude that the assessment procedures in Bogota were, on aggregate, relatively successful in approximating market values during the period.

Table 5 also shows the average incomes of the resident population in each ring. Comparing these figures with the land values suggests that the correlation, if any, is rather weak: while land values decline with distance, the average household income can be either high or low in central areas as well as in the periphery. It is perhaps more instructive to compare the assessment ratios with income. The evidence for 1976, for example, suggests that the assessed values are equal or slightly above the market values in those locations where the richer households live (rings 2, 3 and 6), while the opposite appears to be the case in the lower income neighborhoods (rings 4 and 5). Assuming that market prices did not change substantially over the period, this correspondence is even stronger in 1980 since the assessment ratios are consistently above unity in the richer areas, and lower than unity

^{1/} Villamizar (1980) estimated this growth rate to be approximately 4 percent per annum.

TABLE 5: LAND VALUES,^{1/} ASSESSMENT RATIOS AND INCOME BY RINGS, 1976-80

<u>Radial Sector</u>	<u>Market</u>	<u>Assessed Values</u>		<u>Assessment Ratio^{2/}</u>		<u>Mean Household</u>
	<u>Values (1976)</u>	<u>1976</u>	<u>1980</u>	<u>1976</u>	<u>1980</u>	<u>Income (1978)^{3/}</u>
1 (CBD)	4048	4406	2930	1.09	0.72	8343
2	1283	1407	1270	1.10	0.99	16047
3	951	920	1070	0.97	1.12	19928
4	730	613	768	0.84	1.05	14772
5	511	425	409	0.83	0.80	10818
6	247	312	374	1.27	1.51	15999
TOTAL	621	578	600	0.93	0.97	13805

Notes: 1/ All land values are expressed in 1976 pesos per square meter.

2/ Assessed values in each year divided by market values in 1976.

3/ Monthly income in 1978 pesos.

in the poorer parts of the city. Overall, these results imply a tendency for the appraisal procedures to over-assess the land of the rich and under-assess the land of the poor.

Table 6 reports the distribution of the variables by radial sectors. Again, it can be observed that there is a close correspondence in the spatial patterns of both market and assessed values: that is, the three estimates for each location are about the same order of magnitude. Furthermore, note that the association between land values and income is more pronounced when viewed in this way. In fact, there is a tendency for all land prices to rise with the income of the resident population.

Comparing the assessment ratios with income again reveals that land in the richer neighborhoods was over-valued to a greater extent than in the poorer parts of the city. In 1976, for example, the average assessed value in the rich residential north (sector 8) was 20 percent above its market value, while in the poor residential south (sector 2), the assessed value was over 40 percent below. It is also of interest to note that the changes in the appraisal practices tended, on average, to intensify the differences between the ratios and income. Particularly important were the increases in the appraised values of land in sectors 5 and 7 where the average income of the households is above the average for the city as a whole. In contrast, significant decreases in the assessment ratio occurred in those areas where there is a high concentration of poor households (sectors 1 and 2).

TABLE 6: LAND VALUES,^{1/} ASSESSMENT RATIOS AND INCOME BY RADIAL SECTORS, 1976-80

<u>Radial Sector</u>	<u>Market</u>	<u>Assessed Values</u>		<u>Assessment Ratio^{2/}</u>		<u>Mean Household^{3/}</u>
	<u>Values (1976)</u>	<u>1976</u>	<u>1980</u>	<u>1976</u>	<u>1980</u>	<u>Income (1978)</u>
1 (CBD)	4048	4406	2930	1.09	0.72	8343
2	480	271	217	0.56	0.45	6833
3	429	361	358	0.84	0.83	9930
4	678	656	719	0.97	1.06	12843
5	665	666	800	1.00	1.20	13893
6	592	423	557	0.71	0.94	12801
7	467	475	643	1.02	1.37	16163
8	832	1000	858	1.20	1.03	32804
TOTAL	621	578	600	0.93	0.97	13805

Notes: 1/ All land values are expressed in 1976 pesos per square meter.

2/ Assessed values in each year divided by market values in 1976.

3/ Monthly income in 1978 pesos.

To quantify the systematic association between land values, assessment ratios and income, regression analysis was used. The results are reported in Table 7. With a few exceptions, all the variables are in logarithmic form so that the coefficients of the explanatory variables can be interpreted as the elasticities of the estimated equations. The units of observation are the average values for the 38 comunas.

Equations 7.1 through 7.3 relate the various estimates of land values to income. In all cases it is found that unit land values rise with income. However, the strength of the relationship varies depending on the definition of the dependent variable. Equation 7.1, for example, shows that the elasticity of market values with respect to income is about one third (0.34). In contrast, when the assessed values are used, the elasticities are slightly less than, but not significantly different from unity. The evidence, therefore, provides some support for the notion that wealthier households live in more expensive land. More significant, perhaps, is the fact that the cadastral authorities have tended to exaggerate the link between land values and the income of the resident population in their appraisals. This has had the effect of making the tariff structures more progressive than would have been the case if the assessed values closely approximated the market values.

Figure 5 displays graphically the estimated land value-income relations. It can be observed that the absolute differences in land values between different income groups is rather small for the market values, but more pronounced for the assessment procedures. Interestingly, the curves intersect such that the assessed values lie below the market values at the low end of the income distribution while the opposite occurs in the high income neighborhoods. Finally, note that the revaluations during the period resulted in land values being more responsive to income differences.

TABLE 7: REGRESSIONS RELATING LAND VALUES AND ASSESSMENT RATIOS TO INCOME, 1976-80

<u>Equation Number</u>	<u>Dependent Variable</u>	<u>Constant Term</u>	<u>Independent Variables</u>		<u>R² (F ratio)</u>
			<u>ln Y</u>	<u>ln M</u>	
7.1	ln M	3.47 (1.58)	0.34 (0.17)		.0950 (3.78)
7.2	ln A76	-0.10 (1.71)	0.72 (0.19)		.2890 (14.64)
7.3	ln A80	-1.87 (1.62)	0.92 (0.18)		.4232 (26.42)
7.4	R76	-203.68 (80.64)	33.18 (9.89)		.2384 (11.27)
7.5	R80	-346.16 (99.70)	49.66 (10.99)		.3618 (20.41)
7.6	ln A76	-3.27 (0.98)	0.41 (0.11)	0.92 (0.10)	.8004 (70.17)
7.7	ln A80	-4.60 (1.12)	0.65 (0.12)	0.79 (0.11)	.7629 (56.29)

Standard errors in parentheses.

Legend: M market values; A76 = Assessed values in 1976; A80 = Assessed values in 1980;

R76 = Assessment ratio (1976); R80 = Assessment ratio (1980);

Y = Average Income.

ASSESSED AND MARKET VALUES VS. INCOME

(1978 PESOS)

1976 ASSESSED VALUES (solid line)
1980 ASSESSED VALUES (dotted line)
1976 MARKET VALUES (dashed line)

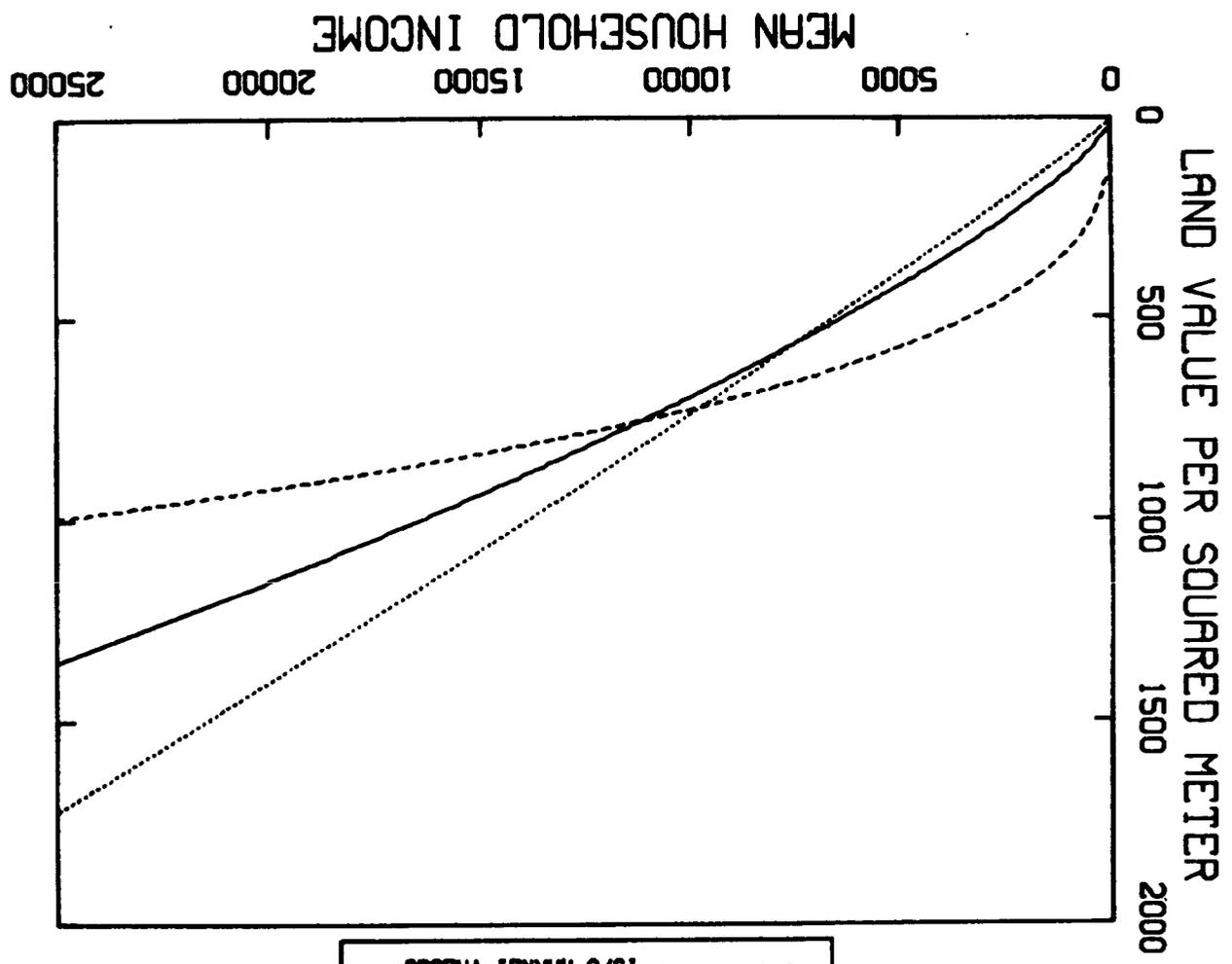


FIGURE 5.

ASSESSMENT RATIO VS. INCOME, 1976-80

(1976 PESOS)

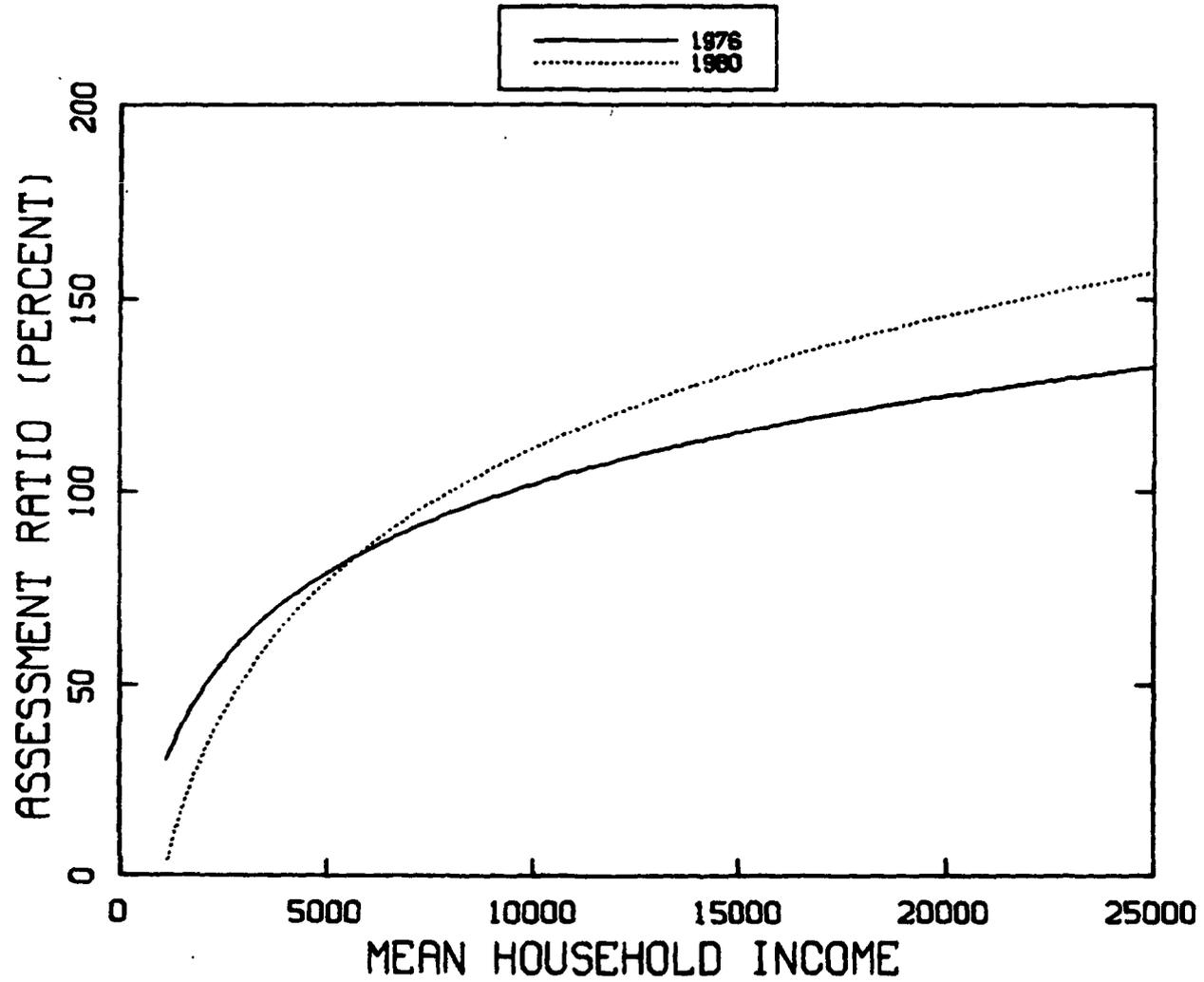


FIGURE 6.

Equations 7.4 and 7.5 document the changes in the assessment practices as they relate to income. Figure 6, which presents the graphs of the estimated relationships, clearly indicates that land in the richer (poorer) neighborhoods was over-appraised (under-appraised) to a greater extent in 1980 than in 1976.^{1/} From the equity point of view, these results are encouraging since they imply an improvement in the progressiveness of those taxes which are based on cadastral assessments.

By way of summarizing the results presented so far, equations 7.6 and 7.7 show the joint effect of income and market values on the assessed values. In both cases it is found that the two explanatory variables are quite significant. However, the degree to which they affect the land appraisals is somewhat different between the two years. The elasticity of the assessed values with respect to market values decreased from 0.92 in 1976 to 0.79 in 1980, while the elasticity with respect to income increased from 0.41 to 0.65 during the same period. If the 1976 market prices are representative of 1980, it thus appears that the cadastral authorities sacrificed a valuation methodology which closely matched market values (i.e., 1976) for one which enhanced the equity of the tax system by making the assessed values more responsive to income (i.e., 1980).

^{1/} This presupposes that the bias introduced by using the 1976 market values instead of the (correct) 1980 market values as the denominator of the assessment ratio is a constant proportion in every neighborhood (comuna).

V. SUMMARY AND CONCLUSIONS

The main objective of this paper was to examine the spatial and behavioural regularities of land values in Bogota, Colombia. Data on land prices covering a 24-year period provided useful insights on the operation of the urban land market. In addition, it was possible to evaluate the land appraisal procedures of the municipal authorities, and to infer the distributive impact of taxes based on land valuations.

The first part of this paper formulated and estimated a simple model on the influence of parcel size on land prices. Spatial segmentation in the urban land market was a key feature of this model. The empirical evidence indicated that the land price-lot size relationship is not constant, but varies depending on the location and on the period under consideration. It was found, for example, that quantity premiums (discounts) tend to decrease (increase) with distance from the city center. Moreover, the "size effects" corresponding to each location generally increase over time.

One of the most interesting findings of this paper is that both quantity premiums and discounts can be present in the sale of land at the same time. The results for the 1973-78 period, for example, show that the "scale effects" are positive in central areas, decline with distance, and become negative in the periphery.

The fact that in some locations unit land prices rise with the lot size sharply contrasts with present assessment procedures. In Colombia, a common practice in obtaining land appraisals consists in applying a "factor of form" to an estimate of the unit land value of the neighborhood.^{1/}

^{1/} See Linn (1977), p. 39.

This conversion factor, in turn, depends on the size and shape of the properties. Other things being equal, the adjustment for size has the effect of lowering the unit prices of larger parcels relative to those of the smaller parcels. If the purpose of the local cadaster is to obtain accurate estimates of land values, such a policy is ill-advised in some locations given that the opposite relation is observed in practice. From the equity standpoint it would seem desirable that the adjustment for size be positive if it is true that the larger properties are typically occupied by owners with higher incomes.

The analysis on the spatial distribution of land values revealed that land prices between the city center and the periphery are declining. While land prices in the CBD remained constant in real terms, the price of land in the periphery increased substantially during the 1955-78 period. It is important to realize that this "flattening" of the land price surface over time is a natural consequence of the growth and decentralization of urban activities.

The relatively high rates of price increase at the periphery undoubtedly resulted in some lucky individuals earning large windfall gains. To the extent that the land owners in these locations were poor, the increments to land values led to an improvement in the distribution of wealth. Conversely if the land owners were already rich to start, these price increases resulted in a further widening of the gap between the rich and the poor. In order to select the situation which best applies to Bogota, more information on the distribution of land ownership needs to be collected. In any case,

it should be noted that the rapid growth of prices in the periphery made land less affordable to low income households who seek it for housing. If shelter for the urban poor is a top policy concern, it may well be necessary for the local authorities to intervene in the land market. Subsidized or free access to land, for example, could be feasible solutions to this problem.

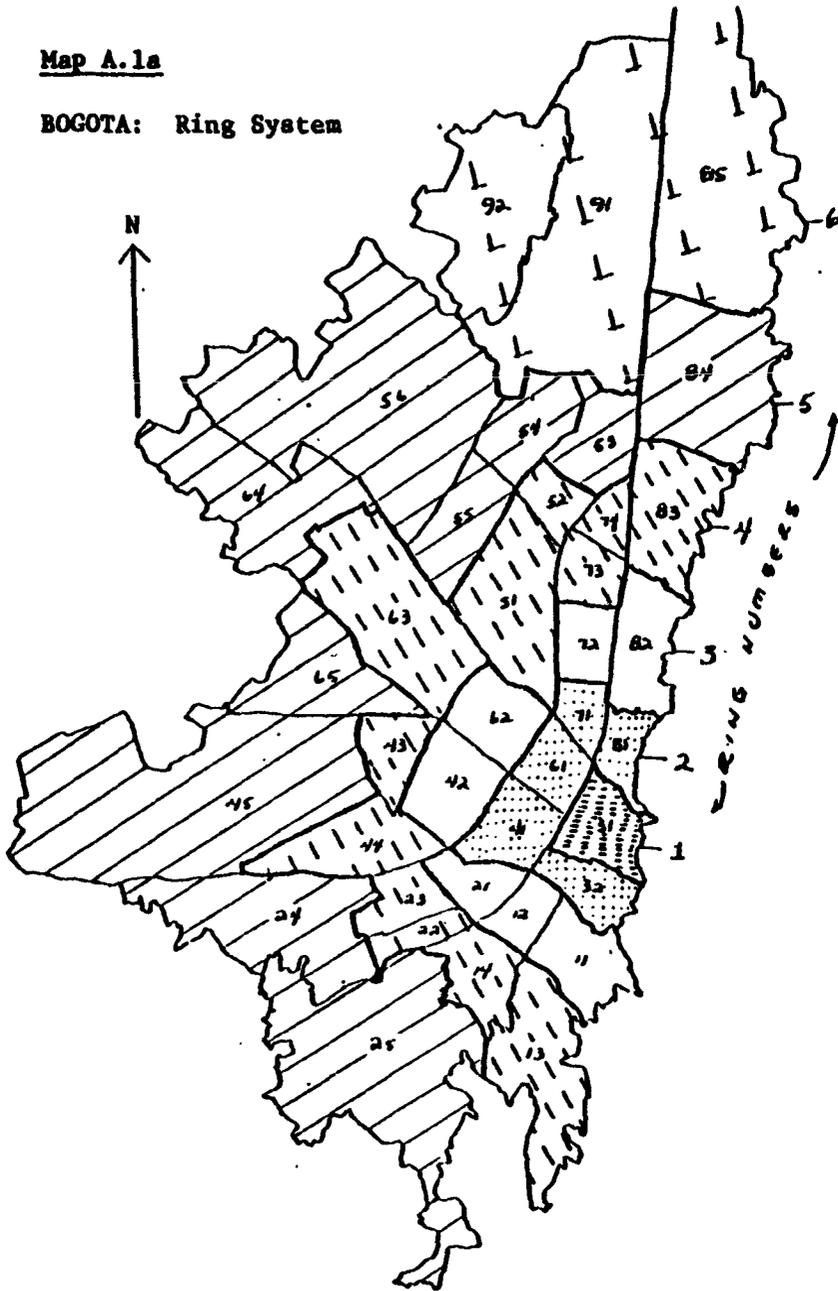
In addition to examining the distribution of land prices within the city, this paper also attempted to compare the value of land, as appraised by the local assessment agency, with its market value. In general, there appears to be a close correspondence between the assessed values and the market values. It is not surprising therefore that the assessment ratio of all land in Bogota was above 80 percent during the 1976-80 period. This figure, however, masks the variability that exists in different parts of the city. In 1976, for example, the assessed values were 20 percent above market values in the richest neighborhoods and 40 percent below them in the poorest neighborhoods.

Because of infrequent land appraisals it is generally believed that assessed values would be lower than market values, especially in times of high inflation. The spatial analysis of assessment practices revealed that this was in fact the case, but the evidence also suggested that the reassessments during the 1976-80 period were quite effective in adjusting for inflation. Particularly significant was the revaluation of land in peripheral locations where the highest growth rates in land prices have been observed.

Finally, this paper attempted to compare land values with the income of the resident population. There was some support, albeit weak, for the hypothesis that high income households live in more expensive land. In contrast, the cadastral appraisals were found to be quite responsive to income differences: the average elasticity of assessed values with respect to income was less than but not significantly different from unity. Moreover, the variations in the assessment ratio indicated that land was under-assessed in low income neighborhoods and over-assessed in high income neighborhoods. These results imply that property taxes and user charges on public utilities based on assessed values were more progressive than if they were based on market values. To the extent that high income land owners have a higher propensity to pay their tax obligations than low income households, this would introduce a further element of progressivity to the tax system, and, at the same time, increase the revenue capacity of the local government.

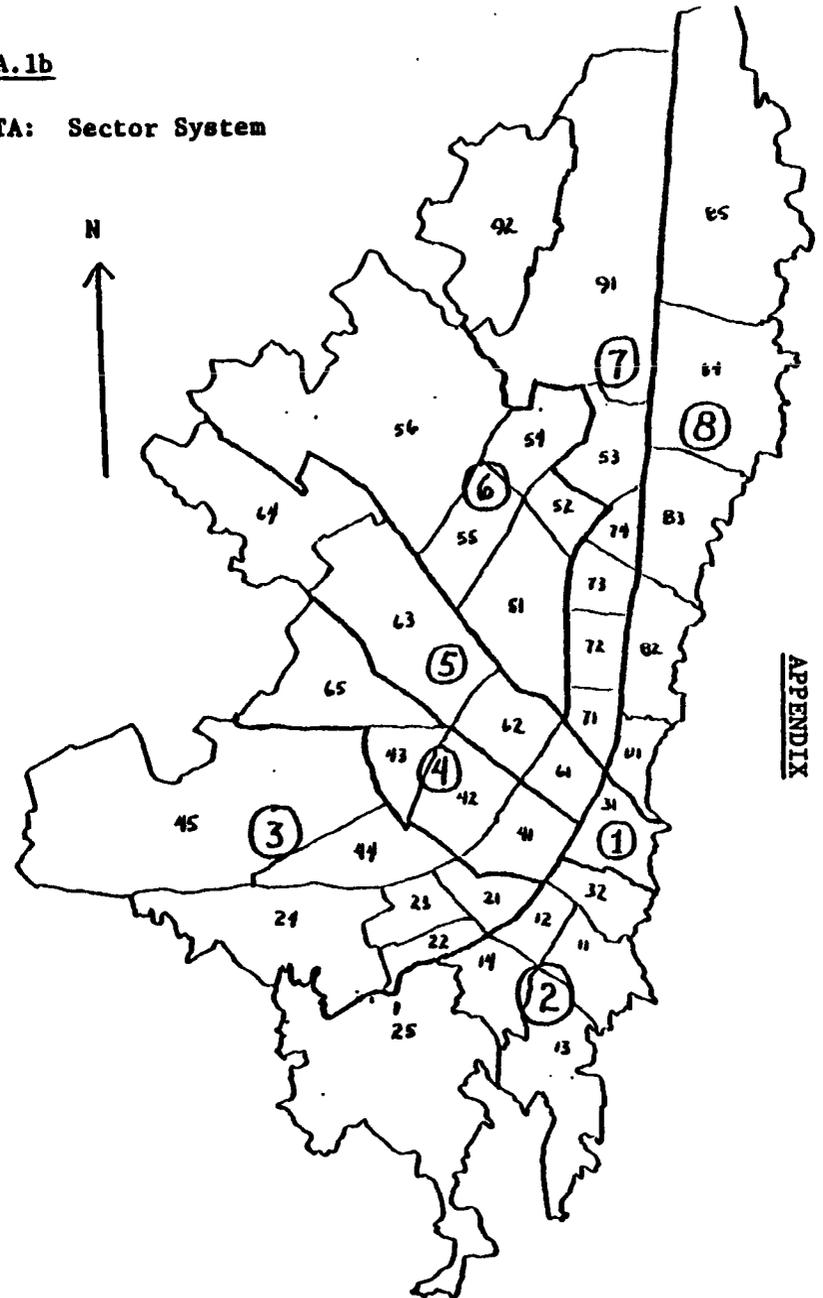
Map A.1a

BOGOTA: Ring System



Map A.1b

BOGOTA: Sector System



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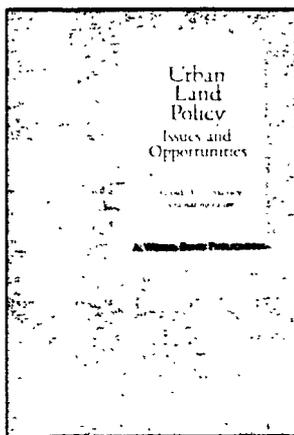
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Harold B. Dunkerley, coordinating
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Christine M.E. Whitehead

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