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THE EFFECTS OF PROPERTY TAX INDUCED
FISCAL DISPARITIES ON SUBURBAN
AND CENTER-CITY HOUSING VALUES

DISSERTATION

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

By
Wade Ronald Ragas, B.A., M.B.A.

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Chapter I

Introduction
Locational decisions by consumers have been linked theoretically to local public goods and taxation for the past twenty years (Tiebout, 1956). Only recently have the necessary conditions been stipulated to allow for household spatial equilibrium within suburban municipalities. Historically, intra-urban models of household migration have argued that fiscal incentives to relocate exist between the center-city and its suburbs.

A long-run equilibrium with respect to local public goods can be shown to exist among income homogeneous suburban municipalities. The imposition of zoning restraints to free intra-urban relocation by income groups below the mean of any specified municipality results in relatively income homogeneous suburban municipalities (Hamilton, 1972). Each suburb is then composed primarily of households with a similar income. A head tax with equal consumption (availability) of public goods by all households within a given municipality does not induce any household to relocate for fiscal reasons and is an equilibrium state. Conversely, this same argument provides for a continuous fiscal disequilibrium state among upper-income households who remain in the income-heterogeneous center-city. If equality of public goods provision exists within the center-city, then neither an income proportionate nor a Lindahl tax will preclude income redistribution from upper-income to lower-income households though local taxation (Wheaton, 1975).

The potential existence of fiscal relocation incentives from the center-city to the suburbs has been previously identified (Hamilton, 1972; Buchanan, 1965), but the relationship of fiscal incentives to other locational considerations has not been examined. In particular, any exogenous factors which could effect the level or slope of the price gradient for housing services should be viewed in conjunction with household income and price elasticities for housing services and the transportation cost.
associated with a change in location. Contemporary urban economic theory that is consistent with Richard Muth's (1969) work allows both a theoretical and empirical examination of the magnitude of fiscal incentives confronting upper-income, center-city households.

This study is one step in the process of examining the magnitude of fiscal incentives confronting center-city households. A model is developed which relates fiscal incentives directly to a shift in the price gradient for housing services and to short-run changes in the observed value of single-family, owner-occupied, housing units. The model was operationalized using data from suburban and center-city locations within two large Midwestern cities.

An understanding of the role fiscal incentives play in household relocation to suburban municipalities is essential for center-city policy formation aimed at retaining upper-income households. The continuous migration of upper-income, center-city households to the suburbs leaves the center-city a haven for the poor and some non-land intensive business enterprises. This trend toward poverty does not offer a long-term, vigorous economic role for the center-city of American metropolises. However, the large number of municipal governments and growth of the suburbs may be in the interest of middle and upper-income households. The existence of fiscal incentives makes suburban relocation by center-city households a rational and efficient economic response. Municipal fragmentation poses problems for the center-city and the nation that may require policy decisions in the larger context of national income redistributive programs.

Outline of the Study

Long-run fiscal equilibrium conditions for the suburbs are examined in Chapter II. The role of zoning restraints to free intra-urban movements by lower-income households is shown to be a necessary condition for fiscal
equilibrium. Zoning restraints coupled with pressures toward a stable equilibrium condition are shown to result in income homogeneous suburban municipalities. Fiscal equilibrium requires that public goods consumption, property tax payments (for each household) and the income distribution of each municipality are independent of the price of housing services. Because of income-heterogeneity, however, the center-city is unable to attain the conditions of a head tax for public goods and therefore cannot attain a stable fiscal equilibrium, one that would not promote further household migration.

The residential spatial equilibrium model of Richard Muth (1969) provides the framework through which changes in fiscal incentives are related to the price gradient of housing services. Chapter III relates changes in the level of municipal goods provision and property taxation levels to shifts in the price gradient for housing services. A shift in the price gradient is shown to effect the household's radial equilibrium distance from the CBD. Estimates of the typical rate of change in radial equilibrium distance are constructed for varying changes in the level of the price gradient.

Suburban fiscal equilibrium conditions were empirically examined in Chapter IV. The data for the empirical analysis were drawn from eighty-six suburban municipalities in Cleveland (49) and Cincinnati (37), Ohio during 1970. In the analysis, the independence of fiscal incentives and the price of housing services, as well as the role of income homogeneity as a prerequisite to fiscal equilibrium are examined. The estimated equations were compared to estimates made by Muth (1969) in his study of residential spatial equilibrium. The slope of the price gradient, household income elasticity and a model of the quantity of housing services were examined.
A group of center-city households were identified in Chapter V to allow a direct examination of fiscal locational incentives. Thirty-two census tracts composed of predominantly upper-income households were selected in two center-cities. The effect of fiscal incentives on the price gradient and the observed value of housing units was examined in two ways. First, a proxy for center-city location was used to examine differences in the value of housing attributable to center-city versus suburban location. Secondly, in order to examine the effects of just fiscal incentives on housing values, a variable was constructed which measured the gain in public goods or reduction in taxes a center-city household could achieve by relocating in a suburban municipality. The fiscal variable was based on the ratio of the average consumption of a public good in dollars to average household property tax payments in dollars. The operationalization of the fiscal variable required the formulation of structural equations for the demand for educational services and tax behavior. These two structural models were empirically estimated for the suburban municipalities. The coefficients determined by an ordinary least square regression were then utilized to predict the level of benefits and taxes that would be attained by the selected center-city households, if they relocated in a suburban municipality. From these estimates, a proxy for the change in benefit/tax level was developed to allow the impact of fiscal incentives on housing values to be directly examined.

In trying to assess the influence of public goods on household locational decisions, most prior studies have assumed a continuously increasing utility function for each public good. In order to investigate the possible effects divergent utility preferences for a public good would have on fiscally related locational decisions, two groups of households were postulated with opposing preferences for a specific public good.
These two groups of households were then empirically examined and appeared to have valid economic reasons for maintaining divergent utility preferences for educational services. Chapter VI summarizes the theoretical and empirical arguments of this study.
Chapter II

Fiscal Variables, Suburban Equilibrium and the Center-City
There is general agreement in the Urban Economics literature that the process of urban decentralization has resulted from three major forces: (1) population growth, (2) income growth, and (3) transportation cost reductions (Mills, 1967; Muth, 1969). As a result of these forces the quantity of urbanized land area has increased and households, responding to economic incentives, move farther from the center of the urban area. A further element which has been suggested as affecting population movements and housing values within the urban area is that of local fiscal expenditures and taxes.

The Tiebout Model

The theoretical relationship between housing values, locational decisions and fiscal incentives has been summarized by Tiebout (1956), who argued that fiscal incentives exist between municipalities (center-city and suburbs) which promote movements among the urban population. The individual household is aware of the price paid for public goods (e.g. education, police, fire protections, etc.) and the quantity of public goods received. A disparity between the price paid and the quantity of public good received causes the household to shop for a municipality where it receives more public goods for a given expenditure. Thus, the public goods market becomes a quasi-competitive market as consumers shop for the maximum level of public goods at minimum cost. Municipal governments simultaneously attempt to attract consumers to their respective municipalities by providing a package of public goods suitable for households involved in this shopping process.

The model described by Tiebout sets forth a world which assumes the dominant locational motive is fiscal goods. The basic assumptions of the model are listed below:

1. Consumers are fully mobile and will move to that community where
their preference patterns which are set, are best satisfied.

2. Consumers are assumed to have full knowledge of differences between public revenue and expenditure patterns and to react to these differences.

3. A large number of communities exist which are suitable as places of residence.

4. Restrictions due to employment opportunities are not considered, and the only source of income is dividends.

5. Public services exhibit no external economies or dis-economies of scale between communities. The production functions of each community are identical and homogeneous of degree one.

6. Competition exists between communities for residents, which forces production of public goods to efficient levels.

The basic Tiebout model views consumers as expressing their preferences for local public goods through "voting with their feet". Migration among communities within a metropolitan area results in each municipality allocating its public output in a manner which approximates the distribution of services in a near free market solution.

In addition to the search process, a second basic outcome of the Tiebout model has been suggested by Hamilton (1972a) which involves a continuous search by consumers for more public goods at lower cost to themselves. As a consequence of this cost minimization process lower income households will seek to migrate to high-income communities. The low-income household receives the same amount of public goods as high income households in that community, but is taxed only on its lower income level. It receives more public goods than it pays for. Consumers will constantly seek to move to a municipality where their income is below the average of the new
A further modification to this cost minimization, benefit maximization behavior has been developed by Hamilton (1972) who shows that the above search behavior does not lead to any long-run equilibrium state. The failure to achieve equilibrium occurs since any consumer benefits by moving to a municipality with a higher income level than his own. Consequently, the Tiebout model would never achieve a stable equilibrium. Consumers would constantly be seeking to crowd into higher and higher average income communities and leave all low income communities. Such behavior would not be in the interest of the new host community; therefore, barriers to such movement in fact exist within the urban area.

Hamilton's solution to the constant disequilibrium is to incorporate into the model two more delimiting assumptions: that all local revenues are raised by a residential property tax, and that each community, in addition to its taxing power, is empowered to impose a zoning ordinance which requires each resident to consume at least some minimum amount of housing, the taxes on which will pay for the resident's share of local public goods. With these assumptions Hamilton argues that the basic model provided by Tiebout, more closely approximates a head tax. The assumptions made by Hamilton alter Tiebout's basic contention that each household must be able to purchase any desired combination of housing services and public services if equilibrium is to be attained. Hamilton's zoning restraint results in an inability of lower-income households to move to the suburbs from the urban core, while not disrupting the suburban movement of upper-income households. As a result lower-income households are deprived of achieving their locally preferred location in the urban market.

The group of households to which fiscal locational incentives are
consistently available are the upper-income, center-city households. If these households stay in the center-city their tax payments exceed the level of public goods provided to the average center-city household. Since by law, public goods are supposedly provided to all households within a municipality equally or without any restraint to consumption, income redistribution from the upper-income household to the lower-income household must be occurring. Lower-income households are receiving more goods than their tax payments would support if purchased at full cost and upper-income households receive less. This pattern of redistribution will occur as long as households are taxed proportionate to their income, while all households receive approximately the same bundle of public goods. It is clear, therefore, that an upper-income household can avoid income redistribution to a degree by relocating in a suburb where the average income level is nearer to his own income. By relocating in such a suburb the quantity of public goods consumed and the cost of those goods are approximately the same for all households at the average income level, hence income redistribution is minimized. The long-run result is a community composed solely of households with a similar income level.

Correspondence Between the Public Goods and Urban Economics Literature

A primary concern of the urban economics literature in recent years has been the issue of spatial equilibrium. Urban Economic theorists such as Muth (1969) do not negate the possibility of fiscal locational incentives, but view them as one of the many externalities which may affect the price

---

1 Contention of exactly equal distribution of goods to all households has been questioned by Weicher (1970, 1974).

2 This is a process in which households of similar income will tend to locate in the same area, so that the tax expenditure pattern tends toward an identical level for all households within the area.
of housing services. In the case of Muth's own research for example, he reports that a fall in the average income of the center-city relative to the suburbs tended to promote a decline in the center-city population of Chicago. The decreases in center-city density produced an increase in urbanized land area surrounding the center-city in an amount greater than the predicted density gradient required. Although no direct evidence on the cause of this larger than expected urbanized area was found, he concluded that the best explanation of this phenomenon was the increased tax burden of higher-income households and business firms in the center-city caused further outward movement from the CBD than income increases alone would warrant (Muth, 1969).

To date, no model has succeeded in incorporating the basic equilibrium conditions of the Muth general equilibrium model and the Tiebout model, due primarily to the difficulty of simultaneously optimizing with respect to housing services, location, public services, and all other goods. Conventional urban economic theory does however, provide an explanation of migration from the center of the urban area to its out-lying fringes. These changes in location are most often due to a rise in income, reduced transportation costs, or a reduction in the level of the price of housing services. Reductions in the level of the price of housing services are the area that offers the greatest insights into fiscal incentives. Typically, upper-income households are relocated farther from the central business district as an outcome of the model. The zoning restraint yields a similar outcome, only upper-income households are allowed to move from the city-center. A zoning restraint alone, however, does not describe the direction of income changes in the suburbs as the distance from the CBD increases. It simply argues that lower-income households will generally not be allowed into the suburbs for fiscal reasons.
Income Homogeneity, A Prerequisite to Fiscal Equilibrium

Assuming that in a municipality with a perfectly homogeneous income distribution all households would pay exactly the same local taxes and would receive the same quantity of public goods, then income redistribution would not occur through taxation. Hamilton, Mac Farlene, and Mieszkowski (1973) have clearly demonstrated that rational residents of a community maximize their benefits from public services by maintaining income homogeneity within the community. In a heterogeneous community, low-income households will receive more public goods than they purchase in an open market. Hence, the marginal value product of these incremental services will be valued below their marginal costs. Conversely, higher income households receive fewer public goods than they purchase in the market. The marginal value product of these services exceeds their marginal costs, yet these households have made total expenditures greater than the value of the services received.

The above argument is no more than a restatement of the classic redistribution argument attached to local financing of public service through property taxation if the tax is proportionately applied yet services are distributed equally (Netzer, 1973). Because of income effects and/or differences in tastes, it would be inefficient to promote the income heterogeneity required by locating large and small houses in the same community. Under conditions of perfect income homogeneity and zoning restraints, no household would have an incentive to move. Movement of lower-income households to higher-income suburbs would be precluded by the zoning restraint. Within each municipality, fiscal expenditure and taxation patterns would no longer offer any incentive to relocate. If household location conformed to the pattern just described, the full burden of the property tax falls
on the consumer and the tax generates no deadweight loss and the property tax behaves as a benefit or head tax. The property tax approaches being a benefit tax within an income homogeneous municipality under long-run equilibrium conditions (Bradford and Oates, 1972). Under these conditions no fiscal externalities exist; hence, the price of housing services is independent of the level of residential property taxation. Wheaton (1975) has recently demonstrated that neither a proportionate tax in an income heterogeneous community or a Lindahl tax solution can produce a stable equilibrium. Only a head tax with equal taxes and benefits for all households produced a mathematically stable system. This result is completely in accord with the income homogeneous community and equal benefit distribution suggested by Hamilton (1972).

In order for an equilibrium relationship between property taxes, public goods, and housing services to occur, it is necessary, but not sufficient, that a large number of municipalities exist at varying distances from the CBD, offering a diversity of benefit-tax relationships. This implies that a number of small geographic areas surrounding the central

3 The crucial issue is whether consumers or producers are most likely to bear the largest portion of the tax. If the price elasticity of housing services is unitary (-1) (Reid, 1962; Muth, 1969) and the factors of production (labor and construction materials) are mobile relative to owner-consumers of housing services, much of the burden of the tax will fall on the consumers of housing services (Netzer, 1973). The greater the immobility of the factor inputs, assuming that other non-residential structures are also taxed at rates near residential structures, the larger the share of the burden that suppliers will bear. Producers of housing services are responsive to the market and appear to be reasonably mobile (Muth, 1961). The higher the tax rate in relation to the equilibrium tax rate for the given public good quantity, the larger the burden of the tax on the consumer of housing services (Netzer, 1973). This forward shifting to consumers has typically been labeled capitalization of property taxes. Implicit rent, as defined by (Aaron, 1969), has fallen thus reducing the discounted present value of the owner-occupied structure.
city, with relatively homogeneous income distributions, will exist. The movement toward long-run equilibrium in such a system would be dependent on the number and size of municipalities in relation to the relative demand for given combinations of benefit-tax relationships.

It is also true that the equilibrium conditions of models developed by Alonso (1961) and Muth (1969) require income homogeneity within any small geographic area in the housing market. This long-run equilibrium result is independent of fiscal incentives and the results attained by the spatial equilibrium models strengthens the argument that long-run equilibrium requires income homogeneity within any small urban area. Center-cities, as presently constituted, have too large a land area and too diverse a population to achieve a high degree of income homogeneity. Therefore, an equilibrium outcome between property taxes, public goods, and housing services is not likely to be attained within the center-city if an income proportionate form of taxation is utilized. Upper-income, center-city households will face a fiscal incentive unless services they receive are proportionate to their tax levels or they have preference functions for municipal services substantially different from suburban households.

Spatial Disequilibrium, Fiscal Variables and Housing Values

The outcomes described in attaining fiscal and spatial equilibrium in most models of residential choice assume long-run relationships. However, it is important to be aware of the potential short-run relationships in residential choice and spatial decisions because of the length of time involved in attaining long-run equilibrium. Households typically make long-run decisions when buying durable items such as housing and choosing a building site. Hence the lag between the realization of an incentive to move and the actual relocation may be considerable. While it is true that
under long-run equilibrium conditions the rate of property taxation in the suburbs is unrelated to the price of housing services, there exist at least two short-run conditions whereby a significant relationship can exist between the effective property tax, fiscal services and the price of housing services.

1. A short-run disequilibrium in which there is a shortage (excess) of municipalities offering appropriate combinations of bundles of housing services and public goods.

2. Differing production functions between municipalities in the raising of property tax revenue or production of public services (Hamilton, 1972).

The first condition requires that the site rents being paid in the short-run depart from equilibrium. Short-run changes in population or income distribution can produce a relative shortage or surplus of a particular community type. Under conditions of scarcity the standard conditions of a rise in the price of housing services in that community will be observed in the short-run (a positive relationship between public goods and the price of housing services). In this case the relative scarcity of communities exhibiting a preferred combination of tax collections and provision of desired public goods results in a premium for housing services being paid by households. Hence the price of housing services will in the short-run at least, be higher than similar properties in other locations. This difference will persist until new communities have been created or the level of public goods in other communities has been adjusted to clear the
Edel and Scalar (1974) have examined the Boston area and found the period of time involved for households to fully respond to fiscal incentives may be considerable. During the final year of the study (1970) effective property tax rates were insignificantly capitalized in housing value, the typical relationship for equilibrium among fiscal variables. Most of the municipalities existing in 1970 in their study were also in existence in 1930.

A second condition under which a systematic relationship can exist between fiscal variables and property values, is the case of different production functions between municipalities. Communities may differ in their efficiency in tax collections and the provision of public goods. Two sources of systematic disturbances could produce this result. Revenues from non-residential sources such as industrial-commercial taxation or State and Federal inter-governmental transfers do exist and could be influencing the level of residential taxation and benefits (Fischel, 1974). State and Federal income redistribution policies could result in a lower level of local property tax rates for lower-income communities as opposed to higher income communities. The relationship between effective tax rates and housing values would then be positive. Indeed, Weisbrad (1964), has suggested that the quality of education services provided per dollar of

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4 A short-run surplus of a given community combination of housing services and public goods versus benefit bundles would result in a negative relationship between the observed value of housing units and public goods.
expenditures rises with income level of the families in a school district. The high income community can produce a given level of educational quality more efficiently and, conceivably, at lower cost than a low income community. This is an important finding, since education expenditures often account for from 60% to 75% of local municipal property tax revenues. If the economies generated by higher quality student inputs were sufficiently great, expenditures per student could be lower in high-income communities than in low-income communities and still produce the same quantity of educational services.

Varying the combinations of the above two broad conditions can yield in the observable short-run either a positive or negative influence in the relationship of property taxes or public goods to value. The only condition completely consistent with the Tiebout equilibrium among suburban municipalities is a complete lack of correlation between fiscal variables and housing value. (Edel and Scalar, 1974; Buchanan, 1965a, P. 493).

After controlling for the quantity of housing services, fiscal variables should be insignificantly related to housing values in the suburbs if all municipalities are in long-run equilibrium. This condition is directly testable and will be addressed in the research design of Chapter IV.

The Center-City, and Fiscal Equilibrium

Income homogeneity is not attainable in a large geographic area with diverse labor requirements such as the central city. Higher-income residents there are deprived of the benefits of municipal fragmentation while lower-income groups enjoy the benefits of income redistribution (Bradford and Oates, 1973). The large geographic area encompassed by the center-city coupled with land uses and zoning tied to historic growth patterns prevent zoning from being as effective an exclusionary device as in the suburbs (Hamilton, 1972b). An income proportionate tax must be generally
redistributive since the city is legally forced to provide the same level of public goods to all residents, whether rich or poor. Zoning alone is not a perfect exclusionary device even in the suburbs, however; minimum lot size requirements, building codes, and locally developed covenants (by subdivisions) can set effective minimums on the size of the improvements placed on each lot. A minimum level of housing expenditure requires a minimum level of permanent income for all new owner-occupants of single-family residences.

The formation of income homogeneous communities beyond the center-city transforms the property tax into a tax with strong benefit taxation characteristics (Hamilton, et al, 1973). By limiting income redistribution due to the property tax, higher income households preclude exploitation by poorer families of the area. Buchanan (1971) has pointed out that the central city can only provide a similar tax-benefit relationship for its high income households if it adopts apparently regressive tax policies in order to retain some of the surplus generated by upper-income residents in the provision of public goods. The public services received by upper-income households must be greater than those by average or lower-income households. Weicher (1974) found that police protection within Chicago appears to be allocated disproportionately to the high-income and low-income classes, with minimal service levels to the middle-income group. Wesibrad (1964) found that the quality of educational services, even with uniform dollar expenditures per child, tend to be higher in upper-income neighborhoods. Such attempts at matching services to taxpayments for upper-income groups within the center-city could reduce any fiscal incentives to move to the suburbs.

However, in the long-run the questionable legality of any such premeditated action by the city could lead to legal requirements of equal
distribution of public services to all consumers with in any single municipality (Schoettle, 1972; Ellickson, 1971). Consequently it is likely that many upper-income, center-city households face a fiscal incentive to move to the suburban municipalities. If consumers predicate housing consumption decisions of permanent income considerations, a long-term concept, then being rational they should also incorporate this long-term outlook into their locational decisions. (Friedman, 1957).

Research to date has not directly examined the magnitude of the fiscal relocation incentives of upper-income center-city households. If the Tiebout model is correct and if households do vote with their feet, then the upper-income, center-city household is the most directly affected portion of the metropolitan housing market.

**Empirical Research Supporting the Tiebout Model**

The basic theoretical literature supporting and revising the Tiebout model has been reviewed in the prior sections of this chapter. Substantial empirical evidence exists which supports the basic outcomes of the model. Wallace Oates groundbreaking work in 1969, although subject to various econometric criticisms (Pollokowski, 1971), supports the basic contention that consumers do shop for combinations of municipal services and benefits. Using 1960 data on fifty-three New Jersey municipalities Oates found a net significant relationship when housing values were regressed on municipal tax rates, education and municipal expenditures. More recent research has addressed the equilibrium conditions of the Tiebout model and the role of fiscal incentives in promoting movements within the urban area.

Edel and Scalar (1974) have shown that between 1930 and 1970 the movement in the relationship between tax rates and education benefits has been similar to long-run, Marshallian adjustment toward equilibrium conditions. The observed conditions in 1970 in the Boston area among the
municipalities in their study suggest that combined impact of fiscal
variables on housing values is negigible. However, they point out that
it is not essential or necessarily reasonable to expect all municipal ser­
vices and their corresponding taxes to approach equilibrium simultaneously.
The tax variables used in the Edel and Scalar study were generally nominal
property tax milleages. Without adjusting for actual assessment to value
ratios, the nominal rates could differ vastly from effective property tax
milleages. The results of their study are generally theoretically consis­
tent, but this failing in variable operationalization leaves open to ques­
tion the actual validity of their empirical conclusions.

The only specific study of center-city versus suburban housing values
was conducted by Hamilton (1972a). In a sample of 12 metropolitan areas
where substantial suburban fragmentation existed, after controlling for
the demand for housing services, center-city housing prices were generally
slightly lower than in the suburbs. A dummy variable was used to examine
the difference in housing values between center-city versus suburban loca­
tions. In most cases, although the dummy was insignificant, the consistent
negative sign associated with the variable may suggest some systematic
influence between center-city location and housing values. The negative
sign is interpreted by Hamilton to support his contention that fiscal
incentives are systematically increasing the cost center-city housing vis
a vis the suburbs. The lack of actual tax and benefit data in the study
makes accurate statements regarding fiscal locational incentives impossible.
It is possible that externalities other than purely fiscal considerations
produced the lower values. In addition, Hamilton used a random sample of
center-city and suburban census tracts. Within the center-city, lower-in­
come households may actually derive some fiscal benefits if substantial
local income redistribution is occurring. The inclusion of both high and
low income center-city tracts simultaneously could be seriously affecting the consistency of the observed relationships.

Teplin (1973) attempted to measure the local revenues and expenditures which would result from the introduction of families of different socio-economic characteristics into the suburbs or center-city. He found that a family of four in Baltimore produced a fiscal deficit in the city or suburbs up to an income of $23,600. However, the level of the deficit decreased much more rapidly with rising family income in the suburbs than in the center-city. The study supports the contention that the suburbs can achieve substantial gains by zoning out lower income households. It also clearly supports the belief that much greater income redistribution occurs through local taxation in the center-city than in the suburbs. The imposition of a zoning restraint that retards lower-income household relocation among suburban communities appears reasonable in view of Teplin's findings.

One of the more direct although unusual studies of fiscal locational incentives has been attempted by Aronson and Schwartz (1973). A measure of the difference between local property taxes per household and educational expenditures per capita for Harrisburg, Pennsylvania and its surrounding suburbs from 1950 to 1970 was operationalized. They argue that the expected direction of migration within the SMSA would coincide with the differing magnitude of fiscal incentives between municipalities and the center-city. To a significant extent, the actual changes in population distribution within the SMSA over the 20 year period agreed with the directions of the migration suggested by the fiscal incentives.

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5 A fiscal deficit means in this instance that the taxes paid by a specific household are less than the cost of the services consumed by that household.
The findings of this research are subject to at least two major limitations. The analysis of variance design used in the study only allowed directional statements to be made. Estimates of the magnitude of the population shifts versus the magnitude of the calculated fiscal incentives were not compared statistically. The Aronson and Schwartz study also did not address other locational motives such as employment redistribution of changes in transportation patterns as an alternative explanation for the observed migration patterns.

Studies by Edel and Scalar (1974), Hamilton (1972), and Aronson and Schwartz (1973) all suggest that fiscal incentives for movement within the metropolitan area may exist and may be systematically (directionally) affecting locational decisions. However, the magnitude of the fiscal incentives is unknown and the household characteristics that may affect the fiscal incentives have not been specified.

Complicating the examination of fiscal incentives are exogeneous factors which affect the level of property taxation and municipal benefits. Fischel (1974) has theorized that industrial and commercial tax payments are compensations for environmental detriments created by them in a manner roughly analogous to the Tiebout model. Using data from 50 New Jersey communities, he found that some fiscal benefits accrue to suburban communities from the firms located within the municipality. The continued presence of some benefits rests heavily on the premise that suburbs continue to effectively zone out noxious industrial and commercial operations in accordance with the preferences of their residents. The benefits, however, are not large relative to other determinants of municipal taxes and expenditures. The greatest benefits accrue from commercial operations rather than industrial firms. A test for capitalization fo commercial and industrial rateables (assessed firm property values) indicates an insignificant impact on
residential housing values: Fischel's research argues against the inclusion of industrial and commercial assessed valuations as meaningful exogenous factors that influence local property tax millage on residential property.

A more substantial influence on the level of public services and property taxes has been established by Hamilton, Mills and Puryear (1973). The level of compensatory or flat per student grants from the Federal or State government to local municipalities across a sample of 22 cities tended to increased residential heterogeneity or reduce the importance of Tiebout fiscal incentives. From this finding they theorized that to the extent any variable reduces the incentive to shop for fiscal goods, it also reduces the incentive for high-income households to migrate to the suburbs. This would tend to increase the income heterogeneity of the central city, without increasing fiscal incentives to relocate.

Hamilton et al also conclude that the larger the city and the more school districts therein, the greater the level of income homogeneity present within the suburban and in-city census tracts. Income homogeneity is a natural outgrowth of the revised Tiebout model and agrees with a basic assumption of the model - a large number of municipalities or taxing districts existing within the metropolitan area.

Subjects Requiring Further Research

The empirical and theoretical analysis of the last six years have revived interest in the Tiebout model as an explanation of governmental fragmentation within the metropolitan area.6 Within the large and rapidly

6 Governmental fragmentation refers to the creation of a large number of small municipalities surrounding the urban center of a metropolitan area.
growing literature this revival in interest still leaves a few gaps in the empirical research literature. The group most strongly affected by fiscal incentives has been shown in this chapter to be upper-income, center-city households. Yet thus far only one empirical study (Hamilton, 1972) has addressed the direction of fiscal incentives for center-city households. Not one study has attempted to directly quantify the level of fiscal incentives.

The benefits derived by migration to the suburbs are greatest for upper-income households, if the suburbs approach a Tiebout fiscal equilibrium condition. Within each suburb consumers purchase local fiscal goods at roughly the point where average cost equals marginal revenue - not a pure Pareto optimum, but quite close, and one with little redistribution of income tied to the public good purchase. If the suburbs of the metropolitan areas included in the research design of chapter IV are functioning in a near Tiebout equilibrium manner, fiscal variables will be insignificantly related to the price of housing services.

A final point of interest is the general trend toward viewing fiscal incentives apart from established models of urban spatial equilibrium. Richard Muth’s basic model addressed property taxation as one of many exogenous factors affecting the level of the price/distance function (price gradient). The simple model presented in the next chapter begins a direct integration of local fiscal variables as an exogeneous moderator of the level of the price/gradient function. The analysis is restricted to only upper-income, center-city households and to just one public good.
Chapter III

A Model of Spatial Equilibrium and the Impact of Fiscal Variables
The role of fiscal goods in promoting movement of households within the urban area was discussed in chapter II apart from other factors affecting locational decisions. In addition to fiscal goods, at least four other factors enter into determination of the degree and direction of any relocation by the consumer. These considerations include the consumer's income elasticity of demand, price elasticity of demand, the importance of transportation cost to the consumer and the rate of change in the price of housing as a household moves farther from the CBD. These four factors, along with other locational considerations, can be examined through Richard Muth's model of urban spatial equilibrium. Fiscal goods are viewed within Muth's model as but one of many exogenous factors affecting the level of the price of housing services. It is in this context that a model of the fiscal incentives facing center-city households will be developed.

Assumptions of Basic Spatial Equilibrium Model

Due to Muth's own research efforts and those of many others, his model is now one of the most widely tested. Historically, the theory of urban spatial equilibrium evolved rapidly after the pioneering efforts of Wingo (1961) and Alonso (1961). Both of these early models rested heavily on theories of agricultural land rents and, in particular, the work of Losch (1954) and Beckman (1957). Subsequent research by Muth (1969) and Mills (1967) resulted in similar formulations of residential spatial equilibrium conditions. The most significant departure in the approaches is Mills' treatment of time congestion factors in the crucial accessibility/distance relationship. A brief sketch of the basic model is necessary before one can examine the impact of fiscal variables on location.

A summary of the basic assumptions is essential for grasping the simple yet abstract nature of the model.
1. The household acts in such a way as to maximize an ordinal utility function composed of housing and all other goods subject to a budget restraint.

2. The central business district (CBD) is the dominant site of employment within the urban area.

3. Travel costs are composed of both a fixed element common to all households and a variable portion based on the value of time and actual operating expense, that is, household specific costs.

4. Accessiblity in all directions from the CBD is uniform, with no impediments to movement or location by consumers.

5. All income is derived from wages, salaries, and leisure time.

6. All consumers have identical tastes and preferences for housing services and are indifferent to neighborhood social characteristics.

7. Households are in a competitive market for goods and services, with all factor markets initially in long-run equilibrium.

8. Producers of housing services are competitive, and all housing services are produced with the same production function of constant elasticity of land and non-land.

9. The land available to the urban area is featureless and extends a sufficient distance to equate demand and supply for residential land.

The above assumptions are those made by Muth and are also similar to Mills' basic assumptions. The quantity element of the model is a unit of housing services (Q). The term "Housing services" (Q) refers to the flow of services and satisfactions they yield per unit of time from residential real estate, and not to activities associated with newly constructed assets of this type. This includes both a quantity and quality component combined to form a homogeneous good, housing services. Reid (1962) in her
pioneering work *Housing and Income* stressed the significant impact that quality of the housing units had on the income elasticity of demand for housing. Quality in her work referred to both structural condition and neighborhood characteristics.

Using the assumptions just formulated Muth's model of residential spatial equilibrium can be developed. The price of housing service \( P(k) \) is functionally related to the distance from the CBD. It is the rent paid by the consumer per unit of time for one unit of housing service. All other goods \( x \) in this analysis consist of both privately and publicly produces goods and services.

Income \( Y \) in this analysis refers to permanent income (Friedman, 1957). Transportation costs \( T(k,y) \) include the value of time which is here valued as the income foregone to consume leisure or other productive pursuits (Moses and Williamson, 1963).

The Household's utility function, \( U(X, Q) \), is maximized subject to an income restraint, \( G = X + P(k)Q + T(k,y) - Y \). Maximizing \( U \) subject to \( G \) yields the following first order conditions:

1. \[ \frac{\partial L}{\partial X} = U_x - \lambda = 0 \]
2. \[ \frac{\partial L}{\partial Q} = U_q - \lambda P(k) = 0 \]

or that the marginal utility per dollar expenditure on housing \( (Q) \) and all other goods \( (X) \) are equal.

\[ U_x = U_q \frac{1}{P(k)} \]

The partial derivative of the function \( L \) with respect to distance \( (K) \) yields an important condition of the model.
3.3 \[
\frac{\delta L}{\delta K} = \lambda (QP + T_k) = 0
\]

if \( \lambda > 0 \) then

3.3a \[
P_k = -1/QT_k = 0
\]

Equation 3.3a requires for a stable equilibrium that the change in real income generated by any small move from a particular location be zero. The individual cannot increase his real income by a small move in any direction. Within this small area, if all individuals are employed in the CBD, then the real income of all households would be identical. A highly homogeneous income distribution within any small area would be a natural condition for equilibrium. The introduction of non-CBD workers complicates the model, but the essential requirements for equilibrium are retained (Muth, 1969, p. 44). The income heterogeneity associated with any given distance from the CBD would rise with the introduction of non-CBD employment. However, if wages paid by all firms decline with distance from the CBD and the CBD is still the dominant place of employment, then the underlying spatial disbursement of households by income remains largely unchanged. The income distribution at all locations is, however, less homogeneous.

Using similar assumptions Moses (1962) reaches similar conclusions for locational equilibrium and non-CBD wage differentials. Equation 3.3a also requires that the price of housing services decrease with distance from the CBD while the cost of transportation per mile for any given income level changes at a constant rate.

**Basic Findings of the Model**

The basic conditions of the model have now been formulated. There are four essential findings from the model. The price of housing services and the rental value of land for residential purposes declines with distance from the CBD (equation 3.3a).
The second conclusion of the model is that the consumption of housing services increases with distance from the CBD. This conclusion rests on the income elasticity of the consumer exceeding 1.00. Research by Reid (1962), Muth (1967) and deLeeuw (1971) suggests the typical owner-occupant has an income elasticity for housing greater than one. In addition, research by Muth (1969) and Mills (1967) argues for the price elasticity of housing to be generally be unitary (-1). Under standard economic analysis (ceteribus paribus) the consumption of a good increases more than proportionately to a price decrease whenever the consumer's income elasticity of demand is greater than one and the consumer is unitary price elastic.

Muth (1969), Mills (1972), and Beckman (1957) have all found that the density of urban population with distance approximates a negative exponential form. This is the third finding of the model -- population density approximates a negative exponential function of the theoretical form:

\[ D(k) = D_0 e^{-D_1 k} \]

where \( D_0 \) is the city center density and \( D_1 \) is the rate of change in population density per unit of distance. Urban geographers and others have found that this negative exponential form will not under all conditions be the best approximation of spatial population distributions. Muth's model theoretically suggests as exponential form although varying short-term conditions could produce second or higher ordered polynomials.\(^1\)

The fourth finding of the model is that the level of household income will generally increase with distance from the CBD. This outcome

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\(^1\) Sibley (1970) found the density gradient to be closer to second degree polynomial with few steady state characteristics. See also Casetti (1971) for extensive discussion of density gradients.
requires that transportation costs as a function of distance and income change at a constant rate. It also requires that the price of housing services decline with distance from the CBD and that households have an elastic demand for housing services. This fourth finding of the model is fully developed in equation 3.6 of this chapter.

The general accuracy of Muth's model in describing the spatial characteristics of urban areas has been established by several empirical studies which are briefly described below.

**Empirical Support for Muth Model**

Mills (1972) has examined density gradients with respect to distance for six cities using 1960 data. He found a negative logarithmic function to be the best approximation of the density function. The density gradient was found to be a function of city size, income level and transportation cost -- a model in basic agreement with Muth's. In addition, Mills' analysis suggests that the relocation of light manufacturing and commercial activities to the suburbs is a function of population movement and not the reverse. This, too, is in keeping with Muth's theoretical examination of the spatial equilibrium of the firm but is beyond the scope of this paper.

Muth (1961) studies 46 American cities using 1950 and 1960 data and found forty of the forty-six cities to exhibit negative exponential density functions. Mose and Williams (1963) conducted an extensive study of travel and time cost by mode of transit and income level in Chicago. Their findings tend to support the view that consumers attach a constant value to the rate of change of transportation cost with distance for each mode. Their findings suggest substantial variation in transport cost by public and private modes. However, the dominant preferred mode without exogeneous financial incentives was the private vehicle, the basic form upon which
Muth's travel cost estimates are based.

Koenker (1972) constructed a model of spatial equilibrium of a form similar to Mills and Muth. The operationalization of his model in Ann Arbor, Michigan found that the price of housing services (an index) declined with distance from the city center in a non-linear manner. He estimated the elasticity of substitution of land and capital to be 0.70. This is in keeping with Muth's estimate in Cities and Housing where the elasticity of substitution of land for capital is .75. Recently Muth (1974) empirically supported his estimate of 0.75.

One of the better reviews of related empirical literature has been assembled by Ball (1973). After reviewing eleven American and British empirical studies prior to 1972, he concludes that the studies support a negative price-distance relationship of a non-linear form. The studies also suggest that the slope of this function by city is a function of center-city density, income level and distribution, transportation costs and preferences, and possible geographic of historic influences. The comparability of the eleven studies is minimal in variable operationalization and equation specification.

Change in Quantity and Income

Before one examines the role of fiscal variables, the basic income and substitution effects inherent to spatial equilibrium need to be considered. The basic equilibrium condition is summarized below as the total derivative of equation 3.3a.

\[ 3.5 \quad -Q_dK - P_k dQ - dT_k = 0 \]

The crucial term in equation 3.5 is \( \delta Q \), the change in the quantity of housing services. This expression can be expanded to

\[ 3.5a \quad \delta Q = P_k \frac{\delta Q}{\delta Y} (1 - \frac{1}{T_k}) dY + P_k \frac{\delta Q}{\delta P_c} dK \]
Graph 3-1

CHANGE IN QUANTITY DEMANDED GIVEN RISE
IN REAL INCOME LEVEL

X

(ALL OTHER GOODS)

\[ y'_1 = y_1 - T_k y_1 \]

\[ (1 - T_y) dz \]

INCOME EFFECT

QUASI PRICE EFFECT
A household's change in the quantity of housing consumed with a change in income depends on its marginal cost of transportation ($T_y$) with respect to income (time value) and the rate of change in housing price with respect to distance, $P_k$. The term $\frac{\delta Q}{\delta Y} (1-T_y)dY$ is the income effect on quantity ($Q$) by an increase in real income where $(1-T_y)dY$ is the adjustment in the change in real income due to the income related rise in transportation costs. The term $(\frac{\delta Q}{\delta P})_c dP$ gives the price or substitution effect on "Q" with income held constant.

By substituting equation 3.5a into equation 3.5 and expanding terms the change in equilibrium location ($k$) can be expressed in terms of a change in real income ($Y^*$).

$$3.6 \quad \frac{\delta K}{\delta Y^*} = -\left( E_{q,y} R (1 - (P_t) E_{T_y}) - E_{T_k,y} \right) - \left( \frac{P_k}{P} \cdot \frac{C_p \cdot P_k}{Tk} + \frac{(P_k - Tk)}{Tk} \right) > 0$$

where $P_t$ is the proportion of income spent on travel.

The numerator above yields the extent of the shift in the $P(k)$ curve (price of housing per unit of time with distance). The denominator measures the amount by which the difference between the ordinates of these curves decreases with distance. The ratio of the numerator and denominator is the change in distance ($K$) expressed in the units of the price gradient (miles).

A graphic presentation of these changes makes their essential compatibility with traditional economic theory clear. Let us assume an increase in real income due entirely to an increase in wages. Graph III-1 shows that the budget line, $B_1$, increased to $B_2$. This is the full increase in real income less the increase in $T_y$. (Note $(1-T_y)dY$, shown adjacent to the "X Goods" axis.) The household increases consumption of housing services from $Q_1$ to $Q_2$ and all other goods from $X_1$ to $X_2$. The increase
in Q leaves the household's old equilibrium location no longer necessarily an equilibrium one. Typically, as has been previously argued, the household moves farther from the CBD. This reduces the price of housing services. The new budget line is $B_3$ and quantity $Q_3$ is consumed. The quantity, $Q_3 - Q_2$, is commonly viewed as a quasi-substitution or price effect induced by the location. Thus, both an income and substitution effect must be considered in evaluating an increase in real income. A similar train of logic can produce an analysis of a price change which also has an income component.

The above finding requires for equilibrium that, in general, an increase in income will require an equilibrium location further from CBD. However, $\delta K/\delta Y$ can equal or approach zero if a raise in income is exactly offset by the increase in elasticity of transportation cost with respect to income ($E_{t,Y}$). The price elasticity of housing must also be highly inelastic. Typically, a rise in real income requires a move farther from the CBD to reestablish equilibrium conditions.

It is possible, however, for some households to find their equilibrium location unchanged by a rise in real income. A rise in real income will have a small effect on income inelastic households ($E_{q,Y;R} < 1$) or households with high time related transportation cost considerations ($E_{T_k,Y} > 1$). Evans (1973) has identified three groups of households who may not shift equilibrium location with a rise in income. These households include older households with few members, households without children and households that highly value commuting time (i.e. two CBD workers in the household or high-income, self-employed persons.)

Rising household income alone can cause many households to move from the center-city to the suburbs. The rising real income experienced by
many middle and upper-income households between 1950 and 1970 would produce a strong stimulus to move farther from the CBD. If fiscal incentives are operating to further increase this relocation, then the impact of this incentive must be viewed after controlling for income induced increases in the consumption of housing services.

In the general case the spatial equilibrium produced by equation 3.6 is clear. Low income households would encircle the area near the CBD and progressively higher-income households would be found increasing distance from the CBD.

**Changes in the Level of the Price/Distance Function**

The preceding analysis has shown that rising income can effect household equilibrium location. In a similar manner, the effect of changing the level of the price/distance function on equilibrium location can also be examined. It is through this analysis that the effects of fiscal locational incentives can be incorporated into the model. The effect of a change in the price level of housing services \((P^*0)\) on equilibrium location can be approached in a manner analogous to equation 3.6.\(^2\)

\[
\frac{\partial X}{\partial P^*0} = -dP_0(E_Q, P; C) \frac{(P(k)Q)}{Y} E_Q, Y; R \leq 0
\]

\[
E_Q, P; C(P_k, \frac{P^*}{P}) + (P_{kk} - \frac{T_{kk}}{T_k})\]

The denominator of 3.7 is identical to 3.6. The numerator relates the change in housing consumption due to a price level change (substitution effect) to the income effect of the price change. If a uniform property tax were imposed that fell equally on all units of housing services, an increase in the level of price of housing services with respect

\(^2\) Appendix C presents a detailed derivation of equation 3.7 and the typical values of each of its components.
to distance would result. The equilibrium location of all households would shift inward toward the CBD.\(^3\) Equation 3.7 is fundamental to the analysis of fiscal variables required in the next section of this chapter. This equation will be re-examined and fully developed after a simple model of fiscal locational incentives is sketched.

**Fiscal Locational Incentives**

The basic equation (3.7) necessary to consider fiscal locational incentives has now been stated. In order to examine fiscal incentives, a simple model must be developed which states fiscal incentives in terms of a shift in the price/distance function. This change in level of the price/distance function is the term \(dP_0\) in equation 3.7.

The assumptions of the spatial equilibrium model require several minor additions in order to consider fiscal incentives. These additional assumptions are designed to conform with traditional fiscal theories (Tiebout, 1956; Hamilton, 1972).

1. Municipalities effectively prohibit the relocation of new households with housing expenditures below the average expenditures of existing households in the community. (Zoning restraint)
2. All local taxes are raised through a property tax on residential housing units, which are the dominant form of land use in each municipality.
3. A large number of quasi-competitive communities exist within the urban area.
4. Municipal government is a category of firm under less competitive restraints than the private producer of goods and services, but still bound to efficiency consideration in production.

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\(^3\) Beckmann (1974) notes that a decline in the quantity of housing consumed at the same location is an alterantive behavior given in increase in the price level of housing services.
5. The production functions of all municipal governments for the production of public goods and revenue collection are identical.

6. The public goods produced by each municipality are all assumed to be homogeneous.

7. All public goods are locally produced and consumed with no spillover effects between municipalities.

8. All local public goods are purchased by owners of residential housing units. Therefore, total expenditures must equal total revenue within each municipality.

9. The utility of each public good per unit consumed is similar across all households.

In addition to the above assumptions, a special relationship exists between the local public good and housing values. The value of housing consumed forms the numeraire or index to which the expenditures on public goods are tied. That is, the total expenditures on municipal public goods for any one household is stated as a linear transformation of the value per unit of time of housing services consumed.

This analysis is limited to a single local municipal good. A few additional notations and definitions must be introduced to proceed with development of the model.

\[ t_i = \text{the effective property tax rate in center-city } i. \]

\[ V_x = b_x Y_x = \text{the observed value of residential housing units is a linear transformation of household } x's \text{ permanent income expectations } (Y_x). \]

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4 See Henderson and Quandt (1958, p. 172-73) for a discussion of the numeraire concept. The numeraire is not money in the sense its units serve as a standard of value. However, it does serve as a store of value, since it is desired only as a productive factor or consumable commodity on the same basis as all other goods.
$V_{x1} = P(k)Q_x$ = the value of the residential unit held by individual $x$ in center-city $i$ per unit of time.

$t_{1}V_{x1}$ = the property tax liability of individual $x$ in center-city $i$.

$N_{i} = \frac{E_{x1}}{V_{x1}}$ = number of households in center-city $i$.

$N_{i} = \frac{E_{x1}}{V_{x1}}$ = the average value of housing in center-city $i$.

$E_{1} = T_{1}V_{1}$ = per household expenditure for a specific public good.

$IFT_{x1} = (E_{1} - t_{1}V_{x1})$ = imputed fiscal transfer received by individual $x$ in center-city $i$.

$a$ = subscript referring to all other municipalities in the metropolitan area of center-city $i$.

$IFT_{xa} = (E_{a} - T_{a}V_{xa})$ = imputed fiscal transfer received by individual $x$ in some suburban municipality $a$.

The imputed fiscal transfer (IFT) is defined as the difference between per household expenditures by the community on the local public good and the tax payment (cost) of the good to household $x$. Household $x$ consumes $V_{x1}$ of housing, an amount by assumption greater than the average housing value in the center-city ($V_{1}$) or any municipality to which $x$ would be able to move.

$V_{x1} > V_{1}$ and $V_{xa} > V_{a}$

If household $x$ is above average in income (housing value), it realizes a negative IFT. The absolute value of IFT given any specific income distribution increases for every household with an increase in the property tax rate. Thus, if only fiscal variables are considered, any individual is better off locating in the community that gives the highest positive...

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5 A similar formulation by Aronson and Schwartz (1973) introduces the concept of an IFT and parallels this formulation to a degree. Miller and Tabb (1973) also have presented a graphical analysis with a similar IFT concept.
Equilibrium for all households with respect to IFT alone requires $IFT_{xi} = IFT_{za} = 0$ for all $i = a$. That is in each community, every household receives public goods (benefits) exactly commensurate to its expenditures (tax payments) on public goods.

A household ($x$) will incur an incentive to relocate, if a move from center-city ($i$) to municipality ($a$) results in $IFT_{xa} > IFT_{xi}$, without considering moving costs, and holding all other factors constant.

$$0 > IFT_{xa} = (E_a - t_a V_{xa}) > IFT_{xi} = (E_i - t_i V_{xi})$$

OR

$$0 > (t_a V_a - t_a V_{xa}) > (t_i V_i - t_i V_{xi})$$

In both of the above instances the imputed fiscal transfer is negative, since household $x$ is limited to new places of residence where his housing expenditure exceeds the average in the municipality. The individual's IFT will be improved by relocating if the difference in the two towns' level of public good expenditure is greater than the change in the tax rates.

The relationship between a household's public good consumption ($E_a$) and its cost of consumption ($V_{xa} t_a$) can be stated as a ratio, $E_a / V_{xa} t_a$. This ratio is the benefit-tax ratio of household $x$ in some community $a$. The change in the benefit-tax ratio can be stated from equation 3.9 if household $x$ has the same housing expenditures in both center-city and municipality $a$. This requires a radial movement along an arc from the CBD. Let $V_{xa} = V_{xi} = V_x$

Then

$$0 > (t_a V_a - t_a V_x) > (t_i V_i - t_i V_x)$$

$$0 > (t_a V_a - t_i V_i) > (t_a V_x - t_i V_x)$$
The benefit-tax ratio of household $x$ must be increased for a fiscal incentive to exist.

The inequality of equation 3.9 requires several limiting conditions that must be met by any potential recipient municipality. The value of $V_a$ is restricted within a minimum and maximum that satisfy the inequality. The maximum value of $V_a$, given a known average value and tax rate in the center-city, is $V_t t_i / t_a$. This maximum is a positive number in excess of $V_t$ which approaches the value of $V_x$. The minimum value of $V_a$ is $V_x - t_i / t_a(V_x - V_t)$. The minimum can be less than $V_t$. The change in IFT from the center-city to municipality "a" now approaches zero at the maximum value of $V_a$.

Equation 3.9 achieves a maximum positive value when $V_a$ is at a maximum. This finding is consistent with a household's achieving a new IFT of zero and having no further incentive to move. The consumption of housing in community "a" by household $x$ is now close to the average housing consumption level of community $a$. Rational center-city households who relocate based on fiscal incentives will seek out those municipalities in which their housing expenditure is close to the average housing expenditure in the municipality.

The term $t_a - t_i$ must be negative for the inequality to be maintained in equation 3.9, since $V_x$ is by definition positive. The analysis

---

6 This is an extreme value for $V$. The difference between $t_a$ and $t_i$ must be quite large. The household must achieve such a substantial decrease in the cost of fiscal goods that he is induced to consuming less public goods in favor of other goods. The analysis presented in this section will generally be limited to cases where $V_a$ exceeds $V_t$. 
presented here is limited to changes in location motivated by implicit price reductions to the migrating household. An increase in \( t_a \) over the level of \( t_i \) with \( V_a \) generally exceeding \( V_i \) requires an increase in the cost of consuming public goods. In fact, an increase in public good consumption beyond a price effect requires a reduction in the consumption on the public goods. The household's preferences for public goods versus all other goods must have changed. Aaronson and Schwartz (1973) reach a similar conclusion that increasing both public goods and expenditures for most households generally will not be an incentive for relocation.

**Fiscal Incentive in Price of Housing Services Terms**

The preceding section has described the basic household behavior given varying changes in IFT. The change in IFT caused by a move to a new location can now be examined in terms of its impact on the price distance function \( (P_k) \). Converting the change in IFT to price of housing services terms is essential for actually describing the possible changes in location induced by a fiscal incentive.

Equation 3.9 can be further rewritten in terms of the price of housing services and the quantity of housing services consumed.

\[
0 \geq (t_a P(k)Q_a - t_i P(k)Q_i) \geq (t_a P(k)Q_x - t_i P(k)Q_x)
\]

rearranging

\[
0 \geq P(k)(t_a Q_a - t_i Q_i) > P(k)Q_x(t_a - t_a)
\]

\[
0 \leq P(k)(t_a Q_a - t_i Q_i) < P(k)Q_x \frac{t_a - t_i}{t_a - t_i}
\]

\[
P(k) \frac{t_a(Q_a/Q_x) - t_i(Q_i/Q_x)}{t_a - t_i} \leq P(k)
\]

43
In equation 3.11 the bracketed term is less than one but greater than zero, and achieves a maximum value of one if \( Q_a = Q_x = Q_f \). If \( P(k) \) is transferred to the left side of the equation the right side becomes less than zero. \( P^*0 \), as shown in equation 3.12 is the reduction in the price level of housing services attributable to radial relocation which increases the household's IFT.

3.12 \[
P(k) \left( \frac{t_a(Q_a/Q_x) - t_i(Q_i/Q_x)}{t_a - t_i} \right) - P(k) = P^*0 \leq 0
\]

The slope of the price/distance function is initially unchanged by the introduction of fiscal incentives; only the level of the function has been shifted. For a given price of housing services the equilibrium distance from the CBD is now farther removed than before the presence of the fiscal incentive. The analysis of equation 3.12 does not address the change in location this shift should cause. Through equation 3.7, which was presented earlier, the change in the price level can be evaluated in terms of change in the equilibrium distance from the CBD. The negative value of \( P^*0 \) reverses the direction of the inequality in equation 3.7.

3.7 \[
\frac{\delta k}{\delta P^*0} = -dP_0(Eq,p,c - \frac{P(k)Q}{Y} Eq,y;r) \geq 0
\]

\[
(P_{c,k} + (P_{kk} - T_{kk}) \frac{P_{k}}{P} \frac{T_{k}}{P})
\]

where \( P^*0 < 0 \)

An exogeneous reduction in the price of housing services due to an increase in IFT promotes a move farther away from the CBD. Households in the central city realize an incentive to move farther from the CBD, if a fiscal benefit disequilibrium exists. The extent of the outward movement, \( \delta k \), is clearly dependent on more than simply the reduction in the level of \( P(k) \) due to fiscal incentives. The price and income elasticity of
housing demand as well as the relationship between the rate of change of transportation cost and the price of housing services all enter into the determination of the extent of the move. The combined income and substitution effects will result in a small positive increase in the value of housing services consumed. This will raise the level of \( V_x \) after the move and, correspondingly, the level of \( t_aV_{xa} \). Therefore the total gain in IFT toward equilibrium will be slightly less than that suggested by equation 3.9.\(^7\)

The numerator of 3.7 contains the demand for housing, holding money income constant. The substitution effect \( (E_{q,P,C}) \) and income effect \( P(k)Q_x (E_{q,Y,R}) \) of the price change are calculated in the usual manner. The partial equilibrium solution is the change in the household's consumption of housing that results from the price change at the old equilibrium location.

The benefits foregone by staying at the original location are transformed into a reduction in the value of housing services consumed at the old location. This is essentially the same result as the capitalization argument, although in current consumption terms rather than capitalization of a long-term income stream. The household is paying more for public goods than necessary; therefore, the cost of consuming a given bundle of public goods and housing services is higher in the center-city location. Since the same bundle of public goods and housing services are available elsewhere at a lower price, no maximizing household will pay the higher price required by the center-city. The market will require a reduction

\[ (E_a - t_aV_x) > (E_a - t_aV_{xa}) > (E_{tV_x}). \]
in the price of housing services in the center-city to compensate for
the higher cost of public goods consumption. This reduction will be
translated into lower observed values for upper-income, center-city hous-
ing with the same quantity of housing services as a house in the suburbs.

Because of the increase in the consumption of housing, after a re-
location, the savings on housing expenditure per unit change in distance
curve, \(-qP_k\), shifts upward to the right. The denominator gives the change
in the difference of the ordinates of the \(-qP_k\) and \(T_k\) curves. This is the
change in net savings on housing and transport costs, per unit change in
distance. The ratio of the ordinate of the \(-QP_k\) and \(T_k\) curves gives the
number of miles (or units of distance) by which location must be shifted
if the net savings in transport and housing cost are to be zero, the basic
precondition for spatial equilibrium (see equation 3.3a). This requires
that the legal boundary of municipality "a" must be within this distance
of the former location of \(x\), if the proposed IFT benefits are to be rea-
лизed.

Graphically, the change in the level of the price gradient can be
easily examined (Graph III-2). A reduction in the level of the price
distance function (gradient) from \(P_{k,1}\) to \(P_{k,2}\) results in an outward
movement of \(K_1\) to \(K_3\). However, this fall in price level has increased
the real income of the household. Correspondingly, the level of trans-
port cost rose upward to \(T_{k,Y2}\) from \(T_{k,Y1}\). The new equilibrium is at
distance \(K_2\). The increase in transport cost caused a reduction in the
distance from the CBD of \(K_3 - K_2\). If transport cost increased first
exogeneously to \(T_{k,Y2}\), the household would move inward to \(K_4\). In this
case, also, the new \(-QP_{k,3}\) curve will be slightly higher and closer to
the CBD, necessitating a further slight inward movement to attain a new
equilibrium.
Graph 3-2
EQUILIBRIUM LOCATION ADJUSTMENTS DUE TO PRICE OR TRANSPORTATION COST CHANGES

$\sum k_y \cdot dY$
Many of the terms in equation 3.7 have been theoretically and empirically estimated in prior research studies. The income elasticity of housing demand has been shown by Muth (1962, 1969), Mills (1967) and Reid (1962) to generally exceed 1.0 for owner-occupied housing units. A recent estimate by Muth (1974) for \( E_{Q,y,R} \) was 1.28, a level in agreement with deLeeuw's (1971) analysis. The analysis presented in Chapter IV estimates income elasticity in the suburbs and finds it to generally be in excess of 1.0.

The price elasticity of housing services with constant real income has been theoretically shown to be unit elastic (-1.0) by Muth (1969) and Mills (1971). Whether all households are unit price elastic is an unresolved issue (Hamilton, 1972), but the typical suburban homeowner would seem to fit the description of both Muth and Mills.

The rate of change in the price of housing services with distance \((P_k/p)\) has been theoretically and empirically estimated by Muth (1969) to be approximately 1% per mile. This estimate is only reasonable for predominantly owner-occupied residential areas. In fact the analysis of Chapter IV does support the contention that the price gradient declines by approximately 1% per radial mile in areas of predominantly owner-occupied, residential land use.

The fourth term for which a value is known or can be assumed is

\[
\frac{P_{kk}}{P_k} - \frac{T_{kk}}{T_k}
\]

Only at long-run equilibrium will the price gradient be exactly tangent to the transportation cost curve then \( \frac{P_{kk}}{P_k} - \frac{T_{kk}}{T_k} \) equals zero. For the sake of analytic simplicity long-run equilibrium is assumed as the initial condition of the household.
The proportion of income expended on housing services \((P_kQ/Y)\) is not exactly known. An estimate of 20% of annual income is in agreement with past studies of household expenditure patterns (Morgan, 1962). The only unknown term in equation 3.7 is \(dP_0\), the change in the level of the price gradient extrapolated to the center of the city.

Substituting the estimated values just described above into equation 3.7 yields:

\[
\frac{\delta K}{\delta P_0} = \frac{-dP_0}{-1.0 - (.20)(1.28)} = \frac{-dP_0}{(-1.26)} > 0
\]

where \(dP_0 \leq 0\).

A one percent (1%) decrease in the level of the price gradient would induce a household to move slightly more than one mile to restore equilibrium, if moving cost and income induced changes in transportation cost are ignored. Fiscal good expenditures probably account for only 20 to 25% of total housing expenditures. Therefore a much larger percentage change in the benefit/tax ratio must occur to induce 1% change in level of price gradient. In very rough terms a 4% or 5% change in the benefit/tax ratio would be necessary to produce a 1% change in the level of the price gradient. A one mile change in radial distance from the CBD may also be insufficiently far to allow the household to reside in a municipality offering the desired combination of municipal goods, property taxes and bundle of housing services.

Given that moving cost do exist and that transportation cost increases would reduce the maximum radial move due to \(P_0\), it may be reasonable to expect that a change substantially in excess of 5% in the price gradient is in

---

Changes in The Slope of The Price/Distance Function

The analysis thus far has assumed that the slope of the price/distance function remains unchanged. The removal of this assumption further increases the tendency of upper-income households to move from the center-city.

The change in equilibrium location which results from a change in the level of prices will tend to change the slope of the price gradient (Muth, 1969). All households exposed to this change will try to move farther from the CBD following a fall in the level of prices. The demand for units more distant from the CBD rises while the demand for housing close to the CBD falls relative to more distant locations. This exacerbates the fall in the observed value of housing near the CBD as compared to those units smaller.

Muth's conclusions may be worthy of a rather extended quotation at this juncture:

"The price gradients in absolute terms will be directly related to the level of housing prices, and hence to construction costs, interest rates, and property taxes. In relative terms, however, the price gradient may increase, remain unchanged, or decrease depending on whether the price elasticity of housing demand is algebraically less than, equal to, or greater than -1 . . . . the price gradient in relative terms varies inversely with expenditures on housing. The latter, in turn, will decline or increase with a price increase (decrease) depending on whether demand is elastic or inelastic."

If households in the center-city, and suburbs are unit elastic, a

---

6 The magnitude of the fiscal incentive necessary to produce actual relocations is purely conjecture on the part of this writer. However, a 4 to 5% increase in the benefit/tax ratio does seem sufficiently large that households would be cognizant of its existence. Only studies of individual household behavior can reveal the degree to which households are aware of fiscal disparities and if a minimum threshold of disparity is essential to the relocation decision.
decrease in the level of $P(k)$ will cause an outward movement and a reduction in observed values of the center-city upper-income housing units.

Upper-income households remaining in the center-city are experiencing a higher total expenditure for housing and the public good. The result is a falling demand for the center-city bundle of housing services and public goods suitable for upper-income households. The foregone gain in IFT due to center-city rather than suburban location is inversely related to observed housing values in the center-city. The greater the potential gain in IFT an upper-income household could realize by a move to the suburbs, the larger the reduction in center-city housing values if all other factors are held constant. The expected negative values can provide an estimate of the magnitude of fiscal migration incentives. Chapter IV presents a research design to begin the analysis of this relationship.
Chapter IV

Analysis of Fiscal Equilibrium in the Suburbs
Chapters II and III have reviewed the conditions for local fiscal equilibrium. Under equilibrium conditions in the suburbs the price of housing services was found to be independent of local property taxes and municipal service levels. Expected equilibrium fiscal conditions were shown to be unattainable in the center-city by upper-income households. The continuation of fiscal disequilibrium in the center-city was contingent on the maintenance of several strict assumptions including similarities in taste and preferences for municipal services and equal distribution of all public services. These assumptions and others discussed in Chapter III will be retained throughout the empirical analysis of Chapters IV and V. The implications of relaxing the two assumptions noted above will be discussed in Chapter V. If the empirical model behaves in reasonable accord with observed conditions then some further understanding of the complex factors involved in residential spatial location decisions and the determinants of housing values will have been attained.

From the model presented in Chapter III and the basic equilibrium conditions of the Tiebout model three testable propositions can be obtained. These three propositions will each be discussed in turn. An empirical model for examining fiscal equilibrium in the suburbs is specified and empirically examined.

**Testable Propositions**

The first proposition seeks to determine if fiscal equilibrium conditions existed among selected suburban municipalities.

I. **Within a metropolitan area under conditions of long-run equilibrium suburban fiscal variables are unrelated to housing values.**

The benefit-tax ratio of any specific municipal public good should be insignificantly correlated with housing values after controlling for the quantity of housing services, if long-run equilibrium has been attained.
The above proposition is no more than a reassertion of the expected fiscal variable versus housing value relationship of the Tiebout model.

However, if the suburbs have achieved a degree of near market behavior in the consumption of public goods, such behavior cannot be achieved in the center-city. Income redistribution must occur to some degree, in the provision of local public goods within an income heterogeneous center-city, if a single effective property tax rate is applied to all households. The presence of a disparity between benefits and costs in the center-city for upper-income households has been demonstrated in both Chapters II and III to result in a fall in upper-income housing values vis a vis suburbs.

II. Under conditions of long-run equilibrium in the suburbs, observed housing values for upper-income single-family units will be lower in the center-city than in the suburbs after controlling for the quantity of housing services.

If the basic spatial equilibrium models in conventional urban economic analysis are fully specified without the direct inclusion of fiscal variables, the same relationships should describe center-city and suburban housing values. A test for the presence of significant differences between center-city and suburban housing values is required to establish directly the similarity or dissimilarity of explanatory variables.

III. The change in Implicit Fiscal Transfer due to a center-city rather than a suburban location is inversely related to observed housing values in the center-city after controlling for the quantity of housing services.

Upper-income households remaining in the center-city are experiencing a higher total expenditure for housing and public goods. The result is a fall in demand for the center-city bundle of housing services and public goods suitable for upper-income households. The greater the gain in IFT an upper-income household could realize by a move to the suburbs,
The larger would be the expected reduction in center-city housing values under ceteribus paribus conditions. The expected relationship between foregone IFT and center-city housing value is negative.¹

The empirical analysis of Chapter V will seek to estimate the magnitude of the fiscal incentives, but no direct theoretical deductions suggest a prior beliefs about the relative magnitude of fiscal incentives.

**Specification of the Empirical Model**

Proposition I requires the specification of a model of urban housing values that will reveal the influence of fiscal variables on the price gradient. In order to avoid problems of under identification of equation systems in proposition III, a general form of the supply equation for producers of housing services, rather than a demand equation, will be developed. In Chapter III it was assumed that the production function of all producers of housing services is homogeneous. This analysis is limited to a single industry—the producers of single-family, owner-occupied housing services. The owner-occupant is here viewed as supplying himself or potential consumers with a bundle of housing services per unit period of time.

Further this assumed that only two classes of inputs to the production of housing services exist—land(L) and non-land(N) inputs. The price of land inputs (rₖ) is assumed to vary with distance (k); however, since labor and capital are relatively mobile within any given urban area, little

¹ The many articles addressing fiscal disparities and their affects on housing values since Wallace Oates (1969) groundbreaking study have implicitly assumed that center-city fiscal incentives are always sufficiently large to significantly affect housing values. However, the theoretical analysis of Chapter III describes only the possible relationships that determine the magnitude of a fiscal incentives impact on housing values and location but does not suggest the expected size of P*q, the change in the level of the price of housing services due to fiscal incentives.
variation is expected in non-land prices (n) with distance.

The firm's (household's) profit is designated as $\Pi$. Under competitive conditions profit maximization requires:

\[
4.1 \quad \Pi = P_kQ(L,N) - r_kL - nN = 0
\]

\[
4.2 \quad \frac{\delta \Pi}{\delta L} = P_k - r_k = 0 \quad \text{or} \quad r_k = P_kQ_L
\]

\[
4.3 \quad \frac{\delta \Pi}{\delta N} = P_kQ_N - n = 0 \quad \text{or} \quad n = P_kQ_N
\]

The terms $Q_L$ and $Q_N$ are the changes in the total quantity of housing services produced with respect to changes in land (L) and non-land (N) inputs (the partial derivative of quantity with respect to each input.)

In Chapter III it was noted that no small move can improve the real income of a household under equilibrium conditions or that

\[
4.4 \quad P_k = -\frac{1}{Q_L} \frac{\partial T_k}{\partial Q_k} \quad \text{or} \quad (PQ) P_k/p = -T_k
\]

Differentiating equation 4.1 reveals the necessary further conditions for equilibrium.

\[
4.5 \quad d\Pi = Q(dP_k - Ldr_k - Ndn) + (P_kdQ - r_kdL - ndN) = 0
\]

The second parenthesis can be rearranged and substituting for $r_k$ and $n$ from 4.2 and 4.3 as

\[
4.6 \quad P_k (dQ - Q_1dL - Q_ndn) = 0
\]

and $dQ = Q_1dL + Q_ndn$

\[
4.7 \quad \text{or} \quad Q = Q_1L + Q_nN
\]

Substituting 4.7 into 4.4 reveals a basic equilibrium condition stated in terms of the inputs to production of housing services and the variation in transportation cost with distance.

\[
4.8 \quad P_k = \frac{-1}{Q_1L + Q_nN} T_k
\]

In equation 4.6, price ($P_k$) and quantity of housing services vary inversely while the price of housing services varies directly with transportation
cost per mile.

Operationalizing the above relationship requires proxies for land and non-land inputs, as well as transportation costs. Proxies for the land and transportation cost variables are readily available. Gross residential density has been selected as a proxy for land inputs. The expected sign of the variable is negative, since the quantity of land per housing unit varies inversely with gross residential density. Density is here measured as total population in housing units within a municipality divided by the gross acreage encompassed by the municipality.\(^2\)

Transportation costs per mile are composed of direct dollar expenditures and the value of time. Since this study will focus on upper-income, center-city households, the time component will clearly dominate in total commuting cost per mile. The average commuting time from the CBD to the center of each municipality has been selected as a proxy for \(T_k\). The expected sign of this variable is negative. Muth has argued that the price gradient under equilibrium conditions will in general decline by approximately one percent per mile (Muth, 1969).

Non-land inputs pose an index number problem that has not yet been satisfactorily resolved (Kain and Quigley, 1971; deLeeuw, 1974). Both structural and quality components enter into non-land inputs of housing services. At least six major studies since 1967 have shown both structural and quality elements to be significantly related to the quantity of housing services.\(^1\) Addendum A to this chapter summarizes eight recent studies

\(^2\) Edel and Scalar (1974) use a similar measure of gross density, persons per square mile.

and describes the wide range of variation in quality proxies that have been utilized. Recent research by deLeeuw (1974) clearly demonstrates the difficulty of constructing an index of the quantity of housing services for which no general theoretical model presently exists.

Two proxíes have been selected which in aggregate may control for the non-land inputs in this analysis. The average number of rooms in owner-occupied housing units is used as a structural proxy. The quality component is represented by the percent of units having central-air conditioning. This quality improvement is one which can be found in both new and older remodeled homes. The exterior age of a building without data on the interior state of repair and remodeling may yield misleading implications as to the general level of interior quality. Another possible quality proxy was the percent of units that are rated as substandard or lacking in some sanitary facilities. This proxy was rejected since the presence of substandard units is relatively minor in the suburbs and it omits all positive quality components. In addition, there is no generally agreed upon standard for substandard units. The structural and quality proxies selected are expected to vary directly with the quantity of housing services.

The resulting model contains four variables-size of the structure (average number of rooms), quality of structure (percent of units with central-air conditioning), intensity of land use (gross population density) and transportation cost (average one-way commuting time). The price gradient is expected to decline by approximately one percent (.01) per

---

2 This suggested specification is not directly taken from a reduced-form model. However, until the theoretical and empirical issues of a non-land index of the quantity of housing services is resolved, all studies in this area will suffer from non-uniform variable specification.
The average commuting speed in Cleveland and Cincinnati is near 30 miles per hour or one mile every two minutes. The expected magnitude of the coefficient of the commuting time variable is roughly .005 times the average observed housing value.

Operationalization of the Model

The basic data for this study were drawn from published U.S. Census data or magnetic tapes, as well as state and local government records on municipalities in Cleveland and Cincinnati, Ohio. Forty-nine municipalities in Cleveland and thirty-seven municipalities in Cincinnati lying both in Kentucky and Ohio were selected. Appendix A summarizes the basic data characteristics.

The signs of all variables other than density are as expected. Significant intercorrelation at a .05 level exists between size and two variables—density and quality in both sets of data. The high level of intercorrelation (possible multicollinearity) may in fact be distorting the observed signs and magnitudes of the density coefficient in the equation estimated for Cincinnati and Cleveland.

The ordinary least square (OLS) estimated equations for both cities without adjustment for intercorrelation were:

**Cleveland**

\[
\text{Value} = -15992.85 + 8171.94 \text{ Size} + 129.52 \text{ Quality} \\
\frac{1}{3.032} + \frac{1}{10.728} + \frac{1}{2.965} \\
+ 613.77 \text{ Density} - 193.01 \text{ Commute} \\
\frac{1}{4.378} - \frac{1}{2.161} \\
\text{R-squared (adj.)} = .8559 \quad \text{d.f.} = 44
\]

---

3 Based on estimates of average speeds on various types of roadways by the Northeast Ohio Area Coordination Agency and Ohio, Kentucky, Indiana Regional Planning Authority. The selection of 30 miles per hour for both cities is based on the authors' review of the varying estimates just cited.
Cincinnati

Value = -40912.86 + 10336.82 Size + 162.80 Quality
(5.39) (7.398) (2.463)
+112.18 Density -113.38 Commute
(1.184) (2.046)

R-squared (adj.) = .9137 d.f. = 44

The signs of most variables are as predicted except for the positive coefficient of the density variable. The positive coefficient may be due to significant intercorrelation (multicollinearity) among three of the independent variables.

Intercorrelation Adjustments

Ferrar and Glauber (1967) suggest that significant intercorrelations often indicates multicollinearity. There are no definitive methods for detecting or adjusting for multicollinearity (Johnston, 1963; Goldberger, 1964). Two characteristics of the ordinary least squares model can be exploited to produce coefficients which strictly meet the independence assumption of the methodology. The calculated residuals from a least squares regression equation are orthogonal to the explanatory variables of that equation. Secondly, the inclusion of a regressor that is orthogonal to previously included regressors will not bias the estimated regression coefficients (Goldberger, 1964; Thiel, 1971).

Using these two characteristics of ordinary least squares, a technique can be devised that imposes independence on intercorrelated independent variables. The basic procedure entails two steps. The first step in the procedure requires regressing one of the intercorrelated

---

4 Appendix B fully explores this procedure and provides a proof in matrix algebra terms of the lack of bias in the procedure. In addition, model equations and residuals are presented that clearly show the procedure does not affect the coefficients of subsequent regressors.
Independent variables (A) on the other independent variable(s) (B) with which it is significantly intercorrelated. The residual from this equation now serves as the multicolinearity adjusted independent variable (A) in all subsequent regressions. The second step is the substitution of adjusted variable (A) into the original regression equation as an independent variable. Whenever A-adjusted is utilized it must be accompanied in that regression by the variables on which it was regressed (B) in the first step. This approach does not bias the coefficients of the adjusted variable or any subsequent regressors included in future equations. It only affects the coefficients of the independent variables in the multicolinearity adjustment equation (step one). A similar method was used successfully by Ridker and Henning (1967) in adjusting for multicolinearity among pollution variables. The method was termed "residualization" after the first step in the adjustment process.

Examination of the correlation matrix revealed that the size variable (average number of rooms per owner-occupied housing units) was significantly intercorrelated with the density and quality measures. Consequently, the size variable (sizea) was adjusted for intercorrelation with both quality and density. In all subsequent analysis the size variable is used in its adjusted form.

The estimated equations for both cities after adjustment for multicolinearity were:

**Cleveland**

\[
\text{Value} = 32638.43 + 8171.45 \text{Size}_a + 400.51 \text{Quality} - 613.77 \text{Density} - 193.01 \text{Commute} \\
\text{(12.865)} \quad \text{(10.728)} \quad \text{(11.263)} \quad \text{(4.378)} \quad \text{(2.162)}
\]

\[
\text{R-squared (adj.)} = .8559 \quad \text{d.f.} = 44
\]
Cincinnati

\[ \text{Value} = 15595.17 + 10336.81 \text{ Size}_a + 582.49 \text{ Quality} - 95.944 \text{ Density} \]
\[ (9.526) \quad (7.398) \quad (16.492) \quad (1.049) \]

-113.38 Commute
\[ (2.046) \]

R-squared (adj.) = .9137 d.f. = 32

The values shown in parentheses are T-values. The signs of the variables are as expected.

Theoretical Consistency of the Basic Model

The magnitude of the regression coefficient for commuting time is not significantly different from the predicted values. The price gradient declines by approximately 1% per mile assuming an average speed of 30 miles per hour in both metropolitan areas (See Table IV-1).

These two SMSA's have not previously appeared in published studies of fiscal variables and residential housing values. However, both metropolitan areas were included in portions of Muth's (1969) analysis of forty-six cities using 1950 census data. At that time, the Cleveland area conformed to theoretical expectations while Cincinnati was theoretically inconsistent. Using 1970 data, two simple analyses were conducted to further determine the current theoretical compatibility of the two metropolitan areas to Muth's.

Both of the earlier SMSA'a findings fit two further basic premises of the Muth model in general. Estimates of the income elasticity of demand with respect to housing are similar in both cities and agree with Muth's (1969) and deLeeuw's (1971) estimates (See Table IV-1). Density, expressed as persons per acre, declines with distance from the CBD. The density gradient is not significantly non-linear in the suburban area of the SMSA's.

---

5 The density gradient in Cincinnati showed a slightly positive slope.
However, inclusion of center-city census tracts, which are described in Appendix A, results in a significant negative curvature to the density gradient in Cincinnati. The gradient is negative, but insignificantly non-linear in Cleveland.

Table IV-1

Estimated Income Elasticity, Price Gradient and Density/Distance Relationships

Cleveland and Cincinnati Suburbs

<table>
<thead>
<tr>
<th>Subject</th>
<th>Cleveland</th>
<th>Cincinnati</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income elasticity with respect to housing.</td>
<td>.94</td>
<td>1.05</td>
</tr>
<tr>
<td>Price gradient$^1$</td>
<td>-.94%</td>
<td>-1.13%</td>
</tr>
<tr>
<td>Rate of change of density with respect to linear distance$^2$</td>
<td>-8.58%</td>
<td>-7.73%</td>
</tr>
</tbody>
</table>

$^1$ Assumes two commuting minutes equals approximately one radial mile. The price gradient is based on the coefficient of the commuting time variable in the adjusted equations.

$^2$ The rate of change in density per unit of distance was interpreted from a simple regression of average gross density per acre on radial distance from the CBD and distance-squared. The latter term was included to check for non-linearity.
The analysis of this section addresses the proposition that under conditions of long-run equilibrium suburban fiscal variables are unrelated to housing values. This is the basic proposition of the Tiebout model. Within a metropolitan area where barriers to movement do not exist and where a large number of municipalities exists, a Tiebout type equilibrium of fiscal goods can be achieved. Both Cincinnati and Cleveland have a large number of municipalities that are scattered around the center-city.

Proposition I requires the operationalization of benefit to tax ratio variables. The numerator of the educational benefit/tax ratio relies on the total non-debt educational expenditure per student in each school system. The number of students is based on October, 1969 enrollment adjusted by the prevailing Federal formula for combining kindergarten, elementary, secondary and special education students for accounting purposes. The numerator of the municipal benefit tax ratio is total municipal expenditures per family. The weakness of dollar expenditures as a proxy for true benefits received is readily acknowledged as one that fails to consider the composition of varying bundles of services (Oakland, 1973). However, at this time no effective or accepted measures of fiscal benefits other than simple dollar expenditures have been fully developed. The denominator for both ratios is calculated as the average tax payment per household of owner-occupied housing units for educational services and municipal services, respectively.

Also included in the regression model is a variable that measures the degree of income dispersion within the municipality. This measure is

---

7 This formula was used by Oates (1969), Edel and Scalar (1974), and Pollokowski (1971).
included as a double-check on the accuracy of the fiscal variable specification. The work of Hamilton et al (1973) and Miezkowski (1972) has established that if equilibrium conditions exist, income dispersion should be insignificantly related to housing values. Both upper and lower income communities should have income distributions of a similar form. If this is not the case, the expected theoretical conditions for achieving fiscal equilibrium have not been fully met and housing values are significantly affected by fiscal disparities. For long-run equilibrium relationship to exist, the income dispersion measure and the fiscal variables should be insignificantly related to housing value.  

Therefore, if the true relationship is one of fiscal equilibrium in the suburbs, the income dispersion variable will be insignificant and will not affect the coefficient of any other variables included in the regression. Conversely, a significant coefficient for the benefit-tax ratio should be accompanied by a significant income dispersion coefficient.

Income dispersion is measured by the Gini coefficient. This is the area between the Lorenz curve of income and the diagonal representing a perfect egalitarian income distribution. The area is then standarized by dividing it by the total area under the diagonal. The resulting coefficient varies between zero and one. The higher the Gini coefficient, the less egalitarian the income distribution and, therefore, the more heterogeneous. Hamilton, Mills and Puryear (1973) have extensively used this measure and note that it is biased upward with higher income.

**Empirical Analysis - Suburban Equilibrium**

Two six-variable models were operationalized for the suburbs of each city.
metropolitan area. The four basic variables described in the previous
section of this chapter were included along with the benefit/tax ratios
for educational services and municipal services. These variables were op­
erationalized as described above. Using 1970 Census data, income distribu­
tions for each municipality were converted into Gini coefficients. Four
separate regression equations are presented in Table IV-2. Among suburban
municipalities of each metropolitan area the educational and municipal bene­
fit-tax ratios are insignificantly related to housing values, which is consis­
tent with Proposition I. In each instance, the fiscal goods and accom­
panying taxes when considered simultaneously do not affect residential pro­
perty values. This is exactly the condition expected if the municipalities
are approaching a long-run equilibrium condition in the provision of fiscal
goods. In neither case does the T-value of a benefit-tax ratio even exceed
1.00. The Gini coefficient in all four regressions is also insignificant,
as was expected. The signs of the four basic variables are also as predic­
ted and are generally significant at the .05 level.

6 Table A-3 lists the average values for fiscal expenditure and tax
variables in both metropolitan areas.
### TABLE IV-2

Value as a Function of Consumption, Accessibility
and Fiscal Benefit Ratios
Cleveland and Cincinnati, Ohio
1970

<table>
<thead>
<tr>
<th>Variables</th>
<th>Education Services</th>
<th>Municipal Services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cleveland</td>
<td>Cincinnati</td>
</tr>
<tr>
<td>Size ( \alpha )</td>
<td>8825.10</td>
<td>9956.95</td>
</tr>
<tr>
<td></td>
<td>(9.062)</td>
<td>(6.676)</td>
</tr>
<tr>
<td>Quality</td>
<td>442.22</td>
<td>586.06</td>
</tr>
<tr>
<td></td>
<td>(10.265)</td>
<td>(15.849)</td>
</tr>
<tr>
<td>Commute</td>
<td>-198.18</td>
<td>-97.63</td>
</tr>
<tr>
<td></td>
<td>(2.174)</td>
<td>(1.618)</td>
</tr>
<tr>
<td>Density</td>
<td>-564.24</td>
<td>-63.58</td>
</tr>
<tr>
<td></td>
<td>(3.798)</td>
<td>(0.646)</td>
</tr>
<tr>
<td>Ghini</td>
<td>-180.27</td>
<td>40.82</td>
</tr>
<tr>
<td></td>
<td>(1.082)</td>
<td>(.321)</td>
</tr>
<tr>
<td>Educational Tax</td>
<td>60.602</td>
<td>-346.60</td>
</tr>
<tr>
<td>Ratio</td>
<td>(.1709)</td>
<td>(.911)</td>
</tr>
<tr>
<td>Municipal/Tax Ratio</td>
<td>37419.95</td>
<td>14678.26</td>
</tr>
<tr>
<td></td>
<td>(6.995)</td>
<td>(3.103)</td>
</tr>
<tr>
<td>R²</td>
<td>.8532</td>
<td>.9109</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>42</td>
<td>30</td>
</tr>
</tbody>
</table>
Proposition I has been generally supported by the empirical analysis of the Cleveland and Cincinnati suburbs. Fiscal variables do not appear to be significantly affecting housing values in suburban Cleveland or Cincinnati at the time of this study.

Most prior studies of suburban fiscal equilibrium have relied upon separate effective property tax rate and fiscal services variables. The property tax rate appears to be no more than a transformation relating property values to income levels. The comparability of this approach to the benefit/tax ratio is demonstrated in Table IV-3. If effective property tax rates (millages) are accurately computed, under equilibrium conditions both the tax rate and fiscal variable should be insignificantly related to housing values. The typical signs for the fiscal variables, although not the only reasonable pattern, is a negative tax to value relationship and a positive fiscal service to value condition.

The four equations of Table IV-3 all have the expected signs and all fiscal variables are insignificantly related to housing values. The basic conditions of fiscal equilibrium or the lack of fiscal incentives for movement among communities in the suburbs are again supported. Therefore, fiscal considerations were not significantly related to household movements among suburban communities of Cleveland or Cincinnati during 1970.
### TABLE IV-3

Value as a Function of Basic Model
Property Tax Rates and Fiscal Services
Cleveland and Cincinnati, Ohio
1970

<table>
<thead>
<tr>
<th>Variables</th>
<th>Education Services</th>
<th>Municipal Services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cleveland</td>
<td>Cincinnati</td>
</tr>
<tr>
<td>Size(_a)</td>
<td>8976.16 (8.887)</td>
<td>10769.47 (6.844)</td>
</tr>
<tr>
<td>Quality</td>
<td>425.91 (9.636)</td>
<td>594.25 (15.422)</td>
</tr>
<tr>
<td>Commute</td>
<td>-152.49 (1.626)</td>
<td>-71.91 (1.008)</td>
</tr>
<tr>
<td>Density</td>
<td>-490.57 (3.158)</td>
<td>-51.61 (0.517)</td>
</tr>
<tr>
<td>Ghini</td>
<td>-238.31 (1.388)</td>
<td>11.06 (0.079)</td>
</tr>
<tr>
<td>Education Services</td>
<td>4.75 (1.196)</td>
<td>0.46 (0.153)</td>
</tr>
<tr>
<td>Municipal Services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education Property Tax Rate</td>
<td>-280.25 (1.316)</td>
<td>-294.47 (1.129)</td>
</tr>
<tr>
<td>Municipal Property Tax Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>37040.79 (6.57)</td>
<td>16658.53 (3.074)</td>
</tr>
<tr>
<td>(R^2)</td>
<td>.8589</td>
<td>.9100</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>41</td>
<td>29</td>
</tr>
</tbody>
</table>
The insignificant benefit/tax relationship reported in Tables V-2 and 3 could be a result of simultaneous equation bias. That is, the observed independent variables may be simultaneously determined by a system of equations composed of variables exogenous to the model. Two-stage least square (TSLQ) regression estimates of suburban benefit/tax levels were constructed for educational services. The first stage equation predicted the benefit/tax level based on the four basic variables and gini coefficient endogeneous to the model, and a series of exogeneous variables. These exogeneous variables were drawn from structural equations of the demand for educational services and tax behavior. Chapter V considers in some detail these two structural equations. The demand for educational services was expressed as a function of income, household preferences, urbanization, and data specific externalities (such as state differences). Tax behavior was specified as a function of income. Proxies for the above exogeneous variables, the four basic variables \(S, QU, D, C\) and the gini coefficient were included as independent variables in the first stage estimation of the bene-fit/tax level.

The two stage least square (TSLQ) regression results agreed with the results attained from the ordinary least squares regression analysis (Table IV-4). The educational services benefit/tax ratio was insignificantly related to suburban housing values at the time of the study.

Structural equations for gross municipal services demand and tax behavior have not been well developed theoretically or empirically in past research studies. The analysis of Chapter V is also restricted to only educational services. Municipal services are funded by a variety of taxes, each of which would require separate estimation procedures. There is no compelling reason to believe each of these taxes, such as sales taxes, will behave in a manner analagous to the property tax. The specification of the
## TABLE IV-4
Two-Stage Least Square Estimates of the Relationship Between Housing Values and E/T

<table>
<thead>
<tr>
<th></th>
<th>S</th>
<th>QU</th>
<th>D</th>
<th>C</th>
<th>E/T&lt;sup&gt;1&lt;/sup&gt;</th>
<th>G</th>
<th>I</th>
<th>R²</th>
<th>d.f.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cincinnati</td>
<td>7354.42</td>
<td>544.88</td>
<td>-64.82</td>
<td>-123.99</td>
<td>-257.90</td>
<td>-11.68</td>
<td>17393.36</td>
<td>.8456</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>(3.48)</td>
<td>(9.20)</td>
<td>(0.53)</td>
<td>(1.62)</td>
<td>(0.70)</td>
<td>(0.26)</td>
<td>(5.30)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleveland</td>
<td>7300.13</td>
<td>346.47</td>
<td>-832.31</td>
<td>-299.34</td>
<td>-1080.46</td>
<td>-6.97</td>
<td>40388.42</td>
<td>.8714</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>(5.77)</td>
<td>(5.97)</td>
<td>(6.28)</td>
<td>(3.07)</td>
<td>(0.80)</td>
<td>(2.55)</td>
<td>(7.15)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup> Predicted as a function of above four basic variables plus gini coefficient, income, person per household, percent renter-occupied units, and externality factor proxies. The role of these exogeneous variables in the demand for public services and tax behavior are described in Chapter V. In the Cincinnati first stage equation two externality factors were included -- state differences and forced school district consolidation.
first stage of a TSLQ procedure to analyze municipal services would be purely conjectual.

The only unexpected result is the significance of the Ghini coefficient in the suburban Cleveland equation. The increase in T-value of the ghini coefficient may be due to positive bias between ghini and household income, which was included in the first stage of the simultaneous model. The ghini coefficient should also be estimated simultaneously. The full model would include a system of equations that explain observed income levels, benefit/tax levels as well as observed housing values. The ghini coefficient could then be addressed in the context of three stage least squares. The low significance of the Ghini coefficient throughout the conventional least square regressions and in Cincinnati under TSLQ procedures suggest that this sudden shift to statistical significance may be an estimation problem and not a theoretically contradiction. Resolution of the problem must await the specification of a multi-equation system that includes the determinants of the ghini coefficient.

The conditions of suburban fiscal equilibrium have been generally supported. However, the role of public goods and property taxes in promoting movements from the center-city to the suburbs has not yet been addressed. Chapter V empirically examines the role of fiscal incentives in promoting population movements from the center-city.
Eight major studies have been selected from all specified empirical models of urban owner-occupied housing values. Table IV-5 summarizes the models used in each study. The eight studies included are:

B. Berry and R. Bednors (1975)

W. Fischel (1974)

M. Edel and E. Scalar (1974)

B. Hamilton (1972)

R. Anderson and T. Crocker (1971)

J. Kain and J. Quigley (1971)

W. Oates (1969)

R. Ridker and J. Hennings (1968)

Only equations for single-family owner-occupied units are included from the above studies, since the focus of this research is restricted to owner-occupied units. Goldstein (1965) found owner-occupants to be much more keenly interested in public schools and fiscal benefits than renters. Thus, the behavior of owner-occupants should more closely approximate the expectations of a Tiebout world. Additionally, Heinberg and Oates (1971) have pointed out that substantial lags may exist between tax increases and rent increases. Owner-occupants become aware of tax increases immediately upon enactment and feel the impact on housing expenses as soon as the tax is implemented.

Several similarities are evident across the studies described in Table VI-1. Generally some measures of distance from the CBD or general transportation accessibility has been included. After controlling for housing consumption the price of housing services should vary negatively with distance from the CBD. The sign of this variable has not been consistent across studies, and in the case of multiple city studies it has varied across cities.
This is theoretically contradictory and may be a function of multicollinearity within the models or inadequate specifications of housing quantity attributes.

Several models include both income and the average number of rooms as independent variables. These two variables tend to be highly correlated with each other and with value. In most cases, average income has been included as a proxy for neighborhood characteristics or desirability. Only Hamilton uses income in specifying a demand for housing function, and in this case he correctly does not include a consumption variable such as size of the housing unit in the equation. However, the use of income as a determinant of value rather than of consumption level is highly questionable. A thorough critique of this role and associated multicollinearity problems has been suggested by Ball (1973) and will not be repeated here.

A quality of housing variable has been explicitly incorporated in most studies since 1967. The most prevalent form of quality variable has been the age of the average unit. Unfortunately, the age of the unit typically refers to the year actually built and not explicitly to current condition of the unit. It effectively overlooks all forms of renovation and most forms of disrepair due to accelerated lack of maintenance. The Bureau of the Census since 1969, has been unable to agree on an acceptable definition of substandard units. Kain and Quigley (1971) exhaustively analyzed housing quality and identified three quality dimensions: Basic Residential Quality (neighborhood characteristics), Dwelling Unit Quality, and Quality of Proximate Units. Neighborhood preferences have been explicitly assumed to not affect housing values in this study. This assumption will be returned to in Chapter I as the characteristics of upper-income, center-city households are examined.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable</td>
<td>Sales Price (actual)</td>
<td>Ave. Value (Census, '70)</td>
<td>Ave. Value (Census, '70)</td>
</tr>
<tr>
<td>Independent Variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neighborhood Characteristics</td>
<td>+avg. Income*</td>
<td>N.A.</td>
<td>+%owner-occupied</td>
</tr>
<tr>
<td>Unit Size</td>
<td>+Sq. Ftage of Bldg.*</td>
<td>+Avg. No. Rms*</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td>+%Non-White*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household Demographics</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Quality of Housing Unit</td>
<td>+%Air-conditioned*</td>
<td>+%Recent Built*</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td>-Age of unit*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>+Attic</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>+Basement</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>+Baths*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>+Garage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td>+Rent/Own Ratio*</td>
<td>+Rent/Own Ratio*</td>
<td>Persons per mile</td>
</tr>
<tr>
<td>Distance</td>
<td>+linear from CBD*</td>
<td>-linear from CBD</td>
<td>N.A.</td>
</tr>
<tr>
<td>City vs. Suburb</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Tax Rate</td>
<td>N.A.</td>
<td>N.A.</td>
<td>-Effective Tax*</td>
</tr>
<tr>
<td>Cross-States</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Municipal Serv.</td>
<td>N.A.</td>
<td>N.A.</td>
<td>+Expend. per Stud.*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-Highway expend.</td>
</tr>
<tr>
<td>Pollution</td>
<td>+Particles</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Avg. R-sq.</td>
<td>.787</td>
<td>.670</td>
<td>.64-78</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>275 units</td>
<td>30 municipalities</td>
<td>64-78 municipalities</td>
</tr>
<tr>
<td>Number of Cities</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

* significant at .05 level.
### TABLE IV-5
(continued)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable</td>
<td>Avg. Value (Census, '60)</td>
<td>Avg. Value (Census, '60)</td>
<td>Sales Price (actual)</td>
</tr>
<tr>
<td>Independent Variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neighborhood Characteristics</td>
<td>+Avg. Income*</td>
<td>+Avg. Income</td>
<td>-%Non-White</td>
</tr>
<tr>
<td></td>
<td>N.A.</td>
<td>+Non-White</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>+Sq. Ft. of Blg.*</td>
<td>+Sq. Ft. of Blg.*</td>
</tr>
<tr>
<td>Household Demographics</td>
<td>N.A.</td>
<td>N.A.</td>
<td>+Avg. Education*</td>
</tr>
<tr>
<td>Quality of Housing</td>
<td>N.A.</td>
<td>-Age of Unit</td>
<td>+Quality Indexes*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+%Substandard</td>
<td>-Age of Unit</td>
</tr>
<tr>
<td>Density</td>
<td>-Persons per household*</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Distance</td>
<td>+linear to CBD</td>
<td>+linear to CBD</td>
<td>+linear to CBD</td>
</tr>
<tr>
<td>City vs. Suburb</td>
<td>+Dummy</td>
<td>N.A.</td>
<td>-Dummy*</td>
</tr>
<tr>
<td>Tax Rate</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Cross-States</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Municipal Serv.</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Pollution</td>
<td>N.A.</td>
<td>+Particles</td>
<td>N.A.</td>
</tr>
<tr>
<td>Avg. R-sq.</td>
<td>.818</td>
<td>.78-92</td>
<td>.73</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>24 tracts/city</td>
<td>120 tracts/city</td>
<td>1500 units</td>
</tr>
<tr>
<td>Number of Cities</td>
<td>15</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

* significant at .05 level.

(continued)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable</td>
<td>Avg. Value (Census, 19)</td>
<td>Avg. Value (Census, '60)</td>
</tr>
<tr>
<td>Independent Variables</td>
<td>+Avg. Income*</td>
<td>+Avg. Income*</td>
</tr>
<tr>
<td>Neighborhood Characteristics</td>
<td>+Avg. Income*</td>
<td>+Avg. Income* +%Non-White</td>
</tr>
<tr>
<td>Unit Size</td>
<td>+Median No. Rms.*</td>
<td>+Avg. No. Rms.*</td>
</tr>
<tr>
<td>Household Demographics</td>
<td>N.A.</td>
<td>+Occupational Index*</td>
</tr>
<tr>
<td>Quality of Housing Unit</td>
<td>+%Recent Built*</td>
<td>+%Recent Built*</td>
</tr>
<tr>
<td>Density</td>
<td>N.A.</td>
<td>+Housing Units/mile* -Persons per unit*</td>
</tr>
<tr>
<td>Distance</td>
<td>-Linear to CBD*</td>
<td>+Commute time to CBD* +Highway time to CBD*</td>
</tr>
<tr>
<td>City vs. Suburb</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Tax Rate</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Cross-States</td>
<td></td>
<td>-State Dummy</td>
</tr>
<tr>
<td>Municipal Serv.</td>
<td>+Expend. per Student* +Municipal Exp./Family*</td>
<td>+Educ. Quality Index*</td>
</tr>
<tr>
<td>Pollution</td>
<td>N.A.</td>
<td>-Particles*</td>
</tr>
<tr>
<td>Avg. R-sq.</td>
<td>.93</td>
<td>.937</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>53 municipalities</td>
<td>167 tracts</td>
</tr>
<tr>
<td>Number of Cities</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

* significant at .05 level.
The land to structure input mix affects the value of the housing unit. We have theoretically assumed a featureless land-scape with equal accessibility in all directions. The more convoluted the land surface, the more questionable becomes the assumption of constant elasticity of substitution between land and capital. Brigham (1966) has established the strong influence terrain features have on land values in Los Angeles. Population density per unit of area thus serves as a proxy for the intensity of land use.
Chapter V

The Influence of Fiscal Incentives on Center-City Housing Values
In Chapter IV the effects of fiscal incentives on suburban housing values were shown to be insignificant and fiscal equilibrium conditions were generally supported. However, the same conditions may not exist between household locations in the center-city versus the suburbs. In the center-city fiscal equilibrium conditions may be unattainable due to the inherently income heterogeneous nature of the center-city. If stable fiscal equilibrium conditions are unattainable, then fiscal incentives for relocation to the suburbs may exist.

This chapter investigates the question of fiscal incentives and central city residence in terms of fiscal advantages which might be obtained by changing location (moving from the center-city to the suburbs). Fiscal incentives have been shown to effect the height of the price gradient \( P(k) \). A shift \( P_0 \) in the level of the price gradient could significantly effect housing values and locational decisions if the magnitude of the fiscally induced shift in the gradient is rather large. For significant fiscal incentives to exist a center-city households must (at a minimum) be able to increase its real fiscal goods consumption without correspondingly increasing the households property tax payments. The presence of fiscal incentives should negatively effect center-city housing values. This is, if two identical housing units (same radial distance and quantity of housing services) occur in both the center-city and suburbs, the center-city housing unit should have a lower value than the suburban unit.

The households most directly effected by fiscal incentives have been shown to be upper-income center-city households. These households are financially able to move to the suburbs and are subject to the greatest fiscal disparities whenever fiscal disequilibrium conditions exist in the center-city. A group of upper-income center-city households must be selected to allow the direct examination of fiscal incentives.
A total of thirty-two census tracts (19 in Cleveland and 13 in Cincinnati) were selected as a sample of upper-income center-city tracts containing predominantly owner-occupied units. The conditions for selecting the tracts were drawn from the basic assumptions of the model presented in Chapter III. The selected tracts must have income levels similar to the suburbs, since a requirement of suburban relocation is an income exceeding the average income of the specified suburb. Secondly, this partial equilibrium analysis precludes changes in household preferences or wage income in the short-run; therefore the center-city households present housing consumption must equal or exceed the lowest consumption level of any suburb included in the analysis. These constraints were operationalized with some necessary arbitrariness in selecting center-city households who were capable of relocating in the suburbs. The general requirements for selection were:

1. The average income of each census tract must be within the top 20% by income of all census tracts within the city limits of the center-city or within one standard deviation of the average income of the suburban municipalities, whichever was greater.

2. Only those tracts in which over 50% of all housing units are single-family, owner-occupied were included.

3. The average value of housing units in each census tract must equal or exceed the average housing value in the least expensive suburban municipality included in this analysis. A description of the selected census tracts is included in Appendix A. These census tracts must be examined in conjunction with the suburban municipal data to determine the effects of fiscal incentives.

**Empirical Analysis of Proposition II**

The second proposition of this study states that under conditions of
long-run equilibrium in the suburbs, observed housing values for upper-income, single-family housing unit will be lower in the center-city than in the suburbs after controlling for the quantity of housing services. If fiscal incentives are the only externality affecting the price of housing services, a center-city location should negatively and significantly affect housing values. Two tests are necessary to examine this proposition. The suburban municipalities and center-city census tracts should all be part of the same population. Therefore, and OLS regression based on only suburban data should have coefficients insignificantly different from OLS regression with the same variables, but including both suburban and center-city observations. A Chow test of the differences between two regressions can establish the similarity of the two regressions for both metropolitan areas. The second general test is to introduce a dummy variable for center-city location (CITDUM). The coefficient of the center-city locational variable should be negative and significant if fiscal incentives are effecting center-city housing values and locational decisions. The results of the above two tests are presented in Table V-1.

A Chow test of differences between regressions did not reveal a significant difference between the suburban and center-city/suburban equations. As shown in Table V-1, the calculated F ratios were below 1.0 in both

---

1 The Chow test to be used is a modified form developed by Fisher (1970). The statistic shown below is distributed as an F with (trM-trM*) and trM* degrees of freedom.

\[
F = \frac{(U'U - U*U*)/trM- trM*}{U*U*/trM*}
\]

U'U is the sum of the squared residuals of the suburban and city equation, while U*U* is the sum of the squared residuals from the suburban equation alone. The trace of M (trM) is the sum of the observations in the suburban center-city regression minus the number of variables (5). The trace of M* is the sum of the observations in the suburban equation minus the number of variables in the regression (5).
instances (.7589 and .4373) and were not statistically significant. The dummy variable introduced for center-city location (CITDUM = 1) in both cities also proved to be insignificant. The expected negative sign of the dummy, if only fiscal incentives were present, was found only in Cincinnati. In both cases, the T-values are near 1.00 and do not suggest substantive differences between suburban and center-city housing values. The positive sign on the dummy in Cleveland may be due to the presence of positive externalities which offset the negative impact of the fiscal incentive. The magnitude of the fiscal incentive is still underdetermined and could itself be relatively small.

Research by Hamilton (1972) and others has relied upon the sign of a dummy variable, as used here, to ascertain the presence of fiscal incentives. Other factors may be influencing center-city housing values such as short-term disequilibrium conditions, and positive or negative externalities not related to fiscal incentives. The center-city dummy variable measures the net effects of all factors that are simultaneously acting on only center-city housing values. If the magnitude of these possible other factors is large as compared to fiscal incentives then the dummy variable reveals very little about the direction and magnitude of the influence of a single specific externality — fiscal disparities. The third proposition suggests the effect only fiscal incentives have on center-city housing values. This requires a further detailed analysis of fiscal variables directly and their influence on housing values.

**Methodology for Directly Examining Implicit Fiscal Transfer**

The direct examination of the fiscal incentive requires the construction of a proxy for the change in implicit fiscal transfer (CIFT). The demand for educational services and residential property tax burden must
<table>
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<th>QU</th>
<th>D</th>
<th>C</th>
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<th>I</th>
<th>R²</th>
<th>d.f.</th>
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<td>(0.17)</td>
<td>(14.68)</td>
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</table>

1 Dummy variable for census tracts located within corporate limits of center-city.

NOTE: Column headings: S (size), QU (quality), D (density), C (commuting time), I (intercept), d.f. (degrees of freedom), R² (adjusted R²).
be determined to arrive at an expected gain in IFT by a move to the suburbs. The change in implicit fiscal transfer was previously defined as the difference between the current benefit/tax ratio and the benefit/tax ratio attainable by a relocation to suburb a.

$$\text{CIFT}_{x a} = \frac{B_{xa}}{T_{xa}} - \frac{B_{xi}}{T_{xi}}$$

The benefit/tax ratio of the average household in each center-city census tract is known if the effective property tax rate is assumed constant for all center-city, owner-occupied housing units. The benefit level for any local good is assumed constant across all center-city households. The analysis to be presented below is limited to only the education benefit/tax relationship for two reasons. Over two-thirds of the property tax collected is dedicated to school operating expenses. Secondly, the property tax is the dominant revenue source for local education in Ohio. Municipal services are predominantly financed through other taxes—sales taxes, fees, personal property tax or inventory taxes, and in some cases income taxes, as well as state and federal aid. This plethora of revenue sources makes the construction of a structural model of municipal services or dedicated property taxes beyond the scope of this study.

Estimation of the change in implicit fiscal transfer requires the specification of structural equations for educational services demand and tax behavior in the suburbs. These structural equations were operationalized using data from the suburbs of the two metropolitan areas. Center-city educational expenditures per student and effective property tax rates were known, therefore the current benefit/tax ratio for each center-city census tract could be calculated. The difference between the predicted benefit/tax ratio (from the structural equations) and the current benefit/tax ratio for the center-city household could be used as a proxy for the change in
IFT (CIFT). This difference should be negatively related to center-city housing values, if the housing and educational preferences of center-city households are similar to suburban households. The CIFT variable will be a binary interaction variable with the center-city dummy (CITDUM). All suburban values of the variable are zero; therefore, the coefficient of the IFT variable is only relevant to the center-city observations.

**Demand for Educational Services**

Educational services expressed in dollar units per student are assumed to offer equivalent quality and quantity of educational services across all school districts. The production function of educational services is not affected by the nature of the student inputs, the generally middle and upper-income character of the suburban school districts should impose some homogeneity on student inputs. Local neighborhood schools with very little busing between neighborhoods were the dominant form of school organization in both the city of Cleveland and Cincinnati in 1970. The center-city neighborhoods selected for this study are at least similar in an economic sense to the suburbs. The quality of their student inputs may more closely approximate suburban student inputs than would generally be true of center-city schools in general.

The demand for educational services is a function of income and household preferences. Income has been included in virtually all prior empirical studies (McMahon, 1970; Denzau, 1975), while household preferences have been included in a wide variety of forms. Let the demand for educational services in community $a$ be:

$$E_a = E_{a/s} = \Omega_a(Y_a)$$
where; \( \gamma_a \) = average household income in community \( a \)
\( \Omega_a \) = a proportionality factor reflecting all other community preferences.
\( E_a \) = the current expenditure for education exclusive of capital expenditures. This includes instructional, administrative, transportation and typical current maintenance expenditures.
\( S \) = the weighted number of students in the school district\(^2\).
\( E_a \) = average educational expenditure per student.

The community preference factor has three components:

\[ \Omega_a = b_1P_a + b_2R_a + b_3E_m + u_a \]

The household's preferences for educational services (\( P_a \)) should vary directly with the presence of children in a household. The larger the number of children in the household, the greater should be the preference for education—a linear, monotonic relation. Many prior studies have hypothesized that the higher the degree of urbanization, the more educational services are required (McMahon, 1970; Fabrican, 1952; Denzou, 1975). In addition, Barr and Davis (1966) have shown that the presence of renter households (\( R_a \)) allows owner-occupants who value education highly to potentially shift a share of the cost burden to renter households. The result is a tendency for owner-households to demand higher levels of educational services the more renter households are present, so long as the majority of the voters are owners. The percent of renter households (\( R_a \)) is here used as a proxy for both urbanization and increased propensity to consume educational services due to voter composition. If urbanization

\(^2\) The federal 1970 formula for weighting school attendance to allow comparability was used in weighting student enrollment. The weights were:
Kindergarten (0.5), elementary (1.0), secondary (1.5), and special education (2.0).
and voter propensity shifts are highly correlated in the suburbs, as seems likely, then a single proxy can measure the effects of both factors.

Externalities \( E_m \) are the third group of input factors. A dummy variable serves as a gross proxy for differences in educational service levels between Kentucky and Ohio (Fischer, 1964). Examination of the data may reveal other externalities which are specific to this sample and are not generally applicable to all metropolitan areas. Any such data specific externality will be discussed when it is introduced into the model. \( U_a \) is a random disturbance term. The structural model described above does not suggest as a priori combinatorial form (exponential, etc.) therefore simple natural numbers will be used.

**Residential Property Tax Behavior**

The model presented in Chapter III requires that residential property taxes and housing values are linearly related to income.

\[
T_a = t_a V_a = t_a (b_a V_a)
\]

where \( b_a \) is a constant income elasticity for housing.

However, two additional factors have been proposed as affecting the level of residential property tax—state or federal aid to education (Saks and Harris, 1971) and the substitution of non-residential for residential property taxation.

\[
T_a = t_a (b_a V_a) - b_1 ST - t_a (1-\Theta_a) C_a - t_a (1-B_a) I_a
\]

\( St \) = State aid per student

\( C_a \) = Average assessed valuations of commercial property per household

\( I_a \) = Average assessed industrial property valuation per household

The impact of state (ST) or federal aid on tax levels has been widely debated with the result that matching grants seem highly related to local
education expenditures and taxes while block grants (per student) seem to have little relationship. (Hamilton, Mills and Puryear, 1973). The Ohio Education Fund is generally disbursed in block grants on a per student basis for specific purposes with some apparent redistributive emphasis from urban to rural areas. The level of state aid is expected to be negatively and insignificantly related to residential tax levels.

The shifting of commercial and industrial property taxes to residential taxes has recently received some empirical support (Ladd, 1975). The relative immobility of commercial investments \( C_i \) and to a degree industrial plants \( I_i \) may encourage residents to shift portions of their property tax burden to the owners of commercial or industrial property. The degree of substitution achieved by residential property owners will depend on the relative immobility of the non-residential resources and on their inability to change political outcomes through economic pressures. The precise tax effects depend on \( \Theta_a \) and \( B_a \) the fractions of commercial and industrial tax bases not shifted to substitute for residential property tax. The estimation of \( \Theta_a \) and \( B_a \) is not possible directly and, in fact, Fischel (1974) has found industrial tax shifting to be minimal. Both Ladd (1975) and Fischel (1974) agree the more important factor is commercial property tax. Data limitations in this study force the omission of the commercial investments in proximity to center-city households are not known, nor are data available to construct such preferences. Fox (1975) has developed a simultaneous equation system to address the equilibrium effects of only industrial location on property tax and educational services in the suburbs. However,

---

3 A sample of 30% of the rural Ohio counties shows that in 1970 the average rural county received $215 in state aid per student while the suburbs of Cleveland and Cincinnati received approximately 40% less per student ($149.26 and $153.29 respectively).
this multi-equation system does not address non-suburban preferences, a necessity in this analysis. The omission of the commercial effects will tend to positively bias the structural equation.

**Production Function for Educational Services**

The production function for educational services is here assumed to be exogeneously in the short-run. That is, households seeking to relocate in the suburbs from the center-city cannot in the short-run change the production inputs for educational services. McMahon (1970) formulated one of the only structural equation systems to explain the level of educational services that explicitly contains a production function. The inputs to the production function were student composition by grade level, teacher-student ratios, and teacher salary levels. The dependent variable used in the present study has been directly adjusted for the composition of the children in the district by class level. For the purpose of this study teacher salaries are viewed as fixed, as are teacher-student ratios. It should be noted that the few studies of state or metropolitan systems which achieve high explanatory power for educational expenditure level depend heavily on production inputs in the reduced form equation. Denzou (1975) in a review of 13 empirical studies found that the three strongest explanatory variables were income, density (urbanization) and the percentage of children in secondary school (a production input variable).

**Empirical Estimates of Educational Service Demand and Taxes**

Empirical estimates of the demand for educational services and tax behavior are presented in Table V-2. The signs of all variables in the two structural models are as predicted. The explanatory power of the regressions (adjusted $R^2$ between .51 - .85) are similar to the typical level achieved by prior cross-sectional studies (Denzou, 1975).
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<th>P</th>
<th>R</th>
<th>S</th>
<th>CORP</th>
<th>I</th>
<th>R²</th>
<th>d.f.</th>
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**NOTE:** Y (average household income), ST (state aid per student), P (persons per household), R (percent of total units renter-occupied), CORP (forced school district consolidation), I (intercept term), d.f. (degrees of freedom).
The estimated equation for property taxes as a function of income agrees with expectations. Netzer (1966) has suggested that property taxes generally represent between 2% and 3% of income, which is similar to the estimated regression coefficient. The intercepts of the tax equations are insignificantly different from zero, as would be the case if the property tax was a linear, monotonic function of income and behaved as a non-necessity good. State aid per student is insignificant at the 0.1 level in both metropolitan areas and has a negative sign. The tax coefficient for income in Cleveland exceeds the same coefficient in Cincinnati also as should be expected. Municipalities in Cleveland have, in general, higher levels of commercial activity than Cincinnati. This would produce a greater positive bias in Cleveland than in Cincinnati by the omission of commercial property tax substitution.

The demand for educational services equation behaves generally as expected. The relatively large negative coefficient of the state difference variable (S) in Cincinnati suggests lower preferences for education in Kentucky than in Ohio. However, state differences were entered in the tax behavior equation and were found to be insignificantly related to the level of property taxation. Taxes appear to be similarly proportionate to income in both states within the metropolitan area of Cincinnati; even though educational service levels in dollars are substantially lower in Kentucky. A second dummy variable in the Cincinnati demand for education equation is also an externality -- forced consolidation (CORP). A school district in Cincinnati composed of five predominantly white municipalities was ordered

---

4 In 1970 average assessed value of commercial property per household in suburban Cincinnati was $1,638, while in Cleveland the average assessed value was $2,612.
by Federal District Court to consolidate with a predominantly Black school
district in 1970.5

Household preferences, persons per household, were positively related
to expenditure per student; however, the insignificance of the coefficient
(near zero T-value) in the Cincinnati suburbs makes the retention of this
variable for use in extrapolation undesirable. All other variables in
the model were significant at the .05 level.

Center-city household characteristics for the selected census tracts
were substituted into the two estimated structural equations for each sub­
curban area. All variables with T-statistics below 2.0 were excluded in the
extrapolation. The low education expenditure level and similar income
proportionate property taxation in Kentucky make this area an unlikely
point of destination for households motivated by purely fiscal incentives.
The state difference dummy was assigned a value of zero. Conversely, the
consolidation dummy suggested a higher preference for educational services
while not affecting property tax levels. The consolidation variable was
given a value of one. The above choices should maximize the potential
fiscal incentives affecting center-city households within the confines of
the structural model of the city.

The predicted levels of educational services and property taxes were
calculated for each census tract by substituting the known value into the

5 Conversations with the Office of the Superintendent of Education of
the Princeton Local School District suggested that local sentiment was not
in favor of the court ordered consolidation. The Princeton School District
at that time almost surrounded the predominantly Negro Lincoln Heights
Independent School District. It is only a conjecture by this writer that
the high level of expenditure per student by the Princeton Local Schools
in 1970 partially reflected local preferences and concern for maintaining
educational quality during a turbulent period.
estimated equation. The actual and predicted levels of educational services and property taxes are summarized in Table V-3. The model revealed that the average gains in educational service levels or reductions in property taxation are not substantial in a relocation to the suburbs. In Cleveland, expenditure per student after adjusting for extraordinary maintenance cost is still 5% higher in the center-city than the average of the suburbs. The observed property tax level in the center-city is only slightly higher than the expected property tax liability of these same households in the suburbs. The variation around these mean differences are substantial, with some households achieving both decreases in property taxation and increases in educational services. The model also suggests, though, that some households would gain little in increased educational services while increasing tax liabilities by 10% or more. Each census tract's average change in IFT (CIFT) was calculated as described earlier (Cleveland, .014;.0816).

**Empirical Examination of CIFT**

Using CIFT as a proxy for the change in IFT calculated in the preceding section the third proposition can be directly examined. The third proposition states that the change in IFT due to a center-city rather than a suburban location should be inversely related to observed housing values in the center-city after controlling for the quantity of housing services. An OLS regression revealed that the change in implicit fiscal transfer was insignificantly and positively related to housing values in both Cleveland and Cincinnati after controlling for the quantity and price of housing services (Table V-4). The t-statistic of the CIFT variable was below 0.25 in both instances, a near random relationship. The four basic variables continued to behave as expected. The insignificantly of the relationship is not entirely empirically unexpected, since the absolute level of fiscal incentives appears to be small. The earlier dummy variable analysis of
### TABLE V-3

**Actual and Expected Educational Service and Tax Levels**

<table>
<thead>
<tr>
<th>Education Expenditure per Student</th>
<th>Actual Suburbs</th>
<th>Averages Center-City</th>
<th>Predicted Center-City</th>
<th>Average Difference</th>
<th>Percent Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cincinnati (Ohio only)</strong></td>
<td>794.78</td>
<td>790.02</td>
<td>854.70</td>
<td>64.60</td>
<td>8.18%</td>
</tr>
<tr>
<td></td>
<td>(114.31)</td>
<td></td>
<td>(91.45)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cleveland</strong></td>
<td>801.28</td>
<td>857.21*</td>
<td>809.59</td>
<td>-47162</td>
<td>-5.55</td>
</tr>
<tr>
<td></td>
<td>(136.28)</td>
<td></td>
<td>(67.53)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Property Tax per Owner Household</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cincinnati</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Cleveland</strong></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

* Adjusted from 881.27 downward by 2.1% to reflect higher physical plant maintenance cost in Cleveland city schools than existed in most of the 38 school districts included in Cuyahoga and surrounding counties.
TABLE V-4
Center-City Housing Values and the Effect of the Implicit Fiscal Transfer

<table>
<thead>
<tr>
<th></th>
<th>S</th>
<th>QU</th>
<th>D</th>
<th>C</th>
<th>CITDUM</th>
<th>CIFT</th>
<th>I</th>
<th>R²</th>
<th>d.f.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cincinnati</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9982.40</td>
<td>538.66</td>
<td>-174.38</td>
<td>-111.10</td>
<td>-1239.58</td>
<td></td>
<td>17872.62</td>
<td>.913</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>(9.90)</td>
<td>(17.80)</td>
<td>(2.28)</td>
<td>(1.30)</td>
<td>(1.30)</td>
<td></td>
<td>(12.98)</td>
<td></td>
<td>.</td>
</tr>
<tr>
<td></td>
<td>9301.21</td>
<td>536.42</td>
<td>-180.04</td>
<td>-94.49</td>
<td>303.99</td>
<td></td>
<td>17283.72</td>
<td>.909</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>(10.29)</td>
<td>(17.45)</td>
<td>(2.27)</td>
<td>(2.05)</td>
<td></td>
<td></td>
<td>(12.53)</td>
<td></td>
<td>.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Cleveland</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8253.74</td>
<td>446.22</td>
<td>-560.76</td>
<td>-80.73</td>
<td>168.04</td>
<td></td>
<td>28791.67</td>
<td>.869</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>(12.21)</td>
<td>(12.98)</td>
<td>(5.81)</td>
<td>(1.12)</td>
<td>(0.17)</td>
<td></td>
<td>(14.68)</td>
<td></td>
<td>.</td>
</tr>
<tr>
<td></td>
<td>8214.89</td>
<td>444.08</td>
<td>-555.85</td>
<td>-84.28</td>
<td>53.77</td>
<td></td>
<td>28897.25</td>
<td>.869</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>(12.35)</td>
<td>(13.87)</td>
<td>(5.97)</td>
<td>(1.22)</td>
<td>(0.04)</td>
<td></td>
<td>(15.61)</td>
<td></td>
<td>.</td>
</tr>
<tr>
<td></td>
<td>8201.51</td>
<td>444.06</td>
<td>-555.39</td>
<td>-83.55</td>
<td></td>
<td></td>
<td>28880.98</td>
<td>.869</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>(12.27)</td>
<td>(13.87)</td>
<td>(5.98)</td>
<td>(1.21)</td>
<td></td>
<td></td>
<td>(15.60)</td>
<td></td>
<td>.</td>
</tr>
</tbody>
</table>
center-city location in this chapter also establishes that housing values did not differ significantly between suburban and center-city locations.

While the preceding analysis suggests fiscal incentives for groups of high income households may be slight, incentives for different types of households may still exist. In the empirical analysis the CIFT coefficient maintains a positive sign which is contrary to the expected inverse relationship. The existence of this unexpected positive relationship led to an examination of the residuals from the two regressions and the calculated CIFT variable. The pattern of calculated changes in IFT and the regression residuals suggested two distinct groups of households may be represented in the center-city observations. These two groups of observations appeared to be affected in an opposing manner by fiscal incentives. One explanation for the existence of two differing groups of upper-income households is that household utility functions for educational services vary widely between the two groups. The marginal utility of additional units of educational services may not exceed zero for all center-city households as has been assumed throughout this study and in most prior research studies. If this assumption is not true then two or more distinctly different groups of households could be included in the census tracts selected for analysis. The inclusion of households with widely differing (even constant) preferences for educational services would produce interaction effects (within group variance), which could cause the unexpected sign of the CIFT variable. The primary cause of differences in the educational services utility function of these households could be the presence or absence of school age children in the household.

**Upper-income, Center-City Preference Groups**

The first group (A) of households is composed of families with school age children. The current formulation of the Tiebout model should describe
the effects of fiscal incentives on these households. The third proposition should be supported -- a change in IFT should vary inversely with center-city housing values.

The second group (B) of households in each center-city had few households with school age children. The CIFT associated with a move to the suburbs may be positively related to center-city housing values for households who do not have school age children. If the household is indifferent to the absolute level of educational expenditures, the utility \( U_{E_x} \) of educational expenditures \( E_x \) is the same for all communities and locations regardless of the dollar differences in expenditures.

\[
U(E_{x1}) = U(E_{xa})
\]

for \( E_{x1} \geq E_{xa} \)

The utility these childless households attach to educational expenditures is constant.

Households indifferent to educational service levels would be benefited by staying in the center-city if \( taV_{xa} \leq tiV_{x1} \). This condition could exist if their current housing consumption \( V_{x1} \) had to increase to allow a move to a suburb with a similar current level as their own. Apart from fiscal incentives, as these households near retirement their permanent income expectations should decline. They will be living past their maximum earnings years. These households may now be occupying housing units that offer a larger quantity of housing services than their future income expectations would support. Their homes may also be largely free of debt.\(^6\) The actual direct dollar cost of occupying these units would

---

\(^6\) The Bureau of Labor Statistics, U.S. Dept. of Labor, found that housing cost for older owners of single-family units only represent 11% of their annual consumption budgets between Autumn 1973 and 1974. The analysis of the Dept. of Labor assumes that most older home-owners are free of mortgage...
be below the cost of purchasing another unit offering equivalent housing services if purchased at current prices and with an incurrence of debt. The cost of relocation, coupled with declining permanent income expectations, could make a relocation to owner-occupied housing of a similar value in the suburbs unappealing.

In order to establish which center-city tracts belonged in Group A or Group B, the average number of households with children in the suburbs was chosen as the basis for categorization. The observed percentage of families with children in a census tract must lie within two standard deviations of the average percentage of families having children in the suburbs to be included in Group A, households children. While this selection procedure is somewhat arbitrary, no more objective and precise method is apparent to this writer. Census tracts where the average percentage of families with children is more than two standard deviations below the suburban mean were placed in the second Group B, families without children.

Table V-5 summarizes the basic differences between the two groups. Group A, households with children, contained a population with similar current income, place of work, and housing values as the Group B census tracts. The average age of the group B population was significantly older than the group A household population.

Each census tract contained some household with children and some without children, but each tract was dominated by one of the two groups. The aggregation of households by census tract concealed some "within group" variations due to mixing of both household types in each census tract. If each census tract were completely homogeneous with respect to households

---

having children and age, an analysis using grouped data would yield results identical to individual data homogeneously grouped. The results drawn from analyses based on the census tracts can only infer the existence of the two groups. Therefore, the findings will only be able to infer the existence of two groups of households with differing preferences for educational services.

The geographic areas covered by the selected census tracts are contiguous to each other and generally lie in small clusters near the corporate boundaries of the center-city. The group A and group B census tracts do form separate spatial formations of census tracts. Maps V-1 and V-2 highlight the location of the selected census tracts. All of the selected upper-income tracts are, as far removed from the CBD as possible while still remaining within the corporate boundaries of the center-city.

Equations for groups A and B were estimated for each city separately, using the same binary interaction variable (CIFT) to differentiate between center-city and suburbs. Results of these regressions are shown in Table V-6. The housing values of households with children (Group A) in both cities were negatively affected by the change in implicit fiscal transfer, but at an insignificant level. In those areas where few households have children, the change in implicit fiscal transfer positively, but insignificantly related to housing values. This suggests for both groups that fiscal incentives effect housing values (in a directional sense) as anticipated.

The consistenctly of the above analysis was supported by the replacement of CIFT with CITDUM in each of the two groups. The sign of the center-city location variable (CITDUM) agreed in three of four regressions with the sign of the CIFT variable. The consistency of the signs of CITDUM
Map V-2
Selected Census Tracts
Cleveland, Ohio
### TABLE V-5

**Basic Demographic Characteristics of Two Primary Center-City Subgroups**

<table>
<thead>
<tr>
<th></th>
<th>Group A*</th>
<th></th>
<th>Group B*</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cincinnati</td>
<td>Cleveland</td>
<td>Cincinnati</td>
<td>Cleveland</td>
</tr>
<tr>
<td>Number of Tracts</td>
<td>8</td>
<td>12</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Average Income</td>
<td>$14,278.75</td>
<td>$13,401.17</td>
<td>$15,718.80</td>
<td>$12,470.00</td>
</tr>
<tr>
<td>Average Housing Value</td>
<td>$22,962.50</td>
<td>$19,666.66</td>
<td>$24,280.00</td>
<td>$22,128.57</td>
</tr>
<tr>
<td>Percent of Households with children under 18 years of age</td>
<td>53.32% (2.97)</td>
<td>58.15% (8.51)</td>
<td>39.26% (4.48)</td>
<td>37.34% (4.21)</td>
</tr>
<tr>
<td>Percent of Work force Commuting to City Daily</td>
<td>71.70%</td>
<td>72.04%</td>
<td>77.22%</td>
<td>70.26%</td>
</tr>
<tr>
<td>Average Age of Population</td>
<td>33.02% (1.44)</td>
<td>31.02% (3.25)</td>
<td>38.84% (2.94)</td>
<td>38.19% (2.30)</td>
</tr>
</tbody>
</table>

* Group A includes census tracts where most households have children of school age, and Group B includes tracts where few households have children.

2 A test of differences between group means revealed groups A and B to be significantly different at a .01 level.
and CIFT suggest that fiscal incentives were now dominating other center-city externalities. The formation of the two groups of center-city households based on differing preferences for educational services does provide results consistent with predicted directional relationships. Only additional research based on homogeneous groupings of center-city households, rather than census tracts, can provide conclusive evidence on the characteristics and public good preferences of the two groups.

The coefficient of the CIFT variable can be evaluated at the mean to estimate the relative shift in the price gradient \( dP_0 \) due to fiscal incentives. Procedurally, the magnitude of \( dP_0 \) can be estimated through the ratio of the absolute value of the CIFT variable versus the transportation costs variable \( C \), both evaluated at the mean. The significance of the implicit fiscal transfer across all the regressions estimated in this study precludes a statistically meaningful estimation of \( dP_0 \) for Cleveland or Cincinnati.

Because of the somewhat ad hoc criterion used in categorizing the census tracts into the two groups an unknown bias may have been introduced into the stability of regression coefficients for sub-samples of the selected observations. Therefore, if the group A household were further sub-divided into two arbitrary sub-groups and the results of the analysis were unchanged, the stability of the grouped equation results would be

\[
\begin{align*}
\text{For example Group A, Cincinnati} & \\
\frac{dP_0}{(1022.84)} & = \frac{(1022.84) \cdot 0.0295}{(103.23) \cdot 20.266} = 0.0144
\end{align*}
\]

Substituting this estimate of \( dP_0 \) into equation 3.7, suggests a maximum change in equilibrium location of 1.79 miles. (See Appendix C) The estimated value of \( dP_0 \) is approximately 1.4%, a decrease in the price gradient that would be theoretically inadequate to induce a change in equilibrium location given moving cost and an income related transportation cost increase.
### Table V-6

Center-City Housing Values and Effect of the Implicit Fiscal Transfers Primary

<table>
<thead>
<tr>
<th>Group</th>
<th>S</th>
<th>QU</th>
<th>D</th>
<th>C</th>
<th>CITDUM</th>
<th>CIFT</th>
<th>I</th>
<th>$R^2$</th>
<th>d.f.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8130.41</td>
<td>440.60</td>
<td>-640.91</td>
<td>-102.69</td>
<td>75.26</td>
<td>29802.13</td>
<td>.873</td>
<td>55</td>
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</tr>
<tr>
<td></td>
<td>(11.82)</td>
<td>(12.85)</td>
<td>(6.15)</td>
<td>(1.37)</td>
<td>(0.07)</td>
<td>(14.45)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8226.26</td>
<td>441.26</td>
<td>-658.50</td>
<td>-113.47</td>
<td></td>
<td>-1171.52</td>
<td>30094.08</td>
<td>.874</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>(12.31)</td>
<td>(13.59)</td>
<td>(6.41)</td>
<td>(1.54)</td>
<td></td>
<td>(0.81)</td>
<td>(14.98)</td>
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</tr>
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<td>-657.15</td>
<td>-113.27</td>
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<td>30083.35</td>
<td>.874</td>
<td>55</td>
</tr>
<tr>
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<td>(12.29)</td>
<td>(13.59)</td>
<td>(6.42)</td>
<td>(1.54)</td>
<td></td>
<td></td>
<td>(14.99)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8384.44</td>
<td>420.31</td>
<td>-676.36</td>
<td>-125.87</td>
<td>912.47</td>
<td></td>
<td>31047.47</td>
<td>.854</td>
<td>50</td>
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<tr>
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<td>(11.53)</td>
<td>(5.42)</td>
<td>(1.47)</td>
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<td>(13.07)</td>
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<tr>
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<td>31742.69</td>
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<td>(12.06)</td>
<td>(5.58)</td>
<td>(1.83)</td>
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### TABLE V-6 - continued

<table>
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<tr>
<th></th>
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<th>QU</th>
<th>D</th>
<th>C</th>
<th>CITDUM</th>
<th>CIFT</th>
<th>I</th>
<th>R²</th>
<th>d.f.</th>
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</thead>
<tbody>
<tr>
<td><strong>Cincinnati</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group A¹</strong></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>10431.95</td>
<td>554.15</td>
<td>-135.10</td>
<td>-116.22</td>
<td>-1858.69</td>
<td>16963.41</td>
<td>.903</td>
<td>40</td>
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<td>(8.99)</td>
<td>(17.64)</td>
<td>(1.69)</td>
<td>(2.34)</td>
<td>(1.68)</td>
<td>(11.83)</td>
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<td>-103.23</td>
<td>-1022.84</td>
<td>16666.06</td>
<td>.908</td>
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<td>(8.71)</td>
<td>(16.98)</td>
<td>(1.88)</td>
<td>(2.03)</td>
<td>(.57)</td>
<td>(11.25)</td>
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<td>-102.48</td>
<td>16625.14</td>
<td>.907</td>
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</tr>
<tr>
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<td>(16.93)</td>
<td>(1.86)</td>
<td>(2.02)</td>
<td>(11.12)</td>
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<td><strong>Group B²</strong></td>
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<tr>
<td></td>
<td>9642.11</td>
<td>569.62</td>
<td>-123.93</td>
<td>-104.39</td>
<td>255.01</td>
<td>16476.84</td>
<td>.914</td>
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<td>(16.71)</td>
<td>(1.41)</td>
<td>(1.98)</td>
<td>(0.17)</td>
<td>(10.48)</td>
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<tr>
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<td>9443.89</td>
<td>569.71</td>
<td>-123.14</td>
<td>-99.08</td>
<td>1579.63</td>
<td>16260.70</td>
<td>.915</td>
<td>36</td>
<td></td>
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<tr>
<td></td>
<td>(9.19)</td>
<td>(16.87)</td>
<td>(1.42)</td>
<td>(1.93)</td>
<td>(0.75)</td>
<td>(10.89)</td>
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<tr>
<td></td>
<td>9434.75</td>
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<td>-98.93</td>
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<td>.915</td>
<td>36</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(9.17)</td>
<td>(16.86)</td>
<td>(1.41)</td>
<td>(1.93)</td>
<td>(10.85)</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

¹ Selected census tracts where most households have children under 18 years old.

² Selected census tracts where most households have children under 18 years old.

**NOTE:** Column symbols: S (size), QU (quality), D (density), C (commute), Dummy (Center-City location), I (intercept), d.f. (degrees of freedom).
further supported. The group A census tracts in Cleveland (12 tracts) could be subdivided into two sub-samples on the basis of average income. The six tracts with the highest average income were placed in one subgroup and the remaining six were placed in the second subgroup. The OLS regression analysis using CIFT and CITDUM was repeated for both subgroups (Table V-7). The results of this analysis were identical for the CIFT and CITDUM variables as in the grouped analysis of the twelve tracts. The signs of the variables were unchanged. CIFT and CITDUM were still insignificant.

The group A census tracts in Cincinnati were too few in number (eight) to allow a subdivision and still retain sufficient observations for meaningful interpretation of CIFT and CITDUM. 8

A second method of examining the stability of the findings can be deduced from the theoretical analysis of the group B households' concern for property taxes and indifference to educational expenditures. Group B households would be fiscally benefited if their tax payments in the center-city were below their expected property tax liability in the suburbs. Future housing consumption is based on permanent income expectations. Suburban taxes would only be higher if the permanent income expectations of older households were substantially below their current income level. A move to the suburbs would be fiscally detrimental to these households; therefore, staying in the center-city offers a positive fiscal gain. These childless households should be more sensitive to changes in property tax payments (CTAX) than the combined change in educational services and property tax liability (CIFT). The expected change in property taxes for

---

8 Professor Jon Cunnyngham has suggested during a discussion of spectral analysis that the interpretation of a variable that is relevant to fewer than five observations is open to serious question. The level of random noise inherent in this small a group of observations is often sufficient to seriously distort any analysis with normality or near normality assumptions.
TABLE V-7

Split-Half Repetition of Group A Households and the Effect of Expected Tax Changes on Group B

<table>
<thead>
<tr>
<th></th>
<th>S</th>
<th>Q</th>
<th>D</th>
<th>C</th>
<th>CITDUM</th>
<th>CIFT</th>
<th>CTAX a</th>
<th>R²</th>
<th>d.f.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleveland</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower-Half</td>
<td>8160.78</td>
<td>431.97</td>
<td>-749.98</td>
<td>-124.72</td>
<td>132.03</td>
<td>30993.68</td>
<td>.862</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(10.92)</td>
<td>(12.11)</td>
<td>(5192)</td>
<td>(1.49)</td>
<td>(0.09)</td>
<td>(13.18)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8178.81</td>
<td>427.14</td>
<td>-755.01</td>
<td>-147.61</td>
<td>-3043.56</td>
<td>31611.60</td>
<td>.865</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(11.59)</td>
<td>(12.47)</td>
<td>(6.01)</td>
<td>(1.80)</td>
<td>(0.94)</td>
<td>(13.86)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper-Half</td>
<td>8192.86</td>
<td>417.47</td>
<td>-689.41</td>
<td>-153.53</td>
<td>288.27</td>
<td>31745.06</td>
<td>.867</td>
<td>49</td>
<td></td>
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<tr>
<td></td>
<td>(11.45)</td>
<td>(12.00)</td>
<td>(5.88)</td>
<td>(1.87)</td>
<td>(0.21)</td>
<td>(13.90)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>8270.82</td>
<td>418.80</td>
<td>-693.57</td>
<td>-153.31</td>
<td>-968.92</td>
<td>31732.11</td>
<td>.868</td>
<td>49</td>
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<tr>
<td></td>
<td>(11.35)</td>
<td>(12.19)</td>
<td>(6.22)</td>
<td>(1.87)</td>
<td>(0.54)</td>
<td>(13.93)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Group B</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleveland</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8165.01</td>
<td>421.42</td>
<td>-705.67</td>
<td>-132.18</td>
<td>42.93</td>
<td>31301.11</td>
<td>.860</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(10.98)</td>
<td>(12.26)</td>
<td>(5.75)</td>
<td>(1.64)</td>
<td>(1.60)</td>
<td>(13.93)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cincinnati</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9898.05</td>
<td>569.51</td>
<td>-126.23</td>
<td>-106.23</td>
<td>26.58</td>
<td>16529.12</td>
<td>.916</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(912)</td>
<td>(11.93)</td>
<td>(1.46)</td>
<td>(2.08)</td>
<td>(0.93)</td>
<td>(11.14)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
educational services (CTAX) was calculated as the predicted suburban property tax minus the current center-city property tax liability for each group B census tract. All suburban values of CTAX are zero—a binary interaction variable only relevant to the center-city.

CTAX was entered in an OLS regression for group B households in both Cleveland and Cincinnati. CTAX was positively related to housing values for center-city households without children (Table V-7). The CTAX variable was insignificant, although the T-statistic in both cities was higher than the corresponding T-statistic for CIFT. The sign of all other variables remained as expected.

While the preceding analysis has tended to support the Tiebout model, the results do not support the premise that fiscal incentives are significantly affecting center-city housing values or locational decisions based in 1970 data. The movement of households from the center-city to the suburbs had occurred in substantial numbers between 1950 and 1970 in both Cincinnati and Cleveland. Whether fiscal incentives played a major role during the 1950-1970 period has not been examined in this study. However, the evidence presented here suggests that by 1970 the remaining upper-income households who choose to live in owner-occupied, center-city housing units were not significantly affected by local fiscal redistribution phenomenon associated with residential property taxation for educational purposes.

The structural specification of the demand for educational services and tax behavior equation could have omitted a yet undisclosed, but essential variable. The omission of such a variable could alter the reported results for CIFT. The present stage of theoretical analysis of the demand for educational services or property tax behavior is hardly complete. However, the CITDUM variable measured the net effects of all center-city
externalities in conjunction and did not find a significant effect on the price of housing services. The consistent insignificance of this variable supports the contention that center-city externalities were not significantly affecting the price gradient for owner-occupied housing units. If the real magnitude of fiscal incentives were greater than estimated, then other equally strong and countervailing externalities are present in both the center-cities examined in this study.
Chapter VI
Summary and Conclusions
The role of local fiscal incentives in promoting household relocation from the center-city to the suburbs was the subject of this study. Three aspects of fiscally induced household relocation were examined using data drawn from metropolitan Cleveland and Cincinnati during 1970. The three areas empirically examined were suburban fiscal equilibrium conditions, fiscally induced center-city/suburban relocation and the magnitude of center-city fiscal incentives.

The conditions of suburban fiscal equilibrium were developed in a theoretical framework consistent with the work of Tiebout (1956) and Hamilton (1972). Suburban fiscal equilibrium requires the price of housing services to be independent of local fiscal variables. This equilibrium condition is analogous to a head tax for public goods within income homogenous municipalities. Three pre-requisites to fiscal equilibrium have been previously identified—(1) municipal income homogeneity, (2) a large number of spatially dispersed municipalities, and (3) zoning restraints effectively prohibiting low income household relocating to the suburbs. Under these three conditions municipal fragmentation can be an efficient means of allocating public goods by income class. The efficiency of the model does not suggest that it is equitable for households nor that it provides the distribution of income which maximize social welfare. Whether income discriminatory suburban zoning can be continued is a matter currently under litigation. The outcome of this class action suit

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1 Nieman V. Hewitt (1974). The U.S. DistrictCourt of Penn. ruled zoning exclusively for single-family residential housing on large lots was unconstitutional as an invalid exercise of state police power and as being so vague and arbitrary as to deny due process. The case is currently under appeal for review by the U.S. Supreme Court. (See Federal Supplement, 387, 926).
will certainly affect the municipal capacity to attain long-run fiscal equilibrium in American suburbs.

The economic diversity of the center-city's population precludes income homogeneity within the municipality therefore leaving center-city, upper-income households subject to local property taxation with adverse income re-distributive effects. The presence of fiscal disparities between households of equivalent income in the center-city and the suburbs serves as an incentive to relocate outside of the center-city. The fiscal incentive reduces the level of the price gradient confronting center-city, upper-income households who are considering relocation beyond the confines of the center-city. This study specifically examined the effect of fiscal incentives on the price of housing services (and therefore housing values) for center-city households. The analysis was limited to upper-income, owner-occupied single-family housing units.

The magnitude of fiscal incentives in terms of the change in equilibrium location has been largely unexplored in prior research studies. Fiscal incentives that induce outward relocation act in concert with economic forces which also support urban decentralization—rising household income with an elastic demand for housing services, and falling transportation costs per unit of distance. Richard Muth's (1969) model of residential spatial equilibrium served as the basis for considering the change in equilibrium location induced by fiscal incentives given household income and price elasticity and transportation costs.
Empirical Findings

The conditions of suburban fiscal equilibrium have been shown, both theoretically and empirically, to be attainable. Fiscal incentives were insignificantly related to residential property values within the suburban municipalities of Cleveland and Cincinnati, Ohio. In addition, the income distribution (Gini coefficient) of each municipality was also insignificantly related to residential property values. These two findings are consistent with the achievement of a near Pareto optimal fiscal equilibrium among suburban municipalities.

Center-city fiscal equilibrium conditions have been postulated to be unattainable within the assumptions of this study. The existence of fiscal disparities in the center-city should lower center-city housing values vis a vis the suburbs. The differences in center-city and the suburban housing values for equivalent bundles of housing services was initially examined through a dummy variable for center-city location. Center-City and suburban housing values (price of housing services) were not significantly different in the two metropolitan areas examined in this study. The sign of a dummy variable for center-city location varied throughout the empirical analysis and did not consistently maintain a negative sign. The variation in the sign of the center-city locational variable may have been due to positive externalities which also simultaneously affect center-city housing values.

Structural equations of the demand for educational services and tax behavior for suburban municipalities were formulated to allow a direct examination of educational fiscal incentives. Property tax levels were
shown to be directly and significantly related to income and behaves as a non-necessity, consumption good. The almost uniform proportion of income consumed by property taxes supports the effectiveness of zoning restraints to entry in trying household property tax payment directly to household income levels. The demand for educational services was found to be a function of income, household preferences and a combination of urbanization and voter preferences. From these two structural equations a proxy for the fiscal incentives confronting upper-income, center-city households was constructed. Direct empirical analysis of the fiscal incentives confronting upper-income, center-city households did not reveal significant relocational incentives. The results were not only insignificant but the sign of the fiscal incentive coefficient was not consistently negative as expected. Examination of the estimated fiscal incentives and regression equation residuals revealed that two groups of households with differing preferences for educational services may have been included among the upper-income households.

The marginal utility of additional units of educational services had been assumed to be positive for all households included in this study and in most prior studies of fiscal incentives. This study has identified a group of households who appear to be indifferent to the level of educational services. Within the center-city households without children are not uncommon, and in this study these upper-income households dominate several census tracts in Cleveland and Cincinnati. These households are either older and beyond the child rearing stage of the life cycle or have chosen for the moment not to include children in their households.
Households without children may be indifferent to the amount of education services publicly provided, but be concerned with the property tax payments required of them. The empirical analysis of Chapter V suggested that the fiscal incentives confronting childless households in the center-city were positively and insignificantly related to housing values. Educational fiscal incentives did not adversely affect these households and did not serve as a strong incentive to relocate in the suburbs. The results of this analysis suggested that these older households may be unaffected by educational services and have fiscally optimizing incentives for remaining in the center-city.

The second group identified within the center-city conforms to the theoretical expectations for households with a positive marginal utility for educational services—households with children of school age. The calculated educational fiscal incentive was negatively and insignificantly related to housing values. The absolute magnitude of the calculated fiscal incentive was also small. The analysis of Chapter V suggest that the level of educational services provided to these high-income neighborhood schools were similar to suburban educational service levels. The advent of school busing could substantially alter the mix of student inputs into these higher income neighborhood schools and correspondingly alter the level of educational services provided per dollar of expenditure.

The expected theoretical (directional) relationship between fiscal incentives and housing values was found in both center-city areas. The estimate magnitude of the predicted fiscal incentive was found to be small in an absolute sense. Educational fiscal incentives were not signi-
significantly related to the observed value of owner-occupied housing or the price of housing services in this study. A one percent change in the level of the price gradient with slope unchanged would include a maximum change in equilibrium location of slightly more than one mile. The maximum theoretical change in equilibrium location due to a change in the level of the price gradient is partially dissipated by the increase in income-related transportation costs. In addition, a minimum threshold level of incentive must also exist to compensate for moving costs. Upper-income households are less likely to be precluded from relocating by moving costs (Muth, 1974), but the reduction in the price of housing services must be sufficient to compensate for this one-time cost of moving. A change in the level of the price gradient of more than one percent and probably of several percent is necessary to actually induce relocation by the typical upper-income household.

While this study was not intended as an empirical analysis of Muth's model of residential equilibrium several empirical estimates do support the model. The observed signs of inputs to the quantity of housing services and transportation costs are consistent with theoretical expectations. The price gradient was found to decline by roughly one percent per mile in areas of predominantly single-family residential land use. Finally, the income elasticity of demand for housing services in the suburbs was found to exceed one.

Policy Implications and Further Research

The research design of this study purposely isolated households who should be strongly affected by fiscal incentives. The fact that the empi-
rical results indicate fiscal incentives were insignificant in both Cleveland and Cincinnati is encouraging for the long-run prospects for the center-city. The dominant forces causing outward movements from the urban core--rising income, population growth, and falling transportation cost--are not directly within the center-city's control. These forces for outward population relocation are not due to an inherent failing by the center-city, (income heterogeneity) which is the state typically ascribed to fiscal incentives. At least during the period of this study the detrimental effects of center-city location on residential property values were minimal. The attraction of upper-income households to the center-city may be best served by policies which concentrate on altering or effecting these three major determinants of urban population movements.

The center-city in seeking to retain these households may follow Buchanan's (1971) advice. The center-city can only provide benefit-tax relationships similar to the suburbs for its high income households if it adopts apparently regressive tax policies in order to maintain some of the surplus generated by upper-income residents in the provision of public goods. The city can also follow a policy of allocating public services such as police protection in proportion to household tax payments. The existence of this policy in Chicago has been recently suggested by Weicher (1970, 1974). This attempt at a marginal benefit tax solution can not achieve a stable equilibrium, but it does reduce the level of fiscal incentive facing some upper-income households (Wheaton, 1975). The combined influence of positive neighborhood externalities
and center-city public goods policy could reduce and substantially offset the fiscal incentives that induce upper-income household relocation in the suburbs. Rising disposable income or a reduction in transportation cost would still include movements away from the CBD for a typical household with an income elastic demand for housing services.

This study has tentatively identified a group of households who may not be affected by the largest, property tax-based fiscal incentive—provision of educational services. This group of households is childless and older persons who were still actively employed at the time of this study. Evans (1973) has suggested that the center-city is the natural equilibrium location for this group as well as younger households who do not have children, single-person households, and upper-income households who highly value commuting time to the CBD. Evans has suggested that many of these households have an income inelastic demand for housing services.

Detailed individual household characteristics and preferences are not discernable from cross-sectional data aggregated on an arbitrary geographic basis. Research using individual data drawn from center-city neighborhoods dominated by these childless households is required if their preferences for public goods and household location are to be accurately determined. If these households prefer a center-city location and are indifferent to many services stressed in suburban municipalities the center-city should orient its public policies toward the attraction and retention of these households.
APPENDIX A

Description of Suburban and Center-City Data
Criterion for Selection of Municipalities

The municipalities selected all lie within the SMSA of Cincinnati or Cleveland. Six criteria entered into retention of a municipality.

1. It must qualify as a "place" according to the U. S. Census Bureau, that is, have a population of 2500 or more.

2. At least 20% of its work force commutes daily to the City of Cleveland or Cincinnati.

3. The majority of all housing units are owner-occupied.

4. The largest proportion of the work force is employed in the City of Cleveland or Cincinnati.

5. The municipality lies within the continuous urbanized area.

6. The availability of complete municipal and educational services data, as well as taxation data, is the final criterion.

A total of eighty-six municipalities were selected—forty-nine in Cleveland disbursed over five counties and thirty-seven in Cincinnati in two Ohio counties and three Kentucky counties. A list of all the municipalities appears in Table A-1.

Basic Characteristics of Selected Suburban Communities

A brief synopsis of the character of the municipalities may be helpful in interpreting the results of Chapter IV. Table A-2 summarizes basic demographic data, while Table A-3 summarizes basic fiscal data.

In terms of broad trends, average housing value, income and average educational attainment are higher in Cleveland than Cincinnati. Even if the seven Kentucky municipalities are deleted from the Cincinnati data, a lower income level still prevails in Cincinnati.

Municipalities in both SMSA's have a similar average commuting time.
<table>
<thead>
<tr>
<th>SMSA/County</th>
<th>Municipalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cuyahoga County, Ohio</td>
<td>Eastlake, Wickcliffe, Willoughby, Willoughby Hills</td>
</tr>
<tr>
<td>Lake County, Ohio</td>
<td>Avon, Avon Lake</td>
</tr>
<tr>
<td>Medina County, Ohio</td>
<td>Brunswick</td>
</tr>
<tr>
<td>Summit County, Ohio</td>
<td>Macedonia, Richfield, Twinsburg</td>
</tr>
<tr>
<td>Cincinnati SMSA</td>
<td>Amberly, Blue Ash, Cheviot, Deer Park, Elmwood Place, Fairfax, Forest Park, Glendale, Golf Manor, Green Hills, Harrison, Indian Hill, Lincoln Heights, Loveland, Lockland, Madeira, Mariemont, Milford, Montgomery, Mount Healthy, North College Hill, Norwood, Reading, St. Bernard, Silverton, Sharonville, Springdale, Woodland, Wyoming</td>
</tr>
<tr>
<td>Boone County, Kentucky</td>
<td>Florence</td>
</tr>
<tr>
<td>Campbell County, Kentucky</td>
<td>Bellevue, Fort Thomas</td>
</tr>
<tr>
<td>Kenton County, Kentucky</td>
<td>Covington, Erlanger, Fort Mitchell, Ludlow</td>
</tr>
<tr>
<td>Subject</td>
<td>Cleveland</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>Average Value</td>
<td>$30,257.95 (7082.08)</td>
</tr>
<tr>
<td>Average Rent</td>
<td>135.29 (37.30)</td>
</tr>
<tr>
<td>Average Income</td>
<td>$15,827.34 (4722.12)</td>
</tr>
<tr>
<td>Average Years of Education of Head of Household</td>
<td>11.43 (0.90)</td>
</tr>
<tr>
<td>Percent of Families with Children under 18</td>
<td>62.20% (6.45)</td>
</tr>
<tr>
<td>Ghini Coefficient of Income Distribution</td>
<td>29.29 (3.39)</td>
</tr>
<tr>
<td>Average Age of Housing Unit</td>
<td>17.29 (5.51)</td>
</tr>
<tr>
<td>Percent of Housing Units with Central Air Conditioning</td>
<td>11.62 (11.07)</td>
</tr>
<tr>
<td>Average Commuting Time (minutes) to CBD</td>
<td>21.62 (5.82)</td>
</tr>
<tr>
<td>Average Straight Line Distance to CBD</td>
<td>12.08 (3.41)</td>
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<tr>
<td>Average Population</td>
<td>18,499.05 (18488.44)</td>
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<tr>
<td>Average Number of Housing Units</td>
<td>5,654.04 (5930.73)</td>
</tr>
<tr>
<td>Average Number of Owner Occupied Units</td>
<td>4,268.36 (4287.78)</td>
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<tr>
<td>Average Acreage of Municipalities</td>
<td>5,092.50 (3469.48)</td>
</tr>
<tr>
<td>Persons Per Acre</td>
<td>4.66 (3.70)</td>
</tr>
</tbody>
</table>
### Table A-3
Fiscal Characteristics of Municipalities

<table>
<thead>
<tr>
<th>Subject</th>
<th>Cleveland</th>
<th>Cincinnati</th>
</tr>
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<tbody>
<tr>
<td>Average Education Expenditure per Student</td>
<td>800.281</td>
<td>744.56</td>
</tr>
<tr>
<td></td>
<td>(136.28)</td>
<td>(181.45)</td>
</tr>
<tr>
<td>Number of School Districts</td>
<td>39</td>
<td>25</td>
</tr>
<tr>
<td>Average Student Enrollment</td>
<td>10627.84</td>
<td>17619.69</td>
</tr>
<tr>
<td></td>
<td>(21178.00)</td>
<td>(29513.59)</td>
</tr>
<tr>
<td>Effective Property Tax (Mills)</td>
<td>16.363</td>
<td>15.60</td>
</tr>
<tr>
<td></td>
<td>(2.855)</td>
<td>(3.218)</td>
</tr>
<tr>
<td>Effective School Property Tax (Mills)</td>
<td>10.62</td>
<td>10.591</td>
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<tr>
<td></td>
<td>(2.229)</td>
<td>(2.459)</td>
</tr>
<tr>
<td>Effective Municipal Services Property Tax</td>
<td>5.748</td>
<td>5.012</td>
</tr>
<tr>
<td></td>
<td>(1.876)</td>
<td>(1.598)</td>
</tr>
<tr>
<td>Average Property Tax per Owner Unit</td>
<td>$500.35</td>
<td>$314.56</td>
</tr>
<tr>
<td>School</td>
<td>325.40</td>
<td>217.11</td>
</tr>
<tr>
<td>Municipal</td>
<td>174.95</td>
<td>97.45</td>
</tr>
<tr>
<td>Municipal Expenditures per Family</td>
<td>$460.82</td>
<td>$427.38</td>
</tr>
<tr>
<td></td>
<td>(230.62)</td>
<td>(372.46)</td>
</tr>
</tbody>
</table>
to the CBD. The similar gini coefficients suggests similarly shaped income distributions within municipalities in Cleveland and Cincinnati.

The average age of housing units in Cleveland is lower than in Cincinnati; however, in both cases the distribution is rather narrow. Quality in this study is proxied for by the percent of units with central air conditioning. The mean of this variable is similar in both cities. However, its wide variance makes it an attractive quality variable.

The geographic area covered by Cleveland municipalities is substantially greater than in Cincinnati, but differences in population level are not nearly as great. This results in the average suburban population density being higher in Cincinnati than in Cleveland.

Fiscal expenditure levels in Cleveland are higher than in Cincinnati. However, after removing the Kentucky municipalities the expenditure levels are almost identical. Effective millage rates are similar in both SMSA's. The effective rates were computed as follows:

\[
\text{Actual Millage Rate} = \frac{\text{Actual Assessed Value}}{\text{Actual Price}} \quad \text{TAXEFF}
\]

The ratio of assessed value to actual sales price was gathered from a census of every residential suburban transaction during the first six months of 1970 for each Ohio municipality included in the study.¹ Kentucky assessment/sales ratios were provided by the tax Commissioner of the State of Kentucky.

¹ The above data was compiled by Professor Fredrick Stöcker and William Fox as part of a separate research project at the Ohio State University during 1973.
Definitions of Terms and Sources of Data

Table A-4 lists the name and definition of each variable used in this study. Table A-5 lists the sources of all data and is referenced to each variable in Table A-4.

The use of average housing values, as calculated by the U.S. Bureau of the Census, in a study of the determinants of residential housing values may disturb some readers who believe U.S. Census and actual market values differ substantially. Most prior studies of urban housing values have used census data in the belief that no serious biases were inherent in the data and that market transactions agreed with census data. A further piece of evidence in support of this belief is presented in Table A-6.

The actual average sales price for 42 municipalities in Cuyahoga county (Cleveland) were obtained for the first six months of 1969 and 1970. These data are based on the official sales transfer records of the County Clerk of Court of Cuyahoga County. The average housing value and distribution (standard deviation) do not differ significantly from the 1969 and 1970 data. The observed sales price does introduce one unknown and difficult to control bias. Sales data contains a disproportionately large number of newly constructed units than is found in the housing stock as a whole.

A similar comparison could not be made in the Cincinnati area since actual sales price data were not readily available. The use of census information should yield reasonable estimates in accord with actual market transactions for the period immediately preceding the collection of the 1970 Census.
### Table A-4

#### Definitions of Variables

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CITDUM =</td>
<td>A dummy variable with a value of 1 for in-city upper-income housing tracts, zero values elsewhere.</td>
</tr>
<tr>
<td>2. C =</td>
<td>Commuting time in minutes from the CBD to the mid-point of each municipality. (7,8)</td>
</tr>
<tr>
<td>3. D =</td>
<td>Persons per gross acre in each municipality. (7,8, 13)</td>
</tr>
<tr>
<td>4. DISTST =</td>
<td>Linear distance from the CBD to the mid-point of each municipality. (7,8)</td>
</tr>
<tr>
<td>5. DISTSQ =</td>
<td>Linear distance from CBD squared.</td>
</tr>
<tr>
<td>6. ED/TAX =</td>
<td>Educational services to dollar tax payment for schools, a benefit/tax ratio proxy.</td>
</tr>
<tr>
<td>7. E/S =</td>
<td>Total educational expenditure per student excluding debt retirement during 1969-70 academic year. (3,5, 4) The average number of students in attendance in October 1969 based on a Federal weighting formula (kindergarten, 1/2; elementary, 1; secondary, 1.5; special education,2). (5,9)</td>
</tr>
<tr>
<td>8. G =</td>
<td>Using 1970 Census income distribution data, the Ghini coefficient is calculated for each municipality. (13,15)</td>
</tr>
<tr>
<td>9. CIFT =</td>
<td>A binary interaction variable of predicted change in benefit/tax level for in-city households given suburban relocation.</td>
</tr>
<tr>
<td>10. KY/OH =</td>
<td>Dummy variable with a value of one for Kentucky municipalities.</td>
</tr>
<tr>
<td>11. MUN/FAM=</td>
<td>Average municipal expenditure per family based on 1970 accounting data. (1,2,11)</td>
</tr>
<tr>
<td>12. MUN/TAX=</td>
<td>Municipal expenditure to average household property tax payment ratio, a benefit/tax proxy.</td>
</tr>
<tr>
<td>13. QU =</td>
<td>Percent of all housing units with central air-conditioning in 1970, a proxy for unit quality, (12, 16)</td>
</tr>
</tbody>
</table>

(continued)
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>14. P</td>
<td>=</td>
<td>Average persons per household. (12,13,14)</td>
</tr>
<tr>
<td>15. R</td>
<td>=</td>
<td>Renter occupied housing units as a percent of total occupied housing units. (13,14)</td>
</tr>
<tr>
<td>16. S</td>
<td>=</td>
<td>Average number of rooms in owner-occupied housing units in 1970. (12,16,14)</td>
</tr>
<tr>
<td>17. ST</td>
<td>=</td>
<td>State aid per student during the 1969-70 academic school year. (3,5)</td>
</tr>
<tr>
<td>18. TAXEFF</td>
<td>=</td>
<td>Total effective tax millage based on actual millage adjusted by 1970 assessed value to sales price ratio, not including debt retirement millage. (8,6)</td>
</tr>
<tr>
<td>19. TAXMUN</td>
<td>=</td>
<td>Effective property tax millage dedicated to local and county municipal services. (8,6)</td>
</tr>
<tr>
<td>20. TAX$MUN</td>
<td>=</td>
<td>Average property tax liability for the average owner-occupied housing unit in each municipality for municipal services. (8,6,2,14,16)</td>
</tr>
<tr>
<td>21. T\textsubscript{1} or T\textsubscript{a}</td>
<td>=</td>
<td>Effective property tax millage dedicated to local public schools support. (8,6)</td>
</tr>
<tr>
<td>22. T\textsubscript{a}</td>
<td>=</td>
<td>Average tax liability for the average owner-occupied housing unit in each municipality for educational services. (8,6,13,14)</td>
</tr>
<tr>
<td>23. V</td>
<td>=</td>
<td>Average value of owner-occupied housing units in each municipality. (12,14,16)</td>
</tr>
<tr>
<td>24. Y</td>
<td>=</td>
<td>Average income of all households in each municipality. (13,14,15)</td>
</tr>
</tbody>
</table>
Table A-5  
Sources of Data

<table>
<thead>
<tr>
<th>Reference Number</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.</td>
<td>Kentucky Department of Revenue, Correspondence with Bureau of Property Tax Receipts. Estimated Sales to Assessment Ratio, tax assessed values by categories and municipality for selected municipalities.</td>
</tr>
<tr>
<td>7.</td>
<td>Northeast Ohio Area Coordinating Agency, Special computer tabulation of estimated commuting time to Cleveland CBD and estimates of municipality land area. (acres)</td>
</tr>
<tr>
<td>8.</td>
<td>Ohio Board of Tax Appeals, Public records of Residential, Commercial, Industrial, and Agricultural assessments and property tax collections.</td>
</tr>
<tr>
<td>10.</td>
<td>Ohio, Kentucky, Indiana Regional Planning Authority, Estimated commuting time to CBD of Cincinnati using 1971 data and assorted maps of SMSA.</td>
</tr>
</tbody>
</table>

1 The alphabetical list of variable provides the specific sources of data used in constructing the variables of Table A-4. Each variable is referenced to the appropriate data source (s).
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Published financial reports of selected Kentucky cities (supplied by each city) - Bellevue, Covington, Ehrlanger, Fort Thomas, Fort Mitchell, Florence, Ludlow.</td>
</tr>
<tr>
<td>Year</td>
<td>Average Value</td>
</tr>
<tr>
<td>------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Sales Transfer</td>
<td></td>
</tr>
<tr>
<td>1969</td>
<td>$31,155.85</td>
</tr>
<tr>
<td>1970</td>
<td>32,703.63</td>
</tr>
<tr>
<td>U. S. Census</td>
<td></td>
</tr>
<tr>
<td>1970</td>
<td>$31,092.60</td>
</tr>
</tbody>
</table>

Source: U. S. Bureau of the Census, Census of Housing; 1970, Detailed Housing characteristics, HC(1) - B(37) and Housing Cuyahoga County: Housing Sales, Cuyahoga County Regional Planning Commission, 1971.
Criterion for Selection of Census Tracts

This research study also requires the selection of upper-income single-family housing areas within the confines of the municipal boundaries of Cleveland and Cincinnati, Ohio. Four criteria have been applied to select a reasonable number of upper-income census tracts.

1. The average income of each tract must fall within the top 20% by income of all census tracts within the city limits of Cleveland or Cincinnati or within one standard of the average income in the suburbs, whichever is greater.

2. Only those tracts in which over 50% of all housing units are single-family, owner-occupied in character are acceptable.

3. The average value of housing in a census tract must equal or exceed the average housing value of the least expensive suburb included in this analysis.

4. Census tracts in the midst of substantial transition in racial character are in general avoided (Baily, 1966; Muth, 1969). Block statistics on population characteristics were utilized in exercising a somewhat subjective judgement of the state of racial transition. Only one otherwise acceptable census tract has been excluded on this basis.

The above criteria produces 13 census tracts in Cincinnati and 19 census tracts in Cleveland. Tables A-7 and A-8 list the tracts selected and provide summative housing value, population, income, and racial data.
<table>
<thead>
<tr>
<th>Census Tract</th>
<th>Average Value</th>
<th>Population</th>
<th>Average Income</th>
<th>Percent Non-White</th>
</tr>
</thead>
<tbody>
<tr>
<td>46.03</td>
<td>$21800</td>
<td>3261</td>
<td>$13520</td>
<td>0</td>
</tr>
<tr>
<td>58.00</td>
<td>18900</td>
<td>6789</td>
<td>12313</td>
<td>58</td>
</tr>
<tr>
<td>82.01</td>
<td>20600</td>
<td>4908</td>
<td>13020</td>
<td>25</td>
</tr>
<tr>
<td>99.01</td>
<td>18000</td>
<td>5599</td>
<td>12597</td>
<td>0</td>
</tr>
<tr>
<td>102.10</td>
<td>20100</td>
<td>6717</td>
<td>12459</td>
<td>0</td>
</tr>
<tr>
<td>102.20</td>
<td>25100</td>
<td>3030</td>
<td>14260</td>
<td>0</td>
</tr>
<tr>
<td>47.00</td>
<td>22900</td>
<td>5048</td>
<td>13309</td>
<td>0</td>
</tr>
<tr>
<td>48.00</td>
<td>29700</td>
<td>4799</td>
<td>14300</td>
<td>0</td>
</tr>
<tr>
<td>49.00</td>
<td>32600</td>
<td>7408</td>
<td>23741</td>
<td>3</td>
</tr>
<tr>
<td>51.00</td>
<td>25700</td>
<td>2990</td>
<td>16904</td>
<td>0</td>
</tr>
<tr>
<td>107.00</td>
<td>17900</td>
<td>2288</td>
<td>12990</td>
<td>0</td>
</tr>
<tr>
<td>111.00</td>
<td>$27600</td>
<td>3256</td>
<td>$16350</td>
<td>0</td>
</tr>
<tr>
<td>Average</td>
<td>$23469.23</td>
<td>4689.38</td>
<td>$14582.00</td>
<td>7.07%</td>
</tr>
<tr>
<td></td>
<td>(4581.92)</td>
<td>(1644.72)</td>
<td>(3295.84)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Census Tract</th>
<th>Average Value</th>
<th>Population</th>
<th>Average Income</th>
<th>Percent Non-White</th>
</tr>
</thead>
<tbody>
<tr>
<td>1065</td>
<td>$19500</td>
<td>3254</td>
<td>$12920</td>
<td>0</td>
</tr>
<tr>
<td>1221</td>
<td>22700</td>
<td>4859</td>
<td>12644</td>
<td>91</td>
</tr>
<tr>
<td>1223</td>
<td>19800</td>
<td>2968</td>
<td>16154</td>
<td>98</td>
</tr>
<tr>
<td>1231</td>
<td>28700</td>
<td>4302</td>
<td>12785</td>
<td>0</td>
</tr>
<tr>
<td>1232</td>
<td>22600</td>
<td>3546</td>
<td>12785</td>
<td>0</td>
</tr>
<tr>
<td>1234</td>
<td>26800</td>
<td>5135</td>
<td>15562</td>
<td>0</td>
</tr>
<tr>
<td>1236</td>
<td>23500</td>
<td>13587</td>
<td>12918</td>
<td>0</td>
</tr>
<tr>
<td>1237</td>
<td>21200</td>
<td>6828</td>
<td>12293</td>
<td>0</td>
</tr>
<tr>
<td>1238</td>
<td>19800</td>
<td>3977</td>
<td>12476</td>
<td>2</td>
</tr>
<tr>
<td>1243</td>
<td>19700</td>
<td>5616</td>
<td>12269</td>
<td>1</td>
</tr>
<tr>
<td>1242</td>
<td>20100</td>
<td>6114</td>
<td>11237</td>
<td>0</td>
</tr>
<tr>
<td>1245</td>
<td>20000</td>
<td>5289</td>
<td>14693</td>
<td>0</td>
</tr>
<tr>
<td>1057</td>
<td>19800</td>
<td>5302</td>
<td>11422</td>
<td>2</td>
</tr>
<tr>
<td>1061</td>
<td>22800</td>
<td>4507</td>
<td>12614</td>
<td>0</td>
</tr>
<tr>
<td>1067</td>
<td>24400</td>
<td>5068</td>
<td>11517</td>
<td>0</td>
</tr>
<tr>
<td>1176</td>
<td>20500</td>
<td>4338</td>
<td>11798</td>
<td>0</td>
</tr>
<tr>
<td>1177</td>
<td>21100</td>
<td>6229</td>
<td>12119</td>
<td>0</td>
</tr>
<tr>
<td>1217</td>
<td>21100</td>
<td>6208</td>
<td>13775</td>
<td>94</td>
</tr>
<tr>
<td>1218</td>
<td>$20200</td>
<td>2779</td>
<td>$15853</td>
<td>92</td>
</tr>
<tr>
<td>Average</td>
<td>$21805.26</td>
<td>5264.00</td>
<td>$13058.10</td>
<td>7.07</td>
</tr>
<tr>
<td></td>
<td>(2561.79)</td>
<td>(2324.49)</td>
<td>(1504.62)</td>
<td></td>
</tr>
</tbody>
</table>

Appendix B

Adjustments for Intercorrelation
One of the least defined areas of regression analysis is multicollinearity. Several procedures have been suggested for treating highly collinear data, particularly when the matrix is nearly singular (Goldberger, 1964; Theil, 1971). The more typical case is not perfect collinearity between variables, but significant intercorrelation.

Significant intercorrelation violates the basic independence assumption of the linear regression model. The strongest condition of independence is orthogonality between independent variables. That is, the product of $X_1X_2$ is zero. Zero intercorrelation is a pre-requisite to orthogonality, but not a sufficient condition alone.

**Intercorrelation Adjustment**

A simple method can be devised to impose independence on intercorrelated independent variables in single equation, ordinary least squares models. The method to be described below relies on two basic characteristics of the least squares regression model. The residual of a regression equation is orthogonal to the independent variables of the regression. In addition, the residual of a regression is distributed identically with the dependent variable of the regression. (Theil, 1971). Succinctly:

1. $X_1\varepsilon = 0 \quad X_2\varepsilon = 0$
2. $YM = \varepsilon M$

Where $M = I - (X'X)^{-1}X'$, the idempotent matrix.
Table B-1
BASIC EXPLANATORY VARIABLES
CORRELATION MATRIX

<table>
<thead>
<tr>
<th>Variable</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VALUE</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIZE</td>
<td>.9398*</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QUALITY</td>
<td>.6067*</td>
<td>.4578*</td>
<td>1.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMUTE</td>
<td>.1455</td>
<td>.2899</td>
<td>.0508</td>
<td>1.0000</td>
<td></td>
</tr>
<tr>
<td>DENSITY</td>
<td>-.3754*</td>
<td>-.4705*</td>
<td>-.2559</td>
<td>-.2588</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

* Significant at a .05 level.
These two characteristics are relied upon in the formulation for intercorrelation adjustment.

1. given \( Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + \varepsilon \)

   Let \( X_1 \) be significantly intercorrelated with \( X_2 \) and \( X_3 \) then a linear combination of \( X_1 \) can be expressed as

2. \( X_1 = \Lambda_0X + \Lambda_1X_2 + \Lambda_2X_3 + \varepsilon^* \)

3. \( Y = B_0 + B_1(\Lambda_0 + \Lambda_1X_2 + \Lambda_2X_3 + \varepsilon^*) + B_2X_2 + B_3X_3 + B_4X_4 + \varepsilon \)

   rearranging

4. \( Y = (B_0 + B_1\Lambda_0) + B_1\varepsilon^* + X_2(B_2 + B_1\Lambda_1) + X_3(B_3 + B_1\Lambda_2) + B_4X_4 + \varepsilon \)

   Equation 4.0 requires that if \( \varepsilon^* \) is substituted for \( X_1 \) the regression coefficient (\( B_1 \)) of \( X_1 \) will be unchanged. In addition the coefficient of \( X_4 \) which did not enter into equation 2.0 is also unchanged in 4.0. The intercept term in equation 4.0 differs from equation 1.0 as will as the coefficients of the two intercorrelation adjusted variables, \( X_2 \) and \( X_3 \). The above is hardly a matrix algebra proof of the procedure and its characteristics, but it indicates the basis relationships and suggests the format for an actual proof.

   An indicator of the accuracy of the above equation specification can be gathered from a numeric example. Table B-1 presents the correlation matrix for the average of owner-occupied units and the four basic independent variables in Cincinnati, Ohio. The size (\( X_1 \)) variable is significantly intercorrelated with quality (\( X_2 \)) and density (\( X_3 \)). The intercorrelation adjustment procedure is applied by regressing \( X_1 \) on \( X_2 \) and \( X_3 \). The residual from the adjustment equation is then substituted for \( X_1 \) in the standard regression equation. Table B-2 lists the three equations—the standard unadjusted OLS, the adjustment equation and the multi-collinearity adjusted OLS.
### Table B-2
Comparison of Standard OLS, Adjustment Equation, and Intercorrelation Adjusted OLS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Standard OLS</th>
<th>Adjustment Equation</th>
<th>Intercorrelation Adjusted OLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable: Average Value</td>
<td>Size ($X_1$)</td>
<td></td>
<td>Average Value</td>
</tr>
<tr>
<td>$Size (X_1)$</td>
<td>10334.031</td>
<td></td>
<td>10334.04</td>
</tr>
<tr>
<td>($7.40$)</td>
<td>($7.40$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size Residual(*)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality ($X_2$)</td>
<td>163.26</td>
<td>0.04058</td>
<td>582.66</td>
</tr>
<tr>
<td>($2.47$)</td>
<td>($9.27$)</td>
<td></td>
<td>($16.45$)</td>
</tr>
<tr>
<td>Density ($X_3$)</td>
<td>113.23</td>
<td>-0.02009</td>
<td>94.39</td>
</tr>
<tr>
<td>($1.19$)</td>
<td>($1.78$)</td>
<td></td>
<td>($1.02$)</td>
</tr>
<tr>
<td>Commute ($X_4$)</td>
<td>-113.63</td>
<td></td>
<td>-113.63</td>
</tr>
<tr>
<td>($2.05$)</td>
<td>($2.05$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-40905.11</td>
<td>5.4666</td>
<td>15587.44</td>
</tr>
<tr>
<td>($5.30$)</td>
<td>($41.49$)</td>
<td></td>
<td>($9.51$)</td>
</tr>
</tbody>
</table>

**Summary Statistics:**

- **R-squared**: .9137, .7698, .9137
- **std. error**: 2748.76, 0.3432, 2748.76
- **sum of squared residuals**: 2417824.9, 2417823.4
- **degree of freedom**: 32, 32, 32
Empirical Verification of Adjustment Procedure

Equation 4.0 suggests a means of directly calculating the values of the regression coefficients of the multicollinearity adjusted OLS equation from the standard and adjustment equations. The direct calculation is shown below:

\[
B_0' = (B_0 + A_0B) = -40905.11 + (5.4666) (10334.031) = -40905.11 + 56491.013
\]

Calculated \( B_0 \) = 15586.903
Adjusted \( B_0 \) = 15587.14

\[
B_2' = (B_2 + A_1B) = 163.26 + (.04058) (10334.031) = 163.26 + 419.3549
\]

Calculated \( B_2 \) = 582.61
Adjusted \( B_2 \) = 582.61

\[
B_3' = (B_3 + A_2B) = 113.23 + (-0.02009) (10334.031) = 113.23 + (-0.2009)
\]

Calculated \( B_3 \) = -94.38
Adjusted \( B_3 \) = -94.39

The difference between the theoretical direct calculation of the coefficients and the computer calculation based only on the residual of the adjustment equation is less than 0.1% in all cases. The direct substitution of the residual from the adjustments equation for \( X_1 \) is equivalent to substituting the entire linear combination of \( X_1 \) into the final regression equation.

Table B-3 lists the residual from the standard OLS and from the multicollinearity adjusted OLS. The residuals are in fact identical. The adjustment procedure does not affect the residuals in the regression and therefore will also not affect the coefficients of any variables added to the regression (Theil, 1971).

The only basic condition that must be met for using the adjustment procedure is that the adjustment residual and the independent variables that form the equation must always appear together in any future equation.
specification. The adjustment procedure is not free of limitations though. It can be easily used for data transformed into logarithms or any other transformation where zero and negative numbers pose problems. Additionally, the technique becomes complex when utilized in multi-equation systems, and may be impractical in some simultaneous equation systems.

As a further proof of the independence that has been imposed on the independent variables Table B-4 list the correlation matrix after multicolinearity adjustment. The adjusted size variable \( X_1 \) now has a zero intercorrelation with both \( X_2 \) and \( X_3 \).
<table>
<thead>
<tr>
<th>Observation Identifier</th>
<th>Observed Dependent</th>
<th>Original Residuals</th>
<th>Adjusted Residuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>70.000</td>
<td>47000.00</td>
<td>-2581.39</td>
<td>-2581.39</td>
</tr>
<tr>
<td>445.000</td>
<td>18300.00</td>
<td>-1227.30</td>
<td>-1227.30</td>
</tr>
<tr>
<td>840.000</td>
<td>16000.00</td>
<td>-967.02</td>
<td>-967.02</td>
</tr>
<tr>
<td>1595.000</td>
<td>17300.00</td>
<td>759.10</td>
<td>759.09</td>
</tr>
<tr>
<td>1910.000</td>
<td>54000.00</td>
<td>-7294.13</td>
<td>-7294.09</td>
</tr>
<tr>
<td>2475.000</td>
<td>25400.00</td>
<td>2376.55</td>
<td>2376.57</td>
</tr>
<tr>
<td>2665.000</td>
<td>16900.00</td>
<td>-44.89</td>
<td>-44.90</td>
</tr>
<tr>
<td>1115.000</td>
<td>16200.00</td>
<td>-21.76</td>
<td>-21.77</td>
</tr>
<tr>
<td>1295.000</td>
<td>11310.00</td>
<td>-2108.47</td>
<td>-2108.48</td>
</tr>
<tr>
<td>1397.000</td>
<td>22700.00</td>
<td>6838.71</td>
<td>6838.72</td>
</tr>
<tr>
<td>1560.000</td>
<td>22700.00</td>
<td>5302.62</td>
<td>5302.66</td>
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### Table B-4
Basic Explanatory Variable
Intercorrelation Adjusted Correlation Matrix

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* Significant at .05 level.
Appendix C

Derivation of a Change in Location with Respect to a Change in the Level of the Price Gradient
The analysis of Chapter III is predicated on equation 3-7 which was derived by Richard Muth in *Cities and Housing*.\(^1\) The derivation of the change in equilibrium location (under ceteribus paribus conditions) due to a change in the level of the price gradient may not be intuitively obvious to the reader. The derivation of equation 3-7 is shown below as well as both the implicit and explicit assumptions necessary to interpret the equation. All of the terms in the derivation are defined in Chapter III. After developing the equation \(\frac{\delta K}{\delta P}\) the likely values of the various components the model are suggested.

The minimum requirement for residential equilibrium is that no small move in any direction will not change the real income of the household.

\[\lambda (QP_k + T_k) = 0\]

or \(P_k = -1/Q T_k\), where \(\lambda > 0\)

differentiating A.1 with respect to \(k\)

\[QP_{kk} - P_k \frac{\delta Q}{\delta K} - T_{kk} = 0\]

A.3 and \(\frac{\delta Q}{\delta K} = (\frac{\delta Q}{\delta P})_c P_k\)

where \(c\) refers to constant income compensated price elasticity.

Substituting A.3 into A.2

\[QP_{kk} - P_k (\frac{\delta Q}{\delta P})_c P_k - T_{kk} \leq 0\]

rearranging

\[P_{kk} - \frac{1}{Q} (\frac{\delta Q}{\delta P})_c P_k^2 - T_{kk} \leq 0\]

multiplying both sides by \(1/P_k\)

\[P_{kk}/P_k - (\frac{\delta Q}{\delta P})_c P_k/Q - \frac{T_{kk}}{P_k Q} \leq 0\]

but \(T_k = P_k Q\), and rearranging

\[E_p, p: (P_k/P) + (P_{kk}/P_k) - T_{kk}/T_k \leq 0\]

\(^1\) The basic form of the equations presented in this Appendix can be found in Chapters 3 and 4 of *Cities and Housing*.\]
The \(-Q_{P_k}\) curve must intersect the \(T_k\) curve from above if a unique equilibrium distance is to exist. The term \(E_{q,P;C}\) is the income compensated price elasticity of housing services. The price of housing services is a function of distance, but it can vary in three ways: (1) \(P_0\), a shift in the level of the price gradient; (2) \(P_kdK\), movement along a specified gradient; or (3) \(dP_vd_v\), a change in the slope of the gradient.

\[
P(k) = P_0 + \int kP_v dV
\]

\[
dP = dP_0 + \int kP_v dV + P_k dK
\]

\[
dP_k = \Gamma + P_{kk} dK, \text{ where } \Gamma = dP_0
\]

For the purpose of this analysis the slope of the price gradient and the transportation cost gradients will not vary. \((\epsilon_k dP_v V \text{ is constant})\)

Similarly the change in the transportation cost with distance function can be specified.

\[
T(k, v) = T_0 + \int kT_v dV
\]

\[
dT = dT_0 + \int k dT_v dV + T_k dK
\]

\[
dT = T_k dK
\]

\[
dT_k = \Psi + T_{kk} dK + T_{ky} dY, \text{ where } \Psi = dT_0
\]

The term \(T_{ky} dY\) is the variation in the rate of change in transportation cost due to changes in income and distance. The analysis presented below does not consider changes in transport cost due to changes in real income. However, most changes in location induced by a shift in the level of the price gradient will also induce changes in real income. As was shown in Graph IV-2 the increase in transportation cost accompanying a change in real income will reduce the maximum expected increase in distance from the CBD, when all other factors are held constant.

The total differential of equation A.1 is also necessary in examin-

\[
\delta K / \delta P* \]

\]
Totally differentiating A.1

A.9 \[-Q_dP_k - P_{kdQ} - dTk = 0\]

A.10 where \(dQ = \delta Q/\delta Y + (\delta Q/\delta P)cP_d\).

The change in quantity is dependent on both income price elasticities.

If equations A.6, A.7, and A.10 are substituted in equation A.9, the effect of change in the price level on radial distance can be examined.

A.11 \(-Q(P_{kkdK}) - P_k ((\delta Q/\delta Y)dP_0Q + (\delta Q/\delta P)c(P_{kdK} + dP_0)) - T_{kkdK} \leq 0\)

expanding and rearranging

A.12 \(-P_k((\delta Q/\delta Y)dP_0 - (\delta Q/\delta P)cP_0) = P_k^2dK((\delta Q/\delta P)c + Q(P_{kkdK} + T_{kkdK}) \leq 0\)

multiplying by \(-1/QP_k\) and noting that \(-1/QP_k = 1/T_k\)

A.13 \(-dP_0 + (\delta Q/\delta P)dP_0/1/Q = -P_k^2 dK((\delta Q/\delta P)c - (P_{kkdK} + (T_{kkdK})dK\)

Grouping and converting to elasticity forms where

\[E_{Q,Y,R,(PQ/Y)} = (\delta Q/\delta Y) \text{ and } P(k) = P\]

A.14 \(dP_0(-E_{Q,Y,R}(PQ/Y) + E_{Q,Y,c}(P_k/P) - P_{kk}/P_k + T_{kk}/T_k\)

multiplying both sides by minus one, and expressing as a partial derivative \(\delta K/\delta P_0\)

3.7 or A.15 \(\delta K/\delta P_0 = -dP_0(E_{Q,Y,c} - (PQ/Y)E_{Q,Y,R}) \leq 0\)

\[P_k/P_{EQ,Y,c} + (P_{kk}/P_k - T_{kk}/T_k)\]

Under equilibrium conditions at the point of tangency between the price gradient and the transportation cost gradient the slope of the two curves are identical, therefore \(P_{kk}/P_k = T_{kk}/T_k\). Equation A.15 can yield numeric estimates of the change in radical distance expressed in the same distance units as \(P_k\) if estimates exist for (1) income and price elasticity, (2) \(P_k\) rate change per unit of distance, and (3) the portion of income consumed by housing expenditures. Most empirical studies have supported estimates of income elasticity for owner-occupied units between 1.00 and 1.30. The price elasticity of housing services has usually been assumed to be
-1.00 (Muth, 1962, 1969; Mills, 1967, 1972). The percentage of income spent on housing per unit of time ($P_0/Y$) is assumed to be 20%. The estimates of this research study concur with Muth's approximation that the price of housing services declines by about 1% per mile.

Substituting these values into equation A.15 an approximation of the typical relationship between $P_0$ and the price level can be developed.

$$\frac{\delta K}{\delta P_0} = -dP_0(-1.0 - (1.20)(.20)) \leq 0$$

$$(1.0)(.01) + 0$$

If $P_0 \leq 0$, then

$$A.16 \quad -dP_0(-1.24) \geq 0$$

-.01

A one percent decrease in the level of the price of housing services would result in a maximum move farther from the CBD of slightly more than one radial mile by the average household. The increase in real income due to this fall in the price level would raise the level of transportation cost curve, thus reducing somewhat the maximum outward movement. In addition, the above analysis assumes no moving costs or other factors simultaneously affecting the relocation decision.
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