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INTRAMETROPOLITAN TAX DIFFERENTIALS AND INDUSTRIAL LOCATION

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

William Franklin Fox, B.S., M.A.

The Ohio State University
1975

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Dedicated to

Debby, Andy, and Carrie Ann
ACKNOWLEDGEMENTS

Preparation of this manuscript was greatly facilitated by the endeavors of several persons. Particularly I would like to take this opportunity to thank William Oakland, my advisor, whose ideas and advice led to significant improvements in the quality of this paper. I would also like to express my appreciation to Frederick Stocker for helping uncover this topic and for helpful suggestions throughout the project. I am also indebted to Richard Tybout for his useful and valuable comments.

Most of all I would like to thank my wife, Debby, without whose love, encouragement, prayers, and typing this paper would not have been possible. Special mention should also be given to two other people who have significantly influenced my decision to pursue this dissertation - my parents.

Naturally, any errors are solely those of the author.
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEDICATION</td>
<td>II</td>
</tr>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>iii</td>
</tr>
<tr>
<td>VITA</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>viii</td>
</tr>
<tr>
<td>Chapter</td>
<td></td>
</tr>
<tr>
<td>I. INTRODUCTION AND LITERATURE SUMMARY</td>
<td>1</td>
</tr>
<tr>
<td>Why an Intrametropolitan Study</td>
<td>2</td>
</tr>
<tr>
<td>Benefits From an Intrametropolitan Study</td>
<td>4</td>
</tr>
<tr>
<td>Literature Summary</td>
<td>7</td>
</tr>
<tr>
<td>What Unanswered Questions Remain</td>
<td>12</td>
</tr>
<tr>
<td>II. A MODEL OF INDUSTRIAL LOCATION</td>
<td>14</td>
</tr>
<tr>
<td>Fiscal Differentials</td>
<td>14</td>
</tr>
<tr>
<td>Assumptions of the Model</td>
<td>18</td>
</tr>
<tr>
<td>The Model</td>
<td>22</td>
</tr>
<tr>
<td>Maximization Procedure</td>
<td>24</td>
</tr>
<tr>
<td>Business Sites Supply Curve</td>
<td>36</td>
</tr>
<tr>
<td>Shape of Community Supply Curve</td>
<td>43</td>
</tr>
<tr>
<td>Nonprice Variables</td>
<td>46</td>
</tr>
<tr>
<td>Metropolitan Area Supply Curve</td>
<td>51</td>
</tr>
<tr>
<td>Conclusion</td>
<td>53</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Range of Effective Tax Rates.</td>
<td>15</td>
</tr>
<tr>
<td>2. Effective Tax Rate Statistics.</td>
<td>17</td>
</tr>
<tr>
<td>3. Solutions to Equations 10-16.</td>
<td>26</td>
</tr>
<tr>
<td>5. Linear Reduced Form Estimates.</td>
<td>106</td>
</tr>
<tr>
<td>6. Log Linear Reduced Form Estimates.</td>
<td>107</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Price of Education.</td>
<td>35</td>
</tr>
<tr>
<td>2. Price of Environment.</td>
<td>36</td>
</tr>
<tr>
<td>3. k and k*</td>
<td>37</td>
</tr>
<tr>
<td>4. Business Supply Curve.</td>
<td>42</td>
</tr>
<tr>
<td>5. Supply of Sites and Income.</td>
<td>48</td>
</tr>
<tr>
<td>6. Supply of Sites and Population.</td>
<td>49</td>
</tr>
<tr>
<td>7. Supply of Sites and the Housing-Income Ratio.</td>
<td>50</td>
</tr>
<tr>
<td>8. Equilibrium Quantity of Sites.</td>
<td>52</td>
</tr>
<tr>
<td>9. Land Rents.</td>
<td>57</td>
</tr>
<tr>
<td>10. Land Rents and Locational Advantages.</td>
<td>58</td>
</tr>
<tr>
<td>11. Supply of Industrial Sites.</td>
<td>74</td>
</tr>
<tr>
<td>12. Changes in Income.</td>
<td>75</td>
</tr>
<tr>
<td>13. Ownership of Land and Supply of Sites.</td>
<td>77</td>
</tr>
<tr>
<td>14. Capital-Land Ratio and Supply of Sites.</td>
<td>78</td>
</tr>
</tbody>
</table>
CHAPTER ONE
INTRODUCTION AND LITERATURE REVIEW

How fiscal variables affect location of industrial activity within a metropolitan area is a topic about which economists have been surprisingly silent - surprising because significant policy considerations for governments may rest upon determinants of intrametropolitan locational patterns. For example, suburbanization of industry has led to fears that center cities cannot finance future public expenditures. Yet, though significant policy considerations rest upon the determinants of industrial location, there are few investigations into this area.

This paper offers an explanation of the pattern of industrial development which has arisen within metropolitan areas. Attention is focused upon the underlying reasons why firms actually choose a specific site within a given urban area - no attention is directed towards why firms have chosen to locate within this metropolitan area.

The difference between interstate or intermetropolitan location decisions and the intrametropolitan location decisions discussed in this paper should be made clear. Interstate locational decisions refer to choices between states - between Illinois and Ohio, for example. Intermetropolitan
locational patterns refer to choices between metropolitan areas - between Cleveland, Ohio and Cincinnati, Ohio, for example. Intrametropolitan locational patterns refer to choices between different sections of the same metropolitan area - between Cleveland, Ohio and Cuyahoga Heights, Ohio, for example. This study gives no attention to patterns of interstate or intermetropolitan locational choices. In other words, we are not considering why a firm chose the particular metropolitan area; our concern is where does the firm locate within its chosen metropolitan area.

Many of the interesting questions which arise from the determinants of intrametropolitan location decisions deal with fiscal variables, such as the property tax and local expenditures. Particular emphasis, therefore, is devoted to differential fiscal variables, with greatest stress on the property tax, and how these differentials affect location decisions.

I Why an Intrametropolitan Study

Numerous studies have concentrated upon patterns of intermetropolitan locational choices. Among these are works by Floyd [10, 11], Greenhut [14], Hunker and Wright [17], and a review paper by Due [8]. Generally, these studies have concluded that taxes are of minor importance at best. John F. Due sums up the general findings of the studies into interstate locational patterns, "On the basis of all
available studies, it is obvious that relatively high business tax levels do not have the disastrous effects often claimed for them. While the statistical analysis and study of location factors are by no means conclusive, they suggest very strongly that the tax effects cannot be of major importance. 1

There are several reasons why differential fiscal variables may be more significant in the location of industry within a metropolitan area. First, elements of the industrial location decision, generally considered more important than fiscal factors are variables like availability of an adequate labor force, accessibility to input and output markets, and availability of building sites. Many of these variables, e.g., adequate labor force, tend to be neutralized as considerations once the metropolitan area has been selected. This argument is supported by McMillan 21 who found that, if locational variables which are neutralized within a metropolitan area are excluded, taxes rank highly among the remaining locational considerations.

The property tax is the largest state-local business tax. The magnitude of the property tax, therefore, is another reason why property tax rate differentials may be significant in determining the location of industry. The ACIR has

argued that intrastate tax differentials often exceed interstate differentials. In Ohio, the property tax accounts for 63% of the taxes which have their initial impact on business. For Indiana and Michigan, two neighbors of Ohio, the property tax on business ranged from 3.2% to 3.7% of total income originating from business during 1965, and since that time tax rates have increased substantially.

In a recent review paper of intraurban location studies, William Oakland argued that the costs of differential property taxes may reduce profits by more than 10%. He concludes that, "Taken alone, therefore, differential local tax costs constitute a non-trivial locational incentive."

II Benefits from an Intrametropolitan Location Study

Several benefits and policy implications suggest the importance of investigating the inputs into the selection of a specific site within a metropolitan area. First, economic theory implies that a firm will locate at that site which minimizes the firm's expected costs. Included in the firm's costs are excises like the property tax, which do not appear to affect manufacturing costs, in addition to costs of

---

3Ibid, p. 100.
production. Production efficiency can only be attained when firms select their site in order to minimize their costs of production. Therefore, whenever location decisions are affected by nonproduction costs, production efficiency is not achieved. So from a theoretical point of view, differential fiscal factors within a metropolitan area may lead to an inefficient pattern of industrial location. Further theoretical analysis of how fiscal variables influence production efficiency is needed as well as empirical investigation into the size of production distortions, if any exist.

A second justification for conducting this study is based upon a potential equity argument. Given a particular level of tax financed services, tax rates and the tax base may be expected to vary inversely. So communities with relatively large industrial tax bases may be expected to have low tax rates. Certain communities, with large industrial tax bases can, therefore, finance public services at lower costs to their residents, than can other communities.

As firms migrate toward communities which already have large industrial tax bases and low tax rates, a circular process may be created whereby low tax municipalities attract industry and industry allows lower tax rates. Communities like Cuyahoga Heights School District, near Cleveland, with a per pupil industrial tax base of over $150,000 and the lowest property tax rate in Cuyahoga County are given as examples of communities which can provide services at a low
cost to residents. At the same time high tax rate communities may be unable to attract additional industrial tax base causing tax differentials between industrial and nonindustrial communities to become increasingly large.

Behind the concern over suburbanization of industry mentioned on page one, lies this argument that reduced industrial tax bases force central cities to raise their tax rates in order to finance public services. As tax rates rise, however, other industrial firms may be motivated to leave the central city. A continual drain on the center city tax base may occur.

From the viewpoint of the entire metropolitan area another problem is created when firms locate in low tax communities - obviously firms pay less property taxes when they locate in low tax rate areas. Total areawide tax revenues would be increased if firms located in higher tax rate communities, so efforts which are designed to avoid high property tax rates may become a negative sum game for the entire metropolitan area. Theoretical analysis of the merits of this problem and the corresponding equity argument is needed as well as empirical investigation (if warranted after the theoretical analysis) into the size of tax effects.

An empirical analysis is also necessary to provide policymakers information for predicting future urban land use patterns. Also, if policymakers want to affect urban land use they must understand what instruments are available and
the impact of these tools on industrial location.

Other benefits may accrue from a study of this type. Insight may be gained into why industrial zoning has evolved the way it has. Also, some understanding may be gained into determinants of public expenditures.

III Literature Summary

Several recent studies have been directed at determining whether fiscal variables are, in fact, a consideration in the selection process for specific industrial sites within metropolitan areas. Beaton and Joun [2] conducted a study of manufacturers, locating in Orange County, California. A two-equation model was adopted to explain the location of new industry and the price of land. In this model, new industry was measured by the percentage growth of manufacturing over the period 1958-1965. The study was conducted both to determine changes in total industry without respect for type of firm and for changes by SIC code.

In a theoretical discussion, the authors hypothesized that firms prefer locations near transportation facilities. Import-export firms (relative to the county) are predicted to choose the prime sites around transportation facilities, since shipping costs are a significant factor to these firms. All other firms will be somewhat randomly distributed around means of shipping and receiving goods. These hypotheses are dependent upon assumptions of fixed land costs
and fixed effective tax rates as well as constant intensity of land use by firms. The hypotheses are altered by changes in any of these other considerations. Also the authors suggest that some, but not complete, capitalization of the property tax into land prices would be expected.

Beaton and Joun conclude that the property tax was a significant negative factor in explaining industrial location within Orange County. Other significant factors explaining industrial location include price of industrial land (itself an endogenous variable) which is positively related to new locations and an index of industrial concentration which is negatively related to industrial location. Essentially the same locational effects of the property tax were found when the model was estimated either for growth in total industry or on an industry by industry basis (by SIC code).

Moses and Williamson [25] analyzed the location choices of new or expanding firms within the Chicago area. Basically, the authors were trying to measure possible decentralization or suburbanization of economic activity. So a single equation was developed to measure the number of new locations or expanding firms per unit area. Taxes and other fiscal factors were not included in this equation. Regressions were estimated individually for the entire Chicago area and for three specific sections of the city. Significant variables included the percentage of land in
manufacturing use which had a positive coefficient and distance from the core which had a negative coefficient. Percentage of land in transportation use, a dummy for presence of a highway, and a dummy if not located within Chicago were significant in several of the regressions. Explanation of expansions and new locations was relatively poor for the area as a whole, so Moses and Williamson conclude that further study is needed to determine other critical variables which help explain location decisions.

Hypothetical firms were established by Helen Cameron[6] to determine whether property taxes were important in the selection of a specific plant site within a metropolitan area. A different prototype was developed for a "growth" firm and for an "established" firm. Based on these hypothetical firms, operating costs were estimated for both the established firms and the growth firms. Property tax differentials between high rate and low rate jurisdictions were found to be approximately one percent of operating costs for both types of firms. Therefore, Cameron concluded, "Are tax differentials sufficient to offset the location decisions? This cannot be answered in categorical terms, but there are a number of considerations that suggest it probably is not."

Several recent dissertations are probably the newest additions to the literature. Using a single equation model, Richard Schmenner [31] studied four Standard Metropolitan Statistical Areas to determine whether the local income or
local property tax was significant in location decisions. Choosing four different samples allowed for variations in the structure of the sample areas and in the state industrial and tax climates. Both the number of new or recently relocated firms and the number of new employees were utilized as dependent variables. Outcomes of this study were inconclusive across the four samples; the results, however, suggested that local taxes do have some negative influence on location decisions. Based on results for Cleveland one of the same areas, Schmenner concludes that local income taxes are a more significant consideration in the location decision than property taxes. However, within two years of the sample period, every community in the Cleveland area had an identical one percent income tax rate.

William Fischel [9] developed a model to apply the Tiebout hypothesis to firms. A basic premise of this work is that fiscal benefits from firms are compensation for neighborhood effects imposed by the firms. Bergen County, New Jersey, was adopted as the sample area in order to test four hypotheses. Fischel hypothesizes that commercial and industrial firms supply fiscal benefits to communities, commercial firms are distributed differently from industrial firms since the neighborhood effect are worse for industry, commercial and industrial firms lead to an increase in municipal expenditures which are environment oriented, and commercial and industrial property does not affect residential
property values.

A different, ad hoc, single equation model was used to test each hypothesis. All four hypotheses are supported by the empirical results. Therefore, Fischel concludes that firms provide fiscal benefits to communities as a compensation for environmental effects.

Helen Ladd [18] conducted a study, tangentially related to this topic, on how the makeup of the property tax base affects government expenditures. Ladd estimates a community demand function for educational expenditures. The share of marginal education expenditures which residents perceive that they must pay was used as her measure of the tax price of education. This marginal price of education is given in the form $1 - \alpha C - \beta I$ where $C$ and $I$ are the commercial and industrial fractions of the tax base. $\alpha$ and $\beta$ represent the fractions of the commercial and industrial property tax not shifted onto local residents. Of interest to this paper is her hypothesis that, $\alpha > \beta$, indicates the residents perceive that the relatively mobile industrial property will relocate if it is heavily taxed. Her empirical analysis finds that $\alpha > \beta$, so she concludes that residents at least believe that high taxes will cause relocation of industrial property.

William Oakland's review paper critiqued the works by Beaton and Joun, Schmenner, Fischel, Ladd, and an earlier study which I conducted on this subject. Oakland argued that empirical analysis is needed to determine whether fiscal
factors are important determinants of intrametropolitan locational patterns and he concluded that the previous work had not adequately answered the question.

IV What Unanswered Questions Remain?

Previous studies have used a variety of approaches to measure the impact of fiscal variables on location decisions. Generally speaking, those studies have been based on underdeveloped theoretical frameworks—ad hoc methods have usually been employed to generate variables which researchers feel might be important in location choices.

Substantive improvements can be made in approaches to studying the impact of fiscal variables on location decisions. How communities and industry act out their respective parts in the location decision has not been thoroughly analyzed. In fact, communities have scarcely been considered as participants in industrial site decisions. Municipalities may actually play significant roles in final site selections, as evidenced by the fact that some communities which appear desirable on the basis of costs, do not have any industry. The Ladd and Fischel works are beginning studies in this direction.

A movement toward a more general equilibrium framework is also needed. Most previous works do not endogenize some factors which are also determined within the urban system. Among these endogenous variables are government-provided
goods and services, rent, capital-land ratio, and the property tax rate. In order to properly interpret location phenomenon, a multiple equation system must be adopted.

Empirically, several areas are open for improvement. Past studies have been primarily concerned with the number of new or relocated firms or the number of new employees that firms bring into each community. From the viewpoint of local policymakers, movements in the number of new firms may be considered less important than the firms' sizes and the changes they bring in the industrial tax base. Communities probably derive most of their benefits from industry through tax dollars and, so, are concerned with the size of their industrial tax base. Further discussion of the tax base as a measure of industrial location is presented later in the paper.

Four more chapters are included in this paper. Chapter Two develops a model of community and industrial inputs into location decisions in a world without land. Chapter Three incorporates land, rents, and locational factors into the model. A multiple equation system, based upon the model, is estimated and interpreted in Chapter Four. Finally, Chapter Five presents conclusions and policy implications derived from the empirical results.
CHAPTER TWO
A MODEL OF INDUSTRIAL LOCATION

This chapter presents a theoretical framework designed to explain the selection by firms of a particular site within a metropolitan area. Among the considerations that are included in this model are differential fiscal variables. Some background information on fiscal variables is given first, before developing the model.

I Fiscal Differentials

Chapter One included several reasons why a study of fiscal differentials is important to policy makers. Among these reasons are economic inefficiencies, inequitable tax rates, and prediction of future patterns of urban growth. Fiscal differentials are defined in this paper as intercommunity differences in effective tax rates and provision of government services.

Tax differentials arise mostly in the case of the effective property tax rates; the effective tax rate is defined as the nominal tax rate times the assessment-sales ratio. Table 1 gives the range of effective tax rates which exist within a number of metropolitan areas. Data was only available for large cities within each metropolitan area, so the range should be viewed as a lower limit of the actual range.
Table 1

Range of Effective Tax Rates (1971)

<table>
<thead>
<tr>
<th>Metropolitan Area</th>
<th>High</th>
<th>Low</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alameda County, California</td>
<td>3.4</td>
<td>2.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Berkley</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>San Leando</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Los Angeles County, California</td>
<td>3.3</td>
<td>2.0</td>
<td>1.3</td>
</tr>
<tr>
<td>Pasadena</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glendale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hartford County, Connecticut</td>
<td>3.5</td>
<td>1.9</td>
<td>1.6</td>
</tr>
<tr>
<td>Hartford</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>East Hartford</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dade County, Florida</td>
<td>1.8</td>
<td>1.0</td>
<td>.8</td>
</tr>
<tr>
<td>Miami Beach</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hialeah</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cook County, Illinois</td>
<td>2.6</td>
<td>1.5</td>
<td>1.1</td>
</tr>
<tr>
<td>Evanston</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cicero</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wayne County, Michigan</td>
<td>4.3</td>
<td>1.2</td>
<td>3.1</td>
</tr>
<tr>
<td>Livonia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dearborn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cuyahoga County, Ohio</td>
<td>2.4</td>
<td>1.6</td>
<td>.8</td>
</tr>
<tr>
<td>Cleveland Heights</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euclid</td>
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</tbody>
</table>


Effective property tax rates vary significantly within each of the metropolitan areas. For example, within Los Angeles County effective property tax rates range from 3.3% of value in Pasadena to 2.0% in Glendale.

Data was only available for the largest cities in each metropolitan area so the range should be viewed as a minimum. It is interesting to note that effective tax rates actually ranged from .79% in Cuyahoga Heights to 2.6% in East Cleveland; a range of threefold within Cuyahoga County.
These differentials are often regarded as being partially determined by diverse community tastes for public services and unequal residential incomes. Other factors which may lead to tax differentials include variations among communities in the number of school age children and the nonresidential components of the tax base.

Cuyahoga County, Ohio has been adopted to test the model because it may be typical of many large metropolitan areas; hopefully results from this county can be applied to other areas. Cuyahoga County is highly fragmented, containing approximately sixty towns and cities. The county is largely industrial and contains no agricultural land. The major city, Cleveland, is completely hemmed in by several types of suburbs. Some suburbs are intensely industrialized and others are solely bedroom communities.

Large effective property tax rate differentials exist within Cuyahoga County. Table 2 presents some historical data on trends of the average, variance, and coefficient of variation for effective property tax rates. Relative dispersion of effective tax rates can be measured by the coefficient of variation which states the standard deviation as a percentage of the mean. The coefficient of variation appears to be somewhat randomly distributed around a value of 20%. No trend, either away from or toward equalization of effective tax rates has occurred over the past twenty-five years.
Table 2
Effective Tax Rate Statistics

<table>
<thead>
<tr>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (excluding Cleveland)</td>
<td>11.17</td>
<td>14.38</td>
<td>17.08</td>
<td>16.46</td>
<td>18.56</td>
</tr>
<tr>
<td>Mean</td>
<td>11.25</td>
<td>14.42</td>
<td>17.10</td>
<td>16.55</td>
<td>18.62</td>
</tr>
<tr>
<td>Variance</td>
<td>4.90</td>
<td>9.45</td>
<td>9.02</td>
<td>13.79</td>
<td>11.71</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>2.21</td>
<td>3.07</td>
<td>3.00</td>
<td>3.71</td>
<td>3.42</td>
</tr>
<tr>
<td>Coefficient of Variation</td>
<td>19.64</td>
<td>21.29</td>
<td>17.54</td>
<td>22.42</td>
<td>18.37</td>
</tr>
<tr>
<td>Cleveland</td>
<td>15.58</td>
<td>16.60</td>
<td>18.56</td>
<td>21.48</td>
<td>21.80</td>
</tr>
</tbody>
</table>

Another tax, the local income tax, is potentially a source of fiscal differentials. In 1969, however, every city and village in Cuyahoga County had an identical 1% income tax rate. Thus, at the present time, local income tax rates are not a significant source of fiscal disparities.

Having established that fiscal disparities exist, a theoretical model of industrial location shall be developed which relates fiscal variables to choice of a specific community within a metropolitan area. The geographic distribution of industry is hypothesized to be determined within
a system of demand and supply for industrial sites. Firms are viewed as demanders for industrial sites, and local communities are seen as suppliers of land. Firms are assumed to choose between communities in order to minimize total costs; whereas local communities seek to maximize the welfare of their residents.

II Assumptions of the Model

To begin with, we assume that the metropolitan area is composed of many small communities, each with its own government. The population of each community is assumed to be fixed. The tastes and income of the residents of any particular community are assumed to be identical, although they may vary among communities. Therefore, we can represent the objective function of any community by the common utility function of its citizens. Utility is assumed to be dependent upon two privately produced goods and two public goods. The private goods are housing and a composite commodity which represents all other private goods. To simplify the analysis, housing and the composite good are assumed to be consumed in fixed proportions; this enables us to represent the two private goods by a single variable - disposable income. Disposable income is defined as income minus property taxes.
The public goods are education and the quality of the environment within the community. Education is assumed to be provided by local governments and to be entirely financed by a uniform tax on the value of housing and the value of industrial capital.\(^2\) The level of education is determined by dividing the total property tax receipts by the community's population. Environment, on the other hand, is assumed to depend entirely upon the level of industrial capital which resides in the community. Unlike education, which is expressed in per capita terms, environment has the characteristics of a pure public good.

In order to focus on the effect of fiscal variables, several strong assumptions are made in the initial formulation of the model concerning the nature of the urban economy. First, commuting costs are taken as identical for each community. Second, land is assumed to be used neither in the production of goods nor housing services. Third, no community has any other "natural" locational advantages. These assumptions have the effect of entirely abstracting from spatial considerations. Land rents can be ignored in the model, leaving only fiscal variables to affect industrial location decisions. Our urban area may be viewed as a set of points where firms and individuals meet. The

\(^2\) Lack of variation in local income tax rates allows non-property taxes to be ignored.
further assumption of constant transportation costs and identical firms makes it possible to treat wage rates as being uniform across the metropolitan area. Since the total number of firms seeking sites in the metropolitan area is assumed to be given\(^3\), the income of each community is also fixed and independent of the geographic distribution of industry.

In this model, the property tax is viewed as the price paid by firms for locating in a community. Firms are assumed to be perfect competitors with fixed factor proportions; the latter assumption prevents firms from substituting labor for capital as the tax rate rises. Only manufacturing firms are included in this analysis. Tax considerations are partially offset by services provided to business. Industry presumably seeks to locate in those communities with a low net tax rate, defined as the tax rate adjusted for the level of business services. If a community sets its tax rate too high relative to business services, no industry will locate there.

Firms are assumed to be unable to shift net property taxes onto residents of the community in which they locate nor upon the consumers of their product within the community. Therefore, industrial tax revenues become the incentive for communities to supply business sites. However, since

\(^3\)A fixed total demand for sites within a metropolitan area is based upon previous research which revealed that taxes are not significant determinants in intermetropolitan location decisions. See John F. Due (6).
the level of business activity is inversely related to quality of the environment, net business property tax receipts are not without cost.

Industrial tax revenues can be thought of as a payment firms make for environmental costs imposed upon a community. Communities are assumed to possess zoning power which they can use to control the level of business capital. Such zoning authority is assumed to be used if, at the community's desired net tax rate, the number of firms wishing to locate within the community is greater than is compatible with the community's desired environmental quality. Zoning, however, is only a tool to control the number of firms; the decision of how much capital to permit in the community is made through the welfare function.

Communities are assumed to seek industry in order to reap tax benefits for its residents. Employment benefits do not exist since the entire metropolitan area can be regarded as one labor market. If the total number of firms in the metropolitan area is fixed, and transport costs are zero, the income of a given community's residents is unaffected by the location of industry.

---

* There may be non-tax benefits to having firms locate in a community, for example, having jobs near to housing. However, these benefits must be lower than the costs imposed by business or every community would seek an infinite amount of industry. The existence of benefits is assumed to leave unaltered the form of the negative relationship between business and environment.
III The Model

At this point, the model can best be summarized by a set of eight equations:

1) $W = W(y^d, e, B)$
2) $y = y^d + e - kbB$
3) $y^d = y - T$
4) $h = \alpha y^d$
5) $T = tVh$
6) $e = tVh + kbB$
7) $k*2k = t - s$
8) $s > s^*$

where:

$W$ = the level of community welfare
$y^d$ = per capita disposable income
$e$ = per capita education expenditures
$B$ = stock of industry, measured by industrial tax base
$y$ = per capita gross income
$T$ = residential taxes per capita
$b$ = inverse of population
$h$ = per capita yearly value of housing consumption
$V$ = present value of an annuity of $1$
$s$ = services provided to business
$\alpha$ = housing-disposable income ratio

Equation 1 is the community's objective function. Since residents are identical and fixed in number, this can
be interpreted as the utility function of the representative citizen. Utility is assumed to depend upon per capita consumption of a composite commodity \( y^d \), per capita education expenditures \( e \), and environmental quality. However, the latter is assumed to depend solely upon the level of business activity \( B \). Hence, we can substitute business activity for environmental quality in the utility function. We must further assume, however, that this modification does not change the convexity properties of the utility function.

Equation 2 represents the community’s budget constraint. Aggregate income \( y \) must be divided among outlays on the composite good and that portion of education not financed by net business tax receipts, \( kbB \), where \( b \) is the inverse of population.

Equations 3 and 4 describe private goods expenditures. Disposable income, given by equation 3, is the money income available for private goods’ consumption. There are two private goods which are consumed in fixed proportions. Housing expenditure is assumed to be a constant percentage, \( \alpha \), of total private goods expenditure. \( 1 - \alpha \) of total expenditures is available for other private goods.

Equations 5 and 6 show the tax and public good expenditure relationships. Residential taxes per capita \( T \) equal the tax rate times the per capita value of residential housing. \( e \) is per capita education expenditures, which must be financed either by residential or industrial tax
receipts. \( e \) is the resident's share of education; this is the average and not necessarily the marginal price of education, as will be shown later.

Equation 7 is a theorem of the model. Let \( k_i \) represent the net tax rate faced by firms who choose to locate in community \( i \). It is assumed that \( k_i = t^i - s^i \), where \( t^i \) is the gross property tax rate and \( s^i \) a "rate" of business services. I.e., \( s^i \) corresponds to the level of business services per unit of taxable business property. Since we have assumed that the urban area is made up of many small, locationally undifferentiable communities, it is easy to show that \( k^i \leq k^* \), for all communities. \( k^* \) corresponds to the maximum net tax rate that any community can impose and still attract industry. This maximum tax rate, which any community can take as given, is established at the metropolitan area level by the interaction of community supply of sites and firms' demand behavior.

Finally, equation 8 puts a lower limit upon business services. A minimum level of business services, \( s^* \), is assumed necessary in order to attract industry.

IV Maximization Procedure

The problem facing the community is to maximize \( W \) subject to equations 2 through 8. The latter can be conveniently reduced to three constraints. The constraints are a budget constraint, a minimum level of business services, and a maximum net tax rate. By setting up the Lagrangian
(M) and differentiating with respect to the choice variables (tax rate, net tax rate, education expenditures, and business activities) we obtain conditions for the optimal tax, education, and siting policies for the community.

9) \[ M = \lambda \left( \frac{V}{1+tW} \right), e, B \] + \( \frac{V}{1+tW} + e - kbB - y \) + \( \delta (k - k^*) + \eta (k - t + s^*) \)

\[ \frac{\partial M}{\partial t} = t(-\lambda y - e) = 0 \]

\[ \frac{\partial M}{\partial e} = e(\delta e + \lambda) = 0 \]

\[ \frac{\partial M}{\partial B} = B(-\lambda bB + \eta) = 0 \]

\[ \frac{\partial M}{\partial B} = \lambda \left( y d - e - kbB - y \right) = 0 \]

\[ \frac{\partial M}{\partial \delta} = \delta (k - k^*) = 0 \]

\[ \frac{\partial M}{\partial \eta} = \eta (k - t + s^*) = 0 \]

Several possible solutions exist for the set of equations, 10-16. The solutions correspond to whether the community chooses a net tax rate equal to or below the maximum, i.e., \( k - k^* \leq 0 \) or \( k - k^* > 0 \) in equation 15, and whether the community provides business with the minimum or more than the minimum level of services, i.e., \( k - t + s^* \leq 0 \) or \( k - t + s^* > 0 \), in equation 16. See Table 3. One infeasible solution and three feasible solutions arise from these relationships. The infeasible solution is \( k < k^* \) and \( t > k + s^* \). In this solution, the community is levying a net tax on business below the maximum and yet the community is providing more than the minimum level of services. While a
Table 3

Solutions to Equations 10-16

<table>
<thead>
<tr>
<th>$k - k^* = 0$</th>
<th>$k - k^* &lt; 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$k - t + s^* = 0$</td>
<td></td>
</tr>
<tr>
<td>Community levies the maximum net tax rate and provides minimum business services. Corresponds to the middle range of $k^*$.</td>
<td>Community levies net tax rate below the maximum and provides the minimum business services. Corresponds to the highest range of $k^*$.</td>
</tr>
<tr>
<td>$k - t + s^* &lt; 0$</td>
<td></td>
</tr>
<tr>
<td>Community levies the maximum net tax rate and provides more than minimum business services. Corresponds to the lowest range of $k^*$.</td>
<td>Community levies net tax rate below the maximum and provides more than the minimum business services. Infeasible solution</td>
</tr>
</tbody>
</table>

Rational community may choose a net tax rate below $k^*$, it has no incentive to provide more than the minimum business services. The latter could be lowered to $s^*$, thereby increasing net business tax receipts ($kBB$), without affecting the amount of industry available to the community.\(^5\) Therefore, no community will charge a tax rate below $k^*$ and still provide more than $s^*$ of services.

For a given community, the three feasible solutions can be conveniently classified according to the relative size of the existing net tax rate, $k^*$.

\(^5\)Services provided to business are assumed to provide no benefit to residents. This assumption is relaxed in the empirical section.
Lowest Range of k*

k* is in its lowest range when k=k* and t>k+s*. Since k=k*, the community is extracting the largest possible tax revenues from industry; yet the community chooses t>k+s* in order to consume more education. The level of education provided when t=k+s* is considered too low by the residents, so the community sets t>k+s*. Whenever t>k+s*, the community must provide business services above s* in order to prevent the net tax rate actually changed (k) from exceeding the maximum net tax rate (k*). Otherwise, no industry could be attracted to the community.

Equation 16 states \( \eta(k-t+s*)=0 \), which means either \( \eta=0 \) or \( k-t+s*=0 \). The case under consideration assumes \( k-t+s*<0 \), therefore, \( \eta=0 \). -\( \eta \) is the marginal utility of an increase in the fixed term, s*. In this case, the actual level of services provided to business (s) is already greater than the minimum (s*) so a marginal increase in s* will not affect the community. Following the same logic, \( \delta<0 \) in equation 15 because \( k-k*=0 \). The constraint given in equation 15 is binding, so the marginal utility of an increase in k* is positive.

Using values determined for \( \eta \) and \( \delta \) in the above discussion, the series of equations, 10-16, can be solved to reveal the community's consumption decisions. Equation 17 shows the solution.
This is a first order condition for utility maximization. The denominators of the marginal utility terms are the marginal prices faced by the community at its optimal consumption pattern. The price of private goods \((y^d)\) is used as a *numeraire* in the remainder of the chapter.

Equation 17 demonstrates that the marginal price of education is one; i.e. the community must give up one dollar of private goods in order to consume an additional dollar of education services. This implies that the marginal cost of education is absorbed entirely by residents; nothing is obtained from business services, which are fixed at \(k^*bB\).

\(-k^*b\) is the marginal price of business.\(^6\) It is negative because business has a negative impact on the community's well-being. The absolute value of the price, \(k^*b\), is the per capita tax revenues from one more dollar of business tax base. Holding education constant, the benefits of one less dollar of business tax base will cost the community's

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\(^6\)It should be noted that the price of business would not include \(b\) if business activity were included in the welfare function in a per capita form. Disutility from business is assumed to come from total business activity; education and disposable income, however, enter the welfare function in per capita form. Since total business activity is included in the welfare function, a nonconvexity enters the system. The result is the community could increase welfare by forcing residents out. Since population is assumed to be constant, this possibility is not within the scope of this paper.
residents $k^*b$ dollars of private goods. This result owes to the fact that the tax increase necessitated by one less unit of business cannot be shared with business since $k$ is already at its maximum. Hence it must be totally absorbed by households.

The most striking feature of this case is that communities will not increase net tax receipts from the existing business tax base in order to finance marginal educational expenditures. This result contradicts the notion popularly held by policymakers and some economists, that the presence of business tax receipts lowers the marginal price of educational expenditures. Such expenditures must be totally financed by residents.

Middle Range of $k^*$

The middle range of $k^*$ corresponds to the case where $k=k^*$ and $t=k^*s^*$. In this range, the community still chooses to extract the highest possible net business tax receipts. Now, however, the community is content with the level of educational services afforded by $s=s^*$.

Since both inequality constraints are binding, two non-zero shadow prices $\delta$ and $\pi$, exist. An increase in the fixed variable, $k^*$, or a decrease in the other fixed variable, $s^*$, increases utility. Equation 18 shows the new first order conditions.
\[ W_y = W_e = \left( \frac{w_B}{R + aI} - k^* \frac{b}{R + aI} \right) \]

\( R + aI \) is the community's marginal valuation of education in this range of \( k^* \). \( R \) and \( I \) are the per capita residential (\( \alpha yV \)) and per capita industrial tax bases (\( bB \)), respectively, and \( a \) is equal to \( \frac{\pi}{R} \).

Though \( \frac{R}{R + aI} \) is the community's marginal valuation of education, it cannot be interpreted as the marginal price of education. In fact, the marginal price of education is kinked when \( k = k^* \) and business services are at their minimum. If the community chooses to finance a marginal increase in education by increasing the tax rate it must raise the tax rate and business services by the same amount, which makes \( t > k = s^* \). In other words, to increase education expenditures the community must step into the case described above. The marginal price of education is one for an increase in education expenditures because business will not share in any increase in taxes.

In order to decrease education expenditures, however, the community must move into the final range of \( k^* \), yet to be discussed. The community must lower the tax rate on residents and the net tax rate incident on business by the same amount when decreasing education expenditures. So the net tax rate charged business will fall below \( k^* \). As we will show later, the marginal price of education, when the net tax rate is below the maximum, is equal to the residential
share of the tax base, \( R+I \). Residents must share the decrease in tax receipts with business.

The marginal price of education is one for an increase \( \frac{R}{R+I} \) and \( \frac{R}{R+I} \) for a decrease. When \( k=k^* \), however, the marginal valuation of education is \( \frac{R}{R+I} \). \( a \), which is equal to \( \frac{\pi}{\delta+\pi} \), is greater than zero but less than one because both shadow prices are negative. The marginal value of education, therefore, lies between one and \( R+I \).

Why does \( a \) appear in the community's marginal valuation of education? \( a \) provides the link between the marginal valuation of education equal to one and the marginal valuation of education equal to \( \frac{R}{R+I} \). It is because of \( a \) that, while the marginal price of education is kinked, the community's valuation of education is continuous.

\( a \) only arises when both the net tax rate and business services constraints are binding. \( a \) differs from one, and therefore, the community's marginal valuation of education is greater than \( \frac{R}{R+I} \) because \( a \), the marginal utility of an increase in \( k^* \), is nonzero. Firms are unwilling to chip in on marginal increases in education. Residents therefore, value the industrial tax base less than its relative size because firms will not pay a share of marginal education expenditures. The community's marginal valuation of education only falls to \( \frac{R}{R+I} \) when the community no longer values an increase in \( k^* \). An increase in \( k^* \) has no value to the community only when \( k=k^* \), or in other words, when industry is willing
to share in marginal increases in education.

The marginal price of business is also discontinuous in this range. If the level of business capital is decreased, while holding education constant, $k^*b$ more taxes must be paid for each unit less of business capital. Residents must absorb all of the cost of education previously paid by the business that leaves. Remaining firms, however, are unwilling to pay a higher tax rate, so the marginal price of business is $-k^*b$ for a decrease in business.

For an increase in business capital, holding education constant, the marginal valuation of business is $-k^*b(R+1)$. Residents must share with existing business, the reduced tax rate that results when new business capital is permitted. The price of environment, therefore, is less than $k^*b$ by the industrial fraction of the tax base.

Several interesting results arise from this range of $k^*$. Both the price of business and the price of environment (business) are discontinuous, each taking on two different values. The marginal valuation of education is unequal to either price of education, lying somewhere between one and the residential share of the tax base. The marginal valuation of environment is also unequal to either price of environment, lying between the tax value of an additional unit of business capital and the residual fraction of the tax base times the tax value of an additional unit of business capital.
Highest Range of $k^*$

In the highest range, the community sets $t=k+s^*$ and $k^*:k$. Since business services are at a minimum and $k^*$ is so large, the community chooses not to take all possible business tax receipts because the net tax rate on business can only be increased by increasing the gross tax rate which residents must also pay. Tax revenues are assumed to be spent only for education and residents may not be willing to buy more education by paying more property taxes. Residents prefer more private goods and less education than would be available of $k=k^*$. So even though industry would pay a share of any marginal education expenditures, residents will not allow the tax rate to rise.

Only the $t=k+s^*$ constraint is binding in this solution. From equation 16, $w^* = 0$ because the constraint given in equation 15 is not binding. Again, the series of equations can be solved to determine the community's optimal consumption decisions. The first order conditions are given in equation 19.

\[ 19) \quad \frac{w_y}{w_d} = \frac{w_e}{w} = \frac{w_B}{R} = -kb\left(\frac{R}{R+I}\right) \]

The marginal price of education is $\frac{R}{R+I}$. This tax price of education equals the residents' share of the total tax base. Marginal education expenditures will be financed both by an increase in the tax on residents and an increase in the
net tax on industry such that each pays a share equal to its fraction of the total tax base. The marginal price of business is \(-kb(R+I)\). If communities let in more business while holding education constant, residents must share the tax reduction with the existing business.

One troublesome result for this solution is the existence of queuing for those communities with \(k < k^*\). Since communities are unwilling to accommodate all industry desiring to locate at a net tax rate below equilibrium, communities operating in this range must use their zoning power to control industrial locations. There are several alternatives for solving this problem of queuing. Low tax communities could be filled on a first come-first serve basis with rents accruing to firms locating in relatively low tax communities.

Other alternatives involve slight changes in assumptions of the model. An obvious solution would be to allow some form of side payments by firms, i.e., to land owners in the form of rent. If side payments are permitted, communities would receive an additional payment, equal perhaps to \(B(k^*-k)\). Another possibility is to allow firms to impose varied environmental effects on communities. Then firms causing little environmental damage would be allowed to locate in low tax communities. The problem of queuing will not be considered in more detail since it would unduly complicate the model. The model with land, presented in the next chapter, allows low taxes to be reflected in rent prices.
How do the prices of education and business move over the range of $k^*$? Holding business capital constant, as $k^*$ rises the marginal price of education is initially one. When business services are at a minimum and the net tax rate is at its maximum, the price of education is discontinuous. Finally, when the net tax rate drops below $k^*$, the price of education is equal to the residential fraction of the tax base. Figure 2-1 illustrates the relationship between the price of education and $k^*$ with all other considerations held constant.

Movement of the marginal price of environment through the ranges of $k^*$ is also discontinuous. In the lowest range of $k^*$, other things equal the absolute value of the price of business is equal to $bk^*$; i.e., it is equal to the tax value of one more unit of business capital. Like education, the price of environment becomes discontinuous in the middle range of $k^*$. In the final range of $k^*$, the price of environment is equal to the residential share of the tax base times the tax value of one more unit of business capital. None of
the variables in the system change so the industrial and residential shares of the tax base are fixed. The price of environment is illustrated in figure 2-2.

Graph 2-2

\[ P_B \frac{R}{k*b(R+I)} \]

VI Business Sites Supply Curve

The community's supply curve for industrial sites can be explicitly derived from the marginal conditions presented above. Equation 20 gives the explicit form of the supply curve.

\[ B = B(y, k^*, b, c, i) \]

The supply of industrial sites is a function of income, the equilibrium net tax rate, population, the percentage of disposable income spent on housing, and the interest rate, i. Zoning is not included as a specific determinant of supply. Zoning is a part of the supply decision only in the sense that it is one method of achieving an optimal amount of industrial capital.

Two of these variables, \( k^* \) and \( i \) require further discussion. First, \( i \) is included because the present value of
an annuity of $1 is solely determined by the interest rate. $V$, the present value of an annuity, converts the flow of housing expenditures to a housing stock. The interest rate, however, is not a determinant of differential supplies of sites because it probably does not vary across communities.

Now consider including $k^*$ in the supply equation. Solving the marginal conditions would lead one to include $k$ rather than $k^*$ in the supply equation. Supply ($B$) and the net tax rate actually charged ($k$), however, are simultaneously determined by communities. Since both variables are endogenous, two equations are required for determination of the two variables. $k$ can be expressed in terms of $k^*$ and the other variables which determine supply. So $k^*$ is included in the supply as a determinant of the net tax rate charged by the community, as shown in graph 2-3.

Whenever the maximum net tax rate constraint is binding, the net tax rate equals $k^*$. In figure 2-3, the lowest and middle range of $k^*$ occur in the upward sloping segment of the curve. $k_1$ is the net tax rate which corresponds to the
highest tax rate residents are willing to pay. In the flat section of the curve, the \( k^* \) constraint is not binding and the net tax rate is determined independent of \( k^* \).

Comparative static analysis of the impact of each variable on the supply of industrial sites reveals the probable form of the community's supply curve and the effect that variables have on the positioning of the curve. Environment, private goods, and education are all assumed to be normal goods.

\( k^* \) is the price variable in the model. An analysis of how \( k^* \) affects quantity supplied \( (B) \) reveals the basic shape of the supply curve. Consider the lowest range of \( k^* \), i.e., when \( k = k^* \) and \( t > k + s^* \). Since \( k^* \) is low, environment is relatively cheap and education is probably being financed by a high tax rate and low business tax receipts.

An increase in \( k^* \) increases the price of environment.

\[
\frac{dP_B}{dk^*} = \frac{\partial P_B}{\partial k} \cdot \frac{dk}{dk^*} = -b, \text{ since } \frac{dk}{dk^*} = 1
\]

The price of education is unchanged by an increase in \( k^* \). The higher price of environment exerts both an income and a substitution effect on the quantity of industrial sites supplied. More sites are supplied due to the substitution effect, but the

\[
\frac{dk}{dk^*} = 1 \text{ at least as long as } t = k + s^*, \text{ or in other words, when } s > s^*. \text{ The justification is the same one given above for eliminating } k^* < k \text{ and } t > k + s^* \text{ as a possible solution. } P \text{ is the marginal price of business which is the business in equations 17, 18, and 19. This is illustrated in graph 2-2. The price of environment is the absolute value of the price of business.}
income effect causes fewer sites to be supplied. When \( k^* \) is low and quantity is small, the substitution effect dominates the income effect causing \( k^* \) and \( B \) to be positively related. As \( k^* \) and \( B \) rise the income effect increases and could outweigh the substitution effect. So the supply curve could be backward bending.

The impact of an increase in \( k^* \) on education and disposable income depends upon the cross substitution effects. It may be easily shown that the compensated price effects, weighted by the prices, must equal zero. Since \( \frac{\partial P}{\partial P_e} = \frac{\partial e}{\partial B} \), this inequality may be written in the following form:

\[
\frac{\partial y^d}{\partial P_B} + \frac{\partial e}{\partial B} - k^* b \frac{\partial B}{\partial P_B} = 0.8
\]

Either \( e \) or \( y^d \) must be a substitute of environment. So either education or private goods must be complementary with business. In other words, communities will only select more of a bad (business) if they are compensated with other goods.

When \( k^* \) is small and, therefore, industrial tax revenues are small, education must be financed by a relatively high tax on a residential property. Both education and private goods consumption are relatively low and environmental quality is high. An increase in \( k^* \) will make environment

\[ P_B \] and \( P_e \) are the relative prices of business and education determined in equations 17, 18, and 19. Note that the prices vary over the three cases.
relatively expensive causing more industrial sites to be supplied. Even when income changes are compensated, the community would only accept more business if it received more education and private goods. So both education and private goods are probably substitutes with environment. A negative substitution effect supports the positive income effect, causing an increase in the consumption of both goods. In order to consume more private goods, the tax rate \( t \) must decrease, and more education can be consumed if the increased business tax receipts are greater than the decreased residential taxes.

As \( t \) decreases and \( k^* \) increases, the level of services provided to industry \( (s) \) must be declining faster than \( t \). Eventually business services reach their minimum level and the middle range of \( k^* \) is reached. Price changes can be analyzed in a fashion similar to when \( t > k^* + s^* \). Increases in \( k^* \) continue to make environment more expensive. So an increase in \( k^* \) will have the same basic impact on business

\[ k = t - s \]
\[ d(k^*) = dk = dt - ds \]
\[ dk^* = dt - ds \]
\[ \frac{dk^*}{dt} = \frac{ds}{1 - dt} = \frac{ds}{dt} \]

\[ \frac{dk^*}{dt} > 0 \]
\[ ds \]
so \( \frac{dt}{ds} < 1 \)

\[ dt < ds \]
sites supplied as was discussed above.

\( t = k^* + s^* \) is a necessary solution, but an interesting question is, does this case continue over any range of \( k^* \) or is it a razor's edge case? Is \( t = k^* + s^* \) one point between \( t > k^* + s^* \) and \( k^* > k^* \)? An entire range in valuation of education lies between one and \( \frac{R}{R+I} \). So it seems likely that the community would remain in an area where \( k = k^* \) for a number of values for \( k^* \). Generally speaking, however, it cannot be proved whether this is a razor's edge case or not.

A digression will be made to discuss the circumstances which must exist for \( t = k^* + s^* \) to hold as \( k^* \) increases.

Disposable income and environment are necessarily complements in the range of \( k^* \) where \( t = k^* + s^* \). An increase in \( k^* \), which increases the price of environment, must result in an increase in the tax rate \( t \) (a reduction in disposable income) in order for the equality to continue to hold. Since the weighted price effects must equal zero, environment and education must be substitutes and more substitutable than the previous solution. Both the income and the substitution effect of an increase in \( k^* \) cause education to increase. Using the education budget constraint, a minimum change can be placed on \( dk^* \).

\[
e(tV+t)y + bBk^*
\]

\[
dt = dk^*
\]

\[
de = yV(1 + vV)^2 + bB + b_k^*dk^* > 0
\]

\[
\frac{dB}{dk^*} > \frac{\alpha V}{y + bB - (1 + vV)^2}
\]
The range of $k^*$ in which $t = k^* + s^*$ continues as $k^*$ increases if equation 22 holds, disposable income is a complement of environment, and education is a substitute of environment. Equation 22 does not appear to be very limiting constraint on the slope of the supply curve, but it does prevent the supply curve from having a large slope in the backward bending section. Communities must have relatively high marginal valuations of education because the residents are trading private goods for public goods. Any community hungry for disposable income would not keep $t = k^* + s^*$, so a high income community is more likely to maintain this equality.

No community would allow disposable income to decline indefinitely. A community would continue making marginal decisions that allow the tax rate to rise until the residents value the additional disposable income more than education and the residents refuse to increase $t$ as $k^*$ increases, $\frac{dB}{dk^*} = 0$. Graph 4 illustrates the relationship that probably exists between $k$, $k^*$, and $B$.
Part B of graph 2 is the community's supply curve for industrial sites. The supply curve is positively sloped when the substitution effect of an increase in $k^*$ dominates the income effect. Once the income effect becomes dominant, communities prefer to consume some of the increase in $k^*$ in terms of more environment.

No definitive statement is possible on the exact area covered by each range of $k^*$ on the supply curve. The consumption pattern that must exist when the curve bends backward suggests the following breakdown between the lowest, middle, and highest range. Probably, the lowest range of $k^*$ continues until after the supply curve bends backward and then by the nature of the highest range, the middle range must hold until the vertical segment. If the supply curve does not bend backward in the lowest range of $k^*$, an unusual consumption pattern must develop. When the community first enters the middle range of $k^*$, an increase in $k^*$ causes more education to be consumed while less disposable income and environment are consumed. Rapidly increasing education expenditures would suddenly result when the community entered this middle range of $k^*$, since business and residential tax receipts would both be increasing. A more likely consumption pattern would find communities moving into the middle range of $k^*$ in the backward bending section of the curve. In this case, communities could consume more
education and environment as $k^*$ increased, at the cost of some private goods.

The perfectly inelastic section occurs when residents are no longer willing to allow the tax rate to rise; this is the highest range of $k^*$. Nothing endogenous to the model changes once $k$ is not a function of $k^*$ (see graph 2-4, A), so the supply curve becomes vertical. The supply curve could become perfectly inelastic while $k^* = k$, but this would require an unlikely set of circumstances; the income and substitution effect of an increase in $k^*$ must exactly offset each other through various values of $k^*$.

Some limitations can be placed on the slope of the supply curve. For education expenditures to increase in a range corresponding to the positively sloped segment of the supply curve, business tax receipts must increase more than residential taxes decrease. So the supply curve cannot be too steeply sloped in the positively sloped section.

An additional limitation can be established between the elasticity of the business supply curve and the relationship in consumption between environment and the other two goods. When the supply curve is positively sloped, both education and private goods can be substitutes of environment. In the negatively sloped section, however, the possibility of both education and private goods being substitutes of environment depends upon the elasticity of supply for
business. If the price elasticity of business is less than minus one, both goods cannot be substitutes with environment. This follows from the fact that the weighted sum of elasticities with respect to the price of business must equal minus the share of income spent on business.\textsuperscript{10} Equation 22 shows this relationship.

\begin{equation}
\frac{P_B}{B} < 0, \text{ so when } \epsilon_{BB} < -1, \frac{P_B}{y} \epsilon_{BB} > -\frac{P_B}{y}.
\end{equation}

Therefore, at least when \( \epsilon_{BB} < -1 \), one of the other elasticities must be negative. The negative elasticity means that the cross substitution effect must be positive (a substitute) and must outweigh the income effect. The assumed institutional relationship between education and business probably causes education and environment to be complements. So environment and private goods must be complements if \( \epsilon_{BB} < -1 \).

If \( \epsilon_{BB} < -1 \), \( \left[ \frac{P_y y^d}{y} \right]_B \left[ \frac{P_e}{y} \epsilon_B \right] \). This inequality can be reduced to reveal \( \left[ \frac{y^d}{\epsilon_B} \right] \left[ \frac{P_e}{P_y} \frac{\partial \epsilon}{\partial y} \right] \). The total effect of a decrease in the price of business is probably greater on private goods consumption than on education expenditures.

\textsuperscript{10} This can be proved using a budget constraint, \( y = p_1 q_1 + p_2 q_2 + p_3 q_3 \) set \( dp_2, dp_3 \), and \( dy = 0 \) and totally differentiate.

\begin{align*}
0 = & \ p_1 dq_1 + q_1 dp_1 + p_2 dq_2 + p_3 dq_3 \quad \text{multiply by } \frac{p_1 q_1 q_3}{y q_1 q_2 q_3 dp_1} \\
- \frac{p_1 q_1}{y} \frac{p_1 q_1}{dp_1} + & \ \frac{p_2 q_2}{y} \frac{dq_2 p_1}{q_2 dp_1} + \frac{p_3 q_3}{y} \frac{dq_3 p_1}{q_3 dp_1}
\end{align*}

\( P_B, P_e, \text{ and } P_y \) are marginal prices determined above. The prices vary across the three ranges of \( k^* \).
A decrease in the price of business causes fewer sites to be supplied and tax receipts fall. So disposable income must decrease enough to offset the decrease in business taxes and still allow education expenditures to increase.

Most communities are unlikely to have so high a demand for education and environment that they would allow the large negative elasticity for business. Therefore, the business supply curve probably has a relatively steep slope in the backward bending section.

VIII Non Price Variables

The lengthy discussion undertaken above was designed to reveal the probable form of the business supply curve. Some attention will be devoted to the effect of each remaining independent variable from equation 20 on the position and shape of the supply curve. Note that the supply curve was specified above in terms of $k^*$, which is only one exogenous variable which determines the endogenous marginal price of business. Other factors will also affect the marginal price of business and, therefore, change supply when it is illustrated in $k^*-B$ space. These factors are listed as non-price variables because they are not supply-demand determined prices like $k^*$, even though they may affect the endogenous marginal prices.

Income is one factor determining the position of the supply curve. Environment was assumed to be a normal good
which means the supply curve moves leftward as income increases; however, income may also affect marginal prices. Remember that relative prices differ between the lowest and highest ranges of \( k^* \) and income only enters relative prices for the highest ranges of \( k^* \). The partial effect of an increase in income makes education and environment relatively more expensive. Education is more expensive because an increase in income increases the residential share of the total tax base and environment looks relatively more expensive as the residential share of taxes tises. Environment looks more expensive because, with education constant, the reduction in residential taxes that occurs when new business is admitted, is larger, the bigger the residential share of taxes. The price effects may increase supply, but the income effect decreases supply. The overall effect on supply of sites is ambiguous, but the most likely result would be a decrease in supply since the price effects are probably small.

The supply curve bends back when the income effect of an increase in \( k^* \) outweighs the substitution effect. Since quantity of industrial sites supplied is larger for low income communities, the income effect is probably also larger. So in poor communities the income effect probably dominates the substitution effect at a lower \( k^* \). Graph 2-5 illustrates the effect of income upon the business sites supply curve. \( y_A > y_B > y_C \)
The Engel curve for business is shown in part B of graph 2-5. Business is a discommodity so the Engel curve is downward sloping. Environment probably has an income elasticity greater than one because poor communities may feel they cannot afford much environment. Low income communities probably finance education with relatively more business than high income communities. So the Engel curve for business is probably falling at a decreasing rate and the curves relating $k^*$ and $B$ become increasingly far apart as income increases.

Rich communities probably move into the vertical section of the supply curve at a higher $k^*$ and lower supply of sites. The lower supply of sites is a simple result of higher income curves lying inside lower income curves. High income communities are probably also more
willing to tax themselves in order to consume more education and environment so they would be willing to allow the tax rate to rise higher than low income communities.

b. An increase in \( b \), the inverse of population, leads to an increase in the price of environment and a decrease in the price of education. Environment becomes more expensive when population declines because the tax value of the business tax base is larger per each individual. The effect on supply depends upon the substitution and income effect. When \( k^* \) is low, the substitution effect probably dominates the income effect and a decrease in population causes more sites to be supplied at each \( k^* \). However, when \( k^* \) is large the income effect could dominate and fewer sites would be supplied.

Graph 2-6, where \( b_1 > b_0 \), illustrates the effect of an increase in \( b \). The \( b_1 \) curve intersects the \( b_0 \) curve in the backward sloping section when the income effect begins to dominate. Also the \( b_1 \) curve bends back at a lower \( k^* \) because the income effect probably is greater.
Marginal prices are unaffected by changes in the housing-income ratio in the lowest range of $k^*$. Communities can adjust the tax rate to leave private goods consumption unaltered by a change in $\alpha$ and can adjust business services to leave the net tax rate unchanged. The partial effect of an increase in $\alpha$ makes environment and education more expensive in the highest range of $k^*$. Education is more expensive because an increase in $\alpha$ increases the residents' share of the total tax base, and environment looks relatively less attractive when the residents pay a larger share of educational expenses. Again, the tax reduction that residents can obtain by accepting more industry becomes greater when the residential fraction of the tax base increases. An income and substitution effect result from the lower price of business. Supply is unaffected in the lowest range of $k^*$ and in the highest range of $k^*$ supply is moved by $\alpha$ similar to the way $b$ affected supply. The effect $\alpha$ has on supply is illustrated in graph 2-7. $\alpha_1 > \alpha_0$

Graph 2-7
Changes in the interest rate result in inverse changes in $V$, the present value of an annuity. $V$ affects the supply of sites in the same manner as $\alpha$ since the two terms are multiplicative in determining the residential tax base.

**IX Metropolitan Area Supply Curve**

Horizontally summing the supply curve for each community may lead to a metropolitan supply curve which is positively sloped over some range but would also bend back. When the community supply curves are summed, the total supply curve could even bend back several times; but this possibility will be neglected. Perfectly inelastic sections of the community supply curves will cause the areawide curve to be steeply sloped in the backward bending range. At the point where the last community's supply is vertical, the areawide curve will be vertical. Also, the summation curve probably bends back at a relatively low $k^*$ since poor communities tend to be plentiful among communities which have industry.

For a given quantity of industrial tax base, there may be two or more intersections of the demand and supply curves both would be stable equilibria. A Marshallian view of stability appears appropriate because communities can increase supply of sites quickly to adjust to changes in demand. Marshallian stability requires an increase in quantity to reduce the excess demand price. In graph 2-8, $A$, $D_0$ is the
original demand with equilibrium at B. Assume demand increases to $D_1$, and a new equilibrium is sought at E. An increase in demand causes a higher excess demand price and quantity supplied moves to E. A similar result is found in moving from point G to F. So two stable equilibria exist, which means communities could be operating at a stable equilibrium in either the upward sloping or backward bending section of the supply curve.

The existence of multiple equilibria would have significant policy implications for local communities. It suggests that communities could receive either relatively low or high taxes from the same amount of industry. Of course communities would prefer the equilibrium which yields the highest tax revenues.

Previously we argued that the supply of sites curve is fairly inelastic in the backward bending section, so the solution may be similar to the one illustrated in Graph 2-8B. In this case there is only one equilibrium, which is point H.
Conclusion

Communities are hypothesized to be suppliers of industrial sites, and firms are demanders. Based on the assumption of many firms interacting with many communities, an area aside maximum net tax rate results; any community that seeks to attract industry cannot levy a net tax rate above this maximum. Communities act such that the marginal prices of both environment and education can take on two possible values. Both prices are discontinuous between the two values. A supply of sites curve can be derived by varying the exogenously determined maximum net tax rate and thereby changing marginal prices - the resulting curve is backward bending with a shape much like a sickle. Supply is negatively related to population, income, the interest rate, and the housing-income ratio.
CHAPTER 3
INDUSTRIAL LOCATION: A MODEL WITH LAND

Location of industrial land and capital is considered in this chapter as opposed to the previous chapter in which we presented a model explaining location of industrial capital. Just considering capital allowed a simple view of interactions involved in a demand-supply model of location. But a more sophisticated model, closer in appearance to the real world, must be developed in order to provide a more precise theoretical framework which can be used as the underpinnings of an empirical analysis. The major change from the previous structure is inclusion of land. Other changes include relaxing several assumptions in a discussion at the end of the chapter.

I Assumptions

Most of the assumptions are identical to those made in the previous model; hence they will not be reproduced here. The assumptions may be reviewed on pages 18-21.

Several strong assumptions concerning the nature of the urban economy were made in the previous chapter. The inclusion of land greatly reduces the restrictiveness of the model. Land is now assumed to be used in producing goods and housing services. Therefore, spatial considerations and
land rents enter into the analysis in this model. Land available for industrial sites, however, is assumed to be used only for industry and land available for housing can be used only for housing. If land is not used for its intended purpose it is assumed to go unused.

Commuting costs are still assumed to be zero, which along with an assumption of identical firms requires wage rates to be identical across the metropolitan area. Since total demand for industrial sites in the metropolitan area is fixed, labor income of each community is also fixed and independent of the geographic distribution of industry. Income, however, does depend upon the level of rents accruing to the community's residents.

Firms are assumed to be perfect competitors with fixed factor proportions, which prevents firms from substituting labor for land or capital as the tax rate rises. There is one locational advantage, nearness to the center city, which affects industrial costs and location decisions. The locational advantage and a limited supply of land provided for industrial use give rise to rents. So rent may be paid in addition to the net property taxes paid by industry. Industry presumably seeks to locate in those communities where the total of locational costs, rents, and taxes is lowest.

Peter Mieszkowski has suggested that land zoning is a form of collective insurance to minimize the possibility of capital losses which may occur when industry locates in a
community. He argues that "industrial and commercial activity may diminish the value of neighboring residential property, and zoning is used to protect residences and to minimize the incompatibility of different activities." 

An alternative hypothesis for zoning is presented in this model. Zoning is used by communities when, at the existing level of rents and taxes, the number of firms wishing to locate within the community is greater than is compatible with the community's desired environmental quality. Zoning itself does not determine the level of industry, but is used when necessary to control the level of business activity.

II Land Rents

A short discussion of rents, taxes, and locational factors will be made before continuing the analysis. These concepts will be included in a more formal fashion in the model.

Equilibrium rent is determined by demand and supply for land. Rent arises whenever the amount of land made available for industrial use at a zero price lies below the amount demanded. Graph 3-1 illustrates determination of rents in a metropolitan area under assumptions of no capital, no locational factors, no taxes, and many communities.

Supply is illustrated with an upward slope in section A. Of course, the total supply of land is fixed, but the supply of land made available to industry is assumed to vary as price changes. This does not violate the assumption of some land restricted to housing use and some to industrial use. We are assuming that industrial externalities result in some land going unused, rather than being provided to business at a low rent. Demand for industrial sites is assumed to be fixed at $L_0$. Part B shows that demand for sites in each individual community is infinitely elastic.

Now several assumptions, implicit in graph 1, will be relaxed. Assumptions of no locational factors, no taxes, and no capital are relaxed one at a time. Locational advantages are defined to be any financial considerations, other than taxes, which are important in the choice between alternative communities. Assume that communities have one differential location factor. Firms would shift their demand for land so that communities with relative disadvantages would...
receive low rents and communities with relatively large advantages would receive high rents. Graph 3-2, section A, shows that rent in an average community equals R₀. In section B, rents in communities with relative advantages are shown to rise by the amount of differential from average (R₁ - R₀) and rents in high disadvantage communities are shown in section C to fall by the amount of the differential (R₀ - R₂). Therefore, industrial location may be seen as being completely responsive to locational factors and location decisions by firms result in locational differentials being totally offset in rents.

Property taxes that are levied directly on industry have the same basic impact on rents as locational advantages. Industrial firms adjust their demand so rents increase in low tax communities. Again, any attempt to shift the average tax will be unsuccessful. Only tax differentials from average are reflected in rents.

Graph 3-2

![Diagram](https://via.placeholder.com/150)
Locational Disadvantage Comm.

Rent

Now both taxes and locational advantages can be considered in the analysis. Assume that the only locational factor is nearness to the center city, i.e., firms desire to locate near the center city because all goods must be shipped to the center city before being distributed. Rents in the center city would be the highest since it is the preferred location, although high rents could be offset by a large property tax.

The center city may be set up as a norm. Center city rents are supply-demand determined and include the relative locational advantage minus any difference between the center city tax rate and the average tax rate. Each community's rent may be determined by equating the suburb's rent, taxes, and relative locational disadvantage with the rent and taxes in the center city. Suburban rents differ from center city rents by the sum of the tax differential \( (k_i - k_0) \) and locational disadvantage \( (m_i) \).
Equation one shows the level of rents for each community; the center city is represented by 0 and the suburbs by 1...n.

1) \( R_0 + k_0 = R_1 + k_1 + m_1 = \ldots = R_n + k_n + m_n \)

\( R_i = \text{rent per unit of land } i=0, 1...n \)

\( k_i = \text{community's net tax rate} \)

\( m_i = \text{differential locational disadvantages adjusted to the center city} \)

\( i=1, \ldots, n \)

Once capital is included in the model, complications may arise in considering rents and taxes. Under stringent assumptions, Mieszkowski has argued that a constant rate property tax will result in a tax on capital being borne by owners of capital.\(^2\) But, with zero commuting costs and therefore perfect, costless mobility of labor throughout the metropolitan area, a differential tax is not borne solely by capital. Capital will bear the average tax rate through a decline in the rate of return on capital.\(^3\) Differentials from the average tax rate are reflected in rents and since land is a relatively small portion of total product, Mieszkowski concludes that rents may be greatly reduced by the tax on capital. His conclusions are based upon a nationwide analysis rather than for a metropolitan area, so the average tax borne by capital is determined nationwide.

\(^2\) Peter Mieszkowski, "The Property Tax: An Excise Tax or a Profit Tax", Journal of Public Economics 1972

\(^3\) ibid
Consideration of capital only complicates the analysis without causing any basic changes. Rent in each community is reduced not only by the tax on land but also by the tax on capital. Communities with above average tax rates will receive even lower rents and communities with below average tax rates will receive higher rents. For simplicity assume the capital-land ratio is constant for all firms. Equation two is equation one rewritten to include capital. Any differential between a community's tax rate and the average tax rate multiplied times the capital-land ratio is the effect of capital on rent.

2) \[ R_0 + k_0 + (k_0 - \bar{k})g = R_1 + k_1 + n_1 + (k_1 - \bar{k})g = \ldots = R_n + k_n + n_n + (k_n - \bar{k})g \]

\(g\) = capital-land ratio

\(\bar{k}\) = average tax rate nationwide

Equation two is a theorem of the model. Firms will adjust their demand so that the total cost of rents, taxes, and locational factors must be identical across communities. Rent will be higher where the sum of locational factors and taxes is low and rents will be low where the sum of taxes and locational factors is high. Note that in the remainder of the paper the total cost of rents, taxes, and locational factors, given by equation two, is assumed to be borne by firms.
III The Model

Equations 3-13 summarize the model presented above.

3) \( W = W(y^d, e, L) \)
4) \( y = N + bcRL \)
5) \( y = y^d + e - kbB \)
6) \( h = ay^d \)
7) \( T = tVh \)
8) \( y^d = y - T = 1 + taV \)
9) \( k = t - s \)
10) \( s > s^* \)
11) \( B = VRL + K = L(VR + g) \)
12) \( e = tVh + kBb \)
13) \( D = R + (k - \bar{k})(1 + g) \)

where:

\( N \) = per capita fixed component of income
\( c \) = fraction of industrial land owned by residents
\( R \) = rent per unit of industrial land
\( B \) = value of industrial land and capital
\( T \) = ax per house
\( V \) = present value of an annuity
\( g \) = capital-land ratio

As in chapter two, environment is assumed to be an inverse function of business activity; business activity is measured by units of land actually engage in business use. 4

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4In chapter two the value of the industrial capital was adopted as the measure of industrial activity. But the
So units of land in business use (L) has been substituted into the welfare function in equation three and changes is L result in inverse changes in the community's well being.

Equation four describes the sources of income. Income includes both a fixed and a variable component. Wages plus dividends and interest comprise the fixed component of income. The portion of a community's rents that accrue to its residents is the variable component of income. RL is the community's total rent and c is the share of rents remaining in the community.

Equation 13 is an equilibrium relation, corresponding to the demand-supply determined result that the total cost of rents, taxes, and locational factors is the same in each community. D is the total level of rents and taxes which a firm is willing to pay in any community. D varies among communities by the differential locational factors.

IV Maximization Procedure

The model presented in equation 3-13 can be reduced conveniently into an objective function and three constraints, summarized in equation 14 by the Lagrangian, M. Differentiation of the objective function subject to these constraints, with respect to the choise variables: tax rate, rents, education, industrial sites, and net tax rate yields

tax rate affects the value of the tax base in this model so the units of land in industrial use are a more consistent measure of business activity.
expression for the optimal tax, education, and siting policies.

14) \[ M = W(y^d, e, L) + \lambda(y^d + e - 1bL(PR+g) - N - bcRL) + \eta(k-t+s^*) \]
\[ + \delta(R+(k-k)(1+g)-D) \]

15) \[ \frac{\partial M}{\partial t}; t(\frac{\alpha \lambda V}{(1+t \alpha V)^2} \frac{\partial W}{\partial y} d^{-\alpha \lambda V} - (1+t \alpha V)^2 - \eta) = 0 \]

16) \[ \frac{\partial M}{\partial e}; e(\lambda e^{-\lambda}) = 0 \]

17) \[ \frac{\partial M}{\partial L}; L(1+t \alpha V^*) \frac{\partial W}{\partial y} d + \lambda \frac{\partial b e}{\partial L} - kb(PR+g) - \lambda bcR = 0 \]

18) \[ \frac{\partial M}{\partial k}; k(-\lambda bL(PR+g) + \eta + (1+g)) = 0 \]

19) \[ \frac{\partial M}{\partial R}; R(1+t \alpha V^*) \frac{\partial W}{\partial y} d + \lambda \frac{\partial b e}{\partial L} - kbLP - \lambda bcL^+ = 0 \]

20) \[ \frac{\partial M}{\partial \lambda}; \lambda(y^d + e - k^b L(PR+g) - N - bcRL) = 0 \]

21) \[ \frac{\partial M}{\partial \eta}; \eta(k-t+s^*) = 0 \]

22) \[ \frac{\partial M}{\partial \delta}; \delta(R+(k-k)(1+g)-D) = 0 \]

Only one of the constraints, \( t \geq k+s^* \), functions as an inequality so there are two possible solutions. Since \( k=t-s \) exists as a definition, \( t \geq k+s^* \) is the minimum constraint on the level of services provided to business; in order to attract industry, communities must provide business services greater than or equal to \( s^* \).

The importance of this inequality arises from the relationship between net taxes and rents. When the net tax rate rises, rents fall and vice versa. The level of business services is one determinant of the net tax rate and therefore
the size of rents in the community. Actual services provided to business are greater than the minimum services \((s > s^*)\) when the net tax rate is kept low in order to secure as much rents as possible. Actual business services equal the minimum \((s = s^*)\) when communities choose more net taxes rather than more rents.

A. \(s > s^*\)

Two solutions, one nonoptimal for most communities, arise from the inequality constraint. No community in which some of the land is owned by nonresidents will ever provide business services above the minimum requirement. An example will be employed to show the infeasibility of the solution corresponding to \(t = k + s^*\). Suppose a community was operating in a position where \(t = k + s^*\) and it wanted to raise additional education expenditures. Two ways are available to raise the required tax revenues. One way is to increase the tax rate and services to business by an equal amount, so rents are left unchanged and the additional education expenditure will be financed solely by a tax on housing. The alternative financing scheme is to raise both the tax rate and the net tax rate by the amount necessary to finance the education expenditures. Which will the community choose? Whenever the residents of a community do not own all of the business land within that community \((c < 1)\), the utility maximizing community will always choose to increase both the tax rate and the net tax rate by the same amount. When the net tax rate is not allowed to rise, residents must pay all
of marginal education costs through a tax on housing. Per capita disposable income will fall by the additional education expenditures. When both tax rates rise by the same amount, however, part of the education cost can be shifted to nonresidents through land rents. An increase in the net tax rate lowers rents, some of which would have gone to nonresidents. Note that the sum of rents and taxes paid by industry is unchanged. So disposable income will fall by less than the marginal education expenditures. In other words, residents pay a lower share of education expenditures when both the tax rate and net tax rate are allowed to rise.

Therefore communities with $c < 1$ would never provide business with more than the minimum level of services and so the case, $t > k + s^*$, would not exist for these communities. Only communities in which all land available for business is owned by local residents would consider operating where $s > s^*$.

Equations 15-22 can be solved to determine relative prices with the condition from equation 21 that when $t > k + s^*$, $\eta = 0$. The solution is given in equation 23.

$$23) \frac{W_d}{W_e} = \frac{W_L}{-kb(PR+g)-bcR}$$

The solution given in equation 23 is very similar to the first solution in the landless model. Using private goods as a numeraire we find that communities must finance marginal education expenditures solely from disposable income.
Total business receipts (rents and taxes) are fixed since an increase in business taxes is reflected in identically lower rents to residents. \(-kb(PR+g)-bcR\) is the marginal price of business land. This represents the dollar value in terms of rents and taxes lost by the community which results when one less unit of business land is supplied. This owes to the fact that the reduction in disposable income through lower rents and higher taxes, necessitated by accepting one less unit of business land cannot be shared with existing business since the maximum level of rents and taxes are already being paid by business. Again, this solution could only exist in a community where the residents own all of the industrial land.

B. \(s=s^*\)

In most communities some land is owned by nonresidents. A value of less than one for \(c\) is a significant factor in the discussion which follows. These communities would not provide business with services above the minimum requirement because some of the net taxes incident upon industry can be shifted to nonresidents through lower rents. The series of equations, 15-22, can be solved for this second case. In this solution the multiplier, \(\eta\), is negative because \(k=t+s^*\). Equation 24 shows the relative prices.

\[
24) \quad w_y = \frac{w}{c_1} = \frac{w_l}{c_1 - c_2 + bB - c_3} = \frac{(c_4 - c_5)c_1}{c_1 - c_2 + bB - c_3}
\]
where:

- $C_1$ = the reduction in residents net income due to tax increase and rent decrease
- $C_2$ = the reduction in gross income due to the lower rent
- $C_3$ = the reduction in business tax base due to the rent decrease
- $C_4$ = the reduction in resident rents due to less business
- $C_5$ = the value in taxes and rents of one more unit of industrial land

Equation 24 shows that education is relatively cheaper in communities where residents do not own all of their land since part of marginal education expenditures can be shifted through lower rents to nonresidents. Holding business land constant, $C_1$ is the reduction in disposable income of residents, due to a marginal increase in education expenditures. $C_1$ is equal to the decrease due to the higher tax rate or residential property ($\frac{\alpha V}{1 + t + v}$) and the decrease in rents paid to residents by business as the tax rate rises $\frac{bc(L+K)}{1+t}$. The denominator represents the total cost of a marginal increase in education expenditures. $C_1$ is the residential costs, $C_2$ is erosion of the residential tax base due to rent decreases ($kbV(L+K)$), $BB$ is the business tax base and $C_4$ is erosion of the business tax base due to rent decreases ($bc(L+K)$). The marginal price of education, therefore, is equal to the share of an increase in education expenditures borne by the residents.
The marginal price of education for this case lies below one since a fraction of marginal education expenditures can be shifted to nonresidents. The marginal price of education differs from the residential share of the tax base because residents may bear part of the business share of taxes through lower rents. Also, the residential and industrial tax bases are both diminished by reductions in rents which may affect the residential share of the tax base.

The marginal price of business is negative, again reflecting the fact that business rents and taxes function as payments for externalities. $C_4$ is the change in net income from accepting one more unit of business land

$$\left( \frac{bcR}{1+\tau_0 V} \right) \left( \frac{W_d}{1+W_e} \right)$$

and $C_5$ is the per capita taxes and rents from one more unit of business lands

$$-kb(\eta R + \gamma) - bcR.$$  

The particular form of price of business reflects the fact that, with education constant, the residents must share with nonresidents the value of reduced tax rates and increased rents that result when less environment is consumed.

V Industrial Land Supply Curve

The supply of industrial land can be determined from consumption decisions regarding business land, education, and private goods. This discussion will be based on communities in which $c < 1$ so the consumption decisions revealed in equation 24 will be used in the analysis. Equation 25 shows that business land supply is a function of fixed income in the community, the share of the community's land owned by
its residents, housing-disposable income ratio, capital-land ratio, and population. Also supply is a function of the demand-supply determined maximum rent and the interest rate since the interest rate determines the present value of an annuity.

25) \( L = L(N, D, c, g, i, b) \)

\( i \) = interest rate used in determining land values

A static analysis of the impact each variable in equation 25 has on the supply of industrial sites leads us to the probable form of the community's supply curve and the effect each variable has on the position of the curve. As in the previous chapter private goods, environment, and education are all assumed to be normal goods. Business is a discommodity since the payment goes from firms to communities. \( D \), representing the maximum possible rent as determined by supply and demand, is similar to \( k^* \) which was exogenous in the previous model. \( k^* \), which was also determined by supply and demand, was the relevant price for determining community behavior in chapter two. But when land is included in the model, the maximum possible rent becomes the exogenous price facing communities. So in two dimensional space the supply curve is graphed in terms of \( D \) and units of land in industrial use. Note that \( D \) represents the exogenous component of price; a change in the price of business however, is not necessarily synonymous with a change in \( D \). Changes in the price of business, not caused by a change in \( D \), will shift the supply curve.
Community consumption decisions are based on the endogenous marginal prices given in equation 24 - the shape of the supply curve may be determined by examining how changes in D affect the endogenous prices. While D does not enter explicitly into the prices, equation 13 shows that D is equal to the sum of rents plus the weighted net tax rate. Therefore, through its effect on rents and taxes, a change in D affects both the price of business and the price of education. The overall effect of a change in D on supply is the weighted sum of the two price effects.\(^6\)

\[ 26) \frac{\partial L}{\partial D} \cdot \frac{\partial P_L}{\partial D} + \frac{\partial L}{\partial P_e} \cdot \frac{\partial P_e}{\partial D} \]

At a point in time only one value of D can exist for a given community. However, D could vary over time so determining a supply of sites curve is of interest. We can determine the shape of the supply curve by determining the sign of each component in equation 26. \(\frac{\partial L}{\partial P_L}\) is negative when the substitution effect dominates. Since business sites is an inferior good, \(\frac{\partial L}{\partial P_L}\) will become positive when the income effect becomes dominant. \(\frac{\partial L}{\partial D}\) is probably negative, although it depends upon the sign of \(dD\) and \(dD\). Environment becomes relatively more expensive when D increases because business rent and tax payments increase. So \(\frac{\partial L}{\partial P_L} \cdot \frac{\partial P_L}{\partial D}\) is positive as long as \(\frac{\partial L}{\partial P_L}\) is negative. But an increase in D causes more

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\[^6\] \(P_L\) and \(P_e\) are the marginal prices given by the denominators in equation 24. \(P_e = \frac{C_4}{C_1 - C_2 + bB - C_3}\) and \(P_L = (C_4 - C_5)P_e\)
environment to be consumed when the income effect of an increase in the price of business becomes larger than the substitution effect.

\[ \frac{\Delta L}{\Delta P_e} \] is probably negative. This depends upon the assumption that environment and education are substitutes. \[ \frac{\partial P_e}{\partial D} \] is probably also negative although this requires \( dD \) to be large relative to \( dD \). So \[ \frac{\Delta L}{P_e} \cdot \frac{\partial P_e}{\partial D} \] is negative.

Education's price effect strengthens the business price effect when \( D \) is low, leading to an increasing quantity of business sites supplied as \( D \) rises. As \( D \) continues to rise, however, the business price effect may become negative.

The probable form of the community's supply curve, when plotted on a \( D-L \) axis, would be a curve that is positively sloped when \( D \) is low, but would become negatively sloped as \( D \) rises. When \( D \) is very low, communities receive little rents and taxes from industry so very few firms are allowed to locate. As \( D \) rises communities will sacrifice some environmental quality because the value of industrial tax base, in terms of rents and taxes, is increasing. In other words, the substitution effect causes communities to choose more business as \( D \) increases. At this point communities are probably increasing their consumption of both education and private goods and decreasing their consumption of environment.

Eventually the income effect of increasing business taxes and rents would offset the substitution effect.
Communities would supply less business and consume more environment - even when D increases. If the supply curve does not bend back too quickly, communities could consume more education, environment, and private goods since more of both taxes and rents could be obtained with the higher D. This appears to be a probable outcome; so the supply curve is likely to be relatively inelastic in the backward bending section.

The supply curve becomes vertical at the point where it begins to bend back. However, a continuous vertical section of the business supply curve, as occurred in the landless model is unlikely. In chapter two a community's supply curve became vertical when residents were no longer willing to allow tax rate increases, even when firms were willing to pay higher net taxes. Prices were unaffected by changes in k*. Rents rise when D increases in this model, even if residents do not want tax rate increases. So unless c=0 price effects still occur as long as rents are increasing. A vertical portion of the supply curve would require an unusual coincidence - the business price effect must be negative and equal in value to the education price effect. Graph 3-3 illustrates the probable form of the business land supply curve.

To determine how the supply curve is affected by changes in other exogenous variables it is necessary first to consider N, the exogenous component of income. Environment is assumed to be a normal good, however, a change in N
also affects relative prices. An increase in \( N \) makes education relatively more expensive because housing values are positively related to income; an increase in housing values means that the residential share of the tax base has increased relative to the business component. With business held constant the residential share of education goes up. Environment also becomes relatively more expensive. Holding education constant, residents would receive a larger tax reduction due to letting in more business, than with a lower level of income.

The overall effect on supply of an increase in \( N \) depends partly on the two price effects and partly on the initial income effect. An increase in the price of environment would shift the supply curve outward. However, environment and education are probably substitutes so an increase in the price of education causes fewer sites to be supplied. The own price effect (price of environment) probably dominates, which means more sites would be supplied.
due to the price effects. Tending to offset the price effects, however, is an income effect which causes fewer sites to be supplied. The price and income effects work in opposite directions; positioning of the supply curve, therefore, depends upon which effect is larger. Graph 3-4 illustrates this in a two good world.

Graph 3-4

Line 1 is the relative price of education to business, with tangency found along curve A. Line II shows an increase in income and line III represents an increase in the relative price of education. Movement to line II is just an income effect and the change in relative prices exerts both an income effect and a substitution effect. The final result depends upon whether the two income effects are greater than the substitution effect. The final result is not determinant but as illustrated in graph 4, the most likely outcome is for the income effects to dominate. So an increase in N probably shifts the supply curve inward.

£ c, the share of a community's rent that accrues to local residents, is also a factor influencing supply of
business land. Changes in \( c \) affect supply by changing the price of education and the price of business, \( \frac{\partial P_e}{\partial c} > 0 \) and \( \frac{\partial P_L}{\partial c} < 0 \). Education is more expensive when \( c \) rises because, with business held constant, an increase in \( c \) means that residents must forego more rents to finance education and also the residential tax base increases relative to business as \( c \) rises. An increase in the share of rents staying in a community makes environment more expensive because residents receive a larger fraction of rent and tax payments from each unit of land. The total effect on supply of a change in \( c \) depends upon the sign and size of the two price effects.

\[
\frac{\partial L}{\partial c} = \frac{\partial L}{\partial P_L} \cdot \frac{\partial P_L}{\partial c} + \frac{\partial L}{\partial P_e} \cdot \frac{\partial P_e}{\partial c}
\]

Equation 27 shows the effect on supply of a change in \( c \). \( \frac{\partial L}{\partial P_L} \cdot \frac{\partial P_L}{\partial c} \) is positive when \( L \) is low and negative as \( L \) gets larger. \( \frac{\partial P_e}{\partial c} > 0 \) so the relationship between business land supplied and \( c \) is somewhat dependent on the sign of \( \frac{\partial L}{\partial P_e} \).

This is analogous to the case described above for \( D \). \( \frac{\partial L}{\partial P_e} \) is probably negative, especially when supply is low.

As supply rises, however, the term could become positive. Assuming that the own price effect dominates, an increase in \( c \) shifts outward the positively sloped section of the supply curve illustrated in graph 3. However, supply could be lower in the negatively sloped area. This is demonstrated in graph 5 where \( c_0 < c_1 \). The \( c_1 \) curve probably bends back
at a lower level of D because a larger supply creates a larger income effect.

Graph 3-5

\[ K \]

\[ J \]

\[ y / g \]

\[ g \]

\[ L \]

\[ D \]

\[ c_0 \]

\[ c_1 \]

\[ \frac{\partial L}{\partial g} = \frac{\partial L}{\partial P_e} \cdot \frac{\partial P_e}{\partial g} + \frac{\partial L}{\partial P_L} \cdot \frac{\partial P_L}{\partial g} \]

\[ \frac{\partial L}{\partial P_e} \] and \[ \frac{\partial L}{\partial P_L} \] have already been discussed. \[ \frac{\partial P_e}{\partial g} \] is negative. An increase in the capital-land ratio makes education cheaper because it increases the business tax base for a given amount of industrial land; residents pay a lower share of marginal education costs. \[ \frac{\partial P_L}{\partial g} \] is indeterminate. Environment probably becomes more expensive when \( g \) rises because an increase in \( g \) raises the business tax base. An increase in the business tax base alters the mix between taxes and rents; for any community in which \( c < 1 \), the total payment of rents and taxes to residents increases.
Therefore, \( \frac{\partial L}{\partial g} \) is positive in the positively sloped section of the supply curve and negative in the backward sloping region. Since \( g \) only affects business rent and tax payments by shifting revenues from rents to taxes, the effect on supply is probably quite small. Graph 6 illustrates an increase in the capital-land ratio where \( g_1 > g_0 \).

Graph 3-6

Next, the housing-income ratio (\( \alpha \)) is considered. \( \alpha \) also affects supply by changing relative prices. Education probably becomes relatively more expensive when \( \alpha \) rises because the residents' share of the tax base increases relative to business. Environment probably looks relatively less attractive because, with education constant, an additional unit of business allows a greater reduction in taxes paid by residents. A change in \( \alpha \) affects supply in the same manner as \( c \) - an increase in \( \alpha \) shifts the supply curve as illustrated in graph 4.

The interest rate, \( i \), is considered as a determinant of supply because it determines the present value of an annuity:
present value of an annuity, $V$ and $i$ are inversely related. A decrease in $i$, which raises $V$, probably results in a decrease in the marginal price of education, although this depends on the relative size of the residential versus the industrial tax base. Education becomes relatively cheaper when $V$ increases because the residential tax base decreases in respect to the industrial tax base. Environment becomes more expensive because communities receive more business rent and tax dollars from the amount of business land in the same manner as changes in $g$ affects the mix of business taxes and rents. A decrease in $i$ probably shifts the supply of business sites curve outward. As with the capital-land ratio, the effect on supply of changes in $i$ is probably small. $i$, however, does not vary between communities, so it does not help explain differences in supply between communities.

Population ($b$) is the final variable to be considered. Education becomes relatively more expensive when population decrease because the residential share of the tax base declines relative to the industrial share. A decrease in population means the fixed business tax receipts may be divided between fewer people. Assuming the per capita residential base is unaffected, the industrial tax base rises relative to the residential tax base. Environment becomes more expensive because there are more business receipts per person when populations declines. So an increase in $b$ shifts
supply out in the manner illustrated in graph 3-4.

VII Summary of Model

A brief summary of the model is presented here. Business sites supply is represented by a backward bending curve. When supply-demand determined maximum rent is relatively low, supply is positively related to rent. As this maximum rent rises, the supply curve would turn back. Increases in the resident's share of rents, the capital-land ratio, inverse of population, and housing-disposable income ratio shift the supply curve outward. Increases in the fixed component of income and the interest rate shift the supply curve inward.

Marginal education expenditures are borne partly by residents and partly by nonresidents. The total value of industrial land (rents and taxes) is fixed; if however, the mix of rents and taxes is changed in order to purchase more education, communities receive all of the additional taxes from business, but must give up only part of rents which are forgone. Nonresidents bear a portion of marginal education costs through lower rents.

VI The Models Compared

Several similarities between the model without land presented in chapter two and the model with land presented in chapter three are discussed in this section. Any differences are also included where appropriate. Both models have the same basic structure. Well being is a function of
three goods: private goods, education, and environment - although environment is is expressed in a slightly different form compared to the other goods. Business capital is used as a proxy for environment in the landless model and units of land in industrial use is a proxy for environment in the land model. Units of land, rather than value of business capital, is used in the land model in order to insure that environment is not affected by the level of rents. Communities have zoning power which can be used in situations where demand for sites exceeds the quantity offered by communities at that price.

In each model a budget constraint is imposed upon the communities. Both constraints are similar in form; however, the budget constraint is nonlinear in the land model since income is partially determined by the level of rents.

An exogenously determined component of the marginal price of environment arises in both models. A maximum net tax rate is determined by supply and demand in the landless model. Communities may choose a net tax rate below the maximum; no firms, however, would locate in a community with a net tax rate above maximum. Queing would develop in communities which establish a net tax rate below maximum. Once land is introduced in the model, spatial equilibrium is guaranteed - zero excess demand for sites will occur in every community.
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The sum of rents and taxes per unit of land is the price determined by supply and demand in the land model. No community can set a price below the one determined by supply and demand because that portion of price that does not go into taxes is automatically reflected in rents. The sum of rents and taxes is fixed so communities are faced with deciding the optimal split between them. Several considerations are involved in this decision: tax dollars are assumed to be spent only for education yet income can be spent on any good. But some of the receipts directed to rents may go to nonresident owners of land. Existence of nonresident owners of land is probably the significant difference between the two models. Through the impact of tax policy on rents, these nonresident owners are forced to share in marginal education costs. Further, the marginal price of environment faced by a community is affected by the amount of land owned by nonresidents.

Another difference arises in terms of the prices. In the landless model the maximum net tax rate is identical for every community; however, when land is introduced in the model, the sum of rents and taxes varies between communities by the size of locational differences.

A backward bending supply curve is likely for communities in both models. The supply curves bend back when the income effect of an increase in receipts from business outweighs the substitution effect. Without land the supply
curve assumes a sickle shape. Residents reach a point
where they are unwilling to pay more taxes even when firms
are still willing to pay more. Supply becomes perfectly in-
elastic because none of the variables in the model change.
So the supply curve is vertical in this region giving the
curve a sickle shape. In the land model, rents rise even
when residents are not willing to pay more taxes. So a
vertical range of the curve would be an unlikely result.

The marginal cost of education may differ between the
two models. Many communities are probably forced to finance
marginal education expenditures solely from residential
taxes in the landless model. Business taxes from existing
firms are fixed and therefore cannot be changed without
changing the level of environment. While total business re-
cceipts are also fixed in the rent model, a community may in-
crease its share of business receipts by increasing the tax
rate—lowering rents. So marginal education expenditures
are partially financed by nonresidents through a reduction
in rents.

VII Extensions of the Model

Some assumptions, implicit in the theoretical model
were unrealistic. Several of these assumptions must be re-
 laxed in order to make the model appear more realistic and
therefore be more appropriate for testing. This analysis is
important for empirical work because it allows us to predict
how the model will react to changes in factors which have
previously been held constant.

Interaction between residential and industrial markets has been ignored. Suppose industry and people compete for location - does relaxing this assumption affect the theoretical analysis? Theoretical results presented earlier are not changed in substance by allowing housing consumers to compete for the same land as industry. More buyers are in the market for the same land so communities will face a higher overall demand for land (consumers and industry). Communities may also alter their supply curves for industrial sites. If a community can attract new residents with above average housing values, residents presently in the community can have more education by just attracting new residents without affecting environmental quality. So an alternative of selling vacant land to consumers as well as industry, shifts overall demand outward and supply of industrial sites inward. Equilibrium rental rates are higher than without consumers competing for sites and quantity of sites supplied depends upon where equilibrium is attained. An inward shift of supply causes fewer industrial sites to be supplied, but an increase in demand may cause more industrial sites to be supplied in the positively sloped portion of the supply curve and fewer sites in the negatively sloped section of the curve.

The capital-land ratio used by firms was assumed to be constant; this assumption can also be relaxed. Initially,
relaxing this assumption affects firms' willingness to locate in certain communities. Firms with high capital-land ratios would prefer to locate in high rent, low tax communities and firms with low capital-land ratios would prefer to locate in high tax rate, low rent communities. Stratification would develop where high tax communities could only attract land intensive firms and low tax communities would attract capital intensive firms - taxes and capital-land ratios are inversely related, while rents and capital-land ratios are positively related.

Stratification of firms would probably lead to adjustments in communities' behavior relative to the case where all firms have identical capital-land ratios. Capital intensive firms would locate in low tax rate areas leading to higher tax receipts and lower rents in these communities (net tax rate times capital is higher) than would have been anticipated with a fixed capital-land ratio. In high tax areas the opposite would occur - firms would yield lower tax receipts and higher rents than anticipated. Communities would adjust their consumption decisions to offset these occurrences. A likely result would be for low tax communities with capital intensive firms to lower their tax further in order to increase their consumption of private goods relative to education. As the tax rate is lowered, even more capital intensive firms will seek out these communities partially offsetting the decline in tax revenues. More environment may also be consumed by these low tax communities.
On the other hand high tax communities will be in a difficult situation. These communities tend to attract only land intensive firms. If these communities increase their tax rate in order to consume more education relative to private goods, they could receive even lower business tax receipts, since less capital intensive firms would locate there. The final effect on high tax rate communities is not clear. A likely solution would be to have small increases in the tax rate and decreases in environment (increases in the number of industrial sites) leading to a reduction in the education lost due to the location of relatively land intensive firms. An increase in the residential share of education is also possible.

In reality steel mills are much more damaging to the environment than, say, computer manufacturers. Another extension, then, is to allow different types of firms to inflict varying degrees of externalities on communities. The model can be easily adapted to allow for different degrees of externalities. At a given price communities are willing to make more sites available to low externality firms than to high externality firms because the marginal environmental damage is lower. Zoning can be used to allow a small number of "steel mills" and many "computer firms". Since high externality firms face a lower supply curve they will pay a higher for locations. If all firms are institutionally constrained to pay the same tax rate high externality
firms could either pay higher rents or receive lower services. In practice communities do this by zoning land to allow only certain types of manufacturing in some locations which is shifting the supply curve for sites facing some firms. Again, communities could enforce a higher price for these firms by using discriminatory zoning between firms.

Another extension is to allow for several locational factors rather than just one. This adjustment is also easy to incorporate in the model. With several location factors to consider, firms merely reduce the rent and taxes they are willing to pay in one community relative to another by the sum of locational differentials. If some locational advantages arise outside the center city, the most desirable community, on the basis of locational factors, may no longer be the center city.

A final extension of the model is to allow residents to be affected by services previously considered only to benefit business firms. Services provided to business by communities probably include goods such as police and fire protection and the quality of roads. These same services, however, probably benefit residents as well. If residents receive value from these services, the actual level of "business" services provided in each community may exceed the minimum suggested above. Variation may develop among communities in the amount of services provided to business.
CHAPTER FOUR

SOME EMPIRICAL ESTIMATES

In chapter three we developed a model which was hypothesized to explain the selection process for industrial plant sites within a metropolitan area. The next step is to empirically test the model to determine its validity and policy implications.

I The Model

Seven variables which are endogenous in the urban system appeared in chapter three. These variables included the supply of industrial sites, demand for sites, local property tax rate, rent, education, business services, and capital-land ratio. Proper estimation techniques would normally require a separate equation for each variable. Theoretical restrictions, however, require that several of these endogenous variables be omitted before estimating the mode. The community budget constraint connects the level of tax rates and the tax base to education expenditures. Once the tax rate and industrial tax base have been chosen, education is determined directly from the budget constraint. A separate supply equation, therefore, is not necessary for education expenditures.
We know that in equilibrium the quantity of industrial sites supplied must be equal to the quantity demanded. This equilibrium condition, which says that the supply of sites must equal the demand, allows a second equation to be eliminated. Either supply or demand for sites can be eliminated. Five endogenous variables remain: quantity of sites, tax rate, business services, capital-land ratio, and rent.

The model describes the location of industry for communities which are in equilibrium. Hence it will predict to the extent that the industrial land market is in equilibrium.

Reduced Form versus Structural Estimates

Ideally, structural and reduced form estimates would be derived for each of the remaining five equations. To get structural estimates we must be able to identify each equation by putting theoretical restrictions on which variables enter each equation. The business demand for sites equation, therefore, is the only one that can be structurally estimated since it can be identified independent of the community supply functions. In other words, business demand is dependent on factors different from those explaining community behavior.

Equations explaining the tax rate, business services, rent, and capital-land ratio can not be individually identified. No theoretical restrictions can be imposed on any of the variables in the community supply equations because
to do so would require knowledge of the specific community utility function.

A community supply of sites curve cannot be structurally estimated in terms of the tax rate. We mentioned in the theoretical section that a community's supply could not be specified in terms of the tax rate because the tax rate is simultaneously determined with the supply. Each community resembles a monopolist in the sense that they can set both price (tax rate) and quantity (supply of sites). Therefore, communities have only a supply point, not a supply curve. If the communities have any monopoly power even this supply point may be unobservable since the cost conditions of a monopolist are not estimable from supply-demand equilibrium points.

Specification of the Equations
A) Business Demand for Sites

This structural equation specifies the variables which explain the demand for sites (DSites) in each community. Little elaboration is needed to explain firms' location behavior. Firms are profit maximizers which is identical to assuming them to be cost minimizers. Firms presumably come into a metropolitan area seeking to locate in those communities where total costs - including production costs and transportation costs - are at a minimum.
Consider the exact specifications of this equation for estimation purposes. Variables in this equation are the property tax rate, rent, capital-land ratio, business services, distance to the center city, and access to interstate highways. Our theory suggested that these six variables, which are the components of D in chapter three, are additive in their effect on business demand. Taken together they represent a cost factor which, ceterius paribus, firms want to minimize.

Four of these variables; rent, property tax rate, capital-land ratio, and business services are endogenous variables and therefore must be simultaneously estimated with the demand for sites. The first three are cost factors which, other things equal, firms want to minimize.

Business services are government provided goods which yield benefits to business firms. Other things equal, firms want to maximize the amount of cost reducing business services, like police and fire protection, which they receive. While these services provide benefits to firms, they also provide benefits to residents, so business services are endogenously determined within the system.

Access to interstate highways and distance to the center city are locational considerations which may reduce costs to firms. Firms are expected, ceteris paribus, to choose those sites which are preferred on the basis of location characteristics.
B) Other Equations

Five other equations can also be estimated. These equations are designed to explain the property tax rate (PRate), rent, business services (BServ), capital-land ratio (KLand), and quantity of sites. Each of these equations is a function of all exogenous variables in the system, therefore, all of these equations must be estimated in reduced form.

The model included four exogenous variables to explain community supply behavior: population (Pop), income (Inc), housing-income ratio (HInc), and percentage of industrial land owned by community residents. The interest rate does not vary between communities so it has been omitted. Data are not available on the percentage of industrial land owned by community residents so it must also be omitted; although population size, already included in the system, may be a proxy variable for this effect.

Cost factors which affect business demand behavior must also be included in the reduced form equation. Two exogenous variables reflecting the demand side are included in the reduced form equations. Access to interstate highways (AHigh) and distance from the center city (DisC) are proxy variables for locational characteristics of a community which lower business costs.

Two other exogenous variables are added to the system. Population density (Dens) was included as a measure of existing crowding in a community. Already congested communities
would presumably choose less industry and firms would not want to enter crowded communities. The percentage change in population (ΔPop) from 1960-1970 was included as a proxy variable for disequilibrium which may exist in rapidly changing communities. These communities may have more industry than in compatible with their new, higher populations.

Information on how each variable was calculated is available in appendix A and average values for each variable are in appendix B. The six equation which will be estimated can be summarized as follows:

1) $DSites = f_1(PRate, Rent, KLand, BServ, AHigh, DisC, e_1)$
2) $PRate = f_2(Pop, Inc, HInc, AHigh, DisC, Dens, ΔPop, e_2)$
3) $Rent = f_3(Pop, Inc, HInc, AHigh, DisC, Dens, ΔPop, e_3)$
4) $KLand = f_4(Pop, Inc, HInc, AHigh, DisC, Dens, ΔPop, e_4)$
5) $BServ = f_5(Pop, Inc, HInc, AHigh, DisC, Dens, ΔPop, e_5)$
6) $QSites = f_6(Pop, Inc, HInc, AHigh, DisC, Dens, ΔPop, e_6)$

II The Sample

Cuyahoga County, Ohio was selected as the area in which to test the model. Cuyahoga County contains approximately 60 cities and towns of which 43 were selected for the sample. These 43 observations include every town in the county with a population above 2500 with the exception of Cleveland. Only towns with 2500 or more population are included because much of the data is unavailable for smaller towns. Cleveland was omitted from the sample because the model developed
above pertains to communities with little or no control over the price of locations. If Cleveland was included in the sample it would account for approximately 40% of the sample's population, 20% of the sample's area, and 50% of the sample's industrial land. For these reasons it seems likely that Cleveland would not operate as a price taker; hence it was eliminated from the sample. Appendix C lists each town in the sample.

Cuyahoga County was selected for several reasons. First, the 43 observations provide a relatively large sample of heterogenous communities. Industrial and bedroom communities are included in the sample. The 43 observations lie solely within one state; therefore, problems of interstate tax differentials are excluded. Further Cuyahoga County accounts for nearly all of the Cleveland metropolitan area, including communities which are more than 16 miles from the center city. This eliminates any problems of bias which might result from studying only one section of the metropolitan area.

III Estimation Technique

Two stage least squares analysis is used in the statistical analysis. This technique was adopted because the demand for sites and several other variables - for example, the tax rate and rent - are simultaneously determined. Two stage least squares involves calculating reduced form
estimates for every endogenous variable which enters as an explanatory variable in the business demand equation. Then the actual data for these variables are replaced with the reduced form estimates in the least squares estimate of the business demand equation.

The main concern of this paper is industrial location. Analysis, therefore, will be concentrated upon the business demand equation and the reduced form quantity of sites equation. The other four equations serve basically as instrumental variables in estimating the business demand curve. These other four equations will be discussed, because the reduced form equation are useful for prediction. The discussion of these variables, however, is limited.

IV Estimation of the Business Demand Curve

We will focus upon three characteristics of the business demand estimates. First, are the size, significance, and elasticity of the coefficients, as these provide a measure of the explanatory power of our model and also provide information on how these variables affect demand. The fiscal variables, property taxes and government services, are of obvious interest. Finally, our model suggests that some communities may use zoning to choose a quantity of industry

below the demand curve. An analysis of whether all com-
munities are on the boundary imposed by the demand curve is
appropriate.

Theoretical results, developed in chapter three, pre-
sented a method to explain the amount of land used by indus-
try within each community. So, land in industrial use was
selected as the dependent variable in the analysis of the
business demand curve. The quantity of industrial land is
measured by dividing the assessed value of industrial real
estate by the assessed value of land per acre. The stock of
industry is used as the dependent variable rather than a
flow; the model, in other words, is designed to explain
variations in the total level of land in industrial use
rather than the yearly changes.

Are Communities on the Demand Curve

Theory (Chapter 2 and 3) noted that some communities
may be supplying less industrial land than the market will
absorb. Before analyzing the coefficients of the demand
curve, therefore, we must determine whether all communities
are in fact operating on the constraint imposed by the
demand for sites curve.

Communities that choose to supply an amount of indus-
trial land less than demanded by industry are not obser-
vations along the demand curve. A consistent set of demand
for sites estimates, therefore, requires that the empirical
analysis include only those communities that are supplying the full amount of land demanded by the market - i.e., are constrained by the demand curve.

To eliminate from the analysis communities that are not clustered around the demand curve, it was hypothesized that these communities would lead to different estimates of the demand curve from those consistent with observation along the demand curve. The procedures to test the hypothesis involves utilizing an F statistic which allows us to determine whether two samples come from the same population - i.e., whether two samples lead to the same estimates for the demand curve. The test consists of comparing the

\[ F = \frac{s's - r'r}{\frac{s's}{k} + \frac{r'r}{T_1 + T_2 - 2k}} \]

Technically speaking, this F statistic tests whether the noise is reduced by estimating the equation in a restricted, rather than unrestricted fashion. The F statistic has the following form:

The F statistic is calculated by estimating the unrestricted demand curve for the entire 43 observation. \( s's \) is the sum of squared residuals for this regression. Then the 43 observations are divided into two samples. One sample contains those communities in which the observed quantity of industrial land lies on the demand curve and the other sample includes those communities choosing an amount of land in industrial use below the demand curve. The restricted demand curve is then estimated for the observations hypothesized to be clustered around the demand curve. \( r'r \) is the sum of squared residuals for this regression. \( k \) is the degrees of freedom for the numerator where \( k \) is the number of independent variables. \( T_1 + T_2 - 2k \) is the degrees of freedom for the denominator where \( T_1 \) is the number of observations in sample one and \( T_2 \) is the number of observation in sample two. See Franklin Fisher, "Tests of Equality Between Sets of Coefficients in Two Linear Regressions: An Expository Note," Econometrica, March, 1970, Vol38 No.2. pp.361-367.
computed $F$ ratio with a specified value, if it is less, than the hypothesis that not all communities are clustered around the demand curve can be rejected.

To test whether some communities are operating below the demand curve we must develop a rule for dividing the 43 observations into two samples. Any community in which less than one percent of the assessed value of real property was classified as industrial are hypothesized to supply an amount of land below the demand curve. Nineteen cities and villages fall into this group, of which twelve have zero industry. The remaining twenty four communities are hypothesized to be in a position where their desired quantity of sites supplied is constrained by the demand curve.

Specifically, we are testing whether the regression estimates obtained from the 24 observations perform better than the estimates for the entire 43, which includes the 19 observations with little industrial land. If the $F$ statistic lies above 3.3 we know with a probability of .99, that including the 19 observations gives us less efficient estimates of the business demand curve. The actual $F$ statistic is $3.71 > 3.30$. Therefore, we accept the hypothesis that the two samples yield different estimates of the demand curve. In other words, the 19 observations do not appear to be clustered around the demand curve.

This result is an important finding. It suggests that empirical estimates of the demand curve cannot be based upon
<table>
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<tr>
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<th>Std. Dev.</th>
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<td>-0.7518</td>
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<td>BServ</td>
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<td>0.0820 -01</td>
<td>-0.4131</td>
</tr>
<tr>
<td>KLand</td>
<td>0.1778 -01</td>
<td>0.1492 +00</td>
<td>-0.4131</td>
</tr>
<tr>
<td>Rent</td>
<td>0.1037 -01</td>
<td>0.1393 +00</td>
<td>-0.4131</td>
</tr>
<tr>
<td>Discrim</td>
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<td>-0.4131</td>
</tr>
<tr>
<td>AHigh</td>
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<tr>
<td>Price</td>
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<td>0.1748 +03</td>
<td>-0.7518</td>
</tr>
<tr>
<td>BServ</td>
<td>0.1069 -01</td>
<td>0.0820 -01</td>
<td>-0.4131</td>
</tr>
<tr>
<td>KLand</td>
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<td>-0.4131</td>
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<tr>
<td>Rent</td>
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<td>0.1393 +00</td>
<td>-0.4131</td>
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<tr>
<td>Discrim</td>
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<td>AHigh</td>
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<td>-0.9907</td>
</tr>
<tr>
<td>Price</td>
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<td>0.1748 +03</td>
<td>-0.7518</td>
</tr>
<tr>
<td>BServ</td>
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<td>0.0820 -01</td>
<td>-0.4131</td>
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<tr>
<td>KLand</td>
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<td>0.1492 +00</td>
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<tr>
<td>Rent</td>
<td>0.1037 -01</td>
<td>0.1393 +00</td>
<td>-0.4131</td>
</tr>
<tr>
<td>Discrim</td>
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<td>0.1037 -00</td>
<td>-0.4131</td>
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<tr>
<td>AHigh</td>
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<td>-0.9907</td>
</tr>
<tr>
<td>Price</td>
<td>-0.2151 +03</td>
<td>0.1748 +03</td>
<td>-0.7518</td>
</tr>
<tr>
<td>BServ</td>
<td>0.1069 -01</td>
<td>0.0820 -01</td>
<td>-0.4131</td>
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<tr>
<td>KLand</td>
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<td>0.1492 +00</td>
<td>-0.4131</td>
</tr>
<tr>
<td>Rent</td>
<td>0.1037 -01</td>
<td>0.1393 +00</td>
<td>-0.4131</td>
</tr>
<tr>
<td>Discrim</td>
<td>0.1054 +00</td>
<td>0.1037 -00</td>
<td>-0.4131</td>
</tr>
<tr>
<td>AHigh</td>
<td>0.0574 +00</td>
<td>0.0915 +00</td>
<td>-0.3569</td>
</tr>
</tbody>
</table>

| Equation 6 |
|------------|-------------|-----------|---------|
| Constant   | 0.1216 +05  | 0.1181 +05 | -0.9907 |
| Price      | -0.2151 +03 | 0.1748 +03 | -0.7518 |
| BServ      | 0.1069 -01  | 0.0820 -01  | -0.4131 |
| KLand      | 0.1778 -01  | 0.1492 +00  | -0.4131 |
| Rent       | 0.1037 -01  | 0.1393 +00  | -0.4131 |
| Discrim   | 0.1054 +00  | 0.1037 -00  | -0.4131 |
| AHigh      | 0.0574 +00  | 0.0915 +00  | -0.3569 |

Table 1: Structural Estimates of the Business Demand Curve
all communities in a metropolitan area. Researchers must be careful to include as observations for demand estimates, only those communities that are supplying land equal to the amount demanded.

Consider predictions of the industrial tax base which would be derived from the demand for sites estimates obtained from all 43 communities, from the 24 communities clustered around the demand curve, and from the other 19 observations, respectively. The estimated industrial tax base in East Cleveland would be $2,376,400, $10,577,600, and $1,253,956. These estimates can be compared with the actual industrial tax base of $9,630,030. East Cleveland is not necessarily a representative community but the tax base estimates show that the choice of the estimating procedure can have a large impact upon the results.

The demand estimates using all 43 estimates do particularly poor for the communities with little industrial land. Rocky River, for example, has an actual industrial tax base of $363,370. Estimated demand for sites in Rocky River using all 43 observations would be $2,470,600, a difference of nearly ten fold from the actual amount of industrial tax base.

Estimates of the demand curve with 24, 43, and 19 observations are presented in table one. Equation one shows the estimates with 24 observations, equation two with 43 observations, and equation three with the 19 observations
not clustered around the demand curve.

B) Structural Coefficients

The estimates derived from the 24 observations clustered around the demand curve are used for this discussion of structural coefficients. Equation one of table one shows estimates for the coefficients of a linear formulation of the business demand curve. Estimates of the structural coefficients for the business demand curve do support the theoretical hypotheses. First, consider the fiscal variables. The effective property tax rate has a significant negative coefficient. This means that increases in the effective tax rate within a community cause firms to demand fewer sites. So quantity of sites demanded and the effective tax rate have the expected inverse relationship.

Previous literature has generally found the property tax is not a meaningful factor in industrial location decisions. Our results, however, show that the property tax is a significant variable in location decisions. This interesting finding can be attributed to three elements. First, the use of a supply-demand framework to explain the location of industry allows the effect of the property tax to

---

3 The properties for small sample distributions of two stage least squares estimates are not known. All we know is that the estimates are asymptotic (efficient). The t statistic, therefore, must be compared with the normal distribution.
be properly measured. Along with this, only the communities which are observations along the demand curve were included in our analysis. Also, the use of a small geographic area, such as a metropolitan area, neutralizes many factors which are generally considered more important than the property tax rate.

Business services is the other fiscal variable. A problem was how to measure public services that benefit business. Per capita police and fire expenditures were used as a proxy for business services. Services were measured in this section in a per capita form because their benefit also goes to residents. Remember in the theoretical section business services were measured as a rate on industrial land since residents were assumed to be unaffected by business oriented services. Only police and fire expenditures are included in this proxy because these services may be more business specific than most other locally provided services.

Business services have a highly significant positive coefficient. Other things equal firms prefer to locate in communities with large business related services because without local government provision, the firms themselves would probably need to provide some of these services. So, as argued in the theory, firms are willing to pay higher taxes and rents in communities with large business related services.
The capital-land ratio times the tax rate is expected to be negatively related to quantity demanded because firms must pay taxes both on their land and capital. So capital intensive firms will have a lower demand for sites at every tax rate. The capital-land ratio has the expected negative coefficient and it is significant.

Surprisingly, rent has a positive, although significant, coefficient. This unexpected sign may mean that the rent variable is picking up some other locational characteristics.

Distance to center city has an insignificant positive coefficient, which suggests that, other things equal, firms prefer to locate further from the central city. The other locational variable, access to interstate highways, is significant and positive. Other things equal, firms prefer to locate near an interstate highway.

The business demand curve was also estimated in a log linear form. Estimates for the log linear regression are presented in equation four of Table 1. Coefficients for each of the variables are similar to the linear model in terms of sign and significance with the exception of distance to the center city and business services. Overall fit of the equation is also essentially the same.

Our theory suggested that demand for sites in each community would be highly elastic with respect to the net tax rate, property tax rate minus business services. This result develops because communities have very little control over the price facing firms.
Business demand has an elasticity at the mean of -5.5 with respect to the tax rate and an elasticity of 4.6 with respect to business services. So we find support for the hypothesis that the business demand curve is strongly elastic with respect to taxes and services.

The elastic property tax rate tells us that for the average community, an increase in the tax rate of .16 mills would lead to a decrease in demand to locate industrial tax base equal to $184,424. If supply adjusted to still equal demand at this higher tax rate, other things equal, communities would lose $27,337 yearly in tax revenues from the industry which leaves. This loss would be partially offset by an increase of $13317 in taxes on remaining industry, but the overall result of the tax increase would be a reduction in business tax revenues equal to $14010.

A decrease in police and fire expenditures of 37% per capita would cause the average community to lose industrial tax base valued at $405,154. This loss would, other things equal, cost the community $22,689 yearly in property tax revenues. The $8579 saved on police and fire expenditures would partially offset the lost tax revenues, however, the community would have a net $14,110 less to spend on other services.

Demand for industrial sites is elastic with respect to three of the four remaining variables. Rent is the most elastic of the remaining variables with an elasticity of 9.16. The capital-land ratio has an elasticity of -2.89, distance to
center city has an elasticity of 4.03 and access to interstate highway has an elasticity of .28.

V Reduced Form Estimates

We discussed in section one above, that only reduced form estimates of the coefficients can be obtained for the property tax rate, business related services, capital-land ratio, and rent. A reduced form estimate can also be derived for the land in business use.

Reduced form equation are obtained by regressing all independent variables in the system on each dependent variable. Reduced form estimates have several uses. Reduced form equations are useful for predicting future values of dependent variables. Also, reduced form estimates are useful in making policy conclusions because they allow us to determine the total effect on a dependent variable of a change in one of the exogenous variables.

Land in Industrial Use

Table two gives linear estimates of the reduced form coefficients, using the exogenous variables discussed above in section one. Equation one in table two is estimates of the coefficients for the land in business use equation. In this equation income, population, and percentage change of population are all significant coefficients at a 90% level of confidence. High income communities are expected to prefer more environment than low income communities. Income
### Table 2

**Linear Reduced Form Estimates**

<table>
<thead>
<tr>
<th>Equation 1</th>
<th>Constant</th>
<th>Inc</th>
<th>HInc</th>
<th>Dens</th>
<th>Disc</th>
<th>AllHigh</th>
<th>Pop</th>
<th>ΔPop</th>
</tr>
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<tbody>
<tr>
<td>Coefficient</td>
<td>0.21390*04</td>
<td>-0.87470*00</td>
<td>0.47460*08</td>
<td>-0.17670*00</td>
<td>0.12770*03</td>
<td>-0.17660*00</td>
<td>0.12770*03</td>
<td>-0.13080*04</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.10230*05</td>
<td>0.41130*06</td>
<td>0.44930*08</td>
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<td>0.62460*03</td>
<td>0.17460*03</td>
<td>0.43650*04</td>
<td>0.27510*02</td>
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<tr>
<td>t-value</td>
<td>0.33239*00</td>
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<td>0.33650*03</td>
<td>-0.75460*00</td>
<td>0.15180*01</td>
<td>0.11420*01</td>
</tr>
</tbody>
</table>

| Equation 2 | Pant  |  |  |  |  |  |  |  |  |
|------------|-------|-----|------|------|------|---------|-----|------|
| Coefficient | 0.71230*01 | 0.47370*09 | -0.23670*08 | -0.1030*02 | 0.10560*00 | -0.14030*01 | -0.14030*01 | -0.72650*02 |
| Std. Dev.  | 0.12370*01 | 0.15770*01 | 0.16580*01 | 0.5170*01 | 0.80660*00 | -0.15230*01 | -0.16260*02 | -0.4130*01 |
| t-value    | 0.24440*03 | 0.42920*02 | -0.51860*06 | -0.38560*06 | 0.71660*01 | -0.11370*02 | 0.3410*03 | -0.13860*00 |

| Equation 3 | Pant  |  |  |  |  |  |  |  |  |
|------------|-------|-----|------|------|------|---------|-----|------|
| Coefficient | 0.24440*03 | 0.42920*02 | -0.51860*06 | -0.38560*06 | 0.71660*01 | -0.11370*02 | 0.3410*03 | -0.13860*00 |
| Std. Dev.  | 0.12370*01 | 0.15770*01 | 0.16580*01 | 0.5170*01 | 0.80660*00 | -0.15230*01 | -0.16260*02 | -0.4130*01 |
| t-value    | 0.24440*03 | 0.42920*02 | -0.51860*06 | -0.38560*06 | 0.71660*01 | -0.11370*02 | 0.3410*03 | -0.13860*00 |

| Equation 4 | Pant  |  |  |  |  |  |  |  |  |
|------------|-------|-----|------|------|------|---------|-----|------|
| Coefficient | 0.35460*02 | -0.21350*07 | 0.10330*06 | 0.17770*02 | 0.19000*01 | -0.64420*01 | -0.94750*04 | 0.14860*07 |
| Std. Dev.  | 0.12370*01 | 0.15770*01 | 0.16580*01 | 0.5170*01 | 0.80660*00 | -0.15230*01 | -0.16260*02 | -0.4130*01 |
| t-value    | 0.35460*02 | -0.21350*07 | 0.10330*06 | 0.17770*02 | 0.19000*01 | -0.64420*01 | -0.94750*04 | 0.14860*07 |

<p>| Equation 5 | Pant  |  |  |  |  |  |  |  |  |
|------------|-------|-----|------|------|------|---------|-----|------|
| Coefficient | 0.13770<em>02 | -0.54320</em>03 | -0.18520<em>05 | -0.57460</em>05 | -0.24730<em>08 | -0.12770</em>01 | 0.63870<em>04 | 0.23920</em>01 |
| Std. Dev.  | 0.12460<em>01 | 0.82140</em>00 | 0.13450<em>01 | -0.10150</em>01 | -0.10700<em>01 | -0.12450</em>00 | 0.72830<em>00 | 0.98330</em>00 |</p>
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<th>Table 3</th>
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<tr>
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<tr>
<td><strong>Equation 5</strong></td>
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<tr>
<td>Coefficient</td>
<td>-0.110 ± 0.01</td>
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<tr>
<td>Std. Dev.</td>
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<tr>
<td>t Value</td>
<td>-0.88</td>
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has a negative coefficient which means, other things equal, higher income communities have less industry.

Population has a positive coefficient. As population rises, the value of a given industrial tax base is less per person. So more populous communities tend to take more industry to maintain the per capita industrial tax base.

Percentage change in the population is positively related to land in industrial use. Communities in which population has increased rapidly appear to have more industry than desired. This reflects a possible disequilibrium in the industrial land market for rapidly growing communities.

Other variables in the equation are the housing-income ratio density, distance to the center city, and access to interstate highways. The housing-income ratio is a wealth variable and is expected to be negatively related to land in industrial use. Communities with a large housing-income ratio have a relatively large residential tax base and want less industrial tax base. The coefficient is positive, although insignificant. The positive result may arise because firms prefer to locate in the relatively wealthy communities. Also, the wealthiest communities which prefer less industry were, in general, excluded when we omitted the observations not clustered around the demand curve.

Population density is negatively related to land in industrial use. This result is expected, although the sign is insignificant. External effects and congestion are
greater in densely populated communities causing the residents to supply fewer sites and firms to demand fewer sites. Furthermore, there is the obvious effect that more people means less room for industry.

Distance to center city and access to interstate highways are proxies for locational characteristics. Communities with preferred locational characteristics are expected to receive larger rents and taxes from industry than other communities and so would probably want more industry. Other things equal, firms were expected to prefer locations near the center city and near interstate highways. So AHigh is expected to have a positive coefficient and DisC a negative coefficient.

Distance to center city has a positive coefficient and access to interstate highways has a negative coefficient. Both coefficients are somewhat unexpected. Notice, however, in equation three that AHigh is negatively related with the level of rents. Further, the coefficients are not significantly different from zero.

Estimates of the reduced form equation in log linear form are given in table three. Better explanation is obtained using the log linear form of the reduced form quantity of sites equation. Also, population density is significant when estimated in log linear fashion.

The quantity of land in industrial use is elastic with respect to income and the housing-income ratio. Consider
income, the most elastic variable. For an average community a one percent increase in income leads to a 3.24 percent decrease in land in industrial use. A $130 increase in average family income causes a $307,100 decrease in the industrial tax base in the average community.

The elasticity of quantity of sites with respect to the housing-income ratio is 1.99. Quantity of sites is inelastic with respect to each of the other variables. Quantity of sites has an elasticity of .54 and .63 with respect to the other two significant variables, population and percentage change in population, respectively.

Property Tax Rate

Equation two of table two contains reduced form estimates of the property tax rate equation coefficients. Significant variables in this equation are income, population density, distance to center city, access to interstate highways, and population. Income has a positive coefficient. Other things equal, high income communities are willing to pay higher tax rates than low income communities. This probably reflects two things. One, high income communities have less industry and so they must pay higher tax rates to maintain a given level of government services. Also high income communities may choose relatively more education and other public services.
Population density also has a positive coefficient. Relatively greater public services may be necessary in dense communities causing higher tax rates. Fewer firms tend to locate in dense communities, perhaps requiring a higher tax rate to maintain services. A densely populated community may also imply a large demand for residential sites. The positive coefficient may, therefore, indicate that residents must be willing to pay higher prices to locate in communities in which there is a large residential demand for sites.

Distance to center city is also positively related to the tax rate. This is a surprising finding because distance to center city is negatively related to rents (see next page). The positive coefficient, however, probably reflects an income gradient effect - further out communities, which generally have higher incomes, are willing to pay higher tax rates.

Access to interstate highways is negatively related to the tax rate. This business demand variable takes the same sign as in the business demand equation and the rent equation. Further discussion of this variable is presented with the rent equation.

Population has the expected negative coefficient. It is negative because communities with larger populations tend to have larger industrial tax bases. Also, there may be some economics of scale in providing education and other
public services. So the populous communities can, other things equal, charge lower tax rates.

The tax rate is not highly elastic with respect to any of the variables. In fact income is the most elastic with an elasticity of .38.

Rent

Reduced form estimates of the coefficients for the rent equation are presented in equation three for table two. Distance to center city and the housing-income ratio both have significant negative coefficients in the rent equation. The negative coefficient for distance to center city simply reflects the rent gradient.

Rent is not highly elastic with respect to any of the variables. Rent has an elasticity of about .8 with respect to both of the significant variables.

Business Services

Equation four of table two contains the reduced form estimates for police and fire prevention expenditures. Significant negative explanatory variables include income and access to interstate highways. Distance to center city and percentage change in population both have positive, significant coefficients.

Income is the only variable with which business services are very elastic. Business services have an elasticity
of -1 with respect to income. A $130 increase in average family income causes an average community to spend 36¢ less per capita for police and fire expenditures.

Capital-land Ratio

Capital-land ratio is the final reduced form equation. None of the variables are highly significant. Several of the variables, however, do have t values exceeding one. One of these variables, the housing-income ratio, has a negative coefficient. This suggests that capital intensive firms may cause greater external effects than land intensive firms and therefore, wealthy communities tend to permit only land intensive firms. Further support to the hypothesis that capital intensive forms inflict greater external effects than other communities is provided by the sign of the density coefficient. Density has a negative coefficient which suggests that land intensive firms tend to locate in these densely populated communities where a greater number of people are likely to be affected by the externalities.
CHAPTER 5
CONCLUSIONS AND POLICY IMPLICATIONS

Empirical estimates of our model, derived from 24 observations in Cuyahoga County, Ohio, go a long way to support the hypothesized theory. Coefficients for almost all of the variables had the hypothesized signs. Also, the fit was good for most of the equations.

The two most significant empirical findings of the paper are in reference to the business demand for sites curve. We found that some communities use zoning to keep the quantity of sites supplied below what is demanded by firms. So all communities cannot be used in estimating a business demand curve.

A significant negative effect on the demand for sites caused by the property tax is a second meaningful finding. This result contrasts with most previous literature, which has found the property tax rate to be unimportant in location decisions. The significant effect of the property tax is a function both of choosing a small geographic area for analyzing the location question and estimating the equations simultaneously.

The theoretical model reveals some insight into the marginal prices of education and environment. In the model with land, we found that the marginal price of education is
greater than the residential share of the tax base. Education is more expensive than the residential share of the tax base because, residents must pay a share of taxes incident upon industry through lower rents and lower rents also lead to a reduction in the value of the industrial tax base.

An important result of the theoretical section was that the marginal price of education is endogenously determined by community behavior. Simultaneous equation bias will result from explaining education expenditures in terms of the marginal price of education. Attempts to explain education expenditures with a single equation approach, therefore appear to be inappropriate.

The endogenously determined price of environment basically reflects the business taxes and rents which a community foregoes at the margin by limiting industry. The value of business to a community is the tax and rent payments, so at the margin the lost environment due to the existence of business firms must equal the taxes and rents received by the community. Neither can this endogenous price be used to explain community behavior in a single equation model - a multiple equation approach must be utilized to explain community behavior.

Empirical results support the theoretically derived view that the sum of rents and taxes paid by firms for locating in a community are determined by supply and demand for
sites. Municipalities establish the supply of sites by permitting industry to enter until the marginal disutility from an additional firm, divided by negative of the taxes and rents from the firm, is equal in value to the marginal utility of income. Municipalities appear to use zoning and to some extent fiscal factors (taxes and business services) to control the amount of land which is used by business.

Firms demand for industrial sites is decided in such a way as to minimize their total costs. Therefore, firms are willing to pay higher rents and taxes in communities with large locational advantages. Firms are willing to pay lower rents and taxes in locationally disadvantaged communities.

Firms' demand curves vary among communities according to locational considerations. The sum of rents and taxes paid by firms responds in such a way to different levels of business demands that locational considerations will tend to be reflected in the level of rents and taxes.

Each community has relatively little control over the total level of rents and taxes from a given amount of industry; communities act as if they are price takers in the market for industrial tax base. Communities, however do have control over the mix of rents and taxes through their decisions concerning consumption of publicly provided versus private goods. Also, communities may be able to get more rents and taxes from industry by allowing more land to be adopted for industrial use.
In the first chapter several reasons were suggested for examining intrametropolitan patterns of industrial locations. The main reasons were to determine whether fiscal variables cause production inefficiencies to examine an equity argument based on industrial tax base differentials between communities, to allow predictions of future industrial land use patterns, to determine which tools policymakers can use to affect future location patterns. Each of these reasons is briefly discussed below.

Is the effect of the property tax on the selection of a specific plant site one that causes production inefficiencies? Our results suggest that, as long as community zoning authorities maintain the property rights for determining the 'proper' use of land, the answer is no! Property taxes function as part of a payment for externalities imposed upon the community's residents. Taxes and rents together are seen as ways to force firms to compensate society for their social cost of production and not just their private costs, alone.

The model did not consider spillovers from a community. Presumably each community would consider only the externalities imposed upon their own residents when making its supply decisions and would ignore the externalities imposed upon residents of other communities. So firms would only compensate the community in which they locate, for externalities imposed on that community's residents. Externalities
imposed on nonresidents would probably not be reflected in rents and taxes.

Nor does local zoning lead to production inefficiencies as long as communities are vested with control over the use of land. Zoning merely insures that each community has control over the amount of land in industrial use and the type of industry using the land. In any case where the number of firms demanding sites in the community exceeds the industrial activity which is consistent with the community's desired level of environment, zoning may be used to limit the number of firms. Zoning, therefore, exists as a tool that communities can use to insure that firms pay a price for industrial sites, equal at the margin to the cost of externalities.

Vesting the property rights for land use in the hands of each community can increase resource costs to business and therefore affect the distribution of income. Local zoning allows externalities to be valued according to each community's welfare function. When communities with high valuations of environment exclude industry, more firms are forced to compete for sites in other, less environment oriented communities. If environment is an increasing negative function of the amount of industry, the level of rents and taxes will be bid up in these other communities.

Do property tax base differentials lead to inequities? Tax receipts equal the tax base times the tax rate.
Certainly, the same level of tax receipts can be obtained in high tax base communities with a lower tax rate than would be necessary in low base communities. The real question, however, is does community supply behavior cause differentials in the tax base. It is difficult to call tax base differentials inequitable if community behavior actually causes much of the pattern of industrial development. Empirical estimates suggested that several determinants of community behavior do tend to reduce the amount of land used by industry, and therefore the base. For example, income and the housing-income ratio both reduce community willingness to accept industry.

What was found, however, was that certain locational considerations - for example distance to center city - do affect the tax rate which communities can charge industry. Inequities may arise in terms of the tax receipts certain communities can receive from a given amount of industry rather than from the actual size of tax base differentials. Some communities may be able to impose higher taxes upon industry and therefore obtain higher tax revenues.

Redistribution schemes, which plan to transfer business tax revenues from communities with large business tax bases to those with relatively small business tax bases appear inappropriate on the basis of production efficiencies. Communities which have chosen relatively large blocks of industry have assessed their welfare functions and determined to
allow a large amount of land in business use. These communities have probably chosen to consume more publicly provided goods and private goods at the cost of some environment. A redistribution of tax revenues would prevent these communities from receiving a payoff equal to the externalities imposed upon the residents.

Production inefficiencies would result if some of the tax revenues were redistributed. When revenues are redistributed communities would provide fewer sites at the prevailing level of rents and taxes. This inward shift of the supply curve would cause the sum of rents and taxes to be bid up. A wedge would be placed between a firm's social costs of production and its actual cost of production — any redistributed taxes would be a surcharge on firms above the social cost of their production (assuming the total number of firms entering the metropolitan area is fixed).

Finally, we must consider what has been discovered about future industrial land use patterns. Unless there are changes in cost conditions or changes in community tastes, equation one of table two gives us a way to estimate where industry will be located in future time periods. Firms tend to locate in highly populated communities. Firms appear to be located in rapidly growing communities. Also firms tend to be discouraged from locating in high income or high wealth communities.
What tools, then are available to control the future patterns of urban land use? At the local level zoning and taxes remain significant tools to control land used by industry in each community.

County, state, or federal governments could affect land use in several ways. One possibility is differential grants or subsidies to communities for use in education or business oriented services. On the supply side, increased subsidies to education would probably cause a negative influence on communities' willingness to admit industry because residents can have more education without looking for business tax revenues. On the demand side, grants to business oriented services could positively affect firms' willingness to enter a community. Firms tend to seek communities with large business oriented services.

Countywide or statewide zoning is another possible policy tool. This tool, however, is not without cost. Vesting zoning authority in larger political units allows any spillover of externalities to be internalized, moving firms closer to their social cost of production. However, countywide or statewide zoning takes the property rights for land use from local governments and gives them to the larger government unit. Local, differentiated welfare functions which include environment would not be possible with wide range zoning, so internalizing the externalities must be balanced against loss of local autonomy. Other problems may include:
countywide zoning setting up the government zoning authority as a monopsonist in the location of industry, which could lead to inefficiencies in the locations of firms. Also distribution of compensation for neighborhood effects to those most affected would become particularly difficult as the zoning area increases.

This study brings economists a step closer to understanding the location of industry within a metropolitan area. Yet substantive areas of study remain. A movement towards an even more general equilibrium model appears appropriate. For example, in this study, as in many previous works, the location of people has been ignored. Location decisions of firms and residents may occur simultaneously.

A more realistic view of zoning would add a further dimension of realism to location studies. Zoning decisions were assumed to be made in order to benefit the average resident. Actual decisions may be made to benefit only a few high income or vocal residents. Using this different, though perhaps more realistic view of zoning, may lead to somewhat different conclusions.
APPENDIX A
Data Appendix

1) Business Land Sites. This variable computed from data in the Real Property Book for 1969, available at the Ohio Board of Tax Appeals, Columbus, Ohio. Real property classified as industrial was divided by the price of land to yield the units of land in industrial use.

2) Property Tax Rate, TRate. This is the effective tax rate, calculated by multiplying the statutory tax rate times the assessment-sales ratio. The nominal tax rate may be found in the Real Property Book and the assessment-sales ratios are available from studies conducted by the Ohio Board of Tax Appeals.

3) Rent on Land, Rent. A sample of sales at arms length for each community was gathered from Ohio Board of Tax Appeals data. This was converted to rent using a 10% discount ratio.


5) Capital-Land Ratio, KLand. The total tangible personal
property in a community was separated into industrial property and commercial property by assuming that the ratio between real commercial and tangible commercial property was the same in each community. The tangible industrial property was divided by Sites to yield the capital-land ratio. Data on tangible personal property are available in the Tangible Personal Property book for 1970, available at the Ohio Board of Tax Appeals, Columbus, Ohio.

6) Density, Dens. This is the population as given by footnote 4 divided by the area in square miles. U.S. Bureau of the Census 1964 Area Measurement Report, GE-20 No. 37, Ohio.

7) Access to interstate highways, AHigh. This is a dummy variable. A one is assigned to any community with any interstate highway passing through all other communities are assigned a zero.

8) Services to industry, BServ. This variable is the per capita police and fire expenditures. Non school expenditures are available in Auditor of the State of Ohio, 1969 Financial Report, Ohio Cities, (Columbus, 1970) and Auditor of the State of Ohio, 1969 Financial Report, Ohio Villages (Columbus, Ohio)

10) Housing-Income ratio, HInc. The median income divided into per capita housing values. Housing value is the real property classified as residential in the Real Property Book, Ohio Board of Tax Appeals.

11) Distance to the Center City, DisC. This is distance from 9th and Euclid in Cleveland to the closest point in the suburb.

## APPENDIX B

### Variable Averages and Standard Deviations

<table>
<thead>
<tr>
<th>Variable</th>
<th>Average</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>QSites</td>
<td>$8,807,700</td>
<td>11,266,000,000</td>
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<tr>
<td>PRate</td>
<td>15.99 mills</td>
<td>3.16</td>
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<tr>
<td>Rent</td>
<td>93.74 6/ft</td>
<td>38.88</td>
</tr>
<tr>
<td>Inc</td>
<td>$12,935</td>
<td>1834</td>
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<tr>
<td>Pop</td>
<td>23,458</td>
<td>24752</td>
</tr>
<tr>
<td>KLand</td>
<td>5.09</td>
<td>3.88</td>
</tr>
<tr>
<td>HInc</td>
<td>.42</td>
<td>33.25</td>
</tr>
<tr>
<td>AHigh</td>
<td>.63</td>
<td>.48</td>
</tr>
<tr>
<td>BServ</td>
<td>$36.76</td>
<td>10.86</td>
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<tr>
<td>DisC</td>
<td>10.27</td>
<td>3.43</td>
</tr>
<tr>
<td>Dens</td>
<td>3735</td>
<td>3382</td>
</tr>
<tr>
<td>Pop</td>
<td>42.72</td>
<td>43.36</td>
</tr>
</tbody>
</table>
APPENDIX G

Towns in the Sample

24 Clustered Around the Demand Curve

Bedford
Bedford Heights
Berea
Brecksville
Brooklyn
Brook Park
Chagrin Falls
East Cleveland
Euclid
Garfield Heights
Highland Heights
Independence
Lakewood
Maple Heights
Newburg Heights
Oakwood
Olmsted Falls
Farma
Richmond Heights
Solon
Strongsville
Walton Hills
Warrensville Heights
Westlake

19 Not Clustered Around the Demand Curve

Bay
Beechwood
Broadview Heights
Cleveland Heights
Fairview Park
Lyndhurst
Mayfield Heights
Mayfield
Middleburg Heights
Moreland Hills
North Olmsted
North Royalton
Farma Heights

Pepper Pike
Rocky River
Seven Hills
Shaker Heights
South Euclid
University Heights
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128


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