AN ESSAY ON EXTERNALITIES, PROPERTY VALUES
AND URBAN ZONING

by

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ABSTRACT

Title: An Essay on Externalities, Property Values and Urban Zoning

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This dissertation is concerned with a cluster of theoretical and empirical problems in the economics of land-use control. Chapter I sets the stage for the analysis of these problems by focusing attention on the importance of urban land as a national resource. Chapter II reviews the economic literature on zoning and neighborhood externalities and concludes that there are several important research problems which remain to be solved.

The first of these concerns the empirical significance of neighborhood quality as a determinant of residential property values. This is taken up in Chapters III and IV. Modern economic research has failed heretofore to establish conclusively that adverse neighborhood environments affect the market price of residential properties. In Chapter III a simple theory of household bidding behavior at a real estate auction is developed -- a theory which suggests (among other things) that residential properties in undesirable neighborhoods will sell for less than those in desirable neighborhoods, ceteris paribus. In Chapter IV this theory is tested econometrically using aggregate data for the single-family homes located in forty-six Boston suburbs. The results of the estimations indicate that the price of a home depends on its structure and lot characteristics, its accessibility to employment, and on the characteristics of its neighborhood environment. Community public service and tax variables are found to be insignificant.

The second research problem noted in the survey of the literature is the paucity of theoretical models which can be used as tools for analyzing the economic aspects of land-use control devices. Chapter V is a response to this deficiency; therein a mathematical model of the land-use control problem faced by a new town developer is presented. The model is then used to show how changes in zoning boundaries affect other urban economic variables such as the size of the labor force, the urban wage rate, and the land value gradient. In addition, the implications of the existence of neighborhood externalities for the behavior of the developer are worked out and some policy recommendations are made.

Thesis Supervisor: Jerome Rothenberg
Title: Professor of Economics
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This dissertation was essentially written in the year between September, 1970 and September, 1971. The debts, emotional and intellectual, which I incurred during this period were not numerous. Yet they were of the most fundamental sort, and I am grateful to have the opportunity here to acknowledge them.

First, let me say that I found the faculty of the economics department at M.I.T. to be most helpful and supportive. John Harris and Jerome Rothenberg were my advisors and they guided my thinking and research from the very beginning. Their contributions to this dissertation were fundamental and too numerous to mention here. My debt to Jerome Rothenberg is particularly great because he was the one who first encouraged me to pursue the line of research contained in this work. In addition, he agreed to serve as my principal advisor. I would also like to thank Ronald Grieson and Robert Solow who read the final manuscript in its entirety and made many useful comments.

The contributions of my friends and fellow students at M.I.T. are perhaps less tangible than those of my teachers and advisors, but they are no less real. My contemporaries at M.I.T. created an intimate and supportive social environment without which the writing of this dissertation would have been much more painful than it was. Some of my friends read and commented upon early drafts of various chapters in
this work. I would especially like to thank Larry Hirschhorn and Bill Wolfson for their efforts in this respect.

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The greatest debt of all I owe to my wife Judy who cheerfully supported me throughout this enterprise -- even while she was carrying a baby and working on her own dissertation. In addition to typing and proofreading, she made numerous stylistic and substantive suggestions which eventually found their way into the final text. Perhaps her greatest contribution, however, was the gentle spur which she applied whenever my energy or will power seemed to flag. Without her, the dissertation would have taken much longer to complete than it did.

Finally, I wish to thank JoAnn Loeb for her expert
typing of a difficult manuscript. And last, but surely not least, I must thank the National Science Foundation for the financial support which it provided during my four years of graduate study. As usual, the Old Testament tells it like it is:

They prepare bread for laughter,
and wine comforteth the living;
but money answereth to all.

Ecclesiastes 10:19
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CHAPTER I
Some Introductory Remarks

A. Public Policy and Urban Land

The declared purpose of the National Housing Act of 1949 was "the realization as soon as feasible of the goal of a decent home and a suitable living environment for every American family." In the early 1950's, for reasons not at all obscure, the first part of this objective tended to take precedence over the second in the eyes of the public and its politicians. The postwar housing shortage produced purchasers (usually subsidized by the federal government) for virtually every suburban, single-family home that the housing industry was capable of supplying. The inevitable result was flimsy construction, humdrum architecture and bleak landscapes. By 1960, however, the wind had begun to shift to a different quarter. The supply of homes of all types had increased dramatically over the previous decade, and households had become correspondingly more fastidious about the housing "packages" which they were being offered. Many came to appreciate that "a decent home" was not enough and that "a suitable living environment" was an important desideratum in its own right.

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1U.S., Statutes at Large, 63, p. 413.
The experience of Levitt and Sons during the 1950's epitomizes some of the changes which took place. Levitt built three large "Levittown" developments during this period. The first, on Long Island, had gridiron streets and identical small bungalows -- the famed $7990 Cape Codders. Few concessions were made to neighborhood beauty. Nonetheless, the development was very profitable, and it set a precedent for numerous imitations throughout the country. The second Levittown, only slightly less monotonous than the first, was built near Philadelphia and was also extremely lucrative. The third, by way of contrast, was a financial disappointment -- even though it offered four distinct models and some environmental amenities such as curvilinear streets. By 1960 it seemed that the American home buyer was no longer willing to be a "Levittowner" when other choices were available. What had been satisfactory, even desirable, in 1950 had thus become quite unacceptable one decade later.  

It is now apparent that this episode only adumbrated further changes to come. If the supply of suburban land were unlimited, the escalation of household expectations concerning home and neighborhood which began during the 1950's could always be met by further new construction at the urban-rural fringe. Each new development would have larger homes,

\[2\]This brief history was culled from "The New Look of Mr. Levitt's Towns," Newsweek, September 13, 1965 and "New Accent for Bill Levitt," Fortune, December, 1965. As these titles suggest, Levitt was able to change his style of operation to satisfy the new breed of home buyer.
a more pleasing physical layout, and more open space and
greenery than the one which came before. To a certain
extent, of course, this was the pattern of suburban growth
through much of the postwar period. As new suburbs came
into being, the older ones were left behind by the upwardly
mobile middle class to be occupied by households further
down on the economic ladder.

In recent years, however, problems have arisen. In
particular, there is now evidence that this filtering
process has stalled. The supply of suitable undeveloped
land, a necessary ingredient for any Xanadu, is no longer
seen as unlimited in many metropolitan areas.\(^3\) Consequently,
its price has risen.\(^4\) Speaking somewhat loosely, the current
situation may be described as one in which a high demand is

\(^3\)Kubla Khan, it will be recalled, required "twice five
miles of fertile ground."

\(^4\)A crude indication of this price increase may be found
in the Department of Housing and Urban Development's statis-
tical profile of new homes purchased with FHA-insured mort-
gages. These figures show that between 1960 and 1969, lot
prices increased much more rapidly (by 74 percent) than did
structure prices (33 percent) or purchaser income (49 percent).
"Typical FHA-Financed New Home cost $20,563 in 1969, up $995;"
HUD News, May 1, 1970. It is possible, of course, that this
large increase in average lot price is completely the product
of increased average lot size rather than increased price per
unit land. This seems doubtful, however.
pressing upon a continually shrinking supply.\(^5\) This pressure is particularly serious in its consequences because, as we indicated above, the suburban experience during the 1950's conditioned Americans to expect a continual improvement in their home and its ambient environment. To make matters even worse, it also reestablished the eventual acquisition of a space-consuming, detached, single-family home as a credible aspiration for all but the poorest citizens. The postwar building boom thus put to rest most of the resignation which was built up during the lean years between 1929 and 1945.

Once all this is understood, many current public controversies become interpretable as specialized responses to a larger problem.

The social consequences of the declining availability of suburban land have been twofold. First, class conflicts over the use of the available supply of residential property have been exacerbated. The home-owning middle class has stoutly defended its turf against the incursions of the lower class

\(^5\)The supply of vacant land suitable for residential development in any given period depends upon the rate of past development and upon changes in zoning practices, transportation facilities, and the location of employment during the previous period. In many of our larger metropolitan areas this supply has been getting smaller year by year -- not because transportation and employment are not decentralizing as fast as they used to, but rather because zoning restrictions in partially developed communities have tightened. The situation around New York City is particularly serious in this regard. Richard Reeves, "Land is Prize in Battle for Control of Suburbs," *The New York Times*, August 17, 1971, p. 1.
using minimum-lot zoning and other devices.\textsuperscript{6} The upper class, on the other hand, has taken the offensive and attempted to reestablish its hegemony over the downtown areas in many of our large central cities.\textsuperscript{7} The poor, as a result, have been forced to fight a war on two fronts -- in the central city to hold what they already have and in the suburbs to acquire what they believe they are entitled to. It does not take much imagination to see that a sudden increase in the available supply of undeveloped suburban real estate (conceivably through some innovation in transportation) would do a great deal to mitigate these conflicts.

The second consequence of the closing of the suburban frontier has been a renewed interest in city and regional planning among those of our society's opinion-making elite who reside in large metropolitan areas. Planning is seen as a way of making the most equitable and efficient use of the now scarce undeveloped urban land.\textsuperscript{8} The general consensus

\textsuperscript{6}A useful survey of such practices in northeastern New Jersey may be found in Norman Williams, Jr. and Thomas Norman, "Exclusionary Land-Use Controls: The Case of Northeastern New Jersey," \textit{Land-Use Controls Quarterly}, 4 (Fall, 1970).


\textsuperscript{8}Throughout this study we shall use the word "urban" to denote institutions, objects, or phenomenon which are metropolitan in scope. Thus, "urban" land includes both central city and suburban land.
here is that this resource is too important to be left to the capricious dictates of suburban governments and private developers. Two of the most frequently discussed planning innovations are new towns and metropolitan government. There is hardly room in the present study for an extended analysis of these proposals. Nonetheless, a few comments are appropriate to make clear the relationship between our work here and the large (one is tempted to say excessively large) literature on these other two topics.

Let us consider metropolitan government first. This reform has come to be thought of as a panacea by all right-minded "urbanologists" in spite of the fact that there has been very little careful empirical analysis of the specific costs to be incurred and benefits to be received from consolidation. Indeed there has been a paucity of writing on existing metropolitan governments. As Roger Starr has observed in an article on New York City politics:

> Earnest citizens in America -- even in New York -- have held up the ideal of a regional government as a misty, glamorous objective; a Valhalla of good government. Many of these gentlemen have forgotten that New York City has for seventy years now, offered a practical demonstration of the possibilities and difficulties of a regional government... Instead of speculating as to how regional government might work, one can see how New York does work -- or doesn't. 9

A careful accounting of the costs and benefits of metropolitan government would do more than just delimit the net welfare gains to be anticipated. It would also provide impor-

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9 "Power and Powerlessness in a Regional City," The Public Interest, 16 (Summer, 1969), p.4.
tant evidence about the political feasibility of such amalgamations. If there are some local government prerogatives which are so deep-seated and jealously guarded as to be untransferable to a superior authority except at very high political cost, it may be that full-blown metropolitan governments will continue to be impossible to establish except under rather special conditions. The most that could then be expected in the majority of urban areas would be a regional authority with distinctly circumscribed powers.

These considerations are particularly important with respect to the policy questions we have been discussing here—namely, those concerned with the nature and extent of governmental interference in the private market for urban property. Traditionally, real estate has been regulated only at the local level. This, of course, is true of many other government activities as well. However, because the control of municipal land is so closely associated with the class segregation and small-town self-determination apparently sought by so many suburbanites when they migrate from the central city, it will be especially difficult to dislodge and vest in a higher level of government.10 Nor, incidentally, is it

10Robert C. Wood documents the "stubborn conviction" of most suburbanites that they are entitled to small-town government and their willingness to go to great lengths to achieve it in his Suburbia: Its People and Their Politics (Boston: Houghton Mifflin Company, 1958). Richard Babcock supplements these observations by noting that municipalities then use their jealously guarded political powers to exclude "outsiders" of all types, be they apartment dwellers, park visitors, motel guests, or customers of a local discount house. The Zoning Game: Municipal Practices and Policies (Madison, Wisconsin: The University of Wisconsin Press, 1966), Chapter II.
entirely clear that this control should be so transferred. The desire of ordinary citizens to live among their own kind and to possess at least a modicum of control over their destiny (henceforth to be known as the desire for home rule) is frequently given virtually no weight by liberals promoting metropolitan government. In spite of this, it may very well be true that some vestiges of home rule should be preserved within the interstices of even the most far-reaching metropolitan political system. In any case, political considerations will probably require it, and a likely field of operation for this residual municipal power is some control over the uses to which local land may be put.

The burden of the previous few paragraphs may be succinctly summarized by saying that one cannot safely dismiss modest proposals to reform existing American land regulation institutions by simply waving hands and uttering the incantation "metropolitan government." The hard realities are, first, that metropolitan government may be a long time coming in many areas and, second, even when it finally arrives its jurisdiction over land use is likely to be distinctly limited. Once

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11A careful theoretical analysis of the optimal size political jurisdiction which does take into account home rule considerations may be found in Jerome Rothenberg's "Local Decentralization and the Theory of Optimal Government," (Massachusetts Institute of Technology, Department of Economics, Working Paper No. 35, December, 1968).

12Babcock comes to this same conclusion. Op.cit., Chapter X.
these facts are appreciated, it becomes obvious that local
control over land use is likely to be with us for some time.
This means in turn that the present techniques used by local
governments to regulate the urban land market and protect
residential neighborhoods (principally zoning) are not apt
to be superseded by more radical methods.

Similar kinds of remarks can be made about the plethora
of proposals to establish new towns. Such enterprises are
obviously the wish dreams of the planning profession. What
is in doubt is the extent to which these dreams are likely
to be fulfilled in the coming decades. The private market
thus far has shown little interest in new towns, principally
because of the large amounts of initial capital which they
require.  

There is, furthermore, little evidence that the
public sector will be any more responsive to the presumed
“needs” of society in this area. William Alonso has argued
rather persuasively that most of the nonaesthetic arguments
for the public provision of new towns turn out to be rather
insubstantial when subject to close scrutiny.  

Given that
even city planners are not united in their support, it is
difficult to imagine Congress or the various state legisla-
tures appropriating significant funds for such “socialistic”

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13 Anthony Downs, “Private Investment and the Public Weal,”
Saturday Review, LIV (May 15, 1971), p.25. This article is
one of the few which carefully analyzes new towns from the
point of view of the prospective private developer.

14 “The Mirage of New Towns,” The Public Interest, 19
(Spring, 1970).
enterprises. The only possible exception appears to be a "demonstration" grant or two designed to raise the level of public tastes. Perforce, the number of people directly affected by such a program would be small.

What then are we left with? The principal message seems to be that serious-minded citizens interested in improving neighborhood environments, resolving the aforementioned land-use conflicts, and generally instituting a more "rational" utilization of scarce urban land in our large metropolitan areas should set aside their passionate commitment to metropolitan government and new towns. Such fancies only promote woolgathering and a general unwillingness to consider less dramatic but more practicable alternatives. The truth is that the vast majority of American urban dwellers will for at least the next decade or two be subject to a system of land regulation and control which is not terribly different from the one we have now. To be sure, the winds of controversy which are currently buffeting this system will undoubtedly produce some reforms. It seems highly unlikely, however, that the resulting changes will be revolutionary in scope. Most will probably be of the order of magnitude of the Massachusetts "Anti-Snob Zoning" law which was passed several years ago.15

These observations suggest that it is not possible to

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15It is worth remarking in this context that as of July, 1971, not one dwelling unit has been built under the auspices of the program set up by this statute. Anthony J. Yudis, "Anti-Snob Zoning Batting Big .000," Boston Globe, July 11, 1971, p.A-47.
justify scholarly indifference to zoning and other existing forms of land regulation on the grounds that these devices are "obsolete" and soon to be discarded. Instead, the argument cuts the other way. The probable permanence of these institutions coupled with the likelihood of their reform in the next few years makes them particularly interesting subjects for scholarly investigation. Furthermore, if reforms are to be made, it is essential that policymakers have sufficient knowledge about the political feasibility and probable effectiveness of the various alternatives to choose among them intelligently. Since the only source of such knowledge at the moment is our past and present experience with existing regulatory devices, the challenge to academic researchers interested in urban affairs seems rather well-defined.

B. The Role of the Economist

Up to now economists have paid scant attention to land-use control devices and have consequently contributed little to their evolution. One searches in vain through the copious legal and planning literature on zoning, subdivision control, land law and other related topics for any important idea or technique which originated with a member of the economics profession. A revealing example of the extent to which the mainstream of economic thought has failed to influence public policy in this area occurred in the first twenty-five years of this century. This was the gestation period for what was later to become the most frequently used tool for regulating urban land -- the comprehensive zoning ordinance. What is
significant is that this same period also saw the publication (in several editions) of Pigou's Wealth and Welfare and The Economics of Welfare, two volumes now thought to be the fountainheads of all modern work on externalities. In these works Pigou proposed the tax and subsidy solutions which have now become part of the litany of economists, to be recited whenever a hiatus between private and social costs or private and social benefits is encountered. The interesting thing is that the lawyers and urban reformers who confronted the eminently practical problems of imposing some social discipline on the private uses of urban land and of protecting residential neighborhoods from the incursion of nuisance industries never gave these particular solutions a moment's thought. This is true even though the main impetus for public land regulation at the time was obviously the desire to minimize nonmarket interdependencies among economic activities -- the very kind of problem which Pigovian methods seemed designed to handle. The point here is not that taxation would have been a better solution than districting, but only that the inevitable first thought of a modern economist on the whole matter of the control of externalities was not even considered by the policymakers of the day.

Returning to the main thread of the argument, we may ask

why it is that economists have not made more intellectual contributions in this area. Part of the reason undoubtedly is the professional myopia of the lawyer and the planner. This perhaps explains why Pigovian thinking has not worked its way further into the law and planning journals than it has. Much more, however, is due to the economist's lack of interest in all policy questions concerning the allocation and regulation of urban land. 17 There has been some academic writing on these subjects, of course, but it is small in amount when compared to the bountiful literature on such important topics as the stability and uniqueness of the perfectly competitive equilibrium.

The origins of this indifference are complex. One possible explanation is that land-use regulation has simply not been thought of as a very important public policy area—or at least not important enough to be worthy of the economist's attention. Perhaps it is true that many economists think this; however, the argument itself has little merit. One may agree with Banfield that urban beauty (or any other objective of land-use control) is not a matter of anyone's essential welfare. 18 Nonetheless, it is obvious that the

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17A very recent exception to this proposition is the spate of writing on urban renewal culminating in Jerome Rothenberg's Economic Evaluation of Urban Renewal (Washington, D.C.: The Brookings Institution, 1967).

typical urban dweller regards policy issues concerning land use in his neighborhood and community to be terribly important. One need only attend a meeting of the local zoning appeals board to ascertain this. The land-use conflicts mentioned in the previous section are manifestly real and frequently vituperative.

The ubiquity of zoning statutes in urban areas lends further credence to this view. Allen Manvel in his report to the National Commission on Urban Problems estimates that in 1967 approximately 90 percent of the cities and towns in the United States with a population over 5000 had some kind of zoning statute.\(^{19}\) In addition, 51 of the 52 largest cities possessed such ordinances.\(^{20}\) The one exception is Houston which, as is well-known, has chosen to substitute an elaborate system of publicly enforced restrictive covenants for zoning.\(^{21}\) If one accepts the proposition that the legislation passed by municipal governments bears some reasonable relationship to the preferences of the electorate, one must conclude from these statistics that land-use control has been "revealed" to be "important." It is interesting to note

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\(^{20}\) Ibid., p. 171.

that Manvel's figures seem to indicate that the number of households subject to some kind of zoning is only slightly smaller than the number subject directly or indirectly to the property tax -- an institution which has inspired a copious amount of economic writing over the past century.

All of this suggests that the real reason for the curious unwillingness of economists to work in this area must lie elsewhere. A useful tentative hypothesis is that the realities of the urban land market were uncongenial to the continued evolution and refinement of the perfectly competitive model. As a result, these realities were ignored. Part of the problem obviously lay in incorporating the various spatial concepts inherent to the study of urban land into the perfectly competitive framework. As Isard and others have reminded us, the traditional assumption underlying this framework is that all of a nation's economic activities take place at a point, thus allowing transportation costs to be ignored.22 It is not at all clear what the welfare properties of a "competitive" model would be once this assumption is relaxed.

Is it significant, for example, that virtually all firms in the retail sector of our economy are imperfect competitors in the sense that they face downward-sloping demand curves? This fact, due of course to transportation costs, is manifestly inconsistent with the traditional assumption that the

atomistic firm can sell all he wishes to sell at the current market price.

A second awkward fact undoubtedly was the prevalence of nonmarket interrelationships among economic agents in urban areas. It is well-known that the presence of such external effects destroys the efficiency properties of the perfectly competitive model. The reasons for this are complex and we shall not get into them here. The essential point is that production and consumption externalities are much more characteristic of life in a metropolis than of life in a rural area or small town. Indeed, one suspects that the economy which the perfectly competitive model most closely describes is a self-sufficient agricultural district in which independent yeoman farmers live on isolated family farms, leaving only to exchange produce at some centrally located market. In such an economy there would be virtually no externalities—all would be "internalized" by the spatial extent of the individual farms. In order for this bucolic vision to remain credible, it was apparently necessary to ignore the urban conditions under which most people lived. It was particularly


24 Some modest evidence for this assertion may be found in the differing urban and rural attitudes toward zoning, Babcock, op.cit., pp.20-25.
important to ignore the land and housing markets since it is here that interdependence is most easily seen.

These contentions are perhaps overly harsh, but the fact remains that until recent years academic economists working in the mainstream of the profession have treated disdainfully all economic problems associated with urbanization. The field was left to the aforementioned city planners and lawyers, aided by a handful of outcast land economists, regional scientists, and some utopians. Since around 1960, however, a sea change has occurred. Economists have responded to the policy interests of the larger society and have begun to analyze urban economies using the tools heretofore reserved for more "important" problems. To be sure there has not been (as we shall see) a great deal of work on the specific topics which this dissertation is concerned with. On the other hand, it is now perfectly clear that an economist can participate in the solutions to the pressing planning and land-use problems of his day without condescension. As will hopefully be brought out in subsequent chapters, many of the key issues in planning, zoning, and modern property law are intimately related to important topics in the burgeoning economic literature on externalities and public goods.

To get a feeling for this interpenetration, consider the particular phenomenon which is the focus of the present study -- namely, the dependence of a household's well-being on the dominant characteristics of its surrounding residential
environment. As we observed above, most Americans now live in fairly densely populated areas; hence, there is a good deal of rubbing of shoulders and elbows. If the private market in land were allowed to operate unfettered, a large majority of these households would have to accept a local environment which might at any moment change in a way which affected them adversely. To the lawyer this interdependence constitutes a fundamental challenge to the presumed inviolability of private property, the cornerstone of Anglo-Saxon law for a millenium. Lawyers, therefore, are very interested in establishing new legal theories which may be used to adjudicate these conflicts and resolve them in a rational fashion. This is where the economist comes in. To him, attractive neighborhoods and other sorts of urban beauty are just another kind of consumption externality, another way in which the decisions of some economic agent have a non-market effect on the utility of one or more households. Ideally, this general experience with external effects will enable the economist to suggest legal decision rules which are rational in the sense that they promote either a more efficient utilization of resources or a more desirable distribution of income, or perhaps both.

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25Henceforth, this dependence shall be known as a "neighborhood externality." It is an externality because individual lots are usually so small that one's "neighborhood" is controlled chiefly by others.

26This is not a particularly new idea. Coase makes a similar kind of proposal. Op.cit., pp.42-44.
C. A Methodological Postscript

This dissertation is a response to both the social problems outlined in Section A and to the assertion in Section B that economists have the capability to aid in solving them. It will use the tools and perspective of the professional economist to analyze some of the intellectual and policy problems which arise when local governments attempt to regulate the land within their boundaries in the public interest. Since successful applications of the economic method usually involve the frequent use of statistical and mathematical methods, we shall not shy away from these here. Indeed, it is not an exaggeration to say that the essential contribution of this study will be the application of such tools to an area of government policy dominated by the professional irrationalities of the lawyer and the city planner.

This commitment to the economic toolbag is not without its costs. Any proper application of econometric or theoretical methods requires careful attention to details and underlying assumptions. This takes time and space which could be devoted to other matters. Consequently, it will not be possible to analyze in great depth the full range of intellectual and policy questions which our topic is capable of posing. Instead we shall have to be selective. Essentially, the particular choices which have been made were determined by the state of the economic art when this study was begun. As we shall see in Chapter II, some gaps in the literature
seemed more serious than others and our priorities were determined accordingly.

There has been some attempt made to ensure that the use of mathematical and econometric methods will not distract the reader from the many policy questions which underlie and motivate this study. Since World War II there has been a regrettable tendency among economic writers to eschew that close contact with reality which in earlier periods was thought to be essential to the good health of the discipline. This contact has frequently been replaced by an arid formalism productive only of isolated stands of prickly theorems. In a sense it is the means of economic research rather than the ends which have come to predominate. Fortunately, urban economics has thus far avoided this drought. Most of the current writing in the area is still characterized by a lively interest in the affairs of men who participate in real world urban economies.

This tradition has inspired the underlying institutional emphases of the present dissertation. In the chapters which follow we shall supplement the formal analysis of economic models with frequent references to the legal and planning literature on zoning and the governmental regulation of land generally. The intent here is both to enrich our analytic work and to promote that interdisciplinary perspective which seems so necessary if economists are going to make useful contributions in this area.
CHAPTER II

Neighborhood Externalities and Urban Land Markets:
A Survey of the Literature

A. Introduction

Let us now begin to scrutinize the specific terrain which lies ahead. As indicated in the previous chapter, this dissertation focuses upon a rather special urban phenomenon: the neighborhood externality (or neighborhood effect). The scarcity of land in urban areas forces households (through the price mechanism) to economize on its use. The result is small lot sizes and a good measure of nonmarket interdependence among the consumers and firms who share the same neighborhood. In a society which attaches a great deal of importance to home ownership, this interdependence becomes a rather serious matter.

Suppose, for example, that a mortuary moves in next door to a single-family house. If the family living in this house does not like to be reminded frequently of the finiteness of human existence, its well-being will fall as a result of the change in land use (assume a vacant lot occupied the site before). Moreover, if this family's feelings about nearby mortuaries are widely shared, the value of the property which they own will fall as well. Thus they will not be able to change their residential location without suffering a financial loss. To make matters worse (assuming our household is a typical one), this house is virtually the only asset in
the family portfolio. Thus, it was not possible for the household to protect itself in advance against such capital losses through diversification.

This unhappy little scenario takes on public policy significance once it is recognized that achieving a very decentralized ownership of residential land has always been an objective, frequently an explicit objective, of government action in America. As John Delafons points out, many state constitutions have taken it upon themselves to add the right to possess property to the list of "inalienable rights" affirmed by the Declaration of Independence.¹ Local government officials, particularly those with an urban constituency, thus found themselves in a quandary beginning around the turn of the century. Two of their basic values suddenly came into conflict with one another. On the one hand, these officials wished to promote homeownership within their communities by somehow reducing the risk (or at least the perceived risk) associated with this particular asset vis-a-vis all other assets. On the other hand, they recognized that the accomplishment of this objective would require some governmental interference in the operation of the private land market, an institution in whose beneficent qualities they were metaphysically predisposed to have absolute faith.

A number of institutional arrangements were suggested

as solutions to the externality problem. The one which eventually achieved the greatest acceptance was the comprehensive zoning ordinance. This device was based upon the operational principle that "incompatible" land uses should be strictly separated from one another by isolating them in homogeneous districts or zones. To paraphrase Justice Sutherland, the pigs were henceforth to be kept out of the parlour by restricting them to the pigpen.\(^2\) The appeal of districting is easily understood once it is realized that many of the early architects of the zoning institution were very impressed with the tendency of the land market to generate a "natural" kind of districting or zoning completely unaided by government action.\(^3\) This empirical fact (subsequently made famous by the sociologists at the University of Chicago in their studies of "natural areas") made it easy to rationalize zoning as a mere adjunct to basic market forces, a device which would prevent these forces from making "mistakes" by containing them within reasonable boundaries. Such theories, coupled with the aforementioned universal desire to promote home ownership (and some general interest in city planning), were sufficient to persuade many of the prominent lawyers, politicians, and reformers of the Progres-
sive era that zoning deserved their support. Eventually, in 1926, even the Supreme Court was moved to speak in favor of the institution. Once the experts pronounced it acceptable, zoning spread rapidly throughout the United States. It became particularly popular in newly-formed suburban areas, first in the 1920's and later in the 1950's.

Naturally, as the years have gone by new regulatory and control devices have appeared. Most, however, have merely supplemented, rather than replaced, the web of restrictions which zoning imposes on the land market. Subdivision regulations now permit a certain amount of municipal control over development on the rural-urban fringe, an area where the legal status of conventional zoning restrictions has always been somewhat in doubt. A second device, one which has received much popular and scholarly attention in recent years, is urban renewal. Putting things a bit loosely, urban renewal projects

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4 The first comprehensive zoning ordinance was passed in New York City in 1916. The story behind this statute is an interesting one. It is ably recounted in two recent books: Seymour Toll, op. cit., Chapters 3-6 and S. J. Makielski, The Politics of Zoning (New York: Columbia University Press, 1966), Chapter 1. The second of these accounts is particularly interesting because it reveals that to a great extent the final decisions concerning the location of boundary lines took place at the borough level or below. This would seem to be a piece of historical evidence in favor of the proposition put forth in the previous chapter that metropolitan government need not necessarily lead to a highly centralized system of land-use control.

5 Euclid v. Ambler, op. cit.

6 An early case which still poses some problems for municipalities wishing to zone completely undeveloped areas is Averne Bay Construction Company v. Thatcher, 278 N.Y. 222, 15 N.E. 2d 587 (1938).
are designed to eliminate configurations of land use which are inefficient and outmoded and which are unlikely to be improved upon by existing market forces. We shall have more to say about the economics of urban renewal a bit later on. The main point to be made here is that renewal in a sense picks up where zoning leaves off. Under current law, zoning is comparatively helpless to change patterns of land use once development has in fact occurred. An important indicator of this weakness is the great difficulty which municipalities have had in eradicating nonconforming uses. Clearly an institution which cannot even be used to alter the economic activities taking place on isolated parcels is not going to be very helpful in effecting the redevelopment of very large areas in the blighted sections of our central cities. This, of course, is where urban renewal comes in. 7

There are now some planners who call for the elimination of most or all zoning ordinances, but it is rather unclear just what kinds of regulations, if any, they are to be replaced with. 8 In general, most American planners regard zoning as a poor substitute for the kind of complete control over land which their brethren in Europe enjoy. It is quite unlikely,


however, that in the foreseeable future either subdivision regulations or urban renewal powers will be extended to give American planners the kind of comprehensive control over the land market which they covet. As we remarked in the previous chapter, it seems highly probable that most urban dwellers twenty years from now will be living under a land-use control system which is little different from the one we presently have, a system in which zoning ordinances and the districting principle continue to play the major role in guiding market forces.

These remarks about the probable durability of zoning should not be taken to mean that the application of the device in specific situations is not without its difficulties. Indeed, the reverse is probably true. It is generally much easier to get planners and local government officials to agree on the districting principle than it is to get them to agree on a specific partition of land for a particular city. In practice what happens is that zoning districts are laid out to conform more or less closely to the existing, market-determined pattern of land use. Partly this is done for reasons of expediency. The lines have to be drawn somewhere and the least controversial solution is obviously to have them follow the use boundaries which already exist. There may be an element of calculation in this as well, however. We remarked above that the existence of "natural areas" in large cities made it easier for zoning experts to justify the districting principle. If one believes that the market-deter-
mined allocation of urban land is very close to the optimal one and that zoning ordinances are only needed to make minor adjustments in that allocation, then it seems logical to choose district boundaries which basically follow the use boundaries determined by private market forces.

Whatever the specific explanations advanced for this sort of behavior, it should be clear that the method need not give satisfactory results in all cases. One obvious point is that you cannot rely on prior market allocations for guidance in areas where these allocations have not occurred. It is undoubtedly this complete absence of development which prompted many early judges to be suspicious of zoning restrictions imposed on large tracts of vacant or agricultural land. How was one to be sure that district lines drawn in such areas were not completely arbitrary?

A more trenchant criticism of the practice of drawing zoning districts so they match pre-existing natural areas is that it is in fundamental conflict with the theoretical underpinnings of the districting principle. Either the laissez faire market solution is optimal or it is not. If it is, then no zoning ordinances are required. If it is not, then presumably some restrictions must be imposed on the operation of market forces. The task then becomes one of determining precisely what kinds of restrictions these should be. Obviously, an operating principle which just says "Follow the market" begs the entire question. It gives no counsel as to when and to what extent the market should not be followed -- the problems
which are in fact the critical ones.

It is at this juncture that economists would seem to be able to make some contribution. What we shall call the land-use problem — that is, the determination of the proper quantities and locations of all types of land use in an urban area — is not fundamentally different from the ordinary kinds of optimization and allocation problems which economists are accustomed to deal with. It is hardly unusual to pick up a scholarly journal and find an article proposing a certain scheme of taxation on the grounds that it is "efficient" or that it is "Pareto superior" to any other. It is not at all clear why similar kinds of articles could not be written about zoning restrictions. Thus far, however, only a few examples have appeared in the economics literature.

B. Some Economic Writings

The professional economic literature on neighborhood externalities and zoning is not copious. Some reasons for the economist's indifference to these topics were suggested in the previous chapter. There has been some writing in the field, however, and in this section we will review it rather carefully. Our conclusions with respect to this literature will serve as points of departure for the excursions into rather specialized areas which will occupy us in later chapters.

Our story begins with Alfred Marshall. He devoted a chapter of his Principles of Economics to the determination
of urban land values. 9 This is really a quite sensible piece of writing (as Alonso and others have pointed out), but one which is only peripherally related to the specific topics we are concerned with here. He was mainly interested in non-residential land uses and the role which accessibility plays in determining the site value for such uses. He did, however, devote a paragraph to residential development in which he recognized that at least a portion of the value of a residential site is due to its neighborhood environment. 10

Pigou extended this observation by noting that such neighborhood effects are really only special cases of a larger class of economic phenomena. He observed in The Economics of Welfare that a divergence between marginal private net product and marginal social net product occurs "when the owner of a site in a residential quarter of a city builds a factory there and so destroys part of the amenities of the neighboring sites." 11 Pigou did not make the further observation, as Marshall surely would have, that this destruction of amenities would in turn lead to a decline in residential property values. He did, however, at least by implication, propose feasible solutions to the inefficiencies which neighborhood externalities presumably bring about. As we remarked earlier, the


10 Ibid., p. 445.

compensation and tax-subsidy principles which Pigou proposed to apply to all situations where marginal private and social products differed are now well-known to all economists.\textsuperscript{12} It is reasonable to assume that Pigou would have suggested that one or both be used to repair the inefficiencies brought about by neighborhood externalities, though he apparently never explicitly made this suggestion.

Neither Marshall nor Pigou discussed zoning or any other form of districting in his work. This is hardly surprising since the institution had not yet appeared in either England or the United States at the time these two men began writing. Moreover, neither was particularly concerned with the government regulation of urban land as a topic in itself. Marshall was mainly interested in the basic operation of the real estate market and how land values were determined. He might have based a discussion of public land policy on his observation that neighborhood quality affects these values but he chose not to. Pigou, on the other hand, was very much interested in the possibility of government intervention to improve the efficiency of the private market economy. He was not, however, very interested in the real estate market. As a result, he concentrated his attention on the aforementioned "general" solutions to the externality problem without ever

\textsuperscript{12} R. H. Coase had observed, however, that Pigou's thinking on the applicability of these two principles to externality problems was not always as clear as it might have been. \textit{Op. cit.}, pp. 28-39.
taking cognizance of the fact that economic activities take place in a spatial context.

To obtain early economic discussion of zoning restrictions and other land-use control devices, it is necessary to consider works coming out of a tradition very different from that of the Cambridge economists. Unlike Pigou and Marshall, the scholars in this tradition -- who have come to be known as the Land Economists -- were concerned exclusively with the nature and operation of real property markets and the effect of government action upon them. A list of the major writers in this school would include Richard Hurd, Robert Haig, Ernest Fisher, Homer Hoyt, and Richard Ratcliff. It is quite beyond the scope of this dissertation to survey all of the important works which these men and their students have produced since the beginning of this century. It suffices for our purposes to observe that they usually recognized that neighborhood externalities might produce important inefficiencies and inequities in the operation of urban land markets and that these might be cured or at least mitigated by some form of zoning. 13

Unfortunately, there was never any attempt made to link up this insight with the conventional economic literature on

externalities which began with Pigou. This is a task which remains largely undone even today.

Modern interest in neighborhood externalities and the public policy problems which they pose really began with a spate of articles on the economics of urban renewal which appeared in the early 1960's. For reasons which are not entirely clear -- except perhaps that it was an instrumentality which originated with the federal government -- urban renewal captured the fancy of economists in a way which zoning never did. As a result, there were quite a few good pieces on the subject published within a comparatively short time.

A useful place to begin is with Otto Davis and Andrew Whinston's "The Economics of Urban Renewal."\textsuperscript{15} This article used a simple game-theoretic model to demonstrate that the existence of neighborhood externalities may produce market equilibria which are not Pareto optimal. The authors go on to discuss alternative institutional arrangements which may prevent such inefficient results from occurring and observe that urban renewal laws may be helpful under certain conditions. They concluded by proposing a criterion which can be used to determine whether or not urban renewal activities

\textsuperscript{14} A few articles have attempted to bridge this gap. Some of these are discussed below.

should take place in particular neighborhoods.

This contribution was followed by a series of articles which elaborated on its basic themes.\(^{16}\) The culmination of this line of writings appeared, however, in book form. This volume — Economic Evaluation of Urban Renewal by Jerome Rothenberg — deepened Davis and Whinston's analysis substantially and integrated it into the conventional literature on cost-benefit analysis.\(^{17}\)

The importance of neighborhood externalities was reiterated in this work and some further implications of the phenomenon were pointed out. Rothenberg noted that neighborhood externalities really enter into the cost-benefit analysis of an urban renewal project in two ways. First, the usual project is large enough in area to "internalize" many of these effects, thus permitting a more efficient utilization of urban land. This was the same point made by Davis and Whinston in the article cited above. The resulting gain in efficiency, typically measured by the increment in total land value brought about by assembling many small parcels into a single large one, is one of the principal benefits associated with urban renewal.

Second, urban renewal projects typically replace "blighted" neighborhoods with ones which are substantially

\(^{16}\) See, for example, Otto Davis, "Urban Renewal: A Reply to Two Critics," Land Economics, 39 (February, 1963) and Hugh O. Nourse, "The Economics of Urban Renewal," Land Economics, 42 (February, 1966).

newer, cleaner, and more spacious than their predecessors. To the extent that this occurs, the neighborhood environment of dwelling units located in areas adjoining the renewal site is improved. The welfare gains attendant to this improvement are real and should be included in any accounting of the benefits of the project. The increase in residential land values in such nearby areas (appropriately adjusted for demand and locational shifts) is conventionally used as an aggregate measure of these welfare changes.

Rothenberg's work thus firmly established the importance of neighborhood externalities to any empirical or theoretical analysis of urban renewal. This accomplished, one might have expected economists to turn their attention to zoning, an institution which is also concerned with externality-induced inefficiencies in the private real estate market. Unfortunately this has not occurred. The definitive work on the economics of zoning has, in fact, yet to be written.

Davis and Whinston have managed to keep the topic before academic readers with a series of articles commencing shortly after their collaborative piece on urban renewal was published. In "The Economics of Complex Systems: The Case of Municipal Zoning" they developed programming and game-theoretic models to show that if each household's well-being at a specific location depends on who its neighbors are, then a completely decentralized, unregulated market mechanism cannot be expected to achieve a Pareto optimal equilibrium -- if indeed it achieves
an equilibrium at all. Some of the arguments employed in this paper are obvious extensions of those used in their analysis of urban renewal. They go on to observe that zoning restrictions may be used to moderate locational interdependencies and thus permit the market to perform more efficiently.

Their basic policy recommendations are straightforward: First, birds of a feather should be encouraged to flock together. The article can thus be interpreted as an endorsement for the districting principle, though it is perhaps easier to see it as a recommendation for racial, ethnic and class segregation in housing. Second, special restrictions ought to be imposed on land usage near the boundary lines separating areas inhabited by different groups. Such restrictions should be designed to mitigate externality "spillovers."

These are not revolutionary proposals; certainly they are less far-reaching than what one would first expect from so technical an article. We remarked earlier that the districting principle goes back at least to the turn of the century in this country. The notion that boundary areas should be planned so as to minimize externalities is of similar vintage. In fact, however, the basic contribution of the article lies not in the novelty of its policy recommendations, but rather in the way in which it brought the conventional tools of economic

18 Kyklos, 17 (Fasc. 3, 1964).

19 Davis and Whinston's proposal here is just a generalization of the "greenbelt" principle first popularized by Ebenezer Howard in his famous book Garden Cities of Tomorrow (London: Faber and Faber, 1902).
analysis to bear on a heretofore neglected problem. We noted above that the land economists felt no compulsion to relate their rather casual endorsement of zoning to the traditional economic literature on welfare economics. Davis and Whinston took it upon themselves to investigate in detail just what this relationship might be.

The remarks in the previous paragraph should not be taken to mean that Davis and Whinston's article is the last word on the economics of zoning. Instead, it is more of a first step. Its principal limitation is that it completely ignored what we have earlier called the land-use control problem. Specifically, how does the practical zoning administrator decide how much land to allocate to each of the homogeneous zones which Davis and Whinston suggest that he set up?20 And does the answer to this question depend in any way on the strength of the neighborhood externalities present in the economy? These questions were ignored by the Davis and Whinston article. If many people have strong, common feelings about their residential environment and if land is scarce, it may not be possible to partition an urban area and insulate boundary lines so that

20Otto Davis, this time without Whinston's assistance, has discussed some of the political factors which enter into such decisions in "Economic Elements in Municipal Zoning Decisions," Land Economics, XXXIX (November, 1963).
neighborhood effects are completely eliminated. If this is indeed the case, our administrator will need more guidance than Davis and Whinston are able to give him.

This criticism suggests that the logical next step for the evolution of economic analysis in this area would be the integration of the theory of externalities into the rapidly growing body of empirical and theoretical work on the urban land market. On the empirical front some progress has been made — as we shall see below. Theoretical articles bridging the gap, however, are scarce. This point is brought home rather forcefully by noting that Alonso's discussion of urban zoning in his *Location and Land Use* (easily the most influential theoretical treatment of the urban land market) completely ignored neighborhood externalities even though these constitute the institution's raison d'être.

21 Note that boundary regulations impose costs as well as confer benefits. Land which is subject to certain (binding) restrictions cannot be as productive (ignoring externalities) as land which is not so constrained. The critical question thus becomes whether or not the direct efficiency loss imposed by the constraint is greater or less than the indirect gain brought about by the reduction or elimination of externalities. This tradeoff is most clearly seen in the case of greenbelts. Here land along boundary lines is completely withdrawn from "productive" use. Obviously such a solution to the neighborhood externality problem will only be feasible in an urban area where land is not a very scarce commodity. It is worth noting in this connection that Howard's greenbelt proposals were coupled with a radical population decentralization scheme which, had it been carried out, would have made urban land much more abundant in England.

One theoretical study of the urban land market which does take into account neighborhood effects is Martin Bailey's 1959 note in *Land Economics.* This article could have perhaps been included in our brief review of the urban renewal literature. But since its focus seemed more general than the other works discussed there, it was reserved for discussion here. Bailey's basic contribution was the establishment of two (alternative) criteria for determining whether or not there is a need for zoning restrictions or redevelopment in any particular residential area. These criteria relate to the spatial pattern of land values across the neighborhood in question. Bailey argued that neighborhood externalities will cause land value reductions in any residential area which adjoins an "undesirable" land use and that these price reductions will in turn cause second-order locational adjustments along the boundary line separating the two kinds of use. The end result is a suboptimal allocation of land between the two activities. Bailey suggested that the extent of the resulting inefficiency varies directly with the difference in land prices at the center of the two areas and inversely with the difference in land prices near their (common) boundary line.

The principal merit of Bailey's approach to neighborhood externalities is that the quantity of land allocated to each economic use in an urban area is allowed to be an endogenous variable in the model. This contrasts, for example, with the

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Davis-Whinston approach which fixes both the number of (presumably identical) sites and the number of households to be assigned to them. As soon as land quantities are variable, it becomes possible to think of zoning ordinances (or urban renewal projects) as embodying planners' decisions about how much land should be allocated to each economic activity in an urban area. Thus, Bailey's article directly confronts the land-use control problem as we have defined it and presents alternative methods for obtaining solutions in specific cases.

The only shortcoming of this analysis is that the model Bailey used was, in fact, a rather restricted one. It only pertained to land-use patterns in a small neighborhood rather than to those in the city as a whole. Moreover, it did not take into account accessibility linkages between different land uses -- such as those between the home and the workplace or the home and the nearest shopping center. Once it is recognized that many land uses which generate external diseconomies also provide goods, services, and jobs, the problem of deciding on an optimal allocation of urban land becomes much more complicated. One wonders whether Bailey's criteria will continue to apply in these more general cases. In spite of such difficulties "Notes on the Economics of Residential Zoning and Urban Renewal" is a pioneering work. It is a pity that it has inspired so few attempts to generalize and deepen its basic findings.

Let us now consider some empirical studies of neighborhood effects. All of the theoretical and policy studies
which we have thus far cited have assumed that neighborhood externalities are in some sense "important." The empirical literature which we are now going to discuss refuses to accept this assumption. Instead, neighborhood externalities are seen only as phenomena whose importance constitutes a hypothesis to be tested. The usual argument is that if the hypothesis is "true," then the effects of neighborhood quality should show up in the prices which residential properties receive in the private market. This is a sensible approach, though as we shall see in the next chapter, neither the presence nor the absence of such price effects is an unambiguous indicator of what everyone thinks is a desirable neighborhood.

In general, there are numerous factors which will help determine the price at which a particular house and lot will be sold when it is placed on the market. The neighborhood surrounding the parcel is only one out of this multitude and probably not the most important. It follows that the researcher who is interested in isolating the influence of neighborhood alone must develop a research strategy which will permit him to control for the separate influences of all the other variables. Two general methods have been employed to do this. The first is the "comparable neighborhood" or "comparable property" approach. The basic strategy here is to obtain two neighborhoods (or properties) which are identical in all ways except one. Price differences can then be attributed solely to the single variable which has not been held constant. Prob-
ably the most famous study ever to employ this methodology was Luigi Laurenti's *Property Values and Race.* An externality study which uses the same procedure is Hugh Nourse's "The Effect of Public Housing on Property Values in St. Louis." In both of these cases a major problem was choosing "control" neighborhoods which were truly comparable to the "experimental" neighborhoods in all ways but the crucial one. Laurenti and Nourse apparently succeeded in doing this. Most other researchers, however, have felt the task to be too difficult and turned instead to other approaches.

The second method for determining whether or not any particular variable influences property values requires the use of multiple regression techniques. Here market price is regressed on the set of variables which the researcher feels will most adequately "explain" why price differs from one property to another. The advantage of this procedure is that one need not worry about obtaining "control" properties or neighborhoods. The principal disadvantage is that one must have data on all variables which enter into the price determination process. The statistical properties of the multiple regression technique are such that it is not acceptable (except in rare cases) to carry out an estimation when it is known

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24 (Berkeley, California: University of California Press, 1960). Laurenti, of course, wished to determine whether Negro occupancy had any effect on property values (ceteris paribus).

that an independent variable is missing. Either a proxy for this variable must be found or the research project must be abandoned.

All of the empirical studies which remain to be discussed use this "hedonic" regression technique. Many do not specifically focus on the neighborhood externality hypothesis described above. Because, however, neighborhood effects must be controlled for in some way in any analysis of property values, all these studies include some neighborhood variables, or at least proxies for these variables, in their regressions.

The standard place to begin any survey of the econometric literature on the determinants of residential property values is Eugene Brigham's 1965 paper on this topic. Brigham sought to determine how land values varied along several rays emanating from the center of Los Angeles. His main interest was the role which accessibility to employment played in influencing these values. However, for the reasons mentioned above, he also included several neighborhood variables as well. The specific variables he chose -- average block income, average block building value and the extent of overcrowding on the block -- were only proxies for the more detailed kinds of neighborhood characteristics which he was

unable to obtain.\textsuperscript{27} In general, Brigham's results support
the neighborhood externality hypothesis, though perhaps not
as strongly as one would have expected. In each regression
at least one "amenity" variable was significant and had the
proper sign. The main problem is that different variables
were significant in different equations. Thus, Brigham's
results (at least those concerning neighborhood environment)
look a little like the product of a determined fishing expedi-
tion. Nonetheless, his findings are highly suggestive, and
they clearly stimulated a good deal of further exploration in
the wilderness which he had pioneered.

Following Brigham there were several more articles of
the same type which used various proxies for neighborhood
quality more or less successfully in their regressions.\textsuperscript{28}
Most of these studies were not specifically interested in
measuring the price effects of neighborhood quality. Thus,
the use of surrogate variables was not perhaps inappropriate.
It is difficult to know, however, whether their findings
really support the hypothesis that neighborhood externalities

\textsuperscript{27}The single variable which might not be a pure proxy
was the one measuring overcrowding. High population density
might be a "bad" by itself, even without the dwelling unit
and neighborhood deterioration which usually accompany it.

\textsuperscript{28}R. N. S. Harris, G. S. Tolley and C. Harrel, "The
Residential Site Choice," \textit{The Review of Economics and Statistics}, 50 (May, 1968); class character of surrounding neighbor-
hood. Wallace Oates, "The Effects of Property Taxes and Local
Public Spending on Property Values," \textit{Journal of Political
Economy}, 77 (November-December, 1969); median family income
in the community. Harold Brodsky, "Residential Land and Im-
provement Values in a Central City," \textit{Land Economics}, XLVI
(August, 1970); median family income in census tract.
exert an important influence on the operation of residential real estate markets.

To see why this is true note that the income class of the neighborhood or community in which the sample properties were located was the standard measure of environmental amenity used by these studies. The problem with this particular proxy is that it may give misleading results in certain cases. Consider, for example, a real estate auction in which the participants care only about the house and lot which they purchase and not at all about its neighborhood. In this market neighborhood externalities as we have defined them do not exist. However, a researcher who felt that income was a suitable proxy for neighborhood quality would come to the opposite conclusion because he would note a positive correlation between the price a property received on the market and the income of its purchaser. This correlation would, of course, be due to the fact that the "better" house-lot combinations will tend both to fetch a high price and to be purchased by high-income families. Clearly the way to avoid this erroneous result is to regress parcel price on the income of the neighbors rather than on the income of the purchaser. This is very difficult to do, however, when the data being used describes geographical aggregates rather than individual properties -- as was the case with several of the studies mentioned above.

Difficulties like those referred to in the previous paragraph are perhaps inevitable whenever the data one really wants are not available and proxies must be used. Let us now
consider some studies where this data constraint does not exist. One rather influential paper in this group is Ridker and Henning's investigation into the effects of air pollution on residential property values in St. Louis.\textsuperscript{29} They concluded that air cleanliness, as measured by sulfation level, had a small but significant effect on the market price of single-family homes in the St. Louis area. This is a nice result, but one which is not immediately relevant to our main interest here since air pollution is not usually thought of as a neighborhood externality as we have defined that term. It is a kind of externality to be sure, but the affected population is typically much larger than the one composed of only those individuals living in the immediate vicinity of pollution-emitting devices.

The two studies which came closest to testing the neighborhood externality hypothesis as we originally proposed it are by Kain and Quigley and by Crecine, Davis, and Jackson.\textsuperscript{30} The first of these found that proximity to nonresidential land uses generally lowered the market value of single-family homes.


The second, on the other hand, found that such proximity had no effect on market value. As we shall now see, there are various defects in both studies. It is impossible therefore to decide which conclusion is the more nearly correct on the basis of the published results.

The study by Kain and Quigley is based upon a sample of residential properties in the St. Louis metropolitan area. A task force of inspectors and interviewers gathered data on a large number of qualitative and quantitative housing characteristics for each of 1500 dwelling units. The qualitative variables were then aggregated into a small number of quality indices through the use of factor analysis. One of the resulting indices (or factors) measured the amount of nonresidential land use in the neighborhood. This index, along with four additional quality indices and numerous other accessibility, public service and quantitative housing variables, was then used as an independent variable in a property value regression of the conventional sort. The results of this estimation indicated that proximity to nonresidential land uses tended to lower the market value of single-family homes (ceteris paribus). This, of course, is direct affirmation of the neighborhood externality hypothesis.

The principal difficulty with Kain and Quigley's result is that it is ultimately contingent upon the factor-analytic technique used to reduce the number of housing quality variables down to a manageable size. This is hardly the place for a detailed critique of this particular use of factor analysis.
However, the main objection may be briefly indicated. Basically the problem is that each of the five factors or indices which were used in the price regression were linear combinations of all the original housing quality variables. Thus even though one of the factors is labeled "nonresidential use," it is still really a composite variable subject to the influence of many housing quality variables having nothing to do with the dwelling unit's proximity to nonresidential activities. The other four indices were similarly contaminated by "irrelevant" variables -- numbering among them, of course, the nonresidential use variable. The point, therefore, is that the factor-analytic method is not particularly well-adapted to the study of a specific housing quality variable because it does not permit the researcher to isolate this variable's separate influence from the influence of all other quality variables. Kain and Quigley concede this point in a sequel to the paper cited above.31

The paper by Crecine, Davis, and Jackson avoids this particular difficulty because it does not rely on factor analysis to effect an a priori reduction in the number of possible independent variables. There are other problems, however -- as we shall now see.

The specific objective of the Crecine study was to determine whether or not a single-family home's proximity

to various types of land use affected its market value. Thus, it was a study whose exclusive interest was the neighborhood externality hypothesis that we have been discussing in the past several pages. The data base consisted of observations on individual properties grouped in several sets, each set corresponding to a particular residential area in the city of Pittsburgh. Market price, lot size, and neighborhood data were obtained for each property, and then market price per square foot of lot size was regressed on the neighborhood variables. Accessibility to both employment and public services was controlled for by restricting each regression to a single residential area. The results of these estimations did not support the neighborhood externality hypothesis. Instead, the authors found a random pattern of regression coefficients, indicating that there was no systematic relationship between the price of a house and the characteristics of its surrounding neighborhood. They concluded from this that neighborhood externalities were probably not operationally important features of urban land markets and that therefore much modern zoning legislation was misguided.

These results, though provocative, are vitiated by numerous defects in the design of the study and in the quality of the data base. The first of these is related to the authors' choice of dependent variable. The basic price figure which they used covered both house and lot; yet no structure characteristics (such as number of rooms, age or condition) were included in the regression. It was argued
that these factors were completely controlled for by dividing lot size into price and by restricting each regression to a single neighborhood. These attempts to compensate for a basic insufficiency in the data base seem inadequate, however, once it is recognized that nearly all studies of residential property values have found structure characteristics to be among the most important determinants of the price of the structure-lot package.32

A second problem with the Crecine study is the definition of neighborhood which it was forced to use. Because of the way the census and land-use data were gathered, the "neighborhood" of a particular parcel covered only the city block in which the parcel was located. Activities directly across the street were not included. Needless to say, this deficiency is a serious one, and it necessarily calls into question all of the study's findings.

Finally, one may question whether restricting each regression to a sample of properties all drawn from the same small area permits a fair test of the neighborhood externality hypothesis. If one accepts a somewhat broader definition of "neighborhood" than the one Crecine et al. used, it could be said that this research strategy actually controls (inadvertently) for the price effects of residential environment

32See, for example, Kain and Quigley, "Measuring the Quality and Cost of Housing Services," op. cit., pp. 12-14. The low $R^2$ which Crecine et al. obtained for most of their regressions is further evidence of the inadequacy of their control techniques.
because all of the properties in a particular sample in fact come from the same "neighborhood." A more reasonable sampling procedure would involve selecting properties from a diversity of environments (presumably from all over the metropolitan area) -- thus introducing much greater neighborhood variation into the sample than the Crecine study permitted. The principal disadvantage of a geographically dispersed sample is that it increases the overall data requirements of the study. For example, specific employment accessibility variables would then have to be included in the regression. Such complications are, however, the price one usually has to pay to obtain a study which is sufficiently well-designed to discriminate among important economic hypotheses.

C. The Shape of Things to Come

Our survey of the economic literature on neighborhood externalities is now complete. What have we learned from this extended review of a dozen or so rather obscure journal articles? The principal impression that this literature leaves is one of fragmentation and incompleteness. There are scattered interesting contributions, but there is no evidence that a cumulative process of scientific investigation is underway, particularly one which will eventually lead to a synthesis of prior work and the resolution of important issues. The main cause of this rather desultory performance is, as was indicated earlier, the general indifference of most economists to

33 The one possible exception to this statement is the literature on urban renewal.
public policy problems concerning the regulation and control of urban land. This dissertation does not pretend to close all gaps and solve all problems. Instead, it will focus only on a small number of particular problems which have not been adequately resolved in the current literature. The ultimate hope is that these modest contributions will prepare the way for more mature works in the future.

Having said this, let us now indicate where these problem areas are. Recall, first of all, the rather unsatisfactory state of the empirical literature purporting to measure the influence of neighborhood externalities on property values. To be sure, many (but not all) of the authors cited in the previous section found some evidence that neighborhood quality affects these values. Unfortunately, however, the specific variables which most of the studies used to quantify neighborhood quality were deficient in important respects. Many were only the crudest sort of proxies; others were composite variables which intermingled neighborhood effects with other components of the housing package. In truth, there has really only been one study -- that by Crecine, Davis, and Jackson -- which used a proper set of variables in its regression.34

34By this we mean that they used real neighborhood land-use data rather than proxies or composites. We have been assuming throughout this chapter that land-use variables are the "correct" ones to include in a property value regression (given that they are available). This is a rather natural assumption to make because land use is what, in fact, zoning ordinances regulate. There is an alternative, however, which we will discuss in the next chapter. Note finally, that our remarks here about the Crecine study do not constitute an endorsement of the definition of neighborhood which they chose.
Ironically enough, however, this article was the only one cited which came up with completely negative results.

There is clearly a need, therefore, for still another careful study of the impact which neighborhood has on residential property values. If the existence of this influence cannot be definitely ascertained by economists using sophisticated econometric techniques, then perhaps it is time to reconsider the rationality of the elaborate system of zoning controls which has been set up in most large American communities over the past half century. This is the challenge which the Crecine study poses.

In Chapter IV of this dissertation, we respond to this challenge by reporting the results of an empirical investigation into the determinants of single-family home property values in the suburban Boston area. This study is unique in that its data base includes both a large number of structure, lot, and accessibility variables and a large number of neighborhood land-use variables. The results of the estimations indicate not only that neighborhood exerts a significant influence on the market price of homes, but also that different kinds of land uses have different kinds of price effects. Thus, for example, we show that industrial uses lower home values more than multiple-family uses do. In addition, commercial uses are shown to have a nonlinear effect on price due to the shopping convenience which they afford. Results such as these last two have never before been obtained because of the data inadequacies which have plagued earlier studies.
Having produced strong statistical support for the hypothesis that neighborhood characteristics influence the price of residential properties, we then go on to Chapter V where we consider some theoretical consequences of this finding. We noted in the previous section of the present chapter that there have been few attempts thus far to integrate the microeconomic theory of externalities into the rapidly evolving body of theory dealing with the urban land market. This has been the case in spite of the fact that such a synthesis is probably prerequisite to any truly systematic economic analysis of zoning and the other forms of government land regulation. Chapter V attempts to remedy this deficiency.

In that chapter we shall construct a model of a new town economy with certain unique features. The model will contain both residential and nonresidential land uses. The latter will impose external costs upon the former because households will be assumed to dislike living in neighborhoods which are not exclusively residential. To complicate things the nonresidential uses will also be the only source of local employment for the households. Thus, the developer in deciding how much land to allocate to each of the two activities will somehow have to balance these competing considerations. The model is clearly a generalization of Martin Bailey's model described earlier. The main innovation is the inclusion of a labor market which links the two sectors of the economy.

Using this model, we shall demonstrate the importance of land-use control devices to the developer. It will turn
out that the strength of the typical household's aversion to nearby nonresidential uses (i.e., the importance of neighborhood externalities) becomes a critical element in the developer's decisions regarding land use and the employment of control techniques. We will then attempt to generalize these results a bit by considering their applicability to urban economies in which land holdings are decentralized. This in turn will produce a few insights into the strengths and weaknesses of the typical urban zoning ordinance.

Chapter III contains a preliminary theoretical discussion of the theory of household choice in a real estate market. The bidding model popularized by Alonso is generalized to cover a broader range of choice situations than his originally allowed. Our findings here are of some interest in themselves, but their principal importance in this dissertation is as theoretical inputs into Chapters IV and V.
CHAPTER III

Neighborhood Quality and the Residential Site Choice

It is a commonplace that households choose among prospective residential locations at least partially on the basis of neighborhood. In the present chapter we shall attempt to model this decision process. To do so it is necessary to devote some analytical attention to the neighborhood externality concept. We gave it a definition in Chapter II which was both casual and intuitive, but which served our purposes at the time. Here we must probe deeper.

In Section A we consider some preliminary methodological issues which must be faced if the neighborhood quality concept is to be made operational. Having settled these, we will then in Section B develop a formal model of consumer bidding behavior for an urban land market. This model will be an attempt to bridge the gap between the theoretical and empirical literature on property values. It is a partial response to those critics who have found the modern theory of urban land valuation to be a sterile enterprise without significant empirical applicability. Finally, in Section C we will attempt to translate our analytical conclusions about consumer bids into empirical inferences about probable price relationships in real-world property markets. Our conclusions there will lead naturally into Chapter IV where the results of an empirical study examining the influence of
neighborhood on residential property values will be presented.

A. Quantifying Neighborhood Quality

Consider a consumer whose well-being depends not only on the goods and services which he himself purchases but also on the way in which land is used in the neighborhood of his residence. How might one usefully extend the classic theory of consumer choice to permit this everyday situation to be handled analytically? Since neighborhood externalities are really nothing more than a matter of "taste," the appropriate procedure would seem to involve the inclusion of some neighborhood variables as arguments in our consumer's utility function.\(^1\) This is simple enough in principle, but for an empirical study we need to know more. Specifically, what sorts of variables should they be?\(^2\)

The traditional literature on zoning and city planning has emphasized land-use variables. Naturally, the relevant authors did not couch their discussions in terms anywhere

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\(^1\)This is the conventional way of dealing with consumption externalities. Obviously, what we are calling a neighborhood externality is a special case within this broader class. For a good survey of scholarly writing on consumption (and production) externalities which discusses the analytical treatment of these phenomena see E. J. Mishan, "The Post War Literature on Externalities: An Interpretative Essay," Journal of Economic Literature, IX (March, 1971).

near as arcane as "utility function" but the substance of their thinking is clear enough. Put simply, they found it very convenient to think and plan using a set of fairly standard land-use categories. Evidence of this predilection may be found in practically all works on zoning or subdivision controls, even the most modern. It is a natural extension of this approach to land regulation to assume that land-use variables are the appropriate neighborhood arguments to use in a study of household residence choice. This is the assumption we shall be making throughout this study.

Since this assumption is an important one, let us scrutinize it a bit before pushing on to other matters. It is appropriate to begin by examining what appears to be the principal objection to land-use variables as indicators of neighborhood quality. The argument goes something like this: Households do not really object to factories in their neighborhoods. What they object to are the characteristics of the typical factory. The typical factory is noisy and ugly, pollutes the air, and fills the neighborhood with traffic and strangers twice a day. If, however, a quiet, nonpolluting, fully automated, and beautiful factory (designed perhaps by Mies or Saarinen) were built in a residential neighborhood, homeowners there might not complain too vociferously.³

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³Jane Jacobs would add the requirement that the structure be small since large buildings are inimical to the "close-grained diversity" she finds so desirable. The Death and Life of Great American Cities (New York: Random House, 1961), p. 234.
haps they would even prefer it to the vacant lot which it replaced. Moreover, what applies to factories applies to other land uses as well. It is the consumer-relevant characteristics of the use rather than the abstract nature of the economic activity being conducted on the land which matters. When comparing residential properties, for example, perhaps it is differences in population density which are really important, rather than differences in the number of dwelling units in the structure.

An immediate corollary is that neighborhood land-use variables are at best proxies for a more basic set of arguments, and it is these which the researcher should ideally include in his consumer's utility function. A partial list of these arguments might include noise (measured in decibels), pollution (measured in parts per million), traffic (measured in vehicles per unit time), and crowding (measured in persons per unit area).

How much ought one to make of this suggestion? One point is fairly clear: From a practical, city-planning point of view it seems quite useful. As was indicated above, the early zoning ordinances (and most still in effect today) were based on the principle that intrinsically "incompatible" land uses should be rigidly segregated, with no provision for

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4 Economists will note that the overall perspective being suggested here is very similar to the one appearing in the goods-as-bundles-of-characteristics literature. See, for example, Kelvin Lancaster, "A New Approach to Consumer Theory," *Journal of Political Economy*, 74 (April, 1966).
exceptional treatment of those uses which were atypical of their general class. It was (and is) a rather heavy-handed method, but the framers of the early ordinances were preoccupied with zoning's constitutionality and were therefore in no position to promote a more innovative approach. Many modern statutes, however, have moved to a less restrictive position on these matters by including a section on performance standards for industrial uses and a section on bulk standards for multiple-family uses. Firms meeting a variety of conditions relating to noise, pollution, traffic, etc. are given a wider range of site choices than those which do not.5 Similar treatment is accorded multiple-family developments conforming to certain overall density or bulk standards.6 Authors in the zoning field who have promoted these regulations have stressed both their underlying logic from the point of view of nuisance law (using arguments identical to the one in the previous paragraphs) and the increase in planning flexibility which they will permit. Many planning authorities are finding the overall approach attractive and it seems to have a bright future.

These policy developments suggest that economists inter-

5A brief summary of the legal status of performance standards may be found in Norman Williams, Jr., The Structure of Urban Zoning (New York: Buttenheim Publishing Corporation, 1966), pp. 218-219, 222-223.

6For a case upholding the right of an appeals board to use bulk criteria in granting a zoning exception to a large apartment complex see Appeal of Borden, 87 Atlantic (2d) 465 (1952).
ested in the role which neighborhood externalities play in the operation of the urban land market might find it useful to think in "performance" rather than "land-use" terms. Unfortunately, however, the "performance" approach to neighborhood externalities is difficult to implement in an empirical study. For the most part "performance" data are simply unavailable.\(^7\) In addition, the technical details associated with the setting of standards and the measurement of the relevant phenomena are usually quite complex and many have yet to be worked out.\(^8\) For these reasons the empirical portion of the present study (in Chapter IV) had to rely upon "land-use" rather than "performance" data. In order to preserve some measure of consistency across chapters we decided to employ land-use variables throughout the study -- even in the theoretical sections where the conceptually more correct "performance" variables could have been used. Thus the discussion in the pages which follow will be couched exclusively in "land-use" terms. The reader should remain aware, however, of the alternative conceptual framework which has been dis-

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\(^7\) The one prominent exception to this statement is data on air pollution. For an excellent study of the effect of air pollution on property values see H. Hidker and J. J. Henning, "The Determinants of Residential Property Values with Special Reference to Air Pollution," *Review of Economics and Statistics*, 49 (May, 1967).

\(^8\) The complexity of the standards and the inability of the laymen to understand them figured prominently in what is perhaps the earliest case on the subject. *International Harvester Co. v. Zoning Board of City of Chicago*, 193 North Eastern (2d) 856 (1963). In spite of these drawbacks, the court decided in favor of the regulations.
Now that we have settled on a general method of quantifying neighborhood quality, let us return to our typical consumer and imagine him to be searching for a home in some metropolitan area. A useful way to begin thinking about this process is to imagine that the typical household organizes its perceptions of a neighborhood along two dimensions. The first, of course, is land use. The household (implicitly) chooses a set of q land-use categories which it finds relevant. Presumably, these categories will be nonoverlapping and exhaustive. The second dimension is spatial. The household partitions the physical space surrounding prospective residential sites into two parts: the neighborhood and the rest of the world. We shall assume that the physical partition used by the household is identical for every property. Consequently all of the neighborhoods which it examines are of the same size. Land-use configurations within neighborhoods are then noted but those outside are not.

When this partition is combined with a land-use classification system, the result for any residential location is

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9 For a beautifully written (and scholarly) account of how urban dwellers perceive their cityscapes see Kevin Lynch, *The Image of the City* (Cambridge, Massachusetts: The M.I.T. Press, 1960). Lynch's ideas quite transcend the crude sort of analysis we are attempting here.

10 A more complicated partition process is possible in which the neighborhood is further subdivided into (roughly) concentric rings. Because of data and time restrictions this refinement has not been incorporated in the present study.
a vector $z$ describing the distribution of land uses in a well-defined local area.

$$z = [z_1 \ z_2 \ z_3 \ \ldots \ z_q].$$

For a particular residential location, $z_i$ is the amount of land use $i$ (in acres, for example) located in the neighborhood. It should be clear that all $q$ of $z$'s elements must appear as separate arguments in our consumer's utility function. We might note also that if the typical consumer is at all discriminating, $q$ could be quite large -- a possibility which might be embarrassing for researchers with small sample sizes. One tends to think, however, that the real-world taxonomies used by consumers are probably fairly coarse since neighborhood evaluation with a very fine set of categories would be quite time-consuming.

A more fundamental difficulty, however, concerns the researcher's a priori knowledge of the land-use taxonomy which defines the elements of $z$ in the real world. Suppose he has some land-use data for certain urban neighborhoods or communities and he wishes to determine the relationship between property values and neighborhood amenities (to take a nonrandom example). It is hardly enough to know that there is some set of land-use categories which the typical consumer uses. He must have a very good idea of in fact which set it is. We will grapple with this problem in the context of a specific estimation a bit later. What is to be stressed here are the various methodological issues involved.
Two preliminary points are worth making. The first is that the researcher can in no way be aided by an conventional application of microeconomic theory since that theory has nothing to say in general about what arguments ought to appear in utility functions (or production functions for that matter). The second is that simple observation of human market activity may not be much help either since externalities, by definition, are "goods" which are outside the control of the households which "consume" them. Therefore, the revelation of preference which is prerequisite to the consumption of ordinary commodities is missing.\footnote{Consumption externalities bear an obvious kinship to public goods in this regard. See Paul A. Samuelson, "The Pure Theory of Public Expenditure," Review of Economics and Statistics, XXXVI (November, 1954), p. 389.}

These observations are not, however, cause for total despair. Man, after all, is a political animal as well as a consumer (conventional economic theory notwithstanding). Tastes not revealed in the marketplace often appear in the city council chamber. This suggests that a solution to the specification problem we are facing may be found by consulting the political and legal literature on zoning and land-use control -- a literature which deals at great length with the problem of choosing useful sets of land-use categories. As we shall see in the next chapter, this approach is a fruitful one. There we will have much occasion to draw inspiration from the zoning literature and from assorted zoning cases and statutes.
B. Household Behavior at a Real Estate Auction

In this section we formalize the residential choice problem by constructing a mathematical model of household behavior at a real estate auction. We imagine that individual consumers bid against business firms and other consumers for the right to acquire desirable sites in the metropolitan space economy. The sites themselves are then occupied by the economic agent whose bid was the highest. In this way the assignment of firms and households to the available sites and the market valuation of those sites are determined simultaneously.

This approach to the urban land market has a long intellectual history.\(^{12}\) It has even been found useful by writers outside the discipline of economics.\(^{13}\) Several modern contributions have distilled the essence out of the earlier, largely verbal, literature and presented it using fairly sophisticated mathematical arguments.\(^{14}\) The model

\(^{12}\)A succinct summary of this history may be found in William Alonso, Location and Land Use (Cambridge, Massachusetts: Harvard University Press, 1964), Chapter 1.

\(^{13}\)For example, when the human ecologists at the University of Chicago spoke of competition, dominance, invasion and succession, they seemed to have a kind of auction model in mind, though they probably would have been offended by this prosaic suggestion. For a concise statement of the Chicago School's theory of urban land use see R. D. McKenzie, "The Ecological Approach to the Study of Human Community," The City, ed. Robert E. Park and Ernest W. Burgess (Chicago: The University of Chicago Press, 1925), pp. 73-79.

to be presented below builds on this recent work. We shall be attempting to modify the theoretical tools which others have bequeathed us to make them suitable to our specific needs. As Orr has observed, much of the theoretical work on the urban land market is not of immediate value to the empirical economist. Our modifications, therefore, will always be aimed at making the various theoretical constructs operational. Above all we want the results obtained by manipulating our model to be useful inputs to the econometric study which follows in the next chapter.

Let us begin by considering a household which is seeking to purchase a single-family home in a metropolitan area. Since much of the scholarly work on the residential site choice has put great emphasis on the work trip as a key locational factor, we shall suppose that the head of the household is already employed. Thus the situation we have in mind is not one in which job and residential location are being determined simultaneously. Because we are dealing with the single-family home market, this is not a particularly restrictive assumption since mortgage financing typically requires evidence of regular employment.


16For a detailed study which confirms many of one's intuitions about the nexus between the work trip and residential location, John F. Kain, "The Journey-to-Work as a Determinant of Residential Location," Papers and Proceedings of the Regional Science Association, 9 (1962).
Our household wants more from the house it finally chooses than just proximity to employment. Among other things, its well-being depends on the structural characteristics of the unit itself (its age, number of rooms, etc.), the physical features of the lot (its size, topography, etc.), the quality of local public services, and the "character" of the neighborhood in which the house is located. We formalize these prosaic notions by writing the household's utility function in the following way:

\[ u = u(z, x, v, c, s), \]  

(3-1)

where

\[ z = \text{a vector of neighborhood land-use variables}, \]
\[ x = \text{a vector of ordinary (nonhousing and nontransportation) commodities}, \]
\[ v = \text{leisure time}, \]
\[ c = \text{a vector of dwelling unit and lot characteristics}, \]
\[ s = \text{a vector of public services}. \]

The \( z \) vector is the same one that was referred to in the previous section. To simplify the exposition which follows we partition it into four subvectors:

\[ z = [z^*; z^{**}] = [z_1^*; z_2^*; z_1^{**}; z_2^{**}]. \]

The land uses included in the \( z^* \) subvector are those which serve a local *convenience* function. Herein we find neighborhood shopping centers, public schools, churches and local
professional buildings. These uses supply frequently pur-
chased private goods and services as well as the most commonly
used public and institutional services. Their presence in a
neighborhood thus reduces overall travel time and expendi-
ture for its inhabitants. The $z^{**}$ subvector, on the other
hand, includes those activities whose presence in a neigh-
borhood does not in general effect important travel time and
money savings for nearby residents. Some examples here might
be cemeteries, warehouses, nursing homes, power plants and
military installations.\textsuperscript{17} In the real world, of course,
convenience is a continuous variable. The distinction we
are trying to draw is therefore somewhat artificial, and it
may be difficult in practice to decide in which polar cate-
gory a particular use belongs. Nonetheless, the dichotomy
is a useful one.

Each of these categories is then further subdivided
into those uses which contribute to the overall "quality"
of the neighborhood or community in which they are located
($z^*_1$ and $z^{**}_1$) and those which detract from it ($z^*_2$ and $z^{**}_2$).
"Quality" as it is used here refers to the \textit{aesthetic} or
\textit{amenity} characteristics of any local residential area. Is
it a "nice" place to live, pleasant in appearance, quiet and
sober? Some uses contribute to this sort of environment

\textsuperscript{17}Obviously, some of these uses may in fact be work-
places for local residents. When we speak of "convenience"
here, however, we are only concerned with the nonemployment
services a use may provide. The accessibility of residen-
tial land to employment will be accounted for elsewhere.
while others do not. Clearly, "quality" is a very subjective concept and different households will generally have different ideas about the meaning of the term. It is one of the central hypotheses of the present study, however, that this diversity of opinion is not so great as to render the concept void of any empirical content. We will return to this problem later on in the present chapter.

One immediate objection to the use of "high quality" and "low quality" categories is that in all real-world situations the aesthetic contribution of any particular use to a neighborhood will depend upon the nature of the activity which it supplants. Thus, an apartment house will improve a neighborhood if it replaces a junkyard, but it will do the opposite if it replaces a single-family home. To handle this problem we shall assume for the moment that we are privy to

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18 "Quality" as it is defined here does not include the social characteristics of the neighborhood population. This is perhaps an important omission and we shall have some more to say about it in the next chapter. The main thing to note here is that the hypothetical auction we are setting up is one in which all homeowners are assumed to participate simultaneously. Once this conceptual framework is adopted, it does not make much sense to say that the social characteristics of a neighborhood determine the size of the bids which local properties receive since the social characteristics of a neighborhood are not determined until after the auction is complete. Note the similarity between our institutional specification and that of Alonso in this respect. The question remains, however, as to whether or not a general auction model represents a reasonable idealization of the quite complex market process which allocates households to sites in the real world. This cannot be answered a priori. However, our empirical results in Chapter IV suggest that this framework is a fairly sensible one, and that therefore it is not completely unreasonable to ignore the social dimensions of neighborhood quality (as we have done) if this enables the researcher to achieve a notable simplification in his working model.
the inner workings of our consumer's utility function and that it is therefore possible to classify land uses into those which raise his utility and those which lower it. Using the standard nomenclature, those uses which raise utility generate positive externalities while those which lower it generate negative externalities. Note that under these definitions a use which generates positive externalities may still lower property values in a particular area if it replaces one which has a stronger positive effect than it has.

A typical element of $z_1^*$ might be a local park or church. Both are used by local residents, and both on balance add to a neighborhood's overall attractiveness. Typical elements of $z_2^*$, on the other hand, might be uses like dry-cleaning establishments, gas stations or grocery stores. Such activities are convenient to have in the neighborhood but they do detract from its appearance and quietude. The difference between $z_1^{**}$ and $z_2^{**}$ activities corresponds exactly to that between $z_1^*$ and $z_2^*$.

It is worth remarking that the distinction we have drawn here between the convenience and aesthetic characteristics of a land-use type is not one which derives its only sustenance from the utility it affords this study. Rather, it goes to the heart of a current controversy among city planners concerning zoning strategy. Old-fashioned zoning laws emphasized the relative degree of objectionableness of the various land uses; they were only concerned with what we have called
a use's aesthetic qualities. The more modern thinking on
the subject has stressed the interrelationships among land
uses.\textsuperscript{19} What this seems to mean is that zoning districts
ought to be drawn up with at least some attention paid to
the input-output relationships among activities. Obviously,
our interest in the "convenience" characteristics of a non-
residential land use is consistent with this overall view.\textsuperscript{20}

Returning now to (3-1), let us indicate the (assumed)
signs of the various partial derivatives. It will be conven-
ient to enumerate the various sets of arguments in the utility
function as follows:

1. $z_1^*$ (desirable, convenience uses)
2. $z_2^*$ (undesirable, convenience uses)
3. $z_{1}^{**}$ (desirable, nonconvenience uses)
4. $z_{2}^{**}$ (undesirable, nonconvenience uses)
5. $x$ (ordinary commodities)
6. $v$ (leisure)
7. $c$ (structure and lot characteristics)
8. $s$ (public services).

\textsuperscript{19}See, for example, John Delafons, \textit{Land-Use Controls in

\textsuperscript{20}In his discussion of the evolution of zoning "theory,"
Williams draws the distinction between "service" criteria and
"nuisance" criteria, \textit{op. cit.}, p. 76. We have obviously used
both to classify land uses.
The partial derivative of $u$ with respect to a particular argument will then be noted $u^1_j$. The $i$ refers to a general set of arguments and $j$ to a specific element of that set. Thus, for example, $u^1_1$ is the partial derivative of the utility function with respect to a small change in the argument corresponding to the first enumerated use in the overall set of desirable convenience uses. For those readers who find this notation clumsy, apologies are in order. However, we wish to make notationally clear the difference between the partial derivative of utility with respect to an argument and the partial derivative of utility with respect to a variable. For the former we use the $u^1_j$ notation; for the latter the more conventional $\Delta u/\Delta$ notation.\footnote{This notation is a variant of one proposed by R. C. Buck, Advanced Calculus (New York: McGraw-Hill Book Company, 1956), p. 193.} The distinction is important because in the analysis which follows a variable change will occasionally induce multiple argument changes.

The signs of the $u^1_j$ are as follows:

\begin{align*}
  u^1_1 &> 0, & \text{(3-2.1)} \\
  u^2_1 &< 0, & \text{(3-2.2)} \\
  u^3_1 &> 0, & \text{(3-2.3)} \\
  u^4_1 &< 0, & \text{(3-2.4)} \\
  u^5_1 &> 0, & \text{(3-2.5)}
\end{align*}
\[ u_1^6 > 0, \quad (3-2.6) \]
\[ u_1^7 > 0, \quad (3-2.7) \]
\[ u_1^8 > 0. \quad (3-2.8) \]

The signs of \( u_1^1 \) and \( u_1^3 \) are positive because they refer to changes in aesthetically desirable land uses. The signs of \( u_1^2 \) and \( u_1^4 \) are negative because the uses involved are undesirable. The additional utility afforded by the convenience uses (1 and 2) is indeterminate in that it is a consequence of intermediate changes in leisure and supernumerary income brought about by the original land-use change. It is therefore not part of the utility increment referred to in (3-2.1) and (3-2.2). Obviously, the total differential of \( u \) with respect to \( z_2^* \) is of indeterminate sign because the indirect (positive) leisure and income effects may outweigh the (negative) externality effect. The signs of \( u_1^5 \), \( u_1^6 \), \( u_1^7 \) and \( u_1^8 \) are positive because we are assuming that all the relevant variables are defined so that increases in them increase the household's well-being.

The household's freedom of choice is subject to two kinds of constraints: income and time. The former is the more conventional so we shall consider it first. We write the budget restraint of the household as follows:

\[ y = \sum p_1 x_1 + r + t + k(d, z_1^*, z_2^*, x), \]

where
\[ y = \text{annual income}, \]
\[ p_i = \text{price of ordinary commodity } i, \]
\[ x_i = \text{quantity of ordinary commodity } i, \]
\[ r = \text{annual housing payment} \]
\[ t = \text{annual local tax payment}, \]
\[ k = \text{the transportation expenditure function}, \]
\[ d = \text{length of the work trip}. \]

The logic of this specification is comparatively straightforward. The consumer's annual income is exhausted by payments for ordinary goods, for housing, for local taxes, and for transportation.\(^\text{22}\)

We shall assume that both the annual housing payment and the annual local tax payment are proportional to the market value \(m\) of the property in question. Thus,
\[ t = b_1 m \text{ and } \]
\[ r = b_2 m. \]

\(b_2\) is a kind of credit parameter; the tighter the market for mortgage money is the larger it will be. \(b_2\) may also depend on the specific characteristics of the house (age, etc.) but we will ignore such refinements here. \(b_1\) is nothing more than the equalized property tax rate (that is, the nominal tax rate

\(^{22}\text{We assume that there are no savings or nonlocal taxes.}\)
times the assessment-value ratio). Both, of course, are positive. Substituting, we obtain

\[ y = \sum p_i x_i + m(b_1 + b_2) + k(d, z_1^*, z_2^*, x). \] (3-3)

Our specification of the transportation expenditure function deserves a comment or two. The inclusion of the work trip length seems unexceptionable. Obviously,

\[ \frac{\partial k}{\partial d} > 0. \] (3-4)

The work trip, however, is by no means the only regular trip taken by the household. John Kain cites a study which suggests that thirty-five to forty percent of the trips originating in the dwelling unit are for shopping, school, or social-recreational purposes. Obviously, the household's total transportation expenditure will be lower if the destinations of such trips are close by. Since \( z^* \) describes the amount of land in the neighborhood devoted to uses which comprise these destinations, it seems sensible to assume

\[ \frac{\partial k}{\partial z_{11}^*} < 0 \quad \text{and} \]

\[ \frac{\partial k}{\partial z_{21}^*} < 0, \] (3-5.1) (3-5.2)

---

23 The distinction between the two tax rates is important because of the wide variation in assessment-value ratios both within and across communities. See, for example, David Black, *Inequalities in Effective Property Tax Rates: A Statistical Study of the City of Boston* (unpublished Ph.D. dissertation, Department of Economics, Massachusetts Institute of Technology, 1967).

where $z_{11}^*$ and $z_{21}^*$ are typical elements of $z_1^*$ and $z_2^*$ respectively. Presumably, the more land in the neighborhood devoted to, let us say, retail establishments, the more variety and hence the fewer shopping trips to nonlocal stores. Finally, to be complete we also include the quantities of ordinary commodities consumed ($x$) as arguments of $k$. In general the more bread a household consumes, the more trips it makes to the bakery. Hence,

$$\frac{\partial k}{\partial x_1} > 0.$$ (3-6)

The second restriction on household behavior is one of time. For purposes of this study we shall suppose that the twenty-four hours of the day can be divided into three groups: work, leisure, and transportation. Thus we may write

$$24 = w + v + h(d, z_1^*, z_2^*, x),$$ (3-7)

where

\begin{align*}
w &= \text{number of hours devoted to work,} \\
h &= \text{the transportation time function.}
\end{align*}

Were we specifying an absolutely general model of consumer behavior, we might wish to make $w$ an endogenous variable. However, such a complication is of rather peripheral relevance to the topic at hand, so we will eschew it and assume $w$ constant. This means that a household's leisure hours ($v$) are determined as a residual as soon as its transportation hours ($h$) are known. Note that the transportation time function
specified here has the same arguments as the transportation cost function described above. The explanation for this is obvious -- to produce a unit of transportation requires in general both time and resource inputs. Reasoning as we did in preceding paragraphs, we shall assume

\[
\frac{\partial h}{\partial d} > 0, \\
\frac{\partial h}{\partial z_{11}} < 0, \\
\frac{\partial h}{\partial z^*_{21}} < 0, \\
\frac{\partial h}{\partial x_1} > 0.
\]

It will be convenient to rewrite (3-7) in the following way:

\[
v = 24 - w - h(d, z^*_1, z^*_2, x) \text{ or } v = v(d, z^*_1, z^*_2, x).
\]

(3-8)

From which it follows that

\[
\frac{\partial v}{\partial d} < 0, \quad (3-9)
\]

\[
\frac{\partial v}{\partial z^*_{11}} > 0, \quad (3-10.1)
\]

\[
\frac{\partial v}{\partial z^*_{21}} > 0, \quad (3-10.2)
\]

\[
\frac{\partial v}{\partial x_1} < 0. \quad (3-11)
\]

Leisure is reduced by increases in commuting distance and additional purchases of ordinary commodities. Leisure is increased when goods and services are provided at more accessible locations.
The reader who is familiar with recent innovations in the theory of the consumer will no doubt feel that the treatment of time presented here scarcely scratches the surface of what is potentially a rather complex subject. The point of this exercise, however, is not to promote the Gary Becker view of the world.\textsuperscript{25} Instead, we are simply trying to come to terms with a frequently observed real-world phenomenon. Nearly all of the critics of urban form in America stress the large amount of time the typical household devotes to intrametropolitan transportation. Supplementing these observations, there is some scholarly work which suggests that it is the time costs rather than monetary costs of commutation which the household finds the most irksome.\textsuperscript{26} The ineluctable conclusion seems to be that the time constraint does affect the location decision, and that therefore it should be included in our model. This we have attempted to do, albeit in a very simple way.

We now return to the auction process discussed above. A useful way to begin our analysis is to select some arbitrary single-family home property and then ask the following question: What is the \textit{maximum} value our consumer will bid for

\textsuperscript{25}The seminal paper on the household as a consumer of time appears to be Gary Becker, "A Theory of the Allocation of Time," \textit{Economic Journal}, 75 (September, 1965).

the particular piece of real estate chosen? As Alonso re-
minds us, the answer to this question is indeterminate unless
one specifies in advance what the consumer's "target" level
of utility is likely to be.27 Consumers with restricted pros-
pcts will bid more for a particular piece of property (in-
come being held constant) than will those who have a wide
menu of residential options (including, perhaps, some in dif-
ferent metropolitan areas). Let us choose, therefore, some
arbitrary utility level $\bar{u}$.28

By rearranging (3-3) we obtain

$$m = \frac{1}{(b_1 + b_2)}[y - \sum p_i x_i - k]. \quad (3-12)$$

The problem of determining the consumer's maximum bid for any
piece of property then becomes one of maximizing (3-12) sub-
ject to the constraint

$$\bar{u} = u(z_1^*, z_2^*, z_1^{**}, z_2^{**}, x, v, c, s). \quad (3-13)$$

27 Alonso, op. cit., p. 59. Much of the analysis which
follows is a simple extension of Alonso's work. Alonso's
mathematics, however, tend to be of the hammer and tongs
variety. We shall be using more economical methods.

28 The choice of $\bar{u}$ here is "arbitrary" only in the sense
that the mathematical results which follow below do not de-
pend on the specific level chosen. In the real world a con-
sumer's "target" level of utility is certainly not arbitrary.
It will depend partly on the level of well-being enjoyed in
the previous period and partly on the level of well-being
which could be enjoyed in other cities. Obviously, this con-
cept may be useful for an analysis of interurban migration.
We shall discuss it in more detail in Chapter V.
Forming the appropriate Lagrangean expression, we obtain

\[ L = \left[ \frac{1}{(b_1 + b_2)} \right] \left[ y - \sum p_i x_i - k \right] - \lambda [\bar{u} - u(z^*_1, z^*_2, z^{**}_1, z^{**}_2, x, v, c, s)]. \] (3-14)

\( \lambda \), of course, is a Lagrangean undetermined multiplier. Since the piece of property on which the bid is to be made has been fixed a priori, the following variables are parametric to the consumer's bidding decision: \( b_1, d, z^*, z^{**}, c \) and \( s \). They vary only when the property is varied. The remaining parameters to the decision (those not associated with the property) are \( b_2, y, p \) and \( \bar{u} \). The decision variables then are the \( x_i \)'s; these are under the control of the consumer and are manipulated to maximize the bid.

The first-order (necessary) conditions for maximizing \( L \) are the following:

\[ \frac{\partial L}{\partial x_1} = \left[ \frac{1}{(b_1 + b_2)} \right] (-p_i - \partial k/\partial x_i) + \lambda [u_1 + u_1 (\partial v/\partial x_1)] = 0; \] (3-15)

\[ \frac{\partial L}{\partial \lambda} = \bar{u} - u(z^*_1, z^*_2, z^{**}_1, z^{**}_2, x, v, c, s) \] (3-16)

If there are \( n \) ordinary commodities, (3-15) and (3-16) together comprise \( n+1 \) equations in \( n+1 \) unknowns -- \( \lambda \) and the \( x_i \)'s. The equilibrium value of leisure may then be found by substituting the equilibrium \( x_i \)'s into (3-8).

Some insights into these conditions may be obtained by
rewriting (3-15) so as to solve for $\lambda$.

\[ \lambda = \frac{p_1 + \partial k/\partial x_i}{(b_1 + b_2)(u_1^5 + u_1^6(\partial v/\partial x_i))}. \quad (3-17) \]

The sign of the numerator is definitely positive by (3-6). The denominator, on the other hand, appears at first glance to be of indeterminate sign because $\partial v/\partial x_i$ is negative (3-11) while $u_1^5$ and $u_1^6$ are positive [(3-2.5), (3-2.6)]. A moment's reflection will reveal, however, that the denominator cannot be negative. If it were, we would be saying that households occasionally consume goods which add less to their well-being than the effort expended to purchase the goods subtracts from it. This is a nonsensical result. For rational consumers, therefore, the denominator as well as the numerator must be positive. It follows that

\[ \lambda > 0. \quad (3-18) \]

If we repeat the calculation for commodity $x_j$, divide the result into (3-17), and rearrange the resulting expression, we produce the following:

\[ \frac{p_1 + \partial k/\partial x_i}{p_j + \partial k/\partial x_j} = \frac{u_1^5 + u_1^6(\partial v/\partial x_i)}{u_j^5 + u_1^6(\partial v/\partial x_j)}. \quad (3-19) \]

This somewhat complicated looking equation is nothing more than a generalization of the familiar rationality condition from consumer theory requiring that the marginal rate of sub-
stitution between any two commodities be equal to their price ratio. The term on the left is the ratio of the marginal costs of the two goods from the consumer's point of view. "Cost" as it is used here includes both "price," as it is conventionally defined, and the out-of-pocket transportation expenditures required to purchase the last unit of the good. The term on the right is a ratio of net marginal utilities. The marginal utility obtained from directly consuming one additional unit of each commodity is adjusted for the loss of leisure attendant to the act of purchasing them. If (3-19) did not hold for a real-world consumer, he would not be behaving "rationally" in that his bid could be increased (for the given utility level) by simply rearranging his purchases.

Let us return now to the maximum bid itself. To distinguish it from the actual amount which the household will pay once the auction is complete, we shall denote this bid by $M$. For every consumer there will be a $M$ associated with each property on which he bids. In the case above, $M$ would be obtained by substituting the equilibrium values of the $x_i$'s into (3-12). The next question is a natural one. How would $M$ change if one or more of the property parameters changed? To answer this question it is convenient to formalize the relationship between $M$ and the various parameters in the consumer bidding problem by writing it as a general function. 29

29 The reader familiar with Alonso's work will note that (3-20) is a generalization of his residential bid price curves. *Op. cit.*, Chapter IV.
Thus,

$$M = M(z^*_1, z^*_2, z^{**}_1, z^{**}_2, d, c, s, b_1, u). \quad (3-20)$$

Some of the parameters listed earlier have not been included as formal arguments in (3-20) since they play no interesting role in the analysis which follows. One may think of them as being embodied in the specific functional form of $M$.

What are the signs of the various partial derivatives of (3-20)? An economical way of obtaining the necessary information is to make use of the Envelope Theorem. In the context of the problem at hand this theorem states that

$$\frac{\partial M}{\partial \alpha} = \frac{\partial L}{\partial \alpha}, \quad (3-21)$$

where $\alpha$ is any variable parametric to the bid-maximizing process and $L$ is the Lagrangean function defined in (3-14). An interesting initial application of (3-21) is the following:

$$\frac{\partial M}{\partial u} = \frac{\partial L}{\partial u} = -\lambda < 0. \quad (3-22)$$

(3-22) informs us that an increase in the consumer's target or expected well-being causes $M$ to fall (other parameters held constant). This conclusion is a generalization of Alonso's result showing that lower residential bid price curves correspond to higher levels of utility.\(^{30}\)

Repeated application of (3-21) produces a not unexpected

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\(^{30}\)Alonso, op. cit., p. 69.
set of results:

\[\frac{\partial M}{\partial b_1} = \frac{1}{(b_1 + b_2)}(-ak/\partial d)\]

\[+ \lambda u_1^6(\partial v/\partial d) < 0; \quad (3-23)\]

[using (3-4, (3-18), (3-2.6) and 3-9)]

\[\frac{\partial M}{\partial c_1} = \lambda u_1^7 > 0; \quad (3-24)\]

[using (3-2.7) and 3-18)]

\[\frac{\partial M}{\partial s_1} = \lambda u_1^8 > 0; \quad (3-25)\]

[using (3-2.8) and (3-18)]

\[\frac{\partial M}{\partial b_1} = -\left[\frac{1}{(b_1 + b_2)}\right]^2[y - \sum p_i x_i - k] < 0; \quad (3-26)\]

[using (3-3)]

\[\frac{\partial M}{\partial z_{11}^*} = \frac{1}{(b_1 + b_2)}(-ak/\partial z_{11}^*)\]

\[+ \lambda \left[u_1^1 + u_1^6(\partial v/\partial z_{11}^*)\right] > 0; \quad (3-27)\]

[using (3-5.1), (3-18), (3-2.1), (3-2.6)

and (3-10.1)]

---

31 This result corresponds to Alonso's finding that residential bid price curves slope downward with distance, op. cit., p. 70. Note, however, that unlike Alonso we have allowed all of the decision variables to adjust to the parameter change, not just a subset of them. Alonso in his proof holds constant the quantity of land purchased. Since land quantity is a decision variable in his model, his is not a mutatis mutandis result.

In words (3-24), (3-25), (3-27) and (3-29) tell us that the maximum bid a household will make on a particular piece of property varies directly with the quality of the property itself, the quality of the public services available in the community where the property is located, and the proximity of the property to land uses which enhance its immediate neighborhood. (3-23), (3-26) and (3-30) tell us that the maximum bid varies inversely with distance from the workplace, the local (equalized) tax rate, and the proximity of the property to land uses which neither add amenities to the neighborhood nor serve any convenience function. Finally, (3-28) tells us that those uses which are unattractive but which provide frequently used goods and services have an indeterminate effect on the maximum bid.

In order to apply (3-27) - (3-30) to any real-world situation it is important to recall that the following side condition holds:

\[
\frac{\partial M}{\partial z_2^*} = \frac{1}{(b_1 + b_2)}(-\frac{\partial k}{\partial z_2^*})
+ \lambda [u_1^2 + u_1^6(\frac{\partial u}{\partial z_2^*})] \geq 0;
\]

[using (3-5.2), (3-18), (3-2.2), (3-2.6) and (3-10.2)]

\[
\frac{\partial M}{\partial z_{11}} = \lambda u_1^3 > 0;
\]

[using (3-18) and (3-2.3)]

\[
\frac{\partial M}{\partial z_{21}^*} = \lambda u_1^4 < 0;
\]

[using (3-18) and (3-2.4)]
$A = \sum z_{11}^* + \sum z_{21}^* + \sum z_{11}^{**} + \sum z_{21}^{**}$, \hfill (3-31)

where $A$ is the area of the neighborhood. (3-31) is merely a mathematical expression of our earlier assumption that the land-use classification system used by our consumer is exhaustive and nonoverlapping. Since we have assumed that the household rather mechanically selects a set of neighborhood boundaries which are then applied to all prospective residential sites, $A$ is constant across properties.

An important implication of (3-31) is that it makes no sense to speak of the effect of a small increase in (say) $z_{12}^*$ on the maximum bid of the consumer without at the same time indicating the nature of the land use being replaced by that increment. A similar caveat applies to interproperty comparisons. It follows that neighborhood-induced bid differences across properties at some point in time or across time for some particular piece of property will be composites of the partial effects given in (3-27) - (3-30). For example if one (area) unit of $z_{11}^{**}$ were converted to one unit of $z_{21}^{**}$ in the neighborhood of some property, our consumer would change his bid for this parcel by an amount equal to $\frac{\partial M}{\partial z_{21}^{**}} - \frac{\partial M}{\partial z_{11}^{**}}$. This result has some implications for model specification and we shall return to it in the next chapter.

\[33\text{ The reader will recall that a similar point was made earlier when we discussed "desirable" and "undesirable" land uses.}\]
C. Consumer Bids and Market Valuation

(3-23) through (3-30) constitute the essential results of this chapter's mathematical analysis. We shall have much occasion to use them in the following chapter -- both to guide model specification and to interpret our empirical results. As one might expect, it will be assumed that the results we have obtained for the bidding behavior of a single consumer can be used to predict the pattern of final valuations produced by the housing auction process. For example, we will make the inference that houses with many rooms ought to sell for more than those with few rooms. This seems reasonable because we have shown that the typical household will bid more for a house with many rooms than it will for a house with few rooms (3-24).

On the surface this extension seems unexceptionable. In fact, however, the precise way which the housing and land markets sort out the various individual bids to produce a final valuation for all properties and a final assignment for all bidders is something of a black box. Alonso struggled with the problem in his seminal book and came up with a solution which seemed fairly satisfactory for the simple consumer choice model with which he was working. Unfortunately, the calculus which he describes is not easily extended to the much richer model we are using here. It would seem, however, that this

\[34\] Alonso, op. cit., Chapter 5. Not everyone has been satisfied with even this solution. For an impassioned dissent see H. G. Berkman, "The Game Theory of Land Use Determination," Land Economics, 41 (February, 1965).
extension is not really necessary to accomplish the objectives of this study. Alonso was interested in explaining the absolute value (or price) of land at every point in his space economy. This study, on the other hand, because it focuses on externalities, is only concerned with value or price differences within that economy. Why does one property or set of properties have a higher value than does another? To answer this question we need not have a full-blown theory of urban land valuation. Instead, simple inferences from the theory of the household, like those described above, would seem to suffice.

It is possible, however, to raise several a priori objections to even this modest proposition. Heretofore we have been implicitly assuming that all consumers have identical incomes and utility functions and that all face the same set of residential location options. Suppose one or more of these assumptions does not hold in the real world. What are the likely empirical consequences? Let us consider some possibilities.

Suppose first of all that consumers have the same utility function and residential choice set but their incomes differ. It follows that the competition for sites among the members of a particular income class guarantees that in equilibrium all (local) members of that class will be at an identical level of utility. At the same time this competition ensures that each member of the class is paying the maximum value possible given the characteristics of his particular
piece of property and the common (class) equilibrium level of well-being.

To see that each of these assertions is true consider a price below this maximum for some piece of property. If a household succeeded in purchasing at this low price, it would subsequently enjoy a higher level of utility than the other members of its class. However, if the auction market is working properly, such a sale will never be consummated. Additional members of the class (perhaps from other cities) will enter the auction looking for a bargain. They will bid on the property in question -- thereby raising its price until the household which actually occupies the site is at the same utility level as everyone else in its income class. Moreover, if the households which participate in this competition are "rational" in the sense that at any point in time one cannot rearrange their purchases so as to make them better off, the equilibrium price paid will in fact be the maximum possible price bid consistent with the common utility and income level.

Our conclusion therefore is that taste homogeneity and competition impose a certain discipline on the auction process which ensures that the prices households actually pay will be fairly close approximations to the maximum bids of their income class for the properties which they occupy. If we make the further (not unreasonable) assumption that each household's "target" utility level is at least partially determined by its previous levels of well-being, then one
would expect repeated land auctions of the type we have been
describing to induce each of the individual "target" utility
levels to converge gradually to one of the common achieved
class levels. Given these assumptions it follows that the
model of consumer bidding behavior developed in this chapter
ought to be useful in explaining price differences among prop-
erties occupied by the same income class.

But what about price differences among properties
occupied by different income classes? There probably exist
special cases where one would expect income differences to be
of no consequence. In general, however, these differences
will be associated with further differences in marginal rates
of substitution among the various pairs of components in the
housing package. Thus one would ordinarily expect the marginal
value of an additional room to differ in equilibrium from one
income class to another. The precise extent of the divergence
will depend, of course, on the specific functional form of the
utility function in question and on the equilibrium level of well-
being achieved by the various income classes. The essential
point, however, is that a diversity of incomes with utility
functions the same would seem to be little different in its
consequences from a diversity of utility functions with in-

35If at the same time there is free migration into and
out of the city, the common local achieved level of utility
will gravitate toward some national figure which holds for all
cities. A model in which this occurs is presented in Chapter
V. Naturally the speed at which all these adjustments occur
in the real world will depend on various institutional factors --
such as information, transaction and moving costs and the degree
of geographic mobility.
comes the same. In both cases, different people can be ex-
pected to attach different valuations to the separate com-
ponents of the housing package. Where all households have
identical utility functions and incomes, on the other hand,
one expects these valuations to be identical as well. Ob-
viously, the model developed in the chapter will be more
useful in the latter case than in the former.

Let us explore this household diversity question in more
detail. Suppose for concreteness that all households have
the same incomes but that their tastes differ. What specif-
ic differences might this make? It is unlikely that differ-
ent households will have markedly different tastes about the
structure or lot characteristics of a property. For most
households more rooms will always be preferred to less, though,
of course, the intensity of the feeling will vary with family
size. It is quite possible, however, that there are major
taste differences with respect to neighborhood. Some house-
holds might violently object to living next door to an apart-
ment house while others would not give it a second thought.

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36Note there are several different ways in which tastes
might differ from one consumer to another. For one thing,
different consumers might use different neighborhood concepts.
One household might be concerned about all that goes on within
a one mile radius of its dwelling unit, while another might
worry only about what happens on its particular block. Alter-
natively, consumers might differ in terms of the land-use taxon-
omy which they find relevant. For the purposes of the dis-
cussion which follows let us ignore these types of taste di-
versities and just focus upon differences in marginal rates
of substitution across a common set of land-use categories
applied to a common neighborhood area.
To simplify our discussion of this problem consider a single-family home one block away from a glue factory, and two consumers, A and B, with identical incomes.\(^{37}\) From the point of view of consumer A the presence of this glue factory is a major blight on the neighborhood which cannot be ignored. Consumer B, on the other hand, is indifferent to this particular land use or perhaps even favorably disposed towards it.\(^{38}\) As James Q. Wilson puts it, "One man's ugliness is another man's home."\(^{39}\) Obviously, if there are enough individuals like B, the house in question might not sell at a significant discount relative to other houses which are identical in every way except for the proximity to the glue factory. It is equally obvious that houses near glue factories will tend to be occupied by consumers more like B than A. Should it come to pass, therefore, that a researcher can find no significant price difference between houses near glue factories and those far away, it would not necessarily follow that everybody was indifferent to glue factories. This would only be one possible

\(^{37}\)The glue factory has a long history of appearances in discussions of this kind. The first writer to single out this particular villain appears to be Robert Haig in "Toward an Understanding of the Metropolis: The Assignment of Activities to Areas in Urban Regions," Quarterly Journal of Economics, 40 (May, 1926), p. 433.

\(^{38}\)The existence of such individuals is not altogether fanciful. Jane Jacobs rather likes glue factories, op. cit., p. 232.

explanation. Another would be that there are lots of consumers around like Mr. B **relative to the number of sites near glue factories** and that the relevant urban property markets were efficient enough to ensure that individuals with such tastes actually inhabited these sites.\(^4\) **Note** that this last possibility does not seem to require large numbers of consumers like B **relative to the number of consumers like A**. Thus there could be a kind of consensus about the undesirability of glue factories, and the researcher still might not find that houses located near these uses sell at a discount.

Consider now the opposite case. Suppose the researcher does find a significant price differential. What can he conclude then? Obviously, he cannot infer that **everyone** dislikes glue factories. It is clear, nonetheless, that **some** people dislike them. In order to make a guess about the ubiquity of this sentiment it is necessary to have information about the number of sites near glue factories relative to the number of sites in the market as a whole. Since such data is apt to be unavailable, our researcher is probably going to be left somewhat in the dark about the true strength of the "consensus" which he has stumbled upon.

What can we conclude from all of this? Admittedly, things are rather untidy from a theoretical point of view. The essential point however seems to be that taste and income differ-

\(^4\) This was the conclusion reached by C. Davis, J. Crecine and R. Jackson in "Urban Property Markets: Some Empirical Results and Their Implications for Municipal Zoning," *Journal of Law and Economics*, X (October, 1967).
ences among consumers may be sufficiently great to obliterate the presumed relationship between market price and neighborhood (or even property) characteristics. If this is true, then a heuristic application of this chapter's principal results, (3-23) through (3-30), to real-world data will bear no fruit. On the other hand, there is no necessity about this. The consumer diversity objection to the use of our bidding model to predict house price differences is really only hypothetical. One can only judge its probable seriousness in the light of some actual estimations. This we shall do in the next chapter.
CHAPTER IV

An Empirical Study of Residential Property Values in a Suburban Area

In Chapter II we noted that economists have enjoyed only indifferent success in their attempts to quantify the impact of neighborhood on residential property values. It was apparent, however, from our discussion there that most of the relevant studies suffered from rather serious methodological flaws. The most ubiquitous shortcoming was the absence of variables which quantified neighborhood "character" or "quality" in a reasonable way. In most cases researchers were forced to resort to proxies which could only capture the impact of neighborhood in the crudest fashion.

In the present chapter we seek to improve on the performance of our predecessors. Our specific objective will be to reexamine the relationship between neighborhood quality and residential property values by exploiting heretofore unused data sources. As the reader will discover, the experiments with these new variables were quite successful. Indeed, this study comes up strongly in favor of the proposition that neighborhood or community "aesthetics" are an important determinant of residential property values. This conclusion then leads us naturally into Chapter V where we will formally analyze some of the public policy issues which neighborhood externalities raise in the real world.
A. A General Specification

We will be analyzing the market for suburban, single-family homes in the Boston metropolitan area. As one might surmise from the preceding chapter, we shall find it expedient to think of the market process which allocates this particular type of housing unit to households as a kind of auction. More concretely, we shall be supposing that in 1960 all of the homes in the Boston suburban area were auctioned off to prospective residents. The results of this event were, first, a distribution of households among communities and residences and, second, a set of market values for the various structure-lot-neighborhood-community combinations available. This study shall focus primarily on the latter set of outcomes.

A natural first question to ask is why the single-family-home market was chosen. Partially the choice was a matter of convenience; the available data for such dwelling units seemed more respectable than the comparable figures for dwelling units in multiple-unit structures. The principal reason for this difference is that the Census of Housing includes a very heterogeneous collection of dwelling unit types in its category "renter-occupied units." Indeed, some of the units in this category are single-family homes which happen not to be owner-occupied. The Census category for which value data is available -- "owner-occupied dwelling units in single-unit structures" -- is, on the other hand, a fairly homogeneous one.¹

¹For additional discussion of this and related matters see the Technical Appendix.
A more important reason for concentrating on the single-family home market is that this is where one would expect the impact of neighborhood externalities to be the strongest. Renters are thought to have only an ephemeral attachment to the dwelling unit and neighborhood in which they currently live — at least compared to owner-occupiers. Consequently, it seems likely that undesirable neighborhood features will influence rents less strongly than they will influence home values. Although this is hardly a proven hypothesis, it has apparently been found satisfactory as a working assumption by several generations of zoning code authors. Nearly all such laws are much more protective of homes than of apartments. In short, therefore, a priori evidence seems to suggest that the single-family home market is the logical place to begin an empirical study of neighborhood externalities.

Let us return to our real estate auction. A useful way of summarizing the valuation outcomes of this auction is to use a simple multiple regression technique in which market value is regressed on the characteristics of the property being sold. Using the notation of the previous chapter, we may express this general relationship (in linear form) as

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2 In most zoning statutes the regulations governing conditional uses are stricter for single-family districts than for multiple-family districts. Newton, a suburb of Boston and one of the communities in our sample, has a fairly typical ordinance in this regard. Its list of acceptable conditional uses for a particular residential district type increases monotonically with the maximum number of dwelling units per structure allowed in the district. City of Newton, The Revised Ordinances of the City of Newton, Massachusetts, Chapter 25 (Newton: Published by the Board of Alderman, 1969).
follows:  

\[ MV = a_0 + \sum a_{1i} c_i + \sum a_{2i} d_i + \sum a_{3i} s_i + a_4 b_i + \sum a_{5i} z_i + e, \quad (4-1) \]

where

\[ MV = \text{market value}, \]
\[ c_i = \text{a structure or lot characteristic variable}, \]
\[ d_i = \text{an employment accessibility variable}, \]
\[ s_i = \text{a community public service variable}, \]
\[ b_i = \text{the local equalized tax rate}, \]
\[ z_i = \text{a neighborhood land-use variable}, \]
\[ a_0 = \text{a constant term}, \]
\[ a_{ij} = \text{a regression coefficient}, \]
\[ e = \text{a stochastic term}. \]

Several remarks need to be made about (4-1). First of all, it is obvious that the independent variables included here are all taken from our analysis of consumer bidding behavior in the previous chapter. Naturally, we expect those variables which affect consumer bids also to affect final market prices in the same direction. At the end of Chapter III we presented some tentative arguments to explain why we might expect these correspondences.

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3 Note the similarity between (4-1) and the so-called "hedonic" regressions used by Griliches and others to "decompose" automobile prices. See, for example, F. Fisher, Z. Griliches, and C. Kaysen, "The Costs of Automobile Model Changes Since 1949," Journal of Political Economy, LXX (October, 1962).
A second point concerns the level of data aggregation to which (4-1) could conceivably apply. Thus far we have spoken of this relationship as if it applied only to individual properties. It would seem, however, that it could also be used to analyze aggregate data in which each observation corresponded to a separate geographic area. Under this alternative interpretation, the dependent and independent variables in (4-1) become submarket averages. This generalization of the relationship is very important for the current study because the only data available is on a community basis. This means that in the present study we shall be estimating the relationship between the "average" (actually the median) value of homes in a "typical" Boston suburb and the "average" structure, lot, accessibility, and neighborhood characteristics of the same units.

Pursuing this matter a bit further, it is important to be clear about the operational meaning to be attached to the term "average neighborhood quality." Ideally, we would like to have land-use data for the "typical" single-family home neighborhood in each community, having defined "neighborhood" in some reasonable geographic way a priori. Such data would theoretically be obtained by averaging the neighborhood land-use distributions for all single-family homes in a community -- thereby obtaining a composite distribution. Multiple observations would then be generated by repeating this calculation for each community in the sample. Regrettably, figures this refined do not exist. Moreover, the prerequisite data acqui-
sition seems too costly and time-consuming for a single re-
searcher to undertake. A task force would be necessary, and
one doubts whether research money allocated to such an effort
would be well-spent.

Fortunately, other data is available which is only
slightly inferior to this ideal -- namely, aggregate land-use
data for entire communities. The basic idea here is that the
percentage distribution of a community's total land among the
appropriate land-use categories ought to approximate roughly
the percentage distribution of neighborhood land among these
same categories for the "typical" single-family home in the
community. This does not seem to be a particularly unreason-
able assumption, though it is possible to quibble about the
implied treatment of properties located very close to community
boundary lines. One might also raise the objection that the
use of these aggregate distributions does not allow the re-
searcher to take into account proximity differences within
the separate communities. For example, two communities might
have identical overall land-use distributions with one having
homes adjoining factories and the other having homes adjoining
only parks, churches, and schools. Naturally, one would expect
rather different market valuations in the two cases. Our re-
response to these criticisms is simply that if they are really
serious they will significantly affect our results. The proof
of the pudding is in the eating.

B. Variables and Database

Our sample consisted of observations on 46 suburban cities
and towns in the Boston Standard Metropolitan Statistical Area. These are listed in the Technical Appendix. Our choice of suburbs was partially determined by the availability of data. Many small towns were not used because the Census data on them was incomplete. These omissions may have reduced the generality of our results since small suburbs may differ systematically from larger ones. However, there was nothing that could be done about this. In addition, all cities and towns outside the Boston SMSA were excluded categorically. We restricted our sample in this way because we wished to have the residents of its component communities participate in the same geographic labor market. Many of Boston's outer suburbs are really more affiliated with the older industrial cities which ring Boston than with Boston itself. These centers -- Lowell, Brockton, Lawrence and Haverhill -- now contain a great deal of low-wage employment. In general, low wages mean low residential property values, other things equal. To control for this effect only those towns which were clearly oriented towards the Boston economy were used.

In spite of these restrictions our sample is a very diverse one. It contains the full range of suburban possibilities outlined by Wood and others.\(^4\) In addition to a number of middle-class bedroom communities of the type celebrated in story and song, our sample also includes manufacturing suburbs (Everett, Lawrence, Brockton, Haverhill).

Cambridge), ethnic enclaves (Somerville, Watertown), university towns (Wellesley, Waltham, Cambridge), and several older, high-income suburbs (Newton, Brookline). This diversity, of course, is absolutely essential for a study of neighborhood externalities. If neighborhoods did not vary a great deal across communities, one would expect their influence on price to be swamped by other factors.

Let us now consider the specific variables to be used in the estimation. For convenience we will organize our discussion around the categories used earlier. The discussion of each variable will be brief and fairly general. A more detailed description of the variables used and their sources is presented in the Technical Appendix. In all cases the variables to be discussed will refer to the single-family housing stock of entire communities rather than to individual properties.

**Structure and Lot Variables**

In the previous chapter we demonstrated how the structure and lot characteristics of a piece of property affect the amount the typical consumer wishes to bid on it (3-24). Perhaps the single most important element here is size. Our model suggests that the larger are the structure and lot components of the homes in a suburb the higher will be their average market price. The two variables we used to capture these effects are the average lot area and the average number of rooms for single-family homes in the community. In addition to size, one expects age to exert some independent (negative)
influence. Older housing is usually less desirable (holding condition constant) because its interior and exterior features are typically "old-fashioned." The variable we used to control for this effect was the average age of owner-occupied dwelling units. Finally, the condition of the houses in a community and the frequency with which certain plumbing facilities are absent ought to affect market price. We attempted to control for these influences by including a proportion sound, with all facilities variable (for owner-occupied dwelling units). If all the owner-occupied dwelling units in a particular community are "sound" (as defined by the Bureau of the Census) and all have complete plumbing facilities (private toilet and bath, hot and cold running water), then this variable will take on the value "1." If not, it will take on some (nonnegative) value less than one. This may seem to be a fairly crude way of capturing what is potentially a multitude of effects. It turns out, however, not to matter very much for this study because the vast majority of the units in all communities (generally well over 90 percent) are both in sound condition and possess all the necessary plumbing. Hence the number of units having some of these characteristics but not others is necessarily small and it would seem that we need not worry about them.

Employment Accessibility

The distance from a piece of property to the workplace

\[ ^5 \text{For a discussion of the difference between the set of "single-family homes" and the set of "owner-occupied dwelling units" in a community see the Technical Appendix.} \]
affects the maximum amount which the consumer feels he can bid for the parcel. This we noted in the previous chapter. In addition, if the distance is great enough, the household may not bid on the property at all. These two effects together suggest that the closer a community is to employment centers the higher its average residential market valuation ought to be (other things equal, of course). Propinquity to employment means both more bids and higher bids, each of which will exert an independent positive influence on price.

We attempted to capture this accessibility effect by introducing two different variables into our equation. The first of these is road distance to the central business district (CBD) from the geographic center of the community. In one form or another the distance to the CBD has figured prominently in urban land price determination studies for more than thirty years. We have chosen the road distance variant because it seemed reasonable and was comparatively easy to obtain. Note that our analysis of consumer bidding behavior in the previous chapter seems to suggest that a distance variable is theoretically more appropriate than a time variable (once a transportation mode has been selected) since the former can capture the effect of both travel time and travel expenditure simultaneously while the latter obviously cannot. In practice, of course, distance, travel time and travel ex-

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*An important early study which focused considerable attention on this variable is Homer Hoyt's One Hundred Years of Land Values in Chicago (Chicago: University of Chicago Libraries, 1933).*
penditure are usually so highly intercorrelated that any one of them can serve as an acceptable proxy for any of the others.

The second employment accessibility variable used was the following ratio:

\[
\frac{\text{total employment in the community}}{\text{total single-family homes in the community}}
\]

The purpose of this variable is to capture the influence of proximity to local (as opposed to central city) employment. This is an important factor in the present study because many of the communities in our sample are substantial employment centers in their own right. It seemed appropriate to "normalize" the quantity of local employment to control for community size. A thousand jobs in a residential community with many homes will have a different effect on average housing price than will the same thousand jobs in a community with very few homes.

What sign do we expect for the local employment coefficient? One might at first suppose it to be indeterminate. Accessibility to jobs should, of course, raise property values. However, the existence of many jobs in a community also implies a large concentration of commercial and industrial land uses which in turn should lower property values through their neighborhood externality effects. The resultant of these two forces could, presumably, be either positive or negative. This argument would be valid were it not the case that the neighborhood effects are being controlled for separately in our equation. Our conclusion therefore is that an increase in (normalized)
local employment should raise property values, ceteris paribus.

Land Use

In the previous chapter we found it advantageous to analyze household bidding behavior using the following heuristic classification system:

1. desirable, convenience uses ($z_1^*$)

2. undesirable, convenience uses ($z_2^*$)

3. desirable, nonconvenience uses ($z_{1**}$)

4. undesirable, nonconvenience uses ($z_{2**}$).

This taxonomy, though useful for us, is not the kind one ordinarily encounters in the city planning or zoning literature. The typical zoning ordinance classifies activities by industry, process, or structure. Most land-use data sources (including the one to be used in the study) follow the same procedure.

Given this situation, it seems important to attempt to bridge the gap between the two types of taxonomy. By so doing, we shall be able to use our formal model of consumer bidding behavior to analyze land uses as the typical zoning ordinance sees them. Our results, moreover, will be in terms of categories which are in some sense "natural" and thus easily understood. The specific strategy we shall follow is to present a simple set of zoning activity categories and then
attempt to fit each category into the desirability-convenience framework outlined in 1 through 4 above.

A typical set of zoning district classes is the following:

A. Residential
   A1. Single-Family
   A2. Multiple-Family
B. Commercial (or Business)
   B1. Local
   B2. General
C. Industrial
   C1. Light (or Restricted)
   C2. Heavy (or General)

In addition there are two other general categories of land use which are controlled in one way or another by most zoning ordinances but for which special districts are not usually set up:

D. Institutional
E. Agricultural and Vacant Land.

Naturally, A through E above do not correspond exactly to the classifications used by every city. This set of categories does, however, constitute the framework of virtually all zoning ordinances; cities will usually differ only in the extent to which they flesh out this skeleton with additional subcategories. A very common way of doing this is to break down one or more of the classes given above into "bulk" sub-
categories which differ among themselves only in the stringency of their building and lot size requirements. Very early zoning statutes did not contain these complexities but recent years have seen their proliferation.

In this study we shall ignore all such refinements -- primarily to keep the set of independent variables to a manageable size. Since it seemed unlikely that the aggregated data we were using would permit us to make very close distinctions among a large number of land-use categories anyway this limitation did not seem to be a serious one.

We shall examine the land uses listed above one at a time. Our objective will be to determine the probable strength and direction of the effect of each on single-family home property values. A through E constitutes an exhaustive classification; hence, it is econometrically incorrect to include all types of land use in the regression equation if at the same time you include a constant term. It did not seem reasonable to drop the constant term on this account alone so it was retained

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7 Boston, for example, has two single-family districts which differ only in that one permits a higher Floor-Area Ratio and a smaller minimum lot size than does the other. City of Boston, Boston Zoning Code and Enabling Act (Boston: City of Boston Printing Section, 1968), pp. 8, 50.


and one of the land-use variables was dropped instead.\textsuperscript{10} We chose single-family homes to be the "numeraire" land use. Operationally, this choice meant that in the present study we tried to determine how average single-family property values varied across a set of communities whose land-use distributions diverged in various ways from that of an "ideal" community which consists of nothing but single-family homes. Given this formulation, the coefficients of the included land uses measure \textit{composite} effects of the sort discussed when we analyzed the influence of neighborhood changes on consumer bids in the previous chapter (3-32). For example, the coefficient of land use $z_1$ in (4-1) is a measure of the marginal change in average community home values brought about by converting one percent of a community's land from single-family homes to $z_1$. In the pages which follow we shall refer to this price change as the "net effect" or "net influence" of the land-use change.

\textbf{Multiple-family} land uses in our sample include two-family homes, "three-deckers," and modern apartment complexes.\textsuperscript{11} All would seem to fall naturally into class 4. They serve no particular convenience function and they are usually thought to be undesirable additions to single-family neighborhoods for

\textsuperscript{10}This is a standard procedure for dealing with dummy variables. A. Goldberger, \textit{Econometric Theory} (New York: John Wiley and Sons, Inc., 1964), p. 221.

\textsuperscript{11}For a more complete listing of the components of all our land-use categories and a discussion of the classification procedure see the Technical Appendix.
both amenity and ethnocentric reasons.\textsuperscript{12} If one examines any real-world zoning disputes in which homeowners are trying to keep multiple-family structures out of their neighborhood or community, it is fairly clear that class, ethnic, and racial considerations play as big a role as the probable appearance of the structures. In this study we shall not attempt to sort out these two effects. Since both probably operate in the same direction (there were few luxury, high-rise apartment buildings in suburban Boston in 1960) and since the proportion of Blacks (the most "undesirable" minority) is very small in the Boston metropolitan area and in each of the sample communities, our overall results should not be much affected by this omission.

Another frequently-heard objection to the construction of multiple-family structures in suburban areas is the burden they will allegedly impose upon the local public sector, particularly the school system.\textsuperscript{13} In this study we will attempt to control for this influence by including public service and tax variables in our pricing equation. We shall, however, defer

\textsuperscript{12}Judicial opinions abound in pejorative references to apartment houses. Some particularly choice invective may be found in Justice Sutherland's famous opinion in Village of Euclid v. Ambler Realty Co., 272 U.S. 375 (1926). A somewhat more positive (but minority) view may be found in Appeal of Borden, 87 Atlantic (2d) 465 (1952). The opinion in this last case was obviously influenced by the postwar housing shortage and baby boom.

\textsuperscript{13}The legal status of such arguments is still in doubt. Norman Williams observes that there are many cases on both sides of the question. \textit{The Structure of Urban Zoning} (New York: Buttenheim Publishing Corporation, 1966), p. 51.
a detailed discussion of these variables until a bit later in the chapter because the issues raised by their inclusion are rather complex.

Our overall conclusion then is that multiple-family land uses probably exert a negative net influence on price [using (3-27) and (3-30)] due to the neighborhood externalities which they generate. As indicated above, this conclusion abstracts from all tax and expenditure questions.

Commercial land uses as they are conventionally defined would seem to fall largely into class 2. One thinks immediately of "Ma and Pa" grocery stores. There is, however, some ambiguity about this nomenclature; certain activities which one could conceivably designate as "commercial" -- such as wholesaling or warehousing -- rather clearly belong in class 4. Finally, to complicate things even more there are many "commercial" uses which fall midway between these two extremes.

Zoning codes confronting this diversity have tended to respond in two ways. Those "commercial" uses which are land-intensive, which generate common-law nuisances, and which serve no local convenience function are frequently confined to industrial districts. We shall follow this practice and de-

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14 Here and in the rest of the chapter we will assume that single-family homes are in class 1 use. They enhance a neighborhood physically and they provide readily accessible social relationships.

15 For example, Boston's zoning code tends to restrict wholesaling, storage, and transportation uses to industrial districts, op. cit., pp. 29-30, 32-33. Newton, on the other hand, places many of these activities in various kinds of "Business" district, op. cit., p. 21.
fine wholesale, public utility, and transportation uses to be "industrial." The uses which remain in our commercial category are retail, service, or office activities. Most zoning codes try to handle these by further dividing their commercial classification into "local" and "general" subclassifications. Ma and Pa grocery stores go in the former; automobile dealerships, funeral homes, large office complexes, and animal hospitals go in the latter. Unfortunately, our land-use data was not refined enough to permit the inclusion of two distinct commercial variables in our regression. As a result we had to improvise.

It seemed likely that all communities would support some local commercial establishments but that only a few of the largest (and oldest) would contain significant amounts of general commercial activity. This suggested that the mathematical relationship between average market price and the proportion of a community's land devoted to (nondifferentiated) commercial activity might be nonlinear with a second derivative which is everywhere negative. The two possible general forms of such a relationship are shown graphically in Figures IV-1 and IV-2. Note that in both cases the price change induced by a one unit increase in the proportion of commercial land (brought about by a corresponding single-family reduction) is lower algebraically than the one which preceded it. This would be due both to a higher marginal proportion of general commercial activity as total commercial activity increases (noted above) and to diminishing marginal travel cost savings to
additional increments of local commercial activity.

But which of the two general functional forms is likely to be the true one? This is a question which cannot be settled theoretically. Recall that in the previous chapter we discovered that class 2 land uses had an indeterminate effect on household bids (3-28). Their influence on market price is presumably the same. Thus, the initial slope of the price-commercial land relationship [at (0,0) assuming the function to be homogeneous] may be either positive or negative. Substituting the first few acres of local commercial activity for single-family homes may raise property values in the community rather than lower them. Either result is theoretically permissible.

There is, however, some empirical evidence which can be brought to bear on this question. Casual inspection of the "New Town" literature suggests that local commercial activity is important enough to such enterprises to be included in them in spite of adverse neighborhood effects. Columbia, Maryland, for example, has a hierarchy of commercial services. Some are located at the neighborhood level and are within walking distance of every house. Others are located at the village level and still others are only to be found "downtown."16 This careful attention to shopping accessibility by a profit-maximizing entrepreneur (who was also counseled by eminent

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social scientists) suggests that a restricted amount of commercial activity may well raise total community residential property values even while lowering the value of those homes immediately adjacent to it. Commercial and residential land uses in Reston, America's other important "New Town," inter-penetrate in a similar way and for similar reasons. All of this evidence suggests that Figure IV-1 depicts the more probable relationship.

Our research strategy will be to include both a linear and a quadratic commercial term in (4-1). The arguments in the previous two paragraphs suggest that the sign of the squared term should be negative (producing a negative second derivative) and the sign of the linear term should be positive (producing a positive initial slope).

Industrial land obviously belongs in class 4. Included here are all of the more obnoxious land uses: factories, warehouses, railroad yards, truck depots, quarries, power plants, etc. Many zoning statutes distinguish between "light" and "heavy" industrial activities on the basis of various nuisance criteria. Unfortunately, our data did not enable us to separate these two types of use in our estimations. We were reduced perforce to a single industrial variable. This limitation did not seem to be a particularly serious one since both industrial subcategories operate on price in the same direction. It is only the strength of their effects which is

likely to differ. The situation is thus rather different from the commercial specification problem we faced above. There the two use subcategories could conceivably influence price in different directions, a contingency which had to be taken account of in the specification.

It is important to observe that our remarks concerning the relationship between industrial land and community property values refer only to the neighborhood externality effects. The presumed positive relationship between manufacturing activity and property values which operates through local tax rates is being held constant. Recall our discussion of a similar problem with respect to multiple-family uses.

We conclude that converting land from single-family to industrial use will lower average single-family home property values [using (3-27) and (3-30)] if local employment and taxes are held constant. The sign of the industrial land coefficient should therefore be the same as the sign of the multiple-family coefficient and for essentially the same reasons. One expects, however, the industrial coefficient to be greater in absolute value than the multiple-family coefficient because industrial uses are obviously the more undesirable.

**Institutional** land uses include churches, schools, hospitals, museums, and public buildings. Virtually none generate important nuisances and most are comparatively
attractive in appearance. In our schema they would seem to belong in classes 1 and 3. We observed in (3-27) and (3-29) that uses in these classes should have a generally favorable effect on property values. However, the specific problem which concerns us here is not whether institutional land uses raise property values more than other uses but specifically whether they raise them more than single-family uses do. If so, then their net effect on price will be positive. If not, it will be negative.

There can be no a priori answer to this question. Many institutional land uses could very well have a positive net influence on the community's single-family property values. Universities may have this effect because of the status they confer on a community and the cultural facilities which they provide. Some local institutional uses such as churches and schools probably have similar potency. Profit-maximizing suburban developers have frequently been known to donate school sites to the communities they were developing. In

There have been occasional attempts on the part of communities to exclude these uses. The usual argument has been that institutional uses generate traffic. A typical case is Roman Catholic Welfare Corporation v. Piedmont, 289 Pacific (2d) 438, 1955. Here a small community attempted to prevent the construction of a Catholic school in a single-family neighborhood. The court found, in a typical holding, that the alleged nuisances were not important enough relative to other countervailing considerations to enjoin the construction.

order for this to be a rational policy it is necessary that schools make the community a more desirable place to live in the eyes of prospective purchasers.

On the other hand, many other institutional uses will not be as highly regarded as single-family homes. Good examples might be hospitals, nursing homes, or trade schools. These uses are apt to have a slightly negative net influence on values because they do not provide any convenience for local residents to counterbalance the various minor nuisances which they may create (traffic in particular).

What are the implications of all this for model specification? One initial point is that the nonlinear model described above for commercial uses seems inappropriate. The negative externalities generated by the "worst" institutional uses are for the most part much weaker than those generated by the more obnoxious commercial uses, such as auto dealerships, filling stations, and drive-in restaurants. Moreover, it is probably not true that communities with high proportions of institutional land have a disproportionately higher proportion of the less desirable institutional uses than do those communities with a low proportion of institutional land. Many of the "institutional" communities in our data base, for example, are university towns.

Both of these considerations suggest that a simple linear specification is the most appropriate. We cannot however, specify in advance the sign of the coefficient. As our remarks above made clear, both a negative and positive sign
are theoretically possible. One does expect, however, that the coefficient's algebraic value (be it positive or negative) will be greater than the corresponding values of the industrial and multiple-family coefficients. This is to be anticipated partly because the typical institutional use provides some local services and partly because these uses are generally more attractive and less disruptive of single-family neighborhoods than the other two.

Vacant Land and Agriculture is a kind of residual category. It includes large parks, swamp and water, golf courses, wildlife refuges, as well as agriculture and other undeveloped private lands. Most of these uses would seem to fall in class 3. In general, they are not distinctly undesirable and most do not provide important local services. Consequently, [using (3-27) and (3-29)] the net effect of vacant land on property values is theoretically indeterminate. However, as was the case with institutional uses, some empirical intuition can be brought to bear on the problem.

The critical fact is that vacant or underdeveloped land is easily converted to some other use if market pressures so dictate. This is generally true even in those communities which make a concerted effort to preserve their open space using zoning and other devices. One of the few things that planning experts seem to agree upon is that a major weakness of traditional zoning ordinances is their inability to disci-
pline development at the urban-rural fringe. The very presence of vacant land thus necessarily creates uncertainty about the future development of the neighborhood or community in which it is located. This suggests that the vacant land and agriculture coefficient in our regression should be negative. Vacant land will have a negative net effect on property values because it may at any time be converted to uses which are markedly less desirable than single-family homes.

One can argue further that this coefficient is apt to be larger algebraically (less negative) than either the multiple-family coefficient or the industrial coefficient but smaller than the institutional coefficient. This ranking, of course, is largely intuitive. It is certainly not unreasonable to suppose that vacant land will have a weaker net effect on property values than will factories or apartments. While it remains vacant such land contributes "light and air" to the community. Moreover, if it is ever developed, the worst that can happen is that one of these latter uses will be built upon it.

It is perhaps less clear that institutional uses should rank higher than vacant land. The argument is essentially that many institutional land uses supply important community services while vacant land does not. In addition, the typical

institution is surrounded by a certain amount of landscaped greenery which contributes to community spaciousness just as vacant land does.

Local Tax and Expenditure Variables

The last variables we will consider in this section describe the tax and expenditure decisions of each community's local government. We have reserved them until the end because their presence in our price equation creates some special problems.

Charles Tiebout, in a now-celebrated paper, has argued that the diversity of local governments in a metropolitan area offers the typical household a "menu" of tax-expenditure combinations which enables him to choose the combination which suits his tastes and income the best. Tiebout's analysis was essentially normative; he saw that forcing a household to choose among a multiplicity of local governments was a way of partially circumventing the public goods "revealed preference" problem outlined by Samuelson. Many subsequent writers have stressed the behavioral significance of Tiebout's work. Some have developed complex game-theoretic models in which suburban and central-city governments vie with one another for high-


income citizens and "clean" industry by manipulating the tax and expenditure variables under their control. Others have taken Tiebout's assertion that household's "shop around" among alternative jurisdictions as a hypothesis which may or may not be supported by close analysis of empirical data.

In the present study we are not directly concerned with this general phenomenon except to the extent that expenditure and tax variables exert an independent influence on the value of single-family homes. Unfortunately, Tiebout's article did not mention property values at all, and the subsequent literature on the subject has been somewhat confused. Dick Netzer comes to the following conclusion: "To the extent that the Tiebout hypothesis holds, there is no a priori expectation of a significant correlation between tax rates and per capita or per pupil property values." Wallace Oates, on the other hand, has taken the position (in effect) that the acid test for the Tiebout hypothesis is precisely such a correlation.

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Which of these views is the correct one? The answer to this question may be obtained rather quickly if we observe that in the real world there is a simultaneous relationship between property values on the one hand and tax rates and public expenditure variables on the other. In the previous chapter we demonstrated that household bids for properties in a community would rise, ceteris paribus, if public services rose (3-25) or if the real property tax rate fell (3-26). Since we have been assuming that bid changes lead to property value changes in the same direction, it follows that the sign of the public service coefficients in (4-1) should be positive and the sign of property tax rate coefficient should be negative.

It will not do, however, simply to regress property values on these local government variables using ordinary least squares. The values taken by tax and expenditure variables for any particular suburb are surely not exogenous to the auction process we have been considering in this study, though both Orr and Tiebout have in effect taken this position. Instead, they are the outcome of political decisions which

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28 The size of the tax coefficient is a measure of the extent to which property taxes are "capitalized" into the value of land. It is here that our study intersects with much of the traditional literature on the incidence of the property tax. A good survey may be found in Netzer, op. cit., Chapter III.

necessarily depend (inter alia) on both the character of the households who have bid the highest for the residential sites in the community and on the size of the winning bids. Since the principal source of local government revenue in the United States is the property tax, one expects the latter to be particularly important. Analytically, all of this suggests that there are separate political decision-making relationships in the real world which determine tax rate and public service levels -- relationships which include property values among their independent variables.

It would seem therefore that the Oates position is the theoretically correct one provided one understands that (4-1) is to be estimated with some technique such as two-stage least squares which takes account of the interdependencies described above. If indeed tax and public service variables are important factors in the household location decision, one expects them to be statistically significant in the estimated form of (4-1). There is, of course, no necessity about this. It may be that local government variables do not enter into household location calculations at all. Alternatively, there may be a great diversity of taste about the proper level and distribution of local government tax and expenditure activity. Recall that the main point of the Tiebout welfare argument was the accommodation of just such diversity. We noted earlier that heterogeneous tastes about neighborhood characteristics might attenuate the statistical relationship between these variables and property values. A similar argument can presumably be made with respect
to the characteristics of municipal governments. Hence, Netzer's comment on Tiebout, while questionable as an a priori deduction, may be quite accurate as an empirical statement, particularly if many other factors influence consumer choice besides the decisions of the local public sector.

The one practical conclusion we can draw from this brief survey of the work of other economists is that it would be irresponsible to ignore the local public sector completely in any empirical study of community property values. Let us consider, therefore, the specific variables to be included in (4-1).

On the tax side the natural choice is the equalized tax rate. Assessment-value ratios differ widely across communities in most metropolitan areas so it is essential to adjust actual tax rates to obtain annual property tax payments as a proportion of market (not assessed) valuation. This is a standard calculation in the empirical literature on the property tax.

Choosing appropriate public service variables is not quite so simple. An important initial problem is the choice of a reasonable public output measure. This is much discussed in the literature on economics of scale in urban public services. Because of space and time limitations, we shall not attempt to break new ground on this subject. Instead, we will use the standard escape hatch and choose appropriate input variables.

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30A good survey may be found in Richard V. Butler, Cost Functions for Urban Public Services (unpublished Master's thesis, Department of Economics, Massachusetts Institute of Technology, 1968).
as proxies. But which variables should they be? Both casual and scholarly examination of suburban political behavior suggests that the most important service provided by these governments from the point of view of the citizenry is education. 31

Many of the empirical studies of property values which preceded the present one have followed this lead and included school input variables (not always successfully) among their independent variables. 32 On the basis of these precedents it seemed fair to conclude that if any public service variable was to affect property values, it would most likely be a school quality index.

Several such indices were available to this study: total expenditure per pupil, teacher-student ratio, average teacher salary, and maximum salary for teachers with bachelor's degrees. On the basis of prior reasoning total expenditure per pupil appeared to be the most satisfactory single variable. It encompasses a teacher quality factor (presumably correlated with

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31 Robert C. Wood notes the preoccupation of suburbanites with their school system and the attendant special qualities of school politics, op. cit., pp. 186-194.

salaries paid) and a class size factor (presumably measured by the teacher-student ratio). Of course, inclusion of both salary and class size variables together also seemed to be acceptable. The maximum salary variable was finally rejected as a teacher quality index because no further evidence was available on the stringency of the requirements which had to be fulfilled to reach this maximum. Thus in the end we were left with two alternative specifications: one which included only total expenditure per pupil and the other which included the teacher-student ratio and the average teacher salary.

C. Some Estimations

As mentioned earlier, our data base consisted of observations on all of the above variables for forty-six suburban Boston communities in 1960. Our procedure was to regress the median value of single-family homes for these communities (as reported in the 1960 Census of Housing) on various combinations of the independent variables we have discussed. The estimation procedures used were ordinary least squares (OLSQ) and two-stage least squares (TSLS). Table IV-1 presents the most interesting and important results of these estimations.

33 More specifically, we used the median value of owner-occupied dwelling units in single-unit structures. The value of these units covers both house and lot and is based upon appraisals by owners. This procedure undoubtedly produces serious errors in the valuation of individual properties. There is some evidence, however, that these errors "wash out" when the individual prices are aggregated into averages. L. Kish and J. Lansing, "Response Errors in Estimating the Value of Homes," American Statistical Association Journal, 49 (September, 1954). Presumably these results also apply to the median.
Table IV-1

Alternative Estimates of a Valuation Equation for One-Family Homes in Suburban Boston in 1960

Regression Coefficients (Absolute t Ratios in Parentheses)

<table>
<thead>
<tr>
<th>Equation Number</th>
<th>1&lt;sup&gt;a&lt;/sup&gt;</th>
<th>2&lt;sup&gt;a&lt;/sup&gt;</th>
<th>3&lt;sup&gt;a&lt;/sup&gt;</th>
<th>4&lt;sup&gt;a&lt;/sup&gt;</th>
<th>5&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Number of Rooms</td>
<td>6223&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4842&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4483&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5025&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5571&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>(in Years)*</td>
<td>(9.59)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>(6.42)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>(6.07)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>(5.40)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>(3.69)&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Average Age</td>
<td>-1.15</td>
<td>-1.25&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-1.04&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-1.19&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-1.28&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>(3.46)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>(2.93)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>(2.31)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>(2.50)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>(2.08)&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Average Lot Size (in Acres)</td>
<td>3861&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6002&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7121&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7393&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7485&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td></td>
<td>(1.71)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>(2.75)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>(2.96)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>(3.06)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>(2.83)&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Road Distance to CBD (in Miles)</td>
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<td>-0.85&lt;sup&gt;d&lt;/sup&gt;</td>
<td>-1.32&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-1.27&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-1.38&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>(1.04)</td>
<td>(1.62)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>(2.42)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>(2.36)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>(2.35)&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Proportion Sound, all Facilities*</td>
<td>13746&lt;sup&gt;c&lt;/sup&gt;</td>
<td>12386&lt;sup&gt;c&lt;/sup&gt;</td>
<td>14761&lt;sup&gt;c&lt;/sup&gt;</td>
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<td>(2.10)&lt;sup&gt;c&lt;/sup&gt;</td>
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<td>Local Employment Number of Homes</td>
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<td>117&lt;sup&gt;c&lt;/sup&gt;</td>
<td>322&lt;sup&gt;b&lt;/sup&gt;</td>
<td>349&lt;sup&gt;c&lt;/sup&gt;</td>
<td>478&lt;sup&gt;d&lt;/sup&gt;</td>
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<tr>
<td></td>
<td>(1.14)</td>
<td>(2.12)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>(2.48)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>(2.31)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>(2.09)&lt;sup&gt;d&lt;/sup&gt;</td>
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<tr>
<td>Proportion Land not to One-Family Homes</td>
<td>-8133&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>(2.96)&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td>Proportion Land to Mult.-Family Homes</td>
<td>-6385&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-5549&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-5456&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td></td>
<td>(1.28)</td>
<td>(1.17)</td>
<td>(0.95)</td>
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<tr>
<td>Proportion Land to Commercial Uses</td>
<td>64035&lt;sup&gt;c&lt;/sup&gt;</td>
<td>72604&lt;sup&gt;c&lt;/sup&gt;</td>
<td>91927&lt;sup&gt;c&lt;/sup&gt;</td>
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<td></td>
<td>(1.86)</td>
<td>(2.01)</td>
<td>(2.07)</td>
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<td>(Proportion Land to Commercial Uses)&lt;sup&gt;2&lt;/sup&gt;</td>
<td>-959410&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-926160&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-1267000&lt;sup&gt;c&lt;/sup&gt;</td>
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<td></td>
<td>(2.75)&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>Proportion Land to Industrial Uses</td>
<td>-8412&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-7312&lt;sup&gt;d&lt;/sup&gt;</td>
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<td></td>
<td>(1.89)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>(1.61)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>(1.90)&lt;sup&gt;d&lt;/sup&gt;</td>
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<td></td>
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<tr>
<td>Proportion Land to Institutional Uses</td>
<td>6348&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4863&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6485&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td></td>
<td>(0.68)</td>
<td>(0.53)</td>
<td>(0.63)</td>
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<tr>
<td>Proportion Land vacant</td>
<td>-4830&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-4006&lt;sup&gt;d&lt;/sup&gt;</td>
<td>-4009&lt;sup&gt;d&lt;/sup&gt;</td>
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<tr>
<td></td>
<td>(1.94)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>(1.52)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>(1.35)&lt;sup&gt;d&lt;/sup&gt;</td>
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<tr>
<td>Equalized Tax Rate</td>
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<td></td>
<td></td>
<td>-45 &lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>(1.75)&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td>School Expenditure per Pupil</td>
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<td>-5</td>
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<td>(0.74)</td>
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Table IV-1  
(Continued)

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<th>Equation Number</th>
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<th>4</th>
<th>5</th>
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<td>Constant Term</td>
<td>(-30600)(^b)</td>
<td>(-16190)(^d)</td>
<td>(-20620)(^c)</td>
<td>(-18550)(^c)</td>
<td>(-21860)(^d)</td>
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<tr>
<td>Estimation</td>
<td>OLSQ</td>
<td>OLSQ</td>
<td>OLSQ</td>
<td>OLSQ</td>
<td>TSLS</td>
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<tr>
<td>Method</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>R(^2)</td>
<td>.880</td>
<td>.902</td>
<td>.933</td>
<td>.939</td>
<td>.923</td>
</tr>
<tr>
<td>R(^2)</td>
<td>.861</td>
<td>.884</td>
<td>.909</td>
<td>.912</td>
<td>-</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>39</td>
<td>38</td>
<td>33</td>
<td>31</td>
<td>3</td>
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</tbody>
</table>

\(^a\)The dependent variable is the median value of owner-occupied dwelling units in single-unit structures.

\(^b\)Significant at the .01 level (one-tailed test).

\(^c\)Significant at the .05 level (one-tailed test).

\(^d\)Significant at the .10 level (one-tailed test).

\(*\)For owner-occupied dwelling units rather than dwelling units in single-unit structures.
We shall discuss the results sequentially, starting with the simpler models and then moving on to the more complex ones. For the moment assume that the true model is one in which government service variables and the local tax rate are not included. It will turn out in the light of some further results that this is really a quite reasonable assumption. We defer discussion of this matter until a bit later, however, when we shall examine some "Tiebout" models which explicitly take cognizance of the local public sector.

Models Exclusive of Local Government

Consider the first three equations in Table IV-1. Equation 1 includes only a fairly conventional set of structure, lot, employment accessibility characteristics. Equation 2 includes all of the variables in equation 1 plus an additional variable describing the proportion of community land not occupied by single-family homes. Equation 3 represents our full-blown neighborhood model. It includes the panoply of neighborhood variables described in the previous section as well as the six structure, lot, and accessibility variables included in equations 1 and 2. Obviously, the three equations represent 3 distinct points along a continuum of increasingly complex neighborhood specifications.

Note first of all that the $R^2$ for all three estimations is fairly high for a cross-section study. Note also that $R^2$ rises as the number of neighborhood variables increases -- even when it is corrected for the decline in degrees of free-
dom (R²).\textsuperscript{34} Turning to the estimates themselves, one very striking preliminary observation is the way that introducing more complicated neighborhood specifications improves the general performance of the structure, lot, and accessibility variables. To be sure, in all three equations these variables have coefficients whose signs are as predicted in the earlier sections of this chapter. However, in equation 3 all six have coefficients which are significant at least at the .05 level (using a one-tailed test), while in equation 1 there are two coefficients which are not even significant at the .10 level.\textsuperscript{35} Note in particular the much higher t ratios for lot size, distance and local employment. These results, of course, lend some credence to our contention that neighborhood should not be ignored when modeling the property valuation process.

The inclusion of neighborhood variables also has the effect of weakening the influence of the structure variables somewhat (smaller coefficients for age and rooms) while dramatically strengthening the employment accessibility effects (larger coefficients for distance and normalized local employment). This latter result suggests that the employment accessibility variables in equation 1 are doing double duty: They are capturing both commutation cost and neighborhood exter-

\textsuperscript{34}Goldberger, op. cit., p. 217.

\textsuperscript{35}One-tailed tests were used because it seemed reasonable to assume that most of the coefficient signs in Table IV-1 were known a priori. The choice was not a particularly significant one, however. Had two-tailed tests been applied, the interpretation of the results given in that table would have been unaffected.
nality effects. Since these separate factors operate in opposite directions on market price, the accessibility coefficients are larger in equation 2 and much larger in equation 3, both of which control for neighborhood quality separately. The general improvement of the CBD distance coefficient, both in significance and in (absolute) size, is particularly gratifying because of the importance attached to this variable in previous studies.

Let us now consider the neighborhood variables themselves. In equation 2 we have included a single neighborhood variable -- the proportion of community land devoted to land uses other than single-family homes. It is a simple general measure of community "attractiveness" from the point of view of the prospective home-owner. The reader will recall that in the previous chapter we considered some land uses which might in certain situations be preferred to homes, but it was fairly obvious that they were special cases. Common sense suggests that this variable should have a negative coefficient, and indeed in equation 2 it does. Note especially its high level of statistical significance. What equation 2 says in effect is that converting 10 percent of a community's land from single-family homes to some other (unspecified) land use will lower average home values in that community by around $810, ceteris paribus.

We put no particular stock in the precise magnitude of this coefficient since the "true" specification is probably more like that of equation 3 than that of equation 2. None-
theless, equation 2 is suggestive. Its most important message is that neighborhood effects are significant and that there is some sort of "consensus" about them. Specifically, it seems clear that homeowners in general prefer communities whose land is exclusively occupied by single-family homes. This is directly contrary to the conclusions of Crecine et al., who have argued that there is a strong possibility that "the urban property market is not characterized by great interdependence and that externalities do not abound in that market."36 We shall have more to say about this position a bit later on.

In equation 3 we decomposed the gross non-single-family effect discovered in equation 2. We did this by subdividing non-single-family land into the five general land-use categories discussed in detail earlier. Each was then treated as a separate variable for estimation purposes. Altogether, six new variables were added to the original specification given in equation 1 (commercial land enters through both linear and squared terms). A natural first test of the reasonableness of this decomposition is a Chow test of the null hypothesis that all six neighborhood variables are jointly equal to zero against the alternative that they are not.37 This statistical


test will in effect tell us how improbable our estimated results are on the assumption that the true neighborhood coefficients are equal to zero and the rest of the specification is "correct." The results of this test are gratifyingly decisive. The value of the appropriate F statistic (with 6 and 33 d.o.f.) turned out to be 4.43, which is significant at the .005 level. Thus it is highly unlikely that the "true" neighborhood coefficients are jointly equal to zero.

Turning to the estimates themselves, note first of all the relationship among the multiple-family, industrial, institutional, and vacant land coefficients. It is essentially as predicted in the previous section. Both the industrial and multiple-family coefficients are negative with the former being larger than the latter -- exactly what one would expect on the basis of neighborhood externality considerations. The vacant land coefficient is also negative but smaller in absolute value than the first two, again a not unsurprising result. Finally, the institutional coefficient is positive, suggesting that over some range it would be profitable for suburban homeowners to promote institutional locations in their community (ceteris paribus). What is most striking about all of this is that the size ranking of these four coefficients conforms exactly to our a priori expectations.

The t statistics of these four coefficients present a somewhat mixed picture. The vacant and industrial coefficients are significant at the .05 level and the multiple-family coefficient just misses being significant at the .10 level. The
in institutional coefficient, on the other hand, is clearly insignificant. There are two possible explanations for this. The first is that households really evaluate neighboring institutional uses in about the same way as they evaluate single-family homes, so that in the true model the institutional coefficient is zero. The second possibility is that the low institutional t statistic is simply the consequence of stochastic influences peculiar to the specific body of data we have used. Observe that there are twelve distinct regressors in equation 3, six of them dealing with land use. Even if all were in fact variables in the true model, there is a reasonable probability that one or two will show up with low t statistics due to "noise" in the valuation process.

There is really no way of deciding between these alternative hypotheses except by consulting an independent set of data and repeating the estimation. Our predisposition, however, is toward the second alternative. The order of magnitude of the institutional coefficient is certainly consistent with that of the others. Moreover, it seems unwise to conclude flatly that institutional uses should be dropped from the regression on the basis of a single experiment. One does not expect, after all, that the two uses will have exactly the same effects. The critical thing is that it is the institutional coefficient to which this ambiguity attaches rather than any of the others. We remarked in the previous section that this coefficient could reasonably be expected to be positive, negative, or zero. Obviously, our estimation does not settle this question. What
does seem to be important, however, is that the institutional
coefficient is greater (algebraically) than the multiple-family,
vacant and industrial coefficients. This result is worth
noting, particularly since changing the institutional coeffi-
cient to zero preserves this ranking.

Commercial land was accorded special treatment. In
Section B of this chapter we argued that there was a strong
possibility that the relationship between commercial activity
and single-family property values was nonlinear. Our estimation
results clearly vindicate this hypothesis. We included a linear
and a squared commercial term in our specification and both
were significant at least at the .05 level. The former is posi-
tive and the latter is negative, indicating that the functional
relationship being estimated has the shape of an inverted U.
These results strongly support our earlier contention that a
small amount of commercial activity in a community may very
well be preferred to additional single-family homes. Large
amounts, on the other hand, are undesirable, and this is the
source of the negative coefficient of the squared term.

By taking the first derivative of equation 3 with respect
to the proportion of commercial land and setting it equal to
zero, we may calculate the "optimal" proportion of community
land devoted to this use. By "optimal" we mean of course the
proportion which maximizes the average value of single-family
homes in the entire community (ceteris paribus). It turns out
that the coefficients in equation 3 imply an "optimal" figure
of 3.3 per cent, which seems reasonable. Approximately 60 per cent of the communities in our data base had proportions which were lower than this and 40 per cent had proportions which were higher.

Several remarks need to be made about this result. Note first of all that the "optimal" amount of commercial activity for the typical suburb is probably dependent upon the availability of alternative facilities in neighboring communities. If all the cities and towns in our sample suddenly increased significantly the amount of land devoted to shopping centers within their boundaries, the "optimal" percentage calculated above would probably decline. If, on the other hand, shopping centers started closing down everywhere, this percentage would probably rise.

Second, the fact that some particular percentage of a community's land maximizes the average value of its single-family homes (ceteris paribus) suggests that it may be worthwhile for homeowners to act collectively to change this percentage if in fact it is not "optimal." Whether in the real world they do this is difficult to say. There are many communities in our sample with commercial percentages both far above and far below the 3-4 per cent range calculated above. This is not in itself evidence of the failure of collective action in the separate suburbs, however. Property tax and public service considerations, for example, may dictate an allocation of land

38 The corresponding figures for equations 4 and 5 are 3.8 and 3.6 per cent respectively.
to commercial activities which is very different from the optimum calculated when only externality and accessibility factors are taken into account. This is a point which many authors have stressed, particularly with respect to office activities. Moreover, if each community separately pursues an optimizing strategy, the collective result may be chaos, with "target" percentages shifting too rapidly for individual equilibria ever to be attained.

Thus without additional data it is impossible to determine whether or not the homeowners in our specific sample of communities actually regulate the amount of local commercial activity with an eye toward increasing their own property values. Some nonsystematic remarks on their probable capabilities in this area can be made however. In general it appears that even if the target percentage (as we have calculated it above) is known and even if it stays constant over a long period, the ability of the collectivity of homeowners in any community to achieve their will in this matter is distinctly limited.

In the first place many communities (including several in our sample) developed fully before they had any kind of land-use controls. The zoning bodies of these municipalities thus confronted a fait accompli when it came time to draw up local land regulations. Frequently, the community contained more commercial (or other) land than was thought to be desirable, but the power of these bodies to eject any established economic activity was (and in general still is) distinctly limited. For example, local governments are just beginning to get judicial
authorization to "amortize" non-conforming uses. 39 Thus it is perfectly possible for a community to have too many commercial uses and still be quite unable to do very much about it.

Those suburbs with too little commercial activity are restricted in other ways. Here the essential problem is a political one. Though homeowners as a body might benefit from commercial expansion in these communities, there are other interest groups who will be hurt and who can be expected to show some opposition. In general, they will be the established local merchants, who want to restrict competition as much as possible, and those owners of residential property who will end up next-door to any proposed development. The objections of the latter group are typically vociferous and their arguments frequently have some legal stature. 40 In typical cases, therefore, the adversely affected parties will hold at least a partial veto power over any expansion of nonresidential activity, even if the homeowners in the community as a whole will benefit from the change.

39 What this essentially means is that it is now possible to restrict the life of a non-conforming use to some finite length. The precise judicial safeguards which will protect property owners from confiscation have yet to be worked out, however. Williams, op. cit., pp. 232-233.

40 A typical conflict situation occurs when the city council amends the existing zoning map (spot zoning) or the zoning board of adjustment grants a variance, and the change is opposed by the neighbors of the affected parcel. They may effectively challenge the power of the decision-making body either on Equal Protection or Delegation of Authority grounds, Mandelker, op. cit., pp. 60-61.
Now we drop the assumption that local government tax and expenditure decisions do not enter into the market's valuation of single-family homes. Representative results from this phase of our analysis are given in Table IV-1, equations 4 and 5. Both of these equations include the community's equalized tax rate and its educational expenditure per pupil in public schools (kindergarten through high school) along with all the other variables in equation 3. Equation 4 was estimated with ordinary least squares (OLSQ), equation 5 with two-stage least squares (TSLS). Many other regressions besides these were run using slightly different tax and service variables in various combinations. On the public service side, average teacher salary and the teacher-student ratio were substituted for total expenditure per pupil. On the tax side, the average property tax bill for homeowners was substituted for the equalized property tax rate. Equations 4 and 5 are perfectly representative of the results obtained from this series of estimations so we shall confine our discussion to them.

There are several points to be made about these equations. Observe first of all that the coefficient estimates for the structure, lot, accessibility and neighborhood variables in equations 4 and 5 are not very different from those in equation 3. What is especially significant from the point of view of this study is the similarity of the neighborhood coefficients across the three equations. Not only does each separate land-use coefficient have approximately the same value in each of
the three equations, but also the size ranking of the institutional, vacant land, multiple-family, and industrial coefficients is the same in each. The t ratios in equations 4 and 5 are generally (but not universally) lower than those in equation 3. Nonetheless, five of the six structure and lot variables and three of five neighborhood variables are significant at least at the .10 level.

More important are the generally poor performances of the tax and school expenditure variables in the two equations, particularly equation 5. In equation 4 these two variables were simply added to the list of those already included in equation 3. OLSQ was then used to estimate the augmented model. The results of this estimation were mixed. The coefficient of the equalized tax rate was negative (as expected) and significant at the .05 level; the coefficient of the school expenditure per pupil variable was statistically insignificant and of the wrong sign. If a joint test is performed, the null hypothesis that both coefficients are equal to zero cannot be rejected even at the .10 level since the value of the appro-

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41 The test statistic for the TSLS coefficients is not the same as the one for the OLSQ coefficients, though both are based ultimately on the t distribution. The degrees of freedom parameter for the TSLS statistic is the extent to which the equation under discussion is overidentified. Phoebus J. Dhrymes, *Econometrics: Statistical Foundations and Applications* (New York: Harper and Row, 1970), pp. 272-277. In the present case there are 3 included endogenous variables and 5 excluded exogenous variables so the degree of overidentification is 3 [5-(3-1)], Goldberger, *op. cit.*, p. 314.
appropriate F statistic (with 2 and 31 d.o.f.) is only 1.54.\textsuperscript{42}

Of course, these OLSQ results may not be very important because, as we argued earlier, there is probably a simultaneous relationship between median home values on the one hand and local taxes and expenditures on the other. If this is the case, our coefficient estimators in equation 4 will be biased and inconsistent.\textsuperscript{43} To produce estimates of the coefficients which were at least consistent, we reestimated using TSLS. The result is equation 5.\textsuperscript{44} We have already commented on the small changes in the structure, lot, accessibility, and neighborhood coefficients which this reestimation brings about. The changes in the tax and education coefficients are, however, much more significant. Both coefficients shifted the "wrong" way.

\textsuperscript{42}The value of the F statistic would have to be at least 2.49 to reject the hypothesis of joint equality to zero at the .10 level.

\textsuperscript{43}Johnston, op. cit., p. 233.

\textsuperscript{44}The method of TSLS involves "purging" the tax and school expenditure variables of their correlation with the error term. To do this each is separately regressed on the other independent variables in the equation and on some additional exogenous variables not included in the equation. The fitted values of the dependent variables from these two regressions were then used to reestimate equation 4. Goldberger, op. cit., pp. 329-336. The additional exogenous variables used were population, population density, the ratio of population to the number of single-family homes, and the market value of commercial, industrial, and multiple-family property per capita and per single-family home. Note that we have carefully avoided any variables based on the characteristics of the community's population. Our auction model implies that all of these are endogenous. Population is taken to be exogenous because it is essentially determined prior to the auction by the number of dwelling units in the community and their size distribution.
The coefficient of the equalized tax rate changed from negative to positive while the coefficient of the expenditure variable become more negative. Thus in equation 5 both variables end up with coefficients which have an incorrect sign. These results are quite typical of all the TSLS estimations with which we experimented. In every case the coefficients either had the wrong sign or very low t ratios.

The message which comes through all of this is clear enough: our study simply finds no evidence that either local tax rates or local school systems are significant factors in the residential site choice. If they were, they should have exerted an independent influence on the market price of the community's single-family homes, an effect which we were quite unable to isolate. These results are perhaps not all that surprising. The economics literature on the capitalization of taxes and public services contains several studies on both sides of the question.45 On the other hand, an important recent paper by Wallace Oates, which was very similar to the present study (except for the absence of direct measures of neighborhood quality), came out with coefficient estimates for

45Netzer cites some (conflicting) early studies on the tax side, op. cit., pp. 34-35. Some representative results on the expenditure side are: Ridker and Henning (school quality weakly significant or not at all) op. cit., pp. 254-256; Kain and Quigley (school quality -- measured by average student test score -- weakly significant or not at all) op. cit., p. 12; Orr (educational expenditure per pupil weakly significant), op. cit., pp. 128, 131; Oates (educational expenditure per pupil and equalized property tax rate strongly significant).
the equalized property tax rate and educational expenditures per pupil which were of the right sign and highly significant.46

How then can the negative outcome of our study be explained?

A very plausible answer to this question may simply be that the diversity of neighborhood environments in our sample swamped the influence of public sector differences across communities. Boston is different from many metropolitan areas in that a significant number of its suburbs are older industrial and commercial centers. Some of these communities are included in our sample. Their residential environments are dramatically different from those available in the primarily residential communities located further from downtown Boston. The land-use distributions of two sample communities, Newton and Somerville, are shown in Table IV-2 below to illustrate the range of possibilities covered by this study. The former is a large wealthy suburb whose school system has a fine reputation; the latter is an old-time industrial area developed in the 1880's and 1890's. The available indices of public school quality, on the other hand, do not vary nearly as much as do the land-use distributions. Several of these indices are also shown in that table for the same two cities. The upshot is that the typical household may not find public service differentials to be particularly important in choosing among cities and towns as heterogeneous as those in our sample. The fact that Oates' results were for a sample of suburbs especially chosen to be "residen-

46Ibid.
Table IV-2
Land Use and School Characteristics for Newton and Somerville, Massachusetts in 1960

<table>
<thead>
<tr>
<th>Variable</th>
<th>Newton</th>
<th>Somerville</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion Single-Family</td>
<td>.50</td>
<td>.09</td>
</tr>
<tr>
<td>Proportion Multiple-Family</td>
<td>.06</td>
<td>.43</td>
</tr>
<tr>
<td>Proportion Commercial</td>
<td>.03</td>
<td>.09</td>
</tr>
<tr>
<td>Proportion Industrial</td>
<td>.04</td>
<td>.23</td>
</tr>
<tr>
<td>Proportion Institutional</td>
<td>.07</td>
<td>.07</td>
</tr>
<tr>
<td>Proportion Vacant</td>
<td>.30</td>
<td>.09</td>
</tr>
<tr>
<td>Educat. Expend. Per Pupil</td>
<td>$435</td>
<td>$362</td>
</tr>
<tr>
<td>Average Teacher Salary</td>
<td>$6545</td>
<td>$5978</td>
</tr>
<tr>
<td>Student-Teacher Ratio</td>
<td>21.9</td>
<td>21.9</td>
</tr>
</tbody>
</table>
tial" supports this conclusion. By selecting his communities in this way he carefully controlled for precisely those influences (i.e., neighborhood) which we are trying to assay in this study.

An alternative explanation for our results is that the school quality indices we have chosen do not really measure "quality" as the typical homeowner sees it. One significant possibility here is that the perceived "quality" of a school system really varies only with the proportion of its students who are poor or of undesirable racial background. The latter consideration is not important for the present study because the percentage of blacks in all of the sample communities is quite small. The former, however, may very well be relevant. It is obviously beyond the scope of this study to model behavior of this kind, since it would require a detailed analysis of the composition of each city's public school population and some study of the public-parochial school choice.

What is worth noting, however, is that we probably have at least partially controlled for this effect through our multiple-family variable. We suggested earlier that part of the typical homeowner's antipathy toward multiple-family structures may be due to the expected class character of their occupants rather than to their appearance. An important component of this class consciousness could very well be the desire of home-owning parents to have their sons and daughters go to

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47 Ibid., p. 960.
schools where most or all of the students are of middle or upper class background. To the extent that this is true one expects the multiple-family parameter in equations 3, 4 and 5 to be negative even if the buildings themselves were beautifully designed. In short, therefore, the negative multiple-family coefficients in these equations are best interpreted as composites, only one component of which is due to visual undesirability or nuisances in the common law sense.

D. Some Objections and Qualifications

Let us now return to the research problem which motivated this study in the first place -- namely, estimating the empirical relationship between neighborhood character and property values. Our conclusions concerning this relationship constitute the heart of the present study's contribution to the urban economic literature. Since these conclusions will surely not go unchallenged, it seems appropriate to try to anticipate probable objections and qualifications to them. This we shall attempt to do in the present section.

The first such objection we shall consider is founded upon the observation that the structure variables included in our regressions (number of rooms, age, and a dichotomous condition and plumbing variable) do not fully capture all important dimensions of structure quality. This is certainly true. There are clearly many other secondary characteristics -- such as the type of building material, the quality of landscaping, the number of repairable defects, the presence or absence of
fireplaces, garages and basements, etc. -- which influence bidders' decisions but which do not appear in our equations. The critical question, however, concerns the significance of these omissions. The core of the argument being presented here consists of the assertion that they are nontrivial. It is argued that this is the case because the missing variables are both important in their own right and probably highly correlated with many of the included variables. Thus, it is likely that the coefficient estimates presented in Table IV-1 are the products of biased (and inconsistent) estimators.\textsuperscript{48} It is further asserted that one particularly important source of bias is the correlation between the omitted structure quality variables and the character of the neighborhood in which the structure is located. Everyone knows that low quality structures are usually located in low quality neighborhoods. Thus the specific negative coefficients we obtained for the industrial, commercial (squared), vacant, and multiple-family land-use variables probably reflect the influence of both the neighborhood and the omitted structure quality characteristics.

If all of this is true, then we have perhaps misrepresented the conclusiveness of our findings. Unfortunately, it was not possible to test the implied hypothesis explicitly because additional structure quality variables were simply not available. However, the allegations presented here are not invulnerable to challenge on a priori grounds. In the first place, it should be noted that the argument in the previous

\textsuperscript{48} Goldberger, op. cit., pp. 196-197.
paragraph is ultimately dependent upon the existence of neighborhood effects. If no one cared about neighborhood, there would presumably be no systematic relationship between the quality of the neighborhood and the quality of the structure. Thus it is not possible to use this argument to discredit our basic conclusions concerning the existence of neighborhood effects.

Second, it may further be the case that our coefficient estimators are not in fact biased. Brodsky and others have pointed out that there are alternative levels of aggregation in land value analysis and that the variables which play an important role at one level may be insignificant at another. Thus it is perfectly possible for a variable to influence price at the block or parcel level, but not at the community level. For example, it may be true that stone houses command a higher price (ceteris paribus) than wood houses. However, if each community in the sample has a similar proportion of stone houses (which might incidentally be the case in our study) then building material will not be an important factor in explaining intercommunity price differences. The main point here is thus that aggregation probably eliminates some variables, and the secondary structure characteristics we have been discussing seem particularly likely candidates.


50 The high $R^2$ we obtained for all our regressions is some additional (though not conclusive) evidence that there were no important variables missing.
Another argument against the conclusions we have drawn from our regression results is somewhat more intricate. It may be stated as follows: Suppose that all households are indifferent to neighborhood. Each is thus concerned only with the characteristics of his particular house and lot and its accessibility to employment. Suppose further that low income households have more limited transportation options than do high income households. Now imagine a real estate auction (of the usual type) in which both income groups participate. The results of this auction are predictable. First, the poor will usually end up paying less for their homes than do the rich. In addition, they will tend to purchase lower quality homes (i.e., those with smaller lots and smaller and older structures), and ones which are more accessible to employment and shopping centers. It follows that in equilibrium there is likely to be a (simple) negative correlation between the price a home receives on the market and its proximity to nonresidential uses. This, it is contended, demonstrates that there is no need to invoke neighborhood externalities to explain the low price of homes in neighborhoods containing many nonresidential uses. Our regression results merely show that the poor value shopping and employment accessibility more than the rich do. This propensity, coupled with the fact that the poor must pay less for housing than the rich, produces the negative land-use coefficients exhibited in Table IV-1.

This argument, though blessed with a superficial plausibility, is fallacious. Its basic error consists in confusing
the total price which a household pays for a composite commodity with the implicit prices it pays for each of the separate components of the composite. Thus, while it is generally true that the poor pay a lower total price for housing than the rich, it does not follow that houses possessing features particularly desired by the poor should be lower in price, other things equal.

Let us consider an automotive example. Suppose again that there are only two types of households, rich and poor. Suppose further that there are only two types of autos, black and yellow. Let the rich be indifferent to color while the poor prefer yellow to black. If a fixed number of yellow and black autos are auctioned off, it is clear that the poor will tend to purchase the yellow ones and the rich the black. It does not follow from this, however, that the yellow cars will sell for less than the black ones. Indeed, if anything, the reverse is true. The price of a yellow car can never fall below that of a black one because the rich are willing to pay the same for both. Whether the price of the yellow car will in fact be higher depends on the proportion of yellow cars to black cars relative to the proportion of rich to poor.

These results generalize to situations where automobiles are differentiated along more dimensions that just that of color. It will still be true that yellow cars will never receive a lower price than black cars, other things equal. The implicit price of "yellowness" must always be positive or zero with the pattern of tastes we have described. It follows,
using an identical argument, that the implicit prices of shopping and employment accessibility must always be positive or zero -- even in the extreme case where these qualities are valued by the poor but not the rich. Thus, income distributional considerations alone are not sufficient (or even necessary) to explain the various negative land-use coefficients we display in Table IV-1. Neighborhood externalities must be invoked.

A third possible objection to the specifications used in this study focuses upon the failure to include average community income among the independent variables. Surely, the argument goes, the value of the homes in a particular community are influenced by the incomes of their purchasers; therefore, to leave income out is to misspecify the price determination equation. Now on the surface this objection seems reasonable enough -- however, it too is falacious. The truth is that the value of a piece of property does not in fact depend in a causal sense upon the income of its buyer. Instead, these two variables are jointly determined by a third -- namely, the quality of the property and its ambient neighborhood and community environment. Thus, if a particular piece of property is of high quality, it will tend both to command a high price and be purchased by a person of high income. To suppose, however, that there must be a *direct* causal linkage between price and owner income because of the positive simple correlation between them is to commit the so-called "fallacy of the lurking factor,"

Thus far we have skirted over the probable generality of
our coefficient estimates. Before leaving the present section it is appropriate to consider this matter, at least briefly. The essential point is that the specific numerical estimates we displayed in the previous section depend partially on the overall distributions of housing and neighborhood characteristics present in metropolitan Boston in the year 1960. These estimates are not, in short, determined only by demand considerations, even though our bidding model might at first suggest this. Supply considerations are also involved. Suppose, for example, that between 1960 and 1965 the average number of rooms for single-family homes in the whole area increased while the population and its demographic composition remained unchanged. One would anticipate that this supply adjustment would cause the implicit price of rooms to fall, other things equal. If we reestimated our "hedonic" regression for the year 1965, it is likely that the rooms coefficient would be smaller than it was in 1960.

Why should we expect this result? Essentially there are two elements involved. The first is the existence of taste differences among the bidders with respect to interior space. As more large homes come on the market, they will tend to be occupied by households whose space preferences are less intense than were the preferences of those who occupied such homes earlier. Since the implicit price of any housing component is presumably determined by the preferences of the marginal bidder, one would expect the price of rooms to fall on this account. The second element is simply the diminishing marginal utility
which each household receives from successive increases in the number of rooms which it occupies. As it acquires more interior space, the additional amount the household wishes to bid for further space increments declines. If enough households improve their housing situation in this way, their bid reductions will eventually translate into market price reductions for those units with large numbers of rooms. Note that this effect is operative even if all households are identical in every way.

These ideas are rather easily extended to the neighborhood variables in our equation. We suggested earlier that an increase in the number of desirable residential locations relative to the number of undesirable locations (near glue factories, for example) may cause neighborhood-induced price differentials to shrink or disappear (holding constant demand and the total number of units available). This is merely another way of stating that the price of a nice neighborhood declines as the supply of nice neighborhoods increases, other things equal. As was the case with rooms, this downward shift in price is the product of two separate effects. The first is a taste diversity effect. As more homes in nice neighborhoods become available, they are occupied by households who are less concerned with neighborhood quality than were the households previously occupying such homes. As a result, the implicit price of neighborhood quality falls. The reader may recall that we touched on this phenomenon in our glue factory example in the previous chapter. The second effect, as before,
is due to diminishing marginal utility. As all households come to live in nicer environments, the incremental value of additional improvements to these environments will tend to fall.

The upshot is that the coefficients given in Table IV-1 are to a certain extent space and time specific. It is definitely not legitimate to assume that they can be applied to some metropolitan area other than Boston without careful consideration of differences in the housing stock and average neighborhood quality between the two cities.\footnote{There may of course be differences on the demand side as well. We are abstracting from these here.} This caveat also applies, as indicated above, to intertemporal comparisons within the Boston SMSA itself. The land-use patterns and housing facilities of a metropolitan area change over time and the set of implicit prices for the components of the housing package will change with them.

E. Conclusions

We have come some distance in this chapter. First of all, we have demonstrated fairly conclusively that neighborhood externalities played a significant role in determining the price of single-family homes in a large American metropolitan area in a particular year. This is not in itself a particularly surprising result. As we mentioned in Chapter II, there have been other empirical studies which have arrived at similar conclusions (though for different cities and years).
Our demonstration is especially compelling, however, because we were not forced to use proxy variables to quantify neighborhood character as so many earlier studies were. In addition, we did not use complicated composite variables of the type used by Kain and Quigley.

We have done much more in this chapter, however, than simply confirm the importance of neighborhood externalities. We have made a first cut at classifying these effects and ranking their separate strengths. Equation 3 is particularly interesting in this regard and summarizes our main conclusions rather nicely. The only other study which attempted to decompose the general influence of neighborhood upon price was the one done by Crecine, Davis, and Jackson. As we have already had occasion to remark, these men obtained completely negative results. Thus the present study appears to be the first ever to have accomplished this decomposition.

Overall, our results would probably come as no surprise to a real estate agent, a suburban developer, or a practicing city planner. It is nice, however, to have some statistical support for hypotheses which "everyone" believes to be true. Occasionally, "everyone" is wrong. It is to be hoped that the work done here will stimulate further explorations into the economics of urban land. Perhaps future studies will produce results which are not so commonplace.

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52 See Chapter II, Section 3.
54 The probable sources of error in this study are described at length in Chapter II, Section 3.
CHAPTER V

Land-Use Control in a Simple Urban Economy with Externalities

A. Introduction

We noted in Chapter II that very few theoretical analyses of land-use control devices have appeared in the professional economics literature. In this chapter we shall attempt to respond to this deficiency. Our first task will be to develop a comparatively simple static, two-sector urban land model which includes neighborhood externalities. This model will be of a rather special type. Specifically, we shall assume that we are analyzing the settlement of a new town which is owned entirely by a private developer prior to its inhabitation. A distinctive feature of this model will be the labor market linkage between the residential and manufacturing areas of the community. Unlike most other urban models, this one will try to take account of the fact that the households and firms located in any city are subject to the discipline of a labor market in which both participate.¹

Having constructed this model, we will then use it to explore the effect of land-use changes on various important economic variables. Once these basic connections are established

¹Another model which possesses this feature may be found in Edwin S. Mills, "An Aggregative Model of Resource Allocation in a Metropolitan Area," Papers and Proceedings of the American Economics Association, LVII (May, 1967).
and it is clear how the model operates, we will turn our attention to the problem of determining and maintaining an optimal allocation of urban land. One particular optimizing strategy -- maximizing aggregate property values -- will be considered in depth, and some implications of such a strategy worked out. Alternative institutional arrangements for sustaining the optimal allocation will then be discussed and compared. It is in this context that some of the practical shortcomings of the zoning tool will be described. We will conclude this chapter with some policy recommendations.

To accomplish all of this it will be necessary to make many simplifications in the basic model being presented. Not the least of these is the new town framework outlined in the previous paragraph. The assumption that some higher authority supervises the initial settlement of the town is patently inconsistent with the history of most American communities. The only exceptions have been a few company towns such as Pullman, Illinois and Lowell, Massachusetts and some planning experiments such as Radburn, New Jersey. Nonetheless, as will be made clear in subsequent sections, the assumption of a carefully regulated primordial auction greatly simplifies the analysis. It enables us, in particular, to avoid the problem of determining what a completely laissez faire private market equilibrium would actually look like.

This would, of course, be an interesting area to explore. However, the problems associated with the construction of a true general equilibrium model of location and land values are very
difficult, and it cannot be said that they are presently very near to being resolved. The Alonso market solution, for example, is clearly inadequate because it does not take into account the numerous interrelationships among the bid rent curves of the economic agents who participate in the land auction. The sources of this interdependence are, first, externalities and, second, the usual sort of labor and product market interactions which economists are accustomed to deal with. Once it is recognized that the amount of money any household or firm is willing to bid for a particular parcel depends on the number and location of all other households and firms, it becomes impossible to form a unique queue based on the relative steepness of bid rent curves. This result in turn makes the market process which Alonso sets up to allocate households and firms to sites seem rather unrealistic. This is especially true if you interpret his model as a deterministic one, capable of generating the same equilibrium solution in repeated trials.

Fortunately, however, our interests in this dissertation do not require us to build the very sophisticated location model which would be necessary to close these gaps in the literature. It turns out that most of the insights we have to offer can be brought out in a satisfactory way using simpler tools.

B. A New Town Economy

We begin by assuming that our town sits on a line which

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2Alonso, op. cit., Chapter 5.
extends indefinitely in two directions. Except for a (fixed) center point, which we shall suppose represents a transportation node connecting our urban economy with the outside world, the line is featureless. ³ We will further assume that this line has been subdivided by a developer into small identical lots of length q* in advance of any property sales. In this economy each of these small parcels can be devoted to only one of two possible economic uses -- residential activities or manufacturing activities. Any parcel not utilized for either of these purposes is assumed to be vacant. Available urban land is allocated to households and firms through a market mechanism which is constrained in its operation by some kind of land-use control instrument. This instrument partitions the linear space economy into homogeneous districts, thus providing a framework of restrictions within which the private market is allowed to operate. An example of such a partition is exhibited below. It makes use of the assumption (to be adhered to throughout this chapter) that the developer chooses to allocate land near the center of the city to manufacturing rather than using it for residential purposes.

³This is a standard assumption. See, for example, Alonso, op. cit., pp. 15-17. As used here and in Alonso, "featureless" means the permanent absence of both distinctive natural features (topographical, geological, and climatic) and all man-made improvements (including structures).
C is the center of the city. Manufacturing is restricted to the interval \((t_b^*, t_a^*)\) while residences are restricted to the open-ended segments extending to the left from \(t_b^*\) and to the right from \(t_a^*\). The natural operation of the private market for residential land produces two "housing" zones: \((t_b', t_a')\) and \((t_a^*, t_a')\). All parcels to the right of \(t_a'\) and to the left of \(t_b'\), the margins of civilization, remain vacant. Associated with this partition there is a market price gradient (not shown) indicating the equilibrium price paid at each location.

In addition to a land market this model possesses a labor market whose freely fluctuating wage rate equilibrates factor supply and demand. Labor will be demanded by the manufacturing sector in accordance with the world price of the output which it produces (appropriately adjusted for intercity transportation costs), the equilibrium urban wage rate, and the amount of land allocated to manufacturing. Labor will be supplied by the residential sector in accordance with the wage rate and the extent to which "desirable" residential locations are available in the economy. Fluctuations in the quantity of labor supplied are ultimately brought about by migration into or out of the urban area in response to changed conditions there or in the rest of the world.

The way in which land-use problems enter the model may now be easily seen. Prior to the primordial auction, the
developer must choose the appropriate locations for $t_a^*$ and $t_b^*$, the manufacturing-residential boundary points. His choice will be conditioned by the fact that there is a dual relationship between these two sectors. The first is through the labor market, a connection we have already discussed. The second comes about because consumers do not like to live in communities which have extensive manufacturing activities in them (other things equal). This of course is a neighborhood externality effect of the type we have discussed at length in earlier chapters. Once the developer has weighed these two factors and chosen a pair of boundary points which maximizes his welfare function, he is faced with a second problem. What institutional arrangements should he set up to ensure that the particular partition he has chosen will endure after he has sold all of the land?

Before we can discuss these policy matters intelligently, it is necessary to go over the details of the basic model rather carefully. This task will occupy us for the remainder of Section B. First, the equilibrium in the residential portion of the land market will be described on the assumption that the urban wage rate and the location of the residential-manufacturing boundary points are exogenous. The properties of the (long-run) urban labor supply curve will follow naturally from this analysis. Then we will repeat these calculations for the manufacturing sector (with the wage rate again

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4Some evidence supporting this proposition was presented in the previous chapter.
taken to be exogenous). Here it will be the (long-run) labor demand curve which will be generated. Finally, we will put the two sides of the urban labor market together and allow the wage rate to adjust so that in equilibrium the quantities of labor supplied and demanded will be equal. Once this is done it will become clear how changes in the initial land-use decision (i.e., changes in \( t_a^* \) and \( t_b^* \)) would affect the overall equilibrium in both the land and labor markets.

Residential Land and Labor Supply

All consumers are assumed to have identical utility functions of the following form:

\[
U = u(x_1, x_2, \ldots, x_n, q, t, t^*, t^{**}), \tag{5-1}
\]

where

\[
x_i = \text{the quantity of ordinary (nonland and non-transportation) commodity } i \text{ purchased},
\]

\[
q = \text{the quantity of land owned},
\]

\[
t = \text{the distance from the consumer's residence to the urban center (C)},
\]

\[
t^* = \text{the distance from one of the zoning boundaries to } C,
\]

\[
t^{**} = \text{the distance from the consumer's residence to the nearest zoning boundary}.
\]

The inclusion of the \( x \)'s and \( q \) is quite standard and requires

---

5 The reader should note that the notation in this chapter does not correspond exactly to that in Chapter III. Recall also that there are no durable structures in this model. This explains why land appears in the utility function and "housing" does not.
no commentary. It is included in (5-1) as a way of indirectly capturing the loss of leisure brought about by the need to devote some time to shopping and work trips. The basic thought underlying this particular specification is that total travel time will always be a positive monotonic function of the distance from the residence to the central city.

The last two arguments in (5-1) introduce neighborhood externalities into the model. This specification takes two kinds of external effects into account. The first is a land quantity effect. Other things equal (including wages, land prices, distance to C, and distance to t*), all of our households would prefer having only a little manufacturing land in their community to having a lot. They might rationally have such tastes, for example, if the overall level of local air pollution or traffic congestion varied directly with the total quantity of town land devoted to industrial purposes. If we assume that our city will always be partitioned symmetrically, then the length of the segment (t* , C) will be equal to the length of the segment (C, t*). Denote the common length by t*. Under this assumption, the total amount of land in the community devoted to manufacturing is 2t*. Since 2t* is only

---

6 In Chapters III and IV these two dimensions were reduced to one through use of the neighborhood concept.

7: We shall also from time to time use t* as a symbol for the boundary point itself. This should cause no difficulty if one thinks of the line along which our city is stretched as an axis with C at the zero point.
a positive linear transformation of $t^*$, it is appropriate to substitute the latter for the former in (5-1) provided it is understood that the underlying mathematical form of the utility function is different in the two cases.

The second externality argument embodies a distance effect. Holding the total quantity of manufacturing land in the community constant (and everything else), households will prefer living far away from industrial zones to living near them. This sentiment seems to be universal and needs no extended explanation. In (5-1) we denoted the distance from the consumer's residence to the (nearest) zoning boundary by $t**$. Since our space economy is one-dimensional, however, the following side condition holds:

$$t** = t - t^*.$$  \hfill (5-2)

This means that the last three arguments in (5-1) are determined as soon as the two distance variables $t$ and $t^*$ are known. In the analysis which follows we shall take advantage of this redundancy by always substituting (5-2) directly into (5-1), thereby reducing the number of variables in the system.

The assumed signs of the first-order partial derivatives are the natural ones:

\begin{align*}
u_1 &> 0 \quad (i = 1, 2, \ldots, n), \quad (5-3.1) \\
u_{n+1} &> 0, \quad (5-3.2) \\
u_{n+2} &< 0, \quad (5-3.3) \\
u_{n+3} &< 0, \quad (5-3.4) \\
u_{n+4} &> 0. \quad (5-3.5)
\end{align*}
Each consumer living in our new town is subject, as in Chapter III, to a simple budget restraint.

\[ y = \sum p_i x_i + rq + h(t), \]  

(5-4)\

where

\[ y = \text{the (annual) urban money wage rate}, \]
\[ p_i = \text{the price of ordinary commodity } i, \]
\[ x_i = \text{the quantity of ordinary commodity } i, \]
\[ r = \text{the annual land payment per acre}, \]
\[ h = \text{the transportation cost function } [h'( ) > 0]. \]

The household's income in this model is thus exhausted by payments for ordinary commodities, for residential land, and for transportation. This specification assumes that the total annual expenditure for the last of these is a function only of the distance from household's residence to the center of the city. This is a strong assumption, considerably more restrictive than the one we made in Chapter III. We are trying to reduce the problem to the bare essentials, however, and this specification seems a sensible way to do it. Essentially, (5-4) is based on two assumptions: first, that all ordinary commodities are only offered for sale at \( C \) (with prices determined by the world market) and, second, that the length of the average (one-way) work trip over the year is \( t \). To justify the latter, it is perhaps useful to suppose that the typical worker changes jobs occasionally during the year and works for firms located on both sides of the urban center.
The actual assignment of households to lots takes place at the primordial auction. Recall first that the size of the lot has been fixed in advance. Thus,

\[ q = q^*, \] (5-5)

a constant at all locations. We make this assumption because it greatly simplifies the subsequent analysis. Basically, it reduces the dimensions of the site choice so that only location-al factors need to be considered. This means in turn that the distinction between the price paid per unit land and the total price paid for the parcel is not particularly important here. One is always a constant multiple of the other.

Once the land is subdivided, the developer chooses a particular \( t^* \) and auctions off the land in the industrial zone to manufacturers and the land outside of this zone to households. For the moment we will focus only on the residential zone, reserving discussion of the manufacturing sector for a bit later on. When the auction is announced, consumers migrate to the city from the rest of the world and bid on the parcels available. We will suppose that existing credit arrangements require that each household which takes title to a parcel must pay back a constant proportion of the purchase price (\( m^* \)) each year for a long period. Thus for each household we have

\[ rq^* = bm^* = bmq^*, \] (5-6)

where \( m \) is the purchase price per acre. As in Chapter III, \( b \) is an exogenous real credit parameter. We assume this kind
of payment system because it is a simple way of dealing with a capital asset (land) within the confines of a static model.

Returning to the auction itself, we shall suppose that the new town is small with respect to the rest of the world so that it is reasonable to assume that there is an infinitely elastic supply of prospective residents at some particular utility level.\(^8\) Note that we need not assume that all of the people living in the rest of the world are at this level. All that is necessary is that there be a large number of such people relative to the number of residential sites available in the new town. Note also that if there are two such large groups of households in the world, both with identical skills, but with one enjoying a higher level well-being than the other, it will be members of the less well-off group who will capture all of the sites in the community. At every possible local wage rate they will be able to outbid the members of the more well-off group and still end up no worse off than they were before.

The reasoning in the previous paragraph, coupled with (5-5), implies the following equilibrium condition for each purchasing household once the auction is complete:

\[
\bar{u} = u(x_1, x_2, \ldots, x_n, q^*, t, t^*, t-t^*). \quad (5-7)
\]

The \(\bar{u}\) in (5-7) is of course the common level of well-being.

---

\(^8\) Another way of putting this is that the world demand for residential sites in the new town is perfectly elastic at a particular level of well-being.
alluded to above. It is determined exogenously by economic conditions in the rest of the world. The logic of (5-7) as an equilibrium condition is easily seen. Suppose at some point in the primordial auction the price of a particular parcel is quite low relative to the local wage rate (held constant for the moment). Assume it is low enough so that if the property were sold at this price the purchaser would achieve a welfare gain. That is, he would subsequently be able to live at a level of well-being higher than the one he enjoyed previously (presumably $\bar{u}$). If in fact the supply of households is perfectly elastic at $\bar{u}$, however, a sale will never be consummated at such a low price. Other households will enter the auction and bid the price of the parcel up until it is just high enough to make its ultimate purchaser indifferent between living in the new town and living elsewhere. Clearly the price cannot rise higher because that would imply a welfare loss for the purchaser. He could do better if he simply left the city. (We are ignoring the influence of intercity transport costs here.) Thus what (5-7) really says is that migration equalizes utility levels across cities. This in turn is a somewhat more general statement of the familiar proposition that migration equalizes real wage rates.

We now have four functional restrictions on the behavior of any household in our economy. First, it must always be on its budget line (5-4). Second, the quantity of land purchased is fixed in advance and constant at all locations (5-5). Third, the price it can actually bid for a parcel is constrained by the size of the annual payment it chooses to make (5-6). And
fourth, it must always be at a fixed utility level \((5-7)\).

These four conditions, together with the assumption (discussed in Chapter III) that households are "rational" in their bidding behavior, are enough to determine a gradient showing how the equilibrium price per acre of residential land varies with distance. Because of the symmetry assumption, it is sufficient to focus on only one side of this overall relationship, a procedure we shall adhere to throughout our analysis of land market operations.

We designate the right-hand land value gradient as follows:

\[
m = m(t; y, t*) \tag{5-8}
\]

A useful way to think about this relationship is as a curve in price-distance space which sifts up or down in response to changes in \(y\) or \(t^*\). The semicolon in \((5-8)\) is used to reinforce this thought.

By applying the envelope theorem procedure described in Chapter III it is possible to determine the signs of the various partial derivatives of \((5-8)\). To do this choose some particular residential location (thus fixing \(t\)) and assume that \(y, t^*, \bar{u}, p_i(i = 1, 2, \ldots, n), b\) and \(h(\ )\) are given. The equilibrium market value for this location may then be determined by sub-

\[9\] Unlike the bidding function in Chapter III \([M(\ )]\), \((5-8)\) may be estimated using real world price data. Indeed, the equations obtained in Chapter IV may be thought of as more general forms of this same type of relationship. Note also that the other parameters to the problem, such as \(\bar{u}\), have been subsumed in the functional form rather than being directly included in the argument list.
stituting (5-5) and (5-6) into (5-4), solving for m, and then maximizing this expression subject to the utility equalization constraint (5-7). The details of a similar calculation were worked through rather carefully in Chapter III so we need not repeat them here. Instead, let us turn directly to the results.

First, what is the slope of the price gradient? By applying the envelope theorem we obtain the following:

\[
\frac{\partial m}{\partial t} = \left[ \frac{1}{(bq^*)} \right] [-h'(t)] + \lambda [u_{n+2} + u_{n+4}]. \quad (5-9)
\]

The sign of this expression is indeterminate because one of the terms in the third set of brackets is negative \([u_{n+2} \text{ using } (5-3.3)]\) and the other is positive \([u_{n+4} \text{ using } (5-3.5)]\). The slope of the price gradient is not always negative (as is its counterpart in Alonso's model) because of the externality distance effect.\(^{10}\) If households did not particularly care how far they lived from factories, then \(u_{n+4}\) would be equal to zero and the sign of (5-9) would be unambiguously negative.\(^{11}\) This result has some potential empirical importance because it suggests that real world residential land value gradients need not slope downward from the center of the city at every point. Concentrations of nuisance-creating industries around the central business district might, for example, cause the price gradient to slope upward rather than downward in nearby residential areas.

In order to simplify the subsequent analysis we shall

\(^{10}\)Alonso, op. cit., p. 70.

\(^{11}\)The sign of \(\lambda\) is easily shown to be positive. See Chapter III.
assume that \( m( ) \) intersects the horizontal (distance) axis only once and that this intersection point is the urban-rural margin.\(^{12}\) We know such a margin must exist because households have limited budgets; there will always be some distance beyond which no one can afford to live. In the present model the actual urban-rural margin (labeled \( t' \)) will always be inside this outer limit because travel is onerous as well as costly and because of neighborhood externalities. The important thing, however, is the necessary existence of such a point. Land prices inside it will be positive (because of capitalized accessibility) and land prices outside it will be zero (because no one wishes to live there).\(^{13}\)

The assumption that there be no additional intersection points is really a further restriction on the regularity of the underlying utility and travel cost functions. We make it because multiple intersections (caused by a price gradient which dips below the horizontal axis and then rises up again) would complicate the forthcoming arguments in a nonessential way. In addition, their existence seems empirically implausible.

In Figure V-1 an arbitrary residential price gradient for one-half of the city is depicted. Note that we have drawn the curve so it slopes upward in that section of the residential zone located close to the manufacturing sector. This follows a suggestion made two paragraphs earlier. There is no

\(^{12}\)Recall that \( m( ) \) describes land prices for the right-hand side of the city only.

\(^{13}\)We are assuming no agricultural demand for land.
necessity about this particular shape, however; many others are possible, even with the single intersection restriction. A rather likely real world situation is one in which transport costs are so high that they swamp the externality effects in (5-9), causing the gradient to be negatively sloped everywhere.

Next, let us consider how the price of an arbitrary residential parcel would change if the developer decided to shift the manufacturing-residential boundaries out slightly further. To answer this question we must calculate the partial derivative of (5-8) with respect to \( t^* \). Using the same procedure as before we obtain

\[
\frac{\partial m}{\partial t^*} = \lambda (u_{n+3} - u_{n+4}) < 0. \tag{5-10}
\]

The sign of (5-10) is determined by (5-3.4) and (5-3.5). This result tells us that the larger the developer makes the manufacturing district prior to the primordial auction the lower will be the price he receives for each residential parcel (other things equal, including the wage rate). This comes about simply because of externalities. If households did not care about their neighborhoods, \( u_{n+3} \) and \( u_{n+4} \) would be equal to zero and so would (5-10).\(^{14}\)

In terms of Figure V-1, an increase in \( t^* \) causes the (prospective) value gradient to shift downward at every point.

\(^{14}\)Note that employment accessibility considerations do not enter into (5-10) because we are assuming that the manufacturing sector is expanded uniformly in both directions. As long as this occurs, the average accessibility of each parcel to employment remains unchanged.
Figure V-1

Residential Land Value Gradient

\[ m(t; y, t^*) \]
This means in that diagram that \( t' \), the urban-rural margin, will shift to the left. Because we have assumed that the urban-rural margin is the only point at which \( m(\cdot) \) intersects the horizontal axis and because the function is necessarily single-valued in distance, this last result is a general one. Thus we have shown (informally) that

\[
\frac{\partial t'}{\partial t^*} < 0. \tag{5-11}
\]

Recall that thus far in the analysis we have assumed that the (annual) urban wage rate received by all households in our economy \( y \) is constant. If we now allow a small increase in this variable, how will the land value gradient (5-8) shift? Proceeding as above we can show the following:

\[
\frac{\partial m}{\partial y} = \frac{1}{(bq^*)} > 0. \tag{5-12}
\]

Basically, (5-12) tells us that a one dollar increase in annual income for all local households will lead to an increase of \( 1/(bq^*) \) dollars in the price of all previously occupied parcels in the community. What this means is that income increases are completely capitalized into the value of land, with the exact size of the capitalization effect being determined by \( b \), the credit parameter. This is a strong result, but it is a natural consequence of our earlier assumptions about intercity migration and the equalization of utility levels. Obviously, local income increases do not lead to long-run welfare increases in this model.

Once again referring to Figure V-1, it is clear that an
increase in \( y \) causes the entire land value gradient to shift upward. It follows immediately, using an argument identical to the one underlying (5-11), that

\[
\frac{\partial t'}{\partial y} > 0. \tag{5-13}
\]

We are now in a position to say something about the (long-run) supply curve of labor in this economy. Given \( t^* \) and \( y \) (and the other parameters), the working population of the city is

\[
L_s = 2(t' - t^*)/q^*, \tag{5-14}
\]

assuming a symmetrical city and one worker per household. Applying (5-13) we obtain

\[
\frac{\partial L_s}{\partial y} = \frac{2}{q^*}(\frac{\partial t'}{\partial y}) > 0. \tag{5-15}
\]

This result tells us that an increase in the urban wage rate prior to the primordial auction will induce a larger equilibrium urban population and labor force. Thus the new town developer faces a labor supply curve which is positively sloped. This is true even though the supply of households at a particular utility level (rather than at a particular wage rate) is perfectly elastic. (5-15) is easily understood in terms of Figure V-1. An increase in \( y \) causes \( m() \) to shift upward, thereby increasing the quantity of inhabited land \( (t'-t^*) \). Since we have assumed population density constant, this necessarily implies an increase in population and labor force.
Manufacturing Land and Labor Demand

Now we turn to the manufacturing sector of our urban economy. We assume first that all firms have identical production functions

\[ Z = F(L, Q), \]  

(5-16)

where

\[ Z = \text{the quantity of output produced}, \]
\[ L = \text{the quantity of labor input}, \]
\[ Q = \text{the quantity of land input}. \]

15 We make the following (usual) assumptions about the partial derivatives of \( F \):

\[ F_i > 0, \quad i = 1, 2, \quad \text{and} \]

(5-17.1)

\[ F_{ii} < 0, \quad i = 1, 2. \]  

(5-17.2)

Each firm hires labor locally at the current urban wage rate and sells its output to the rest of the world at the (exogenous) world price. Before it can be sold, however, it must be shipped from the point of manufacture to \( C \), the interurban transportation node. Because these local transportation costs are absorbed by the seller, a site close to \( C \) is, other things equal (including land price), more desirable than one further out. Annual profit under these conditions is defined

\[ 15 \text{Recall our earlier assumption that there are no durable capital assets in the economy.} \]
as follows:

\[ P = [W - k(t)]Z - yL - RQ, \]  \hspace{1cm} (5-18)

where

\[ W = \text{the world price of the output}, \]
\[ k = \text{the intracity per unit output transport cost function } [k'(t) > 0], \]
\[ t = \text{the distance from the point of production to } C, \]
\[ R = \text{the annual land payment per unit area}. \]

As indicated earlier, we shall assume that the land to be auctioned off for manufacturing has been subdivided in advance into identical lots, each the same size as the residential parcels described above. Thus,

\[ Q = q* \]  \hspace{1cm} (5-19)

at each location. The argument for making all manufacturing lots identical is the same as the one used to justify the corresponding restriction on the residential land market (5-5). The further assumption that the sizes of the manufacturing and residential parcels be equal to each other is not an extremely important one, but it does simplify subsequent discussions of the land succession process. We will then not have to worry about lot size differences impeding the smooth adjustment of the land market in effecting transitions from one land use to another.

We shall further suppose that each firm purchases only a
single lot. This is in fact another restriction on the production function (5-16). Diseconomies of scale set in so quickly that no firm who has purchased one parcel can outbid a new firm for the right to occupy either of the two parcels which adjoin it. In this situation the assumption that firms are atomistic profit maximizers translates into the following single first-order condition:

\[
\frac{\partial P}{\partial L} = (\hat{w} - k(t))L_1 - y = 0. \tag{5-20}
\]

(5-20) says that for each firm the net marginal revenue product must equal the wage rate. There is no condition corresponding to (5-20) for land because the quantity of this factor is not a decision variable in the present model.

At the primordial auction each parcel of land in the manufacturing sector is sold to the firm which bids the highest. As was done in our analysis of the residential land market, we will suppose that existing credit arrangements are such that any firm actually acquiring a parcel is obligated to repay a constant proportion of the purchase price (M*) each year. Thus for every such firm we have

\[
Rq^* = BM^* = BMq^*, \tag{5-21}
\]

where M is the purchase price per acre and B is an exogenous real credit parameter.

Since entry into the auction is free and since we shall assume that our new town faces an infinitely elastic supply of firms willing to earn a "normal" zero profit, the following also
holds:

\[ M = [W - k(t)][Z/(Bq^*)] - y[L/(Bq^*)]. \quad (5-22) \]

To obtain this result, (5-21) and (5-19) were substituted into (5-18) and \( P \) was set equal to zero.

Conditions (5-19), (5-20) and (5-22) taken together imply the existence of an equilibrium price gradient and an equilibrium labor gradient in the manufacturing zone. The former shows how the equilibrium price per unit land varies with distance from \( C \). For the right-hand side of our city we denote this relationship as follows (with \( y \) taken as an exogenous parameter):

\[ M = M(t;y). \quad (5-23) \]

The labor gradient shows how the quantity of labor hired varies with distance from \( C \). We denote this relationship (again for the right-hand side of the city) in an analogous way:

\[ L = L(t;y). \quad (5-24) \]

To see how these relationships are generated consider some arbitrary firm which has purchased a site in the manufacturing zone. Presumably it is in equilibrium; therefore, (5-20) and (5-22) hold. Because we have also assumed that each firm takes \( q, W, y, \) and \( B \) as given, these two conditions together with the production function (5-16) constitute a system of three equations in three unknowns -- \( Z, L \) and \( M \). If we knew their

\[ ^{16} \text{This is not to be confused with the bidding function in Chapter III which is also denoted } M(\ ). \]
functional forms, we could solve these equations for the specific values of the variables at the location in question. By repeating this calculation for all of the industrial locations in the manufacturing zone, we could then trace out three curves, each showing how one of the manufacturing variables varied with distance from C. Two of these relationships are given in (5-23) and (5-24); the third, the output gradient, has been suppressed because it plays no interesting role in the analysis which follows.

Proceeding as we did in our discussion of the residential land market, we now inquire into the signs of the partial derivatives of the labor and price gradients. By substituting the production function into (5-22) and then differentiating the latter and (5-20) partially with respect to \( t \), we obtain the following results:

$$\frac{\partial M}{\partial t} = \left[ -\frac{k'(t)}{(Bq^*)} \right] F(L,q^*) < 0; \quad (5-25.1)$$

$$\frac{\partial L}{\partial t} = \left[ \frac{k'(t)}{(W - k(t))} \right] \frac{F_1}{F_{11}} < 0. \quad (5-25.2)$$

The first of these tells us that the price gradient is everywhere negatively sloped in the manufacturing zone. It also reveals that high (marginal) transportation costs produce a function which is steeply sloped -- hardly a surprising result. A typical curve is shown in Figure V-2.

The second inequality tells us that the manufacturing labor gradient is negatively sloped everywhere. This conclusion follows from (5-17.1), (5-17.2), and the recognition that
Figure V-2
Manufacturing Land Value Gradient

\[ M(t; y) \]
the cost of transporting one unit of output from the firm's location to C can never exceed the price this unit will receive once it reaches its destination.\(^1\) The basic result given in (5-25.2) seems sensible and is roughly consistent with reality. Both in the model and in the real world, accessible land has more labor employed on it than does inaccessible land.

Thus far we have assumed that the urban wage rate is fixed. It is appropriate now to ask how the labor and price gradients would shift if we relaxed this assumption and allowed an exogenous increase in y. Proceeding as above, we partially differentiate (5-20) and (5-22) with respect to y to obtain the following:

\[ \frac{\partial M}{\partial y} = \left[-\frac{L}{(E_q^*)}\right] < 0; \quad (5-26.1) \]

\[ \frac{\partial L}{\partial y} = \left[\frac{1}{F_{11}^*}\right]\left[\frac{1}{(W - k(t))}\right] < 0. \quad (5-26.2) \]

An increase in the urban wage rate causes both the market value of each parcel and the amount of labor hired to work it to decline. The first of these effects would appear in Figure V-2 as a downward shift in the \( M( ) \) curve.

Let us now consider the demand curve for labor in our new town. Given the definition of L, the total quantity of labor demanded by the manufacturing sector at some wage rate y and

\[ \text{17It is worth recalling here that (5-25) also depends rather crucially on our assumption that the wage rate is taken as given by all firms and that it is the same at all locations.} \]
for some particular boundary point $t^*$ is

$$L_d = (2/q^*) \int_0^{t^*} L(t;y) \, dt. \quad (5-27)$$

We are assuming that the lot sizes are small enough so that the labor density curve is a very close approximation to a continuous function and thus can be integrated. It follows immediately that

$$\frac{\partial L_d}{\partial y} = (2/q^*) \int_0^{t^*} \left[ \frac{\partial L(t;y)}{\partial y} \right] \, dt. \quad (5-28)$$

Hence, due to (5-26.2),

$$\frac{\partial L_d}{\partial y} < 0. \quad (5-29)$$

Thus the demand curve for labor in our economy is negatively sloped. An increase in the urban wage rate will lead each of the firms in the manufacturing sector to hire less labor (other things equal). The collective effect, of course, is to reduce the overall quantity of labor demanded.

**Market Equilibrium**

Heretofore we have looked at the two sides of the urban labor market quite independently, treating $y$ in both cases as

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18 Here and elsewhere in the chapter, I make use of the following relationship:

$$\frac{\partial}{\partial a} \left[ \int p^q f(x,a) \, dx \right] = \int p^q \frac{\partial}{\partial a} [f(x,a)] \, dx \quad + f(q,a) \frac{dq}{da} - f(p,a) \frac{dp}{da}. $$

an exogenous parameter. Now we shall close the system by requiring that the equilibrium urban wage rate equalize the quantities of labor supplied and demanded. In Figure V-3 the supply and demand curves for labor are shown superimposed. Since we have already demonstrated that the supply curve slopes upward and the demand curve slopes downward, it is reasonable to assume an equilibrium intersection point exists \((L^*, y^*)\) in Figure V-3.

The market clearance condition, \(L_s = L_d\), implies, using (5-14) and (5-27) that

\[
t^* = \left[ t - t^* = \int_0^1 L(t; y) \, dt, \right] \tag{5-30}
\]

a relationship which could in principle be solved to obtain the equilibrium \(y\). Associated with this \(y\) there are then particular equilibrium price and labor gradients describing outcomes in the land market. Equilibrium conditions such as (5-30) are, however, of little interest in themselves.\(^{19}\) What is important is how the equilibrium values of the variables change in response to parameter changes. Since this dissertation is ultimately concerned with land-use policies, a natural first question to ask is how the equilibria in both the labor and land markets will be affected by a change in \(t^*\), the manufacturing-residential boundary point. From the point of view of the developer, we are asking how his decision about the location of \(t^*\) prior to the primordial auction will influence the outcomes of that auction.

---

Figure V-3
Equilibrium in the Labor Market

\[ L_s(y; t^*) \]
\[ L_d(y; t^*) \]
Let us consider the labor market first. How does a change in $t^*$ affect the supply and demand for labor? On the supply side we have from (5-11) and (5-14)

$$\frac{\partial L_s}{\partial t^*} = \left[\frac{2}{q^*}\right] \left[\frac{\partial t'}{\partial t^*} - 1\right] < 0. \quad (5-31)$$

Thus a small increase in $t^*$ causes the supply curve of labor to shift upward and to the left. The logic behind this result is comparatively straightforward. Basically, an increase in $t^*$ (other things equal) makes our new town a less desirable place to live for the typical citizen. Consequently, at each wage rate fewer people will end up migrating to the city than would have if the change had not occurred. This decrease in desirability comes about for two reasons. First, the length of the average work trip for the entire community is increased because those residential properties closest to $t^*$ (and hence those with the most accessibility) have been converted to manufacturing uses. Second, the externality effects described earlier increase with an increase in $t^*$, thereby causing all sites remaining in residential use to become less attractive than previously. The combined effect can easily be seen by examining Figure V-1. Increasing the amount of land devoted to manufacturing simultaneously moves $t^*$ to the right and $t'$ to the left (5-14), thus effecting a shrinkage in both the quantity of inhabited residential land and the labor force. Note that if there were no externalities in the economy, $t'$ would not shift to the left (because the price gradient would not shift downward). Labor supply would then be less sensitive to land use
changes than it would be if externalities were present. The analytical consequences of this last situation are that $\frac{dt'}{dt^*}$ would equal zero in (5-31).

The demand for labor is given in (5-27). It follows immediately that

$$\frac{\partial L_d}{\partial t^*} = \frac{2}{q^*}L(t^*;y) > 0, \quad (5-32)$$

because $q^*$ and $L(t^*;y)$, the quantity of labor hired by the firm located immediately to the left of $t^*$, are always positive. Thus, an increase in $t^*$ causes the demand curve for labor to shift upward and to the right. At each wage rate, more workers than before are demanded by the manufacturing sector. This is a sensible result because increasing $t^*$ allows more firms to participate in the economy.

It should now be clear how a small increase in $t^*$ will affect the city's wage rate and labor force. Both the demand and supply curves for labor in Figure V-3 will shift upward. Thus the developer will find that the more land he allocates to manufacturing prior to the primordial auction the higher the equilibrium money wage will be after the auction is complete. That is,

$$\frac{dy}{dt^*} > 0. \quad (5-33)$$

The effect on the size of the equilibrium labor force and population, on the other hand, will be indeterminate. As any introductory student knows, a simultaneous upward shift in both supply and demand has a positive effect on price but an ambigu-
ous effect on quantity. Thus a new town with a large amount of land devoted to manufacturing may have either a bigger or smaller population (and labor force) than one with a lesser amount of land devoted to this purpose.

The results in the previous paragraph have several interesting implications. First of all, we have demonstrated that there is a connection between the quantities of land allocated to different activities and some other seemingly unrelated economic and demographic variables. This suggests that zoning and other land policies should not be implemented in isolation but rather should be coordinated with existing economic planning or development programs being carried out in other governmental departments. This is hardly a new idea as far as very small governmental units are concerned. Very often they will regard the local zoning ordinance as the only effective way of controlling economic activity within their boundaries. Large cities, on the other hand, typically have separate zoning and economic development (or redevelopment) agencies which operate quite independently of each other. Our analysis suggests that this is not a sensible way to run a city.

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20 A typical small town situation is described in Shannon v. Building Inspector of Woburn, 328 Mass. 633 (1952). Here the rezoning of a district from residential to industrial was upheld on the grounds that it would promote local economic development.

A second point concerns the positive relationship we have established between the location of the residential-manufacturing boundary point and the urban wage rate. This result indicates that it may be possible to explain money wage rate differences among certain communities at least partially in terms of their differing land-use policies. Of course, the magnitude of the real world effects here are probably fairly weak so that to isolate them the researcher would have to control for the influence of other variables rather carefully.

Finally, note that our new town can be in equilibrium with the rest of the world at any of an infinity of different money wage rates (each associated with a different land-use policy). This is a natural consequence of our assumption that it is utility levels rather than wage rates which are equalized between cities by interurban migration. The essential point thus is that utility levels can be equalized between two cities (thereby bringing them into migratory equilibrium with respect to one another) even though their money wage rates are very different. It is this characteristic of real world urban economies which induces social scientists studying migration processes to deflate money wage rates with amenity and price level indices.

Let us now trace the labor market adjustments described above back through to the underlying land market changes. The effect on the price gradients in the two zones of the economy is mixed. Because of (5-33) and (5-26.2), an increase in \( t^* \) will cause the auction prices for land in the manufacturing
sector to be lower than they would have been in the absence of the increase. In terms of Figure V-2, the change induces a downward shift in the $M(\ )$ function. In the residential sector, on the other hand, the price gradient does not necessarily shift in either direction. To see this note that the following relationship holds for any residential parcel:

$$\frac{dm}{dt^*} = (\frac{\partial m}{\partial y}) (\frac{dy}{dt^*}) + \frac{\partial m}{\partial t^*}. \quad (5-34)$$

$(5-34)$ is obtained by differentiating $(5-8)$ fully with respect to $t^*$. The first term is positive [the induced income effect, $(5-12)$ and $(5-33)$], but the second is negative [the externality effect, $(5-10)$]. The net effect is indeterminate. It is impossible therefore to ascertain in advance how the price of any particular residential parcel would change if the developer decided prior to the auction to increase the quantity of manufacturing land available for sale. To answer such a question more specific knowledge about the functional forms of $m(\ ), M(\ )$ and $L(\ )$ would be necessary.

Finally, we may ask what difference the neighborhood externality assumptions make to all of this analysis. In truth, they do not play nearly as big a role here as they will in subsequent sections when we consider the specific policy problems associated with setting up and maintaining an optimal allocation of urban land. Several comments can now be made, however. The basic fact is that the existence of consumer tastes about the quantity and location of manufacturing land in the space economy causes the size of the urban population (and labor force) to
be more sensitive to land use changes than would otherwise be the case. This we noted earlier in our discussion of the properties of the labor supply curve. As is clear from (5-31), if there are no neighborhood externalities a marginal increase in $t^*$ will induce a smaller upward shift in the labor supply curve than would occur if externalities did exist. Thus both the wage increase and the labor quantity decrease will be less in the no externality case (other things equal) than they would be in the externality case.

This result suggests in turn that cities in the real world which are characterized by particularly offensive environments (due to smell, air pollution, ugliness, etc.) ought to have higher prevailing money wage rates and smaller populations (in equilibrium) than those cities which are not so characterized. Obviously, to test such a hypothesis the influence of all variables — including the industrial structure of the economy — must be controlled for. Such a task would not be simple to do because there is usually a close relationship between the economic base of an urban area and its environmental undesirability. Nonetheless, this seems like an interesting area to explore.

C. Maximizing the Aggregate Value of Urban Land

Thus far in this chapter we have concerned ourselves with the structural characteristics of a simple model of a new town economy. Using this model we have demonstrated that a change in land use has a diverse set of consequences which extend throughout the entire economy. Nothing has been said, however,
about the developer. It is he who is in charge of planning the new town and who in the end must make all land allocation decisions. In the model economy which has been constructed in the present chapter the scope for decision making has been reduced to the bare minimum. All the developer must do is decide on the location of a single point: \( t^* \), the point which separates the residential zone from the manufacturing zone. How this choice is made is the subject of the present section.

We will assume that our developer wishes to maximize profits. Once the developer has purchased and subdivided the land (i.e., once the costs associated with these two activities are sunk), a strategy which maximizes profits is equivalent to one which maximizes land values. Thus we will assume that our developer chooses the \( t^* \) which maximizes the total receipts to be obtained from the primordial auction.\(^22\) We will now try to indicate some of the implications of this choice.

The total of the receipts which the developer will obtain by auctioning off all parcels on the right-hand side of the city is equal to the sum of the following two integrals:

\[
V = \int_0^{t^*} M(t;y) \, dt + \int_{t^*}^{t'} m(t;y,t^*) \, dt. \tag{5-35}
\]

\(^22\) A more complex model would begin at an earlier stage and include the land purchase and subdivision decisions as well. These aspects of the development problem were, however, peripheral to the main interest of this study. Consequently, we ignored them.

\(^23\) Because we have assumed that our developer always lays out a symmetrical new town, we can focus (as before) on only one side of the urban land market.
The first term gives the total sales in the manufacturing zone, the second total sales in the residential zone. We now wish to maximize \( V \) with respect to \( t^* \), the land-use boundary parameter. Differentiating, we obtain

\[
\frac{dV}{dt^*} = \frac{d}{dt^*} \int_0^{t^*} M(t;y) \, dt
\]

\[
+ \frac{d}{dt^*} \int_0^{t^*} m(t;y,t^*) \, dt.
\]  

(5-36)

But

\[
\frac{d}{dt^*} \int_0^{t^*} M(t;y) \, dt = \frac{\partial}{\partial t^*} \int_0^{t^*} M(t;y) \, dt
\]

\[
+ \left[ \frac{dy}{dt^*} \right] \left[ \frac{1}{B_q} \int_0^{t^*} L(t;y) \, dt \right].
\]

(5-37)

Hence, utilizing (5-26.1),

\[
\frac{d}{dt^*} \int_0^{t^*} M(t;y) \, dt = M(t^*;y)
\]

\[
- \left[ \frac{dy}{dt^*} \right] \int_0^{t^*} \left[ \frac{1}{B_q} \right] L(t;y) \, dt.
\]

(5-38)

Moreover, we know from (5-27) that the integral in the second term is nothing but a constant multiple of the quantity of labor demanded at wage rate \( y \). Hence
\[
\frac{d}{dt} \int_0^t M(t;y) \, dt = M(t^*;y) - \left[ \frac{dy}{dt^*} \right] \left[ 1/(2B) \right] L_d. 
\] (5-39)

Now let us look at the second term of (5-36).

\[
\frac{d}{dt} \int_{t^*}^{t} m(t;y,t^*) \, dt = \frac{\partial}{\partial t^*} \int_{t^*}^{t} m(t;y,t^*) \, dt \\
+ \left[ \frac{dy}{dt^*} \right] \left[ \frac{\partial}{\partial y} \int_{t^*}^{t} m(t;y,t^*) \, dt \right]. 
\] (5-40)

The first term of (5-40) becomes

\[
\frac{\partial}{\partial t^*} \int_{t^*}^{t} m(t;y,t^*) \, dt = \int_{t^*}^{t} \frac{\partial m}{\partial t^*} \, dt \\
- m(t^*;y,t^*). 
\] (5-41)

The second term of (5-40) becomes

\[
\left[ \frac{dy}{dt^*} \right] \left[ \frac{\partial}{\partial y} \int_{t^*}^{t} m(t;y,t^*) \right] dt \\
= \left( \frac{dy}{dt^*} \right) \int_{t^*}^{t} \frac{\partial m}{\partial y} \, dt. 
\] (5-42)

Both of these results are obtained by noting that \( m(t^*;y,t^*) = 0 \). Inserting (5-41) and (5-42) into (5-40), we obtain
\[
\frac{d}{dt^*} \int_{t^*}^{t'} m(t,y,t^*) \, dt = \int_{t^*}^{t'} \frac{\partial m}{\partial t^*} \, dt 
- m(t^*;y,t^*) + (dy/\partial t^*) \int_{t^*}^{t'} \frac{\partial m}{\partial y} \, dt. 
\] (5-43)

Furthermore, utilizing (5-12) we see that
\[
\int_{t^*}^{t'} \frac{\partial m}{\partial y} \, dt = \frac{(t' - t^*)/(bq^*)}{L_s/(2b)}. 
\] (5-44)

Finally, substituting (5-39), (5-43), and (5-44) into (5-36) we obtain
\[
\frac{dV}{dt^*} = M(t^*;y) - m(t^*;y,t^*) + \int_{t^*}^{t'} \frac{\partial m}{\partial t^*} \, dt 
+ [dy/\partial t^*][(1/b)(L_s/2) - (1/B)(L_d/2)]. 
\] (5-45)

If we now assume that \( b = B \) and that the labor market is always in equilibrium \( (L_s = L_d) \), it follows that
\[
\frac{dV}{dt^*} = M(t^*;y) - m(t^*;y,t^*) 
+ \int_{t^*}^{t'} \frac{\partial m}{\partial t^*} \, dt. \tag{5-46}
\]

\[24\] The assumption that the two credit parameters are the same is consistent with the static framework we have been using throughout this chapter. If we drop this assumption, the boundary condition described below (5-47) simply becomes more complex. Our basic arguments concerning the role of neighborhood externalities would remain unchanged, however.
Setting $dV/dt^*$ equal to zero, we then obtain

$$t^*$$

$$M(t^*; y) = m(t^*; y, t^*) - \int_{t^*}^{t'} \frac{\partial m}{\partial t^*} \, dt.$$  \hspace{1cm} (5-47)

(5-47) is the first-order condition for the maximization of $V$. What does it tell us? Essentially, (5-47) is a restriction on the (per unit) land prices paid by the two uses at $t^*$, the boundary point. $M(t^*; y)$ is the price paid by the manufacturing firm located immediately to the left of $t^*$. And $m(t^*; y, t^*)$ is the price paid by the corresponding household immediately to the right.

Note, first of all, that if there are no externalities in the economy the integral term on the right-hand side of (5-47) is equal to zero due to (5-10). In this situation

$$M(t^*; y) = m(t^*; y, t^*).$$  \hspace{1cm} (5-48)

Thus, if there are no externalities, a necessary condition for the maximization of aggregate land values is that the prices paid by the two uses at the boundary point be the same.

If there are externalities in the economy, however, the integral term in (5-47) is negative. In this case a necessary condition is that the two prices be different. More specifically, the condition (5-47) states that for a maximum the manufacturing price at $t^*$ must be greater than the residential price at the same point, with the difference being equal to the total decrease in residential land values which would come about if the boundary point were moved out slightly and $y$ were held con-
This last decrease is of course the consequence of neighborhood effects. The reader will recall from the previous section how an outward shift in $t^*$, other things equal (including $y$), caused the entire residential price gradient to shift downward.

In either case it is now clear that the developer will determine what is the most profitable allocation of urban land between the two uses by solving (5-47) for $t^*$. Since (5-47) is only a necessary condition, there may in fact be more than one solution to this equation. Presumably, however, the number of local maxima in real world cases is small so that the typical developer possesses sufficient professional acumen to choose among them.

D. The Land-Use Control Problem Revisited

In earlier chapters we referred at several points to what we called the land-use control problem. As we described it, this problem seemed to be strictly a matter of resource allocation. How much land should be allocated to each of the competing economic activities in an urban area and where should it be located? We are now in a position to see that this emphasis was a trifle misleading. Resource allocation is an important part of the land-use control problem. It is not, however, the whole story.

To see this, let us return to our private developer. In the previous section we described (rather formally) how he

\[\text{25} \text{ The implied configuration of manufacturing and residential prices curves is shown in Figure V-4.}\]
Figure V-4
Residential and Manufacturing Land Value Gradients
would go about choosing a \( t^* \) which maximized the total market value of his land holdings. Thus in this rather special case we solved the allocation problem, strictly defined. If we know the functional forms of the various curves and if we know the developer is a profit maximizer, then we can easily determine the partition of the urban space economy he will choose.

If our developer wishes only to lease all of the lots in the town, this partition is all he needs to know. Suppose, however, he wishes to sell his holdings immediately (the assumption we have been making throughout this chapter). This decision generates a new problem. How can the developer be sure that the value-maximizing allocation will be preserved after the land is sold? At first this might appear to be an irrelevant question. After all, why should the developer care about what happens to his land after it has been sold? In fact, he does not really care. He does, however, care about the expectations which prospective purchasers have about the future appearance of the community in which they are considering buying a lot. If these purchasers do not expect the present allocation of land (determined by the developer) to persist in the future, this expectation will affect (probably adversely) the price which they are willing to pay.

Thus the developer must really make two decisions. First, he must decide upon a land-use partition which, if it is viewed as immutable by all purchasers (firms as well as households), will maximize his total sales revenue. This is the allocation decision described above. Second, he must choose some insti-
tutional arrangement which will provide a credible guarantee that in fact the chosen partition will persist into the future.

This distinction is a general one; it applies to land-use decisions made by communities as well as those made by private developers. In the community case, of course, the appropriate choice criteria are not nearly as clear-cut as they are in the developer case. There is simply no single behavioral assumption which commands wide agreement among experts in the field of local government. In some cases it may be reasonable to assume that communities strive to maximize total land values; in other cases such an assumption is clearly inappropriate. Whatever the criteria actually employed, however, it should be clear that a community faces the same problem that a private developer does. It must determine an "optimal" allocation of the land within its boundaries among all alternative economic activities. In addition it must set up one or more institutional mechanisms for achieving this optimal arrangement and preserving it once it has been achieved. Obviously, the developer does not have to worry about achieving the initial optimal arrangement since in the beginning he has complete control over the land. Otherwise, however, the situations faced by the developer and the community are very much the same.

It is worth remarking at this point that the distinction we are drawing here between the allocational and the institutional aspects of the land-use control problem corresponds closely to the conceptual distinction drawn in the legal and planning literature between a community's master plan and its
The standard planning view is that the master plan is a document which contains the ultimate planning goals of the community. A zoning statute, on the other hand, is regarded only as one of several alternative control or regulatory devices which can be used to achieve these goals. Thus (in theory) the master plan stands behind the zoning statute and has an existence independent of it. From the point of view of the present study it is useful to think of the master plan (or at least the physical portion of it) as embodying the community's land allocation objectives (derived presumably from some social welfare function). It thus indicates what the community regards as the optimal pattern of local land use. The zoning ordinance then becomes only an institutional tool for bringing this optimal pattern into existence and preserving it once it has been achieved.

Unfortunately, few communities in the real world have paid much attention to "proper" planning procedures. In nearly all cases, municipalities passed their first zoning ordinance long before they had a master plan, a sequence of events which most city planners find preposterous. As Haar has demonstrated in the article cited above, the courts have had to employ some rather far-fetched arguments to certify the constitutionality of zoning in the absence of any "comprehensive" plan. Most communities in fact end up treating their zoning map as if it

26 The most famous piece of writing on this subject is Charles Haar's "In Accordance with a Comprehensive Plan," Harvard Law Review, 68 (April, 1955).
were the same thing as a municipal plan, a practice which leads to awkward moments when these same communities wish to demonstrate in court that changes which they have made in their map were dictated by "general welfare" considerations rather than by the caprice of the zoning board of appeals.

One may ask at this point what the preceding discussion has to do with neighborhood externalities, the phenomenon with which this chapter is ostensibly concerned. To see the relationship we must make use of the results obtained in the preceding section. We have assumed that our developer wishes to maximize the total value of his land holdings. It follows (as demonstrated above) that a necessary condition for achieving this maximum when neighborhood externalities are present is a land price gradient which is discontinuous at the (optimal) residential-nonresidential boundary. When externalities are not present, on the other hand, a necessary condition is that the gradient be continuous at this location.

What is the significance of these results? The critical point concerns the relative stability of the value-maximizing allocations in these two cases. In the no-externality case the optimal allocation is stable because there will be no market forces operating to alter the developer's original partition (i.e., his choice of t*) once he has divested himself of all of the land in the new town.27

27 The implicit assumption here is that the (absolute) slope of the manufacturing price gradient at t* exceeds the (absolute) slope of the residential price gradient at the same point. This will typically be the case because one expects the developer to put the economic activity with the steepest bid price curves closest to the urban center.
In the externality case, however, these forces do exist. Suppose, for example, the developer makes all of the lots in the new town subject to a restrictive covenant which requires the boundary point separating the two types of land use to be at a specific location. Suppose further that all the purchasers regard this system of covenants as watertight. If in fact the chosen \( t^* \) was the optimal one, then the spatial pattern of prices received by the developer for all of his lots will be similar to the one shown in Figure V-4. That is, there will be a discontinuity in the price gradient at \( t^* \), with the residential price lying below the manufacturing price at this point.

Now what will happen if subsequent to the primordial auction the covenant system is found to be legally void? Clearly, there will be conversions from residential to nonresidential uses in the area immediately to the right of \( t^* \). The motivation behind these conversions will be the desire of households to realize capital gains on the property which they purchased. Such conversions will continue until prices are equalized at the boundary. Once this occurs the system will have reached an equilibrium and no more changes will take place.

In this particular example, of course, the developer was unaffected by the legal errors which he committed when he drafted the covenants. This is the kind of mistake, however, which a developer cannot afford to make too often. If his promises to prospective purchasers in successive developments are to remain credible, it is essential that the arrangements which he sets up to perpetuate a certain pattern of land use be effec-
tive. Thus the presence of neighborhood externalities makes the institutional aspects of land-use control rather important to the profit-maximizing developer. If he cannot set up his controls properly, he will probably end up getting less than the maximum value for his land holdings because of the attendant uncertainty.28

The device which developers typically use to ensure that the land-use patterns which they set up will be sustained through time is the restrictive covenant.29 Since covenants are a kind of private contract, the restrictions which they can impose on land use are much greater than those which can be imposed under police power regulations such as zoning. One need only to look at the covenants used by Levitt and Sons to affirm this.30 This is one of the reasons that developers find the device very useful. Another reasons is that the typical set of covenants (or "building scheme") can be enforced by

28This result need not obtain in all cases. It is quite possible that in some instances a higher value will be obtained because of a particular pattern of (mutually inconsistent) expectations on the part of the purchasers. One does not expect such results generally, however. Most households do not buy real estate for speculative purposes.

29A brief discussion of the legal aspects of covenants may be found in Williams, op. cit., pp. 18-22. This topic, incidently, would be an interesting area to explore using the economic theory of coalitions. Bargaining and the costs of organization enter into the creation and maintenance of covenant systems in obvious ways.

30Delafons, op. cit., pp. 76-79. Levitt's covenants even go so far as to impose some restrictions on the hanging of laundry outdoors.

any one of the property owners who purchased subject to it. This makes the restrictions much more difficult to alter because any changes require virtually one hundred per cent agreement to be implemented.

Neighborhood externalities introduce similar kinds of complications in the community case too. Municipalities, like developers, typically wish to impose locational restrictions on those land uses which generate strong neighborhood effects. One suspects that they will want to do this even if they do not choose to follow an explicit land value maximizing strategy. These restrictions are likely in turn to lead to price discontinuities of the type shown in Figure V-4. The problem which the community must solve in this situation is then identical to the one faced by the developer -- namely, what institutional arrangements should be set up to preserve a particular status quo. As in the developer case, there is an inherent source of instability in the system. The more people there are who regard some particular pattern of land use as permanent (due to faith in a zoning statute) the more incentive there is for particular individuals (speculators!) to try to undermine the statute in order to achieve capital gains. These simple dynamics account for much of the distrust which has come to surround the zoning institution in the past half century.

A specific example will clarify these observations. Sup-

31Typical members of this last group are entrepreneurs who seek to build apartment buildings and shopping centers in heretofore homogeneous single-family home neighborhoods.
pose that the point labeled $t^*$ in Figure V-4 is the community optimum (on the basis of some social welfare function). Suppose further that the community is able to bring about this optimal partition through public action \(^{32}\) (perhaps urban renewal) and that it seeks to perpetuate its handiwork by passing a zoning law. If every prospective purchaser in the town believes the location of $t^*$ to be permanent due to the invulnerability of the zoning ordinance, then the spatial pattern of land values will be as indicated in Figure V-4.

The villain of the piece, a speculator, now appears. If he believes, contrary to everyone else, that the zoning ordinance is not immutable, he will purchase one or more of the (residential) lots immediately to the right of $t^*$ at the low price which prevails there. The price is low, of course, because of the proximity of manufacturing processes. He will then endeavor to persuade the zoning board of appeals to grant him a use variance. Alternatively, he will try to get the city council to amend the zoning map in his favor ("spot zoning"). If he succeeds in either of these endeavors, he will be able to resell his holdings to one or more manufacturing firms and make a capital gain of (roughly) $M(t^*;y) - m(t^*;y,t^*)$ dollars per unit area.

What arguments will he use to persuade the relevant government officials to grant him this windfall? For one thing \(^{32}\)

\(^{32}\) We remarked in Chapter IV and elsewhere that zoning itself is not well-designed for this purpose.
he may seek to persuade them that external circumstances have changed (even though they have not), and that therefore a re-
 zoning is necessary to return the statute to optimality.
Second, he may assert that the current zoning restrictions im-
 pose unreasonable "hardship" on him and that therefore he is entitled to a variance. Third, he may attempt to challenge
the entire zoning ordinance on grounds of legal insufficiency.
Last, but certainly not least, he may attempt to bribe the appropriate officials to obtain the adjustments desired.

This last method is worth a comment or two. We noted above that a strategy of land value maximization in the presence of externalities meant a discontinuous land price gradient. We went on to observe that although communities might not always want to pursue that particular strategy, it seemed likely that they would still wish to restrict externality-generating land uses in such a way that price discontinuities would result. If these speculations are correct, one would expect corruption of the type described in the previous paragraph to be a rather com-
 mon characteristic of American zoning systems -- which indeed it is. The simple truth is that government-imposed price discon-
tinuities, such as the one exhibited in Figure V-4, will always

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33 In fact, of course, the only "hardship" he endures is the prospect of not achieving a lucrative capital gain if the zoning is not changed. On occasion even the courts fail to appreciate this point. See, for example, Vernon Park Realty, Inc. v. City of Mount Vernon, 307 N.Y. 493, 121 N.E. (2d) 517 (1954). In this case a sharp developer bought a parking lot subject to a zoning restriction and then persuaded the court to invalidate the restriction on due process grounds so he could build a shopping center.
be standing invitations to bribery.

In real world situations at least one of the strategies described in the previous paragraph will frequently work. Indeed, the ease with which variances and map changes are obtained has generated widespread cynicism and anxiety among zoning experts. The problem here is a real one. If there is any merit at all to the view that the allocation of a community's land should be planned in some way rather than left exclusively to market forces, then it is a problem worth solving. Zoning can probably never be made into a positive instrument for effecting major land use changes. Perhaps, however, it can still be usefully employed as a holding device for preserving worthwhile configurations of urban land which already exist. The question to be asked then is the following: What changes should be made in the zoning instrument and the way in which it is typically administered to enable it to perform this particular task more effectively than it has in the past?

This is hardly the place for an extended discussion of

34 Some evidence for this proposition may be found in data revealing that in most American cities a very high percentage of variance requests are granted by the local zoning board of appeals. A few such statistics are presented in Stephen Sussna, "Zoning Boards: In Theory and In Practice," Land Economics, 37 (February, 1961). Sussna argues that most of the requests granted by zoning boards are reasonable in the light of changed circumstances. This is definitely a minority view.

35 Sussna lists a number of representative sources. Ibid., p. 82.
institutional reform in this area. Several suggestions, however, have been made which are worth mentioning. First of all, some modern zoning enabling acts explicitly prohibit spot zoning. In addition, many of the more recent zoning ordinances forbid use variances.\textsuperscript{36} Obviously, if such restrictions become universal, much of the problem of instability described above will be solved. One difficulty with this solution, however, is that it disallows legitimate marginal map changes in response to changing conditions in the local economy.

Other reforms are less restrictive of planning initiative. Delafons and Babcock separately propose that the procedure at zoning board hearings be formalized.\textsuperscript{37} They feel that in most municipalities these proceedings are so anarchic that a rational weighing of the public and private interests in specific disputes is completely impossible. This state of affairs encourages both arbitrary and illegal decision making on the part of local officials.

Finally, Haar and others argue that the way to protect a zoning map from administrative or legislative incursion is to found it upon a well-articulated, comprehensive, municipal plan.\textsuperscript{38} This plan will presumably embody the social goals of the community and will thus be optimal according to at least some (appropriately weighted) set of social indices. This set,\textsuperscript{36,37,38}

\begin{itemize}
  \item Delafons, \textit{op. cit.}, p. 59.
  \item Ibid., p. 97 and Babcock, \textit{op. cit.}, pp. 154-159.
  \item Haar, \textit{op. cit.}
\end{itemize}
of course, may or may not contain the index which has been
given prominence in this study -- namely, aggregate community
land values. In any case, Haar's point is that the existence
of a plan will give the courts an additional check on official
irresponsibility in zoning administration cases. Those vari-
ance or spot zoning decisions which are not in accordance with
the community plan can then be easily ascertained and rejected.
We have now completed the limited range of tasks which we set out for ourselves in Chapter II. Having come this far, it is reasonable to ask about what lies ahead. The Ph.D. dissertation by its very nature is an extremely restricted art form -- one whose preeminent virtue is depth rather than breadth. The main implication of this unwritten law for the present study was that many interesting topics in the economics of neighborhood externalities and land-use control systems were either inadequately treated or completely ignored in the main text. Such exclusions were, of course, the price paid for the moderately high level of mathematical and econometric detail which characterized the last three chapters of this study. Now that the main work of the dissertation is over, however, it seems appropriate to make amends by indicating at least briefly what some of these topics are and how they might be fruitfully analyzed by future researchers.

Let us begin by considering the empirical work on neighborhood externalities contained in Chapter IV. The reader will recall that our principal conclusion there was that neighborhood environment appears to exert an empirically measurable (but fairly complex) effect on the market values of single-family homes. It is now a generally accepted canon of empirical research that no study can ever be truly conclusive since there is always the possibility that there are "lurking factors" oper-
ating unbeknownst behind the scenes. Nonetheless, the general results given in Chapter IV seem, in retrospect, to be fairly solid. Consequently, most of the empirical topics which immediately spring to mind are basically refinements of the work done in that chapter. This is not to say, however, that they are not worth looking into.

Surely it would be interesting, for example, to determine the precise generality of the results presented in Chapter IV. To do this it will probably be necessary to repeat (at least in broad outline) the empirical study described in that chapter for assorted city and year combinations other than 1960 Boston. It would perhaps also be useful if at least some of these subsequent studies used less aggregated data than we were forced to use here. Data on individual properties would be ideal, although, as indicated in the text, it will probably be difficult to obtain. Finally, it would be desirable for someone to consider the impact of neighborhood externalities on the market value of properties other than single-family homes. Solid statistical evidence on this question would be of obvious utility to city planners and local government officials.

Now let us turn to the theoretical results presented in Chapter V. What, if any, avenues for future research do they open up? It seems fair to say that these results are much more suggestive than definitive. The main reason for this is that the model developed in Chapter V is a fairly restricted one; it does not have a great deal of utility outside of the specific applications for which it was constructed. Indeed, as indicated,
in the text, a truly general theory of the urban land market does not yet exist. Alonso's model and the one in Chapter V are useful beginnings, but there are still a large number of important real world complexities which remain to be incorporated into them. Many of these were discussed in the main text. The principal task ahead, therefore, for economists wishing to extend the theoretical results appearing in this study is quite well-defined — namely, build a better model. Once such a paradigm is available, it will be possible to investigate the economic aspects of land-use control devices in a much more systematic way than was done here. Hopefully our efforts in this dissertation will stimulate further research along these lines.

The final set of research problems suggested by our study concerns the impact which zoning ordinances and other land-use control devices have had on real world urban space economies. Surprisingly enough, very little is known about this in spite of the fact that these policy tools have been in widespread use for over fifty years. The principal difficulty here has been the absence of any sound theoretical framework which could be used to guide empirical investigations. We discussed this general problem in the previous paragraph. Once a full-blown theory of the urban land market is developed it will become possible to make reasonable guesses about what would happen to cities if zoning ordinances were abolished. And this, of course, is what one has to know if he wishes to assay their effectiveness.
Technical Appendix

A. Introduction

The purpose of this appendix is to explain the various technical procedures used to prepare the data base for the estimations presented in Chapter IV. Included here will be a list of the Massachusetts cities and towns which made up our sample. In addition, we will go through each one of the variables introduced in Chapter IV and discuss its origin in detail. Some of these variables were taken directly from other sources; others were the product of special manipulations. In the latter cases we shall show explicitly what assumptions were introduced and how the calculations were performed. As is true of all econometric studies, many choices had to be made. Hopefully this appendix will make clear what these choices were and why we resolved them the way we did.

B. Cities and Towns

The forty-six Massachusetts cities and towns which made up our sample are listed alphabetically in Table A-1. Note that Boston is not included in this sample. This was done deliberately because it is much larger in area and population than any of its satellite communities. It has been suggested elsewhere that the older industrial cities surrounding Boston (such as Cambridge and Somerville) should also be excluded from a study which purports to analyze "suburban" property
<table>
<thead>
<tr>
<th>Arlington</th>
<th>Needham</th>
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<tr>
<td>Belmont</td>
<td>Newton</td>
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<td>Beverly</td>
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<td>Braintree</td>
<td>Peabody</td>
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<td>Brookline</td>
<td>Quincy</td>
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<td>Cambridge</td>
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<td>Chelsea</td>
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<td>Cohasset</td>
<td>Revere</td>
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<td>Concord</td>
<td>Salem</td>
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<td>Danvers</td>
<td>Saugus</td>
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<td>Dedham</td>
<td>Scituate</td>
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<td>Everett</td>
<td>Sharon</td>
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<td>Framingham</td>
<td>Somerville</td>
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<td>Stoneham</td>
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<td>Lexington</td>
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<td>Lynn</td>
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<td>Waltham</td>
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<td>Watertown</td>
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<td>Wellesley</td>
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<td>Melrose</td>
<td>Weymouth</td>
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<tr>
<td>Milton</td>
<td>Winchester</td>
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<tr>
<td>Nahant</td>
<td>Winthrop</td>
</tr>
<tr>
<td>Natick</td>
<td>Woburn</td>
</tr>
</tbody>
</table>
values. This thought was rejected because we wished to have a sample of communities which were highly diverse in their residential environments.

C. Variables

Our procedure in this section will be to go through the variables used in Chapter IV one by one. In each case we will indicate the source of the data and what manipulations, if any, were performed prior to its use in our regression equations.

**Median Value of Single-Family Homes**

This series was taken from the 1960 Census of Housing. Technically, the figures used cover only "owner-occupied dwelling units in single-unit structures." Hence, they do not take account of single-family homes which were renter-occupied rather than owner-occupied in 1960. Unfortunately there was no way of obtaining any value data for renter-occupied homes; consequently, no corrections were possible. However, because the number of renter-occupied dwelling units in single-family structures was probably small for most of the sample communities, it is unlikely that such corrections

---


would have affected our results significantly.

In addition to the median value series, the Census also provided data from which a series of average values could be calculated. The principal difficulty here was that in order to calculate these averages a representative number had to be assigned to each of several value categories -- one of which was open-ended -- for all communities. Since it seemed wiser to avoid arbitrary choices whenever possible, we decided to use the median. In addition, it was felt that the median would be somewhat less sensitive to extreme response errors than the average would be.

Unfortunately, it was not possible to use the same measure of central tendency consistently throughout the regressions. Some of the independent variable series are made up of median values and others of average values. This situation was caused by the diversity of data sources which had to be brought together to control for all possible influences on housing price. It did not seem likely, however, that this minor inconsistency had any substantive effect on our general results.

Median Number of Rooms for Single-Family Homes

The basic source for this series was again the 1960 Census of Housing. This volume contained a figure for the median number of rooms in owner-occupied dwelling units for all of the larger cities and towns in Massachusetts. It

\[3\text{Ibid.}\]
also usually contained additional data from which an average could be calculated once a representative value was assigned to the open-ended rooms category. As above, the arbitrariness of any choice for this value suggested that the median was a more satisfactory measure of central tendency. In addition, there were a number of small towns in our data base for which an average could not be calculated because of limitations in Census coverage. Consequently, if we had wished to use the average number of rooms instead of the median, it would have been necessary to drop these observations from our already too small sample. All factors, therefore, seemed to favor the use here of the median instead of the average.

There are two kinds of corrections which could have been made in the Census median room series to make it more suitable for our purposes. First, it would have perhaps been desirable to adjust the Census figures so that they would cover renter-occupied dwelling units in single-unit structures as well as all owner-occupied units. This is the same adjustment suggested above for the value series. Again, however, the number of units involved did not appear large enough to make it worth the trouble.

A second possible correction seemed more imperative. The owner-occupied room series included owner-occupied dwelling units in multiple-unit structures. Since many of the communities in the sample (such as Waltham, Watertown, and Somerville) had a large number of such units, it did not seem reasonable to ignore their presence in the Census data. In
general one would expect owner-occupied units in multiple-unit structures to be smaller than owner-occupied units in single-unit structures. Consequently, those communities with a large number of units in the former category would probably have an owner-occupied room figure which was significantly lower than the (unavailable) single-family home room figure. For those communities with no owner-occupied dwelling units in multiple-unit structures this difference would not exist.

A fairly complex adjustment procedure was devised to correct this difficulty. We defined the following variables:

- \( MR \) = the median number of rooms in owner-occupied dwelling units.
- \( MRS \) = the median number of rooms in owner-occupied dwelling units in single-unit structures.
- \( MRM \) = the median number of rooms in owner-occupied dwelling units in multiple-unit structures.
- \( NOO \) = the number of owner-occupied dwelling units in the community.
- \( NOOS \) = the number of owner-occupied dwelling units in single-unit structures in the community.
- \( NOOM \) = the number of owner-occupied dwelling units in multiple-unit structures in the community.

Given these definitions the following relationship was then assumed to be approximately true:

\[
MR = \frac{[(NOO)(MRM) + (NOOS)(MRS)]}{NOO}. \quad (A-1)
\]

If in every case the median were equal to the average, \( A-1 \) would hold exactly. All the variables in this expression
were known from the Census except for MRM and MRS. The last of these, of course, was the figure we were seeking.

We then supposed that MRM and MRS differed only by an additive parameter which was the same in all communities. That is, we assumed,

\[ \text{MRS} = \text{MRM} + \alpha. \quad (A-2) \]

Obviously, in the real world \( \alpha \) will not be constant across all cities and towns. An assumption such as (A-2) was necessary, however, if we were going to make any progress with the limited data which was available.

The next task involved obtaining an estimate for \( \alpha \). To do this we consulted the 1960 Census of Housing volume covering the Boston metropolitan area.\(^4\) This source cross-tabulated number of rooms against ownership characteristics and structure type for the city of Boston and its suburban ring. Using these figures and some simple arithmetic it was possible to obtain the value of \( \alpha \) for the entire Boston suburban area. This number turned out to be approximately 0.4. Thus in the suburban portion of the Boston SMSA the median number of rooms in owner-occupied dwelling units in single-unit structures was about 0.4 greater than the corresponding figure for owner-occupied units in multiple-unit structures.

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We then substituted this figure into (A-2), substituted this expression into (A-1) and solved for MRS.

\[
MRS = MR + (0.4)\frac{NOOM}{NOO}. \tag{A-3}
\]

All variables on the right-hand side were then known, thus making it possible to obtain an estimate of MRS for each community. This was the series which we then used in our estimations.

**Average Age of Owner-Occupied Dwelling Units**

The *1960 Census of Housing* provides no median age figure for single-family homes or indeed for any other kind of dwelling unit. All that was available were distributions of owner-occupied dwelling units among the following age-of-construction categories:

- 1959 - 1960
- 1955 - 1958
- 1950 - 1954
- 1940 - 1944
- 1939 and earlier.

In order to calculate an average age of structure for the owner-occupied units in each of our sample communities it was necessary to assign a representative age to all of the above birthday categories. For the closed categories the midpoint was chosen. For the open-ended category a somewhat more elaborate procedure was required. Before explaining it

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in detail, let us be clear about why it was necessary.

The simplest procedure here would have been to choose a reasonable representative age for the owner-occupied dwelling units built before 1940 and then apply it to all communities in our sample. The main problem with this method is that it frequently does not enable the researcher to discriminate very effectively among communities with housing stocks of different ages. Two cities might have an identical distribution of units among the five construction-date categories mentioned above and yet still have housing stocks whose average ages were very different. The problem is particularly acute, of course, when a high proportion of the total number of units in each of the communities is in the open-ended category. This, it turns out, is the case for the set of cities and towns in our sample.

Fortunately, supplementary figures were available which enabled us to sharpen our average age estimates a good deal. The basic data source used for this correction was the 1940 Census of Housing. 6 In this volume dwelling units were distributed among the following ten construction-date categories:

- 1935 - 1940
- 1930 - 1934
- 1925 - 1929
- 1920 - 1924
- 1910 - 1919
- 1900 - 1909
- 1890 - 1899
- 1860 - 1889
- 1859 and earlier.

---

Regrettably, for most of the communities in our sample this distribution was available only for all units and not for owner-occupied and renter-occupied separately. There was nothing we could do about this. As a result we were forced to assume throughout that the separate 1940 distributions for all units and for owner-occupied units were not very different.  

Our procedure then was to calculate the median date of construction for the 1940 stock of dwelling units in each of the communities in our sample. The median was chosen over the average for reasons previously described. The fact that the median is less sensitive than the average to response errors seemed particularly important in this context because people living in older dwelling units typically have only a poor idea of precisely when their structures were built.

Once we obtained this figure for each community, we subtracted it from 1960 to obtain the median age (in 1960) of dwelling units constructed before 1940 on the assumption that none of the dwelling units available in 1940 were withdrawn from the housing stock in the subsequent twenty years. This, of course, is an unreasonable assumption. Dwelling units are withdrawn from the housing stock over time, and typically in any period it is the older units which disappear. To control for this phenomenon (although in a very simple-

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7 More specifically, we assumed that the median values of the two age distributions were identical.
minded way) we subtracted five years from the age previously calculated.

These adjusted median age figures, different for every community, were then used as the representative values for the open-ended category in our average age calculations. The averages themselves were computed as simple weighted sums of all the representative values (i.e., those assigned to both the closed and open-ended categories) with the weights being the proportion of units in each category. This calculation produced an average age figure for the owner-occupied dwelling units in each community.

One may ask why we did not go on to make an adjustment for the presence of owner-occupied dwelling units in multiple-unit structures as was done in the case of the rooms variable. Basically, there were two factors involved. First of all, it was felt that such an adjustment was less important for age because this variable is really only a rough proxy for a large number of other factors which enter into the residential site choice (condition, architecture, quality of kitchen and bathroom facilities, etc.). Since the influence of age on housing price is not particularly well-defined in the first place, further improvements in the accuracy of our age data seemed less important than corresponding improvements in the accuracy of our rooms data.

Secondly, it was not completely clear which way the bias should go. Do we expect that owner-occupied dwelling units in single-unit structures will be on balance older or
younger than owner-occupied dwelling units in multiple-unit structures? For some communities one might expect the former to be older, for others the latter. Consider Table A-1, covering those cities for which separate age data on owner-occupied and renter-occupied dwelling units was available for both 1940 and 1960. Clearly, if we wished to assume that on the average owner-occupied dwelling units in multiple-unit structures were the same age as renter-occupied units, we could not go on to assert that the former are necessarily older than owner-occupied dwelling units in single-unit structures. In Cambridge and Somerville this is manifestly not the case. Moreover, one suspects that the owner-occupied dwelling units in multiple-unit structures are probably a bit newer on balance than renter-occupied units generally. This suggests that there might be more than just two cities in Table A-2 whose owner-occupied dwelling units in single-unit structures are on the average older than their owner-occupied dwelling units in multiple-unit structures.

The point of these speculations is to demonstrate that the probable direction of the bias introduced into our age series by ignoring owner-occupied dwelling units in multiple-unit structures is more difficult to determine than it was in the case of the rooms variable. This consideration, coupled with the fact that age is basically only a proxy for a multitude of other structure characteristics suggested that the kind of adjustment we made in the rooms series was unnecessary here.
Table A-2

Average Age (in Years) of the Housing Stock for Selected Massachusetts Cities in 1960

<table>
<thead>
<tr>
<th>City</th>
<th>Average Age</th>
<th>Average Age</th>
<th>Average Age</th>
<th>% Units Owner-Occupied</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>all units</td>
<td>0-0 units</td>
<td>R-0 units</td>
<td></td>
</tr>
<tr>
<td>Cambridge</td>
<td>55</td>
<td>59</td>
<td>54</td>
<td>22</td>
</tr>
<tr>
<td>Lynn</td>
<td>50</td>
<td>45</td>
<td>54</td>
<td>44</td>
</tr>
<tr>
<td>Malden</td>
<td>48</td>
<td>47</td>
<td>49</td>
<td>48</td>
</tr>
<tr>
<td>Medford</td>
<td>38</td>
<td>36</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Newton</td>
<td>37</td>
<td>36</td>
<td>38</td>
<td>60</td>
</tr>
<tr>
<td>Quincy</td>
<td>37</td>
<td>36</td>
<td>38</td>
<td>60</td>
</tr>
<tr>
<td>Somerville</td>
<td>52</td>
<td>54</td>
<td>51</td>
<td>36</td>
</tr>
</tbody>
</table>

0-0 = Owner-Occupied
R-0 = Renter-Occupied
Proportion Owner-Occupied Dwelling Units Sound, With All Plumbing Facilities

This series was essentially taken from the 1960 Census of Housing. The only complication encountered was the necessity of estimating for two communities (Nahant and Hull) the proportion of vacant units which were sound and had all plumbing facilities. This was done by calculating the corresponding percentage for a randomly selected group of small towns for which the necessary data was available. This average figure was then applied to the two communities in question.

Again no attempt was made to correct the Census owner-occupied series for the presence of owner-occupied dwelling units in multiple-unit structures. It was felt that there would not be a significant difference between the two kinds of owner-occupied units with respect to this condition and plumbing variable.

The Ratio of Local Employment to the Number of Single-Family Homes

The denominator of this fraction was taken from the 1960 Census of Housing. The specific figure used was the number of owner-occupied dwelling units in single-unit structures. No adjustment was made for renter-occupied units in single-unit structures for reasons previously discussed.

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8 Ibid.
9 Ibid.
For the numerator, total local employment, we used estimates provided by Wilbur Smith and Associates, a firm which served as a consultant to the Boston Regional Planning Project. These estimates covered every type of employment, including all jobs in the public sector.

Road Distance to Downtown Boston

This series was obtained by measuring the road distance from some major crossroads near the geographic center of each community to the Massachusetts statehouse in downtown Boston. The road distance was chosen over the linear distance because the former was felt to be a much more accurate measure of the typical suburbanite's accessibility to core employment (and shopping). This refinement seemed especially important for the present study because some of our communities (particularly those along the south shore) were located in such a way that a linear distance measure would seriously overestimate their accessibility.

Average Lot Size for Single-Family Homes

Vogt, Ivers, and Associates, a Cleveland consulting firm, performed a land-use survey in 1963 covering most of Eastern Massachusetts. The basic tool employed in this survey was air photography (though this technique was supplemented by on-the-

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10 The figures themselves were taken from David M. Schroedl, op. cit., Appendix. Schroedl apparently got the data from Smith and Associates personally.

ground inspections in areas where economic activities were highly concentrated). Two of the outputs of this inventory for each community were the number of single-family homes and the total amount of land devoted to single-family homes. We took the ratio of the latter to the former to obtain an estimate of average lot size for single-family homes in each community.

Proportion of Community Land Not Devoted to Single-Family Homes

The source for this series was the Vogt, Ivers, and Associates study mentioned above. We defined the following variables:

\[
\text{TLAND} = \text{total land area of the community.} \\
\text{ROADS} = \text{total land area of community devoted to roads.} \\
\text{HOMES} = \text{total land area of community devoted to homes.}
\]

The specific ratio used as an independent variable in the estimations was then

\[
\frac{\text{TLAND} - \text{ROADS} - \text{HOMES}}{\text{TLAND} - \text{ROADS}}.
\]

\[\text{12Vogt, Ivers, and Associates, Comprehensive Land Use Inventory Report (Boston: Metropolitan Area Planning Council, Department of Commerce and Development, 1965). Note that throughout this study we have implicitly assumed that land-use patterns in 1960 were essentially the same as those in 1963.}\]

\[\text{13Ibid. All of the land-use variables in this study come from Vogt, Ivers, and Associates. Consequently, we will not continue footnoting this source.}\]
Land devoted to roads and highways caused some classification problems in this study because these uses did not fit naturally into any of the zoning categories described in Chapter IV. The simplest and most sensible procedure seemed to be to use a total land figure in all our calculations which was net of land devoted to roads and highways. This is why ROADS is subtracted from the numerator and denominator of the above ratio. This procedure seemed preferable to forming an additional roads and highways category because we wished to restrict the total number of land-use categories to six. To be sure, one additional category probably would not have made any great difference. However, there were numerous other candidates for this seventh position besides roads and highways, and there seemed to be no good criteria for choosing among all the possibilities. The line had to be drawn somewhere and we decided to confine our attention to the six zoning categories previously described.

Proportion of Community Land Devoted to Multiple-Family Uses

The specific ratio used here was

\[
\frac{\text{MULFAM}}{\text{TLAND} - \text{ROADS}}
\]

where MULFAM is the quantity of land devoted to multiple-family uses. "Multiple-family" as it is defined here includes the following list of activities:

Two-family dwellings,

Multiple-family dwellings (apartments, boarding houses, dormitories, trailer camps).
Proportion of Community Land Devoted to Commercial Uses

The specific ratio used here was

$$\frac{\text{COMMER}}{\text{TLAND} - \text{ROADS}}$$

where COMMER is the quantity of land devoted to commercial uses. "Commercial" as it is defined here covers the following list of activities:

Retail (local and general),
Services (personal, professional, financial and office),
Hotels and Motels,
Indoor Recreation and Entertainment (bowling alleys, skating rinks, lodges, movie theaters, YMCA's, etc.).

Proportion of Community Land Devoted to Industrial Uses

The specific ratio used here was

$$\frac{\text{INDUST}}{\text{TLAND} - \text{ROADS}}$$

where INDUST is the quantity of land devoted to industrial uses. "Industrial" as it is defined here covers the following list of activities:

Manufacturing (heavy and light),
Transportation and Utilities (railroad yards and right-of-way, airports, bus and truck terminals, depots and garages, dock and port facilities, large parking lots, power stations, gas and power lines, sewerage treatment plants and other sanitary facilities, radio and TV stations, antennas, telephone facilities),
Wholesaling, Warehousing, and Storage (indoor and outdoor),

Mining and Quarrying.

Proportion of Community Land Devoted to Institutional Uses

The specific ratio used here was

\[
\frac{\text{INSTIT}}{\text{TLAND - ROADS}}
\]

where INSTIT is the quantity of land devoted to institutional uses. "Institutional" as it is defined here covers the following list of activities:

Medical, Religious, and Cultural (hospitals, clinics, nursing homes, churches, museums, and assembly halls),

Schools and Public Buildings (all schools -- public and private -- up to and including secondary schools, post offices, city halls, fire and police stations),

Colleges and Universities.

Proportion of Community Land Vacant

The specific ratio used here was

\[
\frac{\text{VACANT}}{\text{TLAND - ROADS}}
\]

where VACANT is the quantity of land in the community which is either completely unused or devoted to activities which involve the addition of only a minimal number of immobile improvements to the land. This category is something of a residual; it covers the following activities:
Forests,
Agriculture and Vacant Lots,
Swamps and Marshes,
Rivers, Lakes, and Ponds,
Construction Projects (residential and nonresidential),
Military Installations,

Outdoor Amusement Facilities (golf courses, driving ranges, athletic fields, public beaches, fairgrounds and amusement parks, outdoor swimming and wading pools, racetracks, drive-in theaters, major parks, botanical gardens and zoos).

Construction projects were included here because there seemed to be no other place to put them. In general their influence on the composite proportion was insignificant because the amount of land under construction in 1963 in all of the sample communities was very small. Military installations were included here because the large ones, really the only ones that matter, are mostly vacant land.

**Equalized Tax Rate**

A community's equalized tax rate may be calculated by multiplying its actual tax rate by an assessment ratio which measures the extent to which properties in the community are assessed at fair market value. The actual 1960 property tax rate for the cities and towns in our sample was obtained from the December, 1960, issue of *TaxTalk*, a publication of the Massachusetts Federation of Taxpayers Associations.\(^\text{14}\)

The only assessment ratios available ultimately derived from 1961 State Tax Commission data on the full market value of property in all Massachusetts communities. We obtained the ratios themselves indirectly using the actual and equalized tax rates for 1962 as reported in later issues of Tax-Talk.15

School Expenditure Per Pupil

This series was obtained from data provided in the 1960 Annual Report of the Massachusetts Department of Education.16 The actual variable used was the following ratio:

\[
\frac{\text{Total Expenditure for Support of Public Schools}}{\text{Net Average Membership in Public Schools}}
\]

The numerator does not include what is known as school "outlay." This means that purchases of land, plant and equipment were omitted from our total expenditure figures. It should also be noted that these "support" figures covered all public schools, including evening and vacation schools. The amounts spent on these last two educational services, however, were so trivial that it did not seem worthwhile to subtract them out.


16 Commonwealth of Massachusetts, Department of Education, Annual Report, Part II, 1960. Two of the other education variables mentioned in the text, the teacher-student ratio and average teacher salary, were also calculated from data available in this report.
The denominator of this fraction is a pupil enumeration measure used by the Massachusetts Department of Education. It is always a bit less than the total number of pupils enrolled and a bit more than the average daily attendance.


These three variables were used in the two-stage least squares estimations. All entered as excluded exogeneous variables. The first was obtained directly from the 1960 Census of Population. The second was calculated by dividing the population figure by the Vogt, Ivers, and Associates total area figure (net of the area covered by roads and highways). The third, a crude measure of the relative political strength of homeowners, was obtained by dividing population by the number of owner-occupied dwelling units in single-unit structures.

**Market Value of Non-Single-Family Home Property per Capita and per Home**

These two variables were also used only in the first stage of the two-stage least squares procedure. The denominators of the two fractions (population and the number of owner-occupied dwelling units in single-unit structures)

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are familiar and require no commentary. The numerator of both -- the total market value of all land and buildings devoted to uses other than single-family homes -- has not yet been discussed in this Appendix. The way we obtained this series will now be briefly discussed.

The Massachusetts Department of Commerce published data for 1960 showing the total assessed value of the land and buildings in all Massachusetts cities and towns. We took this figure for each of our sample communities and converted it to a total market value figure by multiplying it by the reciprocal of the assessment-value ratio described above. Next we obtained an estimate of the total market value of single-family homes in each sample community by multiplying the median value of these homes by the number of owner-occupied dwelling units in single-unit structures. This last figure was then subtracted from the total market value of all land and buildings to obtain an estimate of the market valuation of all real estate used for purposes other than single-family homes. This difference was then used as the numerator of the two ratios described here.

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18 Massachusetts Department of Commerce, Division of Planning and Research, Statistics of Massachusetts Cities and Towns by Subregions, September, 1963.
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