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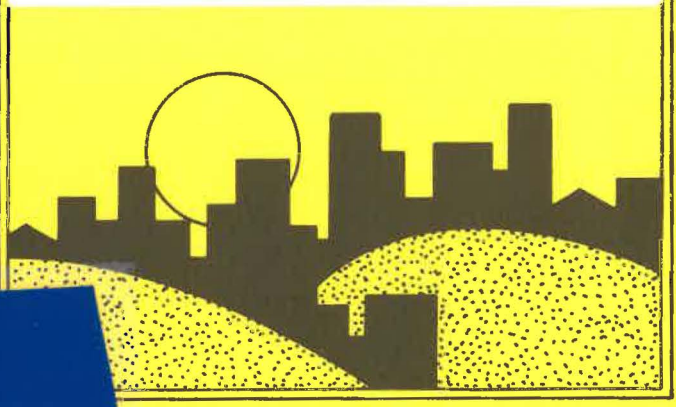

AUSTRALIAN NATIONAL UNIVERSITY
RESEARCH SCHOOL OF SOCIAL SCIENCES

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ABSTRACT

This paper reviews theories about the economic effects of land value taxation as well as research which suggests hypotheses addressing the disparate circumstances of central cities such as Pittsburgh, suburban cities such as McKeesport, and relatively isolated cities such as New Castle.

In order to test those hypotheses, specified a general econometric model of the housing market is specified. The model is adjusted to fit the circumstances of each city, and then the adjusted models using time-series data for each city is estimated. The periods of study for each city cover spans of time during which there were both increases in the tax rates applicable to land and decreases in the tax rates applicable to improvements. Incentive effects of decreases in the tax rate on buildings are expected to encourage housing development in Pittsburgh and, possibly, New Castle, but not in McKeesport. Liquidity effects of increases in the tax rate on land may encourage housing development in the three cities.

All three cities employ land value taxation as an economic development tool and as a means for helping to stem or reverse the loss of population. By encouraging the construction of housing, land value taxation may help to attract households that would otherwise locate in other jurisdictions. Although Pittsburgh has had land value taxation since 1913 (Williams 1962), McKeesport and New Castle did not adopt such a tax system until 1979 and 1982, respectively.

LAND VALUE TAXATION AND HOUSING DEVELOPMENT FOR THREE CITIES IN PENNSYLVANIA[1]

Steven C. Bourassa
Urban Research Unit

I. INTRODUCTION

This paper summarises and revises my previously published research on land value taxation[2] and housing development in Pittsburgh, McKeesport, and New Castle, Pennsylvania (Bourassa 1987; in press).[3] In this paper, I review theories about the economic effects of land value taxation as well as research which suggests hypotheses addressing the disparate circumstances of central cities such as Pittsburgh, suburban cities such as McKeesport, and relatively isolated cities such as New Castle.

In order to test those hypotheses, I specified a general econometric model of the housing market, adjusted the model to fit the circumstances of each city, and then estimated the adjusted models using time-series data for each city. The periods of study for each city cover spans of time during which there were both increases in the tax rates applicable to land and decreases in the tax rates applicable to improvements. *Incentive* effects of decreases in the tax rate on buildings are expected to encourage housing development in Pittsburgh and, possibly, New Castle, but not in

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[1]This paper was presented in the Department of Economics Seminar Series, Research School of Social Sciences, The Australian National University, 26 May 1989. It has benefitted from discussion with Max Neutze as well as members of the Department of Economics.

[2] *Land value taxation* generally refers to the taxation of land at rates higher than those applied to buildings and other improvements. Most local jurisdictions in the United States apply the same rates to both land and improvements.

[3] The primary substantive change between this and the previous papers is in the discussion of liquidity effects of taxes on land and consequent expectations about the behavior of land tax variables.

McKeesport. *Liquidity* effects of increases in the tax rate on land may encourage housing development in the three cities.

All three cities employ land value taxation as an economic development tool and as a means for helping to stem or reverse the loss of population. By encouraging the construction of housing, land value taxation may help to attract households that would otherwise locate in other jurisdictions. Although Pittsburgh has had land value taxation since 1913 (Williams 1962), McKeesport and New Castle did not adopt such a tax system until 1979 and 1982, respectively.

II. PREVIOUS STUDIES

Writing in the mid-1960s, Heilbrun (1966) noted that he was unable to find any conclusive evidence of the effects of land value taxation on urban housing markets. Since the mid-1960s, several researchers have completed econometric studies of the effects of real estate tax rates on the supply of housing services or, more generally, structural services.[4] Tanzer's (1985) cross-sectional study of 91 Standard Metropolitan Statistical Areas in the United States concluded that a given per cent reduction in the tax rate on structures results in equal per cent increases in housing quality and quantity. Pollock and Shoup's (1977) study of the tourist hotel district in Waikiki, Hawaii, suggested that elimination of the tax on structures would result in a significant increase in the amount of investment in hotels. Grieson's (1974) general equilibrium study reached a similar conclusion with respect to the supply of structures, in general, using aggregate data for the United States. None of these studies explicitly addressed the possible effects of increases in the land portion of the real estate tax.

In contrast, a few researchers have examined the effects of land taxes. Mathis and Zech (1982) undertook a cross-sectional analysis of 27 cities in Pennsylvania and found no evidence that those cities with land value tax

[4] The term *structural services* is used because it allows for a common, albeit abstract, unit of measurement which takes into account all qualitative and quantitative aspects of structures. Compare Olsen's (1969) use of the term *housing services*.

schemes experienced more development than those with standard real estate taxes. Mathis and Zech's analysis was marred, however, by their misspecification of the tax variable as the ratio of the improvement and land tax rates.[5] Pollakowski's (1982) study of the liquidity effects of the land portion of Pittsburgh's real estate tax found a statistically significant relationship between land tax payments and the probability of transfer of a property. Pollakowski was unable to determine whether properties were improved after transfer, however. Writing about the same time as Heilbrun, Richman (1965, p. 260) commented: "Whether or not the Pittsburgh graded tax has proved to be beneficial to the city is difficult to establish". This is still true today because the negative results obtained by Mathis and Zech may be attributable to the methods employed by those researchers and Pollakowski's results are inconclusive.

III. REVIEW OF ECONOMIC THEORY

Economic theory suggests that shifting the tax burden from improvements to land may encourage development in two ways. These are the liquidity and incentive effects. Increases in the land tax rate *may* result in a liquidity effect, while decreases in the improvement tax rate *should* result in an incentive effect in central cities and possibly in isolated cities, but not in suburban jurisdictions.

The Liquidity Effect

The literature on the economic effects of land value taxation suggests that the liquidity effect has two complementary components. One component is the effect on current landowners, who must bear increased holding costs and who are thereby encouraged to improve their properties or sell to someone who will. Netzer (1966, p. 33) explains this as follows:

> *It is generally agreed that taxes on the value of bare land—the sites themselves exclusive of applications of reproducible capital*

[5] The relationship between that ratio and the level of development is theoretically ambiguous. See Coffin and Nelson's (1983) apt critique of Mathis and Zech's methods.

> *in the form of grading, fertilizer, and the like—rest on the owners of the sites at the time the tax is initially levied or increased. The tax cannot be shifted because shifting is possible, under reasonably competitive conditions, only if the supply of sites is reduced. But the supply of land is, for all practical purposes, perfectly inelastic. Individual landowners will not respond to an increase in land taxes by withdrawing their sites from the market, since doing so will not affect their tax liability. Indeed, their only chance of reducing the burdensomeness of the tax relative to their income streams is to seek to raise the latter by encouraging more intensive use of the sites they own. Collectively, landowners cannot reduce the stock of land: If individual landowners wish to liquidate in the face of higher taxes, they must sell the sites to other owners.*

This does not, of course, imply that additional development will actually take place. The actual extent of the holding cost effect would seem to depend on the existence of land which could be developed profitably but is being withheld from development for non-financial reasons, such as the direct utility of landownership (*see* Neutze 1987). In this case, increased land taxes would have to more than offset the direct utilities preventing landowners from supplying land for development.

Following Bentick's (1979) analysis, it might be thought that another type of holding cost effect might occur. This would involve land being held for a future development project that would provide a stream of land rents with a higher present value than that of an alternative project which could be developed immediately. In this case, the effect of the higher land tax may be to give the stream of land rents from the immediately developable project the higher present value. In regard to this possibility, Bentick compares two hypothetical projects, one of which could be developed immediately, while the other could be developed profitably only at some point in the future. Bentick assumes that (p. 861) "project 1 uses specialized and fixed buildings which cannot be used in project 2 or elsewhere and ... the time of commencement of project 2 is too short to allow these structures to be amortized". The first project yields one dollar of land rent per year in perpetuity and has a present value, P_1, of $1/r$, where r is an appropriate discount rate. The other project yields c dollars per year after a period, t.

The present value of the second project, P_2, is $e^{-rt}c/r$. The delayed project will be preferred if $e^{-rt}c/r > 1/r$. In this case the critical value of t is:

$$t' = (\ln c)/r$$

and the second project will be preferred only if $t < t'$. If a tax on land value, b, is introduced, then for the second project to be preferred, the following must be true:

$$e^{-(r + b)t}c/(r + b) > 1/(r + b).$$

In this case, the critical value of t is:

$$t'' = (\ln c)/(r + b)$$

and now the second project will be preferred only if $t < t''$. It is clear that $t'' < t'$ and, therefore, that the second project is less likely to be preferred after the tax than before.

A fatal problem with Bentick's analysis is his confusion regarding the normal base for taxes on land.[6] This is usually defined as *land value*, or the value of a site as if it had no improvements. Land value and rent are not a function of the current use of land, but instead are a function of the so-called "highest and best use" of a site. Highest and best use for a given site is a function of uses on surrounding sites and is the use to which the site would be put if it were bare. As Gaffney (1969) puts it, land rent is best defined as (p. 141): "the highest latent opportunity cost of land". Land rent does not change because the use of a site has changed. In other words, at any given time, land value is constant and does not change as one considers different potential uses for a site. Thus Bentick is incorrect in speaking of the land value or rent of a particular site as if it were a function of the use of that site;[7] consequently, his analysis collapses. Since the value of a site is independent of the use of that site, a tax on land value will not have the

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[6] I am grateful to Max Neutze for pointing this out.

[7] Douglas (1980) makes this same error.

impact on the timing of development claimed by Bentick (Tideman 1982).[8] Given the flaw in analyses such as Bentick's, one would have to conclude that the only circumstance in which the holding cost effect might be significant would involve land withheld from development for non-financial reasons.

The other component of the liquidity effect is simply the obverse of increased holding costs. This obverse component is due to capitalisation of the tax. The relationship between the tax rate, b, and the capitalised market value of the land, L, is:

$$L = E/(r + b)$$

where E is the economic rent of the land (before any tax) and r is the discount rate (Becker 1969).[9] It is clear that, as b approaches infinity, L approaches zero. Capitalisation of the land tax makes it easier for potential developers to acquire land and could thereby encourage development. Becker (1969, p. 25) observes: "The benefit would be the equivalent of an automatic perpetual loan to the developer for purposes of land acquisition in the amount of the capitalised value of the land tax". This, of course, assumes that imperfect capital markets are preventing developers from obtaining sufficient capital for land purchases for otherwise viable development projects. This is largely an empirical question.

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[8] For an example of the traditional analysis which shows that land taxes do not have an effect on the timing of development, see Neutze (1969).

[9] This must be qualified in view of Feldstein's assertion that the tax on land is not fully capitalised. He writes (1977, pp. 350-351):

> *The essential oversight of the classical analysis is to ignore the fact that land and produced capital are alternative components of individual life-cycle wealth. Each generation wishes to accumulate a certain level of wealth with which to finance retirement in old age. If the tax on pure land rent reduces the value of land, a larger amount of the desired wealth must be accumulated in the form of produced capital. The tax on rental income thus induces an increase in the equilibrium capital stock and therefore in the equilibrium ratio of capital to land. This raises the marginal productivity of land and reduces the rate of interest at which net land rents are capitalized. Part of the tax on pure rent is thus shifted in the form of a lower net yield on capital and a higher wage rate. Moreover, the price of land does not fall as much as the traditional theory predicts.*

The Incentive Effect

The incentive effect of decreasing the tax rate on improvements is due simply to the reduction in the excise effects of the improvements tax. The tax on improvements is in part an excise tax which reduces the quantity of improvements produced. Mieszkowski (1972) has argued that the system of local property taxes in the United States has both *global* and *excise* effects.[10] The global effect is a reduction in the real rate of return to capital by the average property tax rate. More important for my purposes is the excise effect, which depends on geographical variations in tax rates, with low tax communities having a lower cost of capital than high tax jurisdictions. Given the assumption of highly mobile capital, it is reasonable to expect that changes in tax rates will result in flows of capital from jurisdictions with high rates to those with low rates. With regard to housing, Mieszkowski observes (pp. 78-79): "After the imposition of taxes, residents of high tax communities will decrease their demand for residential capital and some households will shift their residential capital to low tax areas".

Mieszkowski's analysis employs a number of simplifications, one of which is particularly worthy of mention here. His analysis for the most part ignores the fact that varying levels of public goods and services are provided in different communities with their differing tax bases and rates. As he notes (p. 75):

> *Throughout most of the analysis we shall abstract from the effects of the expenditure side of the budget. The only justification of this simplification is convenience, as the level and quality of public expenditures influence housing values and locational decisions.*

It is important to consider the effects of public expenditures because the obvious benefits of a reduction in the improvement tax rate could be offset to some degree by the adverse impact of a decrease in provision of public goods and services.

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[10] Mieszkowski uses the term *property tax* to refer to taxes on reproducible capital; he does not consider the effects of taxes on land.

The effects of expenditures could be neglected if real revenues (and expenditures) remained constant while the tax burden was shifted from improvements to land. That hypothetical situation is unlikely, however, as municipal revenue needs tend to be increasing. In the case of Pittsburgh, for example, the improvement tax rate has remained relatively constant in recent years while the land tax rate has increased substantially. Presumably, real estate tax revenues have been increasing in Pittsburgh along with overall revenues and expenditures. While it would be easy to obtain statistics on expenditures, it would be patently difficult to reach any useful conclusions about changes in the levels of public goods and services provided in a city and the effects of those changes on real estate investment. Because the effects of changes in public expenditures are so difficult to account for and probably vary considerably over time and among places, it is prudent to conclude that the results presented here are likely to be rather time- and place-specific.

Another important consideration is the possibility of migration of capital among various sectors due to differences in effective tax rates. Mieszkowski gives the following example (p. 81):

> *[C]apital is mobile between industry and residential real estate and the possibility of tax differentials between broad industry groups must be accounted for. Housing services, in the aggregate, may be taxed more heavily than industrial capital or vice-versa.*

Although different types of real property are assessed ostensibly at the same rates in Pittsburgh, McKeesport, and New Castle, hidden biases may exist. If so reductions in the improvement tax rate would affect the various classes of property in a nonuniform manner and capital may migrate among the classes. It is also likely that different classes of land use would be affected in different ways by changes in land or improvement tax rates because some uses are land-intensive while others are capital-intensive. As in the case of public expenditures, geographical and temporal variations in assessment practices or land use characteristics make it difficult to generalise from results such as those presented here.

Incentive Effects in Different Types of Jurisdictions

Elaborating on Tiebout's (1956) well-known hypothesis, Hamilton (1975b) concluded that property taxes in suburban jurisdictions act as benefit taxes rather than excise taxes. Tiebout posited that consumers' preferences for local public services are satisfied by migration among communities, given a fairly large number of communities providing varied sets of services in a metropolitan area. Hamilton observed that Tiebout's model failed to adequately address the matter of prices for local public services. As Hamilton (1975b, p. 205) notes: "[T]he Tiebout Hypothesis seems to be a formula for musical suburbs, with the poor following the rich in a never-ending quest for a tax base."

Hamilton argues that property taxes act as the efficient prices for public services. In Hamilton's model, proportional property taxes are the only source of local revenue, and zoning mandates a minimum level of housing consumption per family in each jurisdiction. Given a choice of jurisdictions with varying levels of public expenditures and zoning requirements, a household moves to the community that best satisfies its needs for housing and local public services. In this model, the property tax rate is proportional to the level of public services provided and the tax is, in effect, the price of those services. All households in a jurisdiction consume the same amount of housing—the minimum required amount—because they would not be maximising their levels of utility by consuming more than the minimum. If a household wants to consume more housing, it will maximise its utility by moving to a jurisdiction which requires exactly the amount of housing consumption desired. This is because such a move will reduce the household's tax bill relative to the amount of public services consumed.

This mechanism does not, however, work in central cities because such cities are heterogeneous—i.e., they cannot mandate city-wide minimum levels of housing consumption (Hamilton 1975a). According to Hamilton (1975a, p. 14):

> *[T]he property tax in the central city does inhibit housing consumption in exactly the manner that an excise tax on any commodity inhibits its consumption. This leads to the prediction*

that the property tax will depress central-city residential property consumption relative to suburban consumption.

Hamilton's analysis relies on a number of simplifying assumptions and it is clear that the suburban property tax is not a completely efficient benefits tax. Nevertheless, Hamilton (1975a) has provided some empirical evidence that clearly supports his theoretical conclusions. More recently, Ihlanfeldt (1984) has reported additional empirical results in support of Hamilton's thesis. Both Hamilton and Ihlanfeldt show that, in metropolitan areas with a large number of suburban jurisdictions, housing consumption is *ceteris paribus* less in central cities than in their suburbs by the amount one would expect if there were an excise effect in the former but not the latter. Thus it seems that Hamilton's model may be a reasonably good approximation of reality.

To the extent that Hamilton's model is correct, one would not expect decreases in the improvement tax rate to have an incentive effect in suburban jurisdictions such as McKeesport, which is one of a large number of suburbs in the Pittsburgh metropolitan area. In the simple case in which a shift to land value taxation does not involve a change in revenues or expenditures, the suburban household's tax bill will be unchanged by the shift. Households will continue to maximise their utilities by consuming the minimum required amount of housing specified by the zoning in their chosen jurisdictions and, therefore, the amount of housing will not increase due to reductions in the tax rate applied to structures.[11]

Consider, for example, the case of an incoming household deciding whether to settle in community X or community Y. To simplify this analysis, assume that both communities provide the same level of public services and both have the same zoning restrictions. Community X has land value taxation while Y does not. Presumably, the household has decided to live in X or Y because the zoning in those two communities requires a minimum level of housing consumption which matches the amount that the

11 There remains, however, the possibility that a shift to heavier taxes on land will have a liquidity effect. If housing lots are being withheld from development for non-financial reasons, a shift to a heavier tax on land may motivate the owners of those lots to release them for development.

household wishes to consume. Clearly, the household has no incentive to chose X over Y because its tax bill will be identical in both places.

In contrast to McKeesport, in a heterogeneous central city such as Pittsburgh one would expect an incentive effect. As for the case of New Castle, which is a relatively isolated city, one would expect the incentive effect to be less significant than in Pittsburgh, or possibly insignificant, because it is more difficult for households to adjust their locations between urban areas than within an urban area.

IV. THE MODEL, DATA, AND EXPECTATIONS

The General Model

The general model of the urban housing market contains elements of both supply and demand. I assume that there is a log-linear relationship between quantity and the various elements of demand and supply. The logarithm of the demand function is:

$$\ln Q_d = \alpha_0 + \alpha_1 \ln R_n + \alpha_2 \ln R_e + \alpha_3 \ln Y + \alpha_4 \ln N + \alpha_5 \ln P_x$$

where:

Q_d = quantity of housing demanded;
R_n = the average rent for new housing services;
R_e = the average rent for existing housing services;
Y = average household income;
N = the number of households;
P_x = the prices of other goods and services; and
$\alpha_0, \alpha_1, \ldots, \alpha_5$ are the parameters of the equation.

The logarithm of the supply function is:

$$\ln Q_s = \alpha_6 + \alpha_7 \ln R_n + \alpha_8 \ln P_o + \alpha_9 \ln P_m + \alpha_{10} \ln r$$

$$+ \alpha_{11} \ln b + \alpha_{12} \ln z$$

where:

Q_s = quantity of housing supplied;
R_n = the average rent for new housing services;
P_o = the price of operating inputs;
P_m = the price of maintenance inputs;
r = the cost of housing capital;
b = the effective land tax rate;
z = the effective improvement tax rate; and
$\alpha_6, \alpha_7, \ldots, \alpha_{12}$ are the parameters of the equation.

The relevant reduced form equation is:

$$\ln Q = \beta_0 + \beta_1 \ln R_e + \beta_2 \ln Y + \beta_3 \ln N + \beta_4 \ln P_x$$

$$+ \beta_5 \ln P_o + \beta_6 \ln P_m + \beta_7 \ln r + \beta_8 \ln b + \beta_9 \ln z$$

where:

$Q = Q_d = Q_s$;
the variables are defined as before; and
$\beta_0, \beta_1, \ldots, \beta_9$ are the parameters.

One immediately obvious problem is that R_e is not exogenous—it is dependent on Q_d. The solution to this problem is to use a lagged value of R_e in estimation. Another problem is that N may be dependent on the tax rates; however, it will be assumed that the proxy for N and Y, resident employment, is exogenous.[12] On the supply side, it is assumed that operating and maintenance inputs are in perfectly elastic supply so that their prices are exogenously determined.

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12 While this may not be true in the long run (i.e., a shift to land value taxation could result in industrial and commercial development and greater employment), it is probably true in the short run. The model specified here obviously captures only short-run effects of the tax rates.

The Data and Adjustments to the Model

The periods of study were 1978-1984 for Pittsburgh, 1978-1986 for McKeesport, and 1979-1986 for New Castle.[13] In view of the small number of years in each study period and the relatively large number of parameters to be estimated, monthly data were used. Virtually the only available monthly measure of new housing development is the dollar value of building permit applications.[14] It is assumed that there is a reasonably uniform relationship between the values given on building permit applications and the actual costs of construction. Even though permits may substantially underestimate or overestimate costs, if they do so uniformly, there will be no distortion in the results. With respect to the McKeesport and New Castle data, it was in some cases difficult to determine whether a given permit was issued for residential or for other types of construction. This ambiguity in the data may have affected the results somewhat.

The available data and the peculiar circumstances of each city necessitated adjustments to the basic model. In the case of Pittsburgh, the building permit data used for the dependent variable contained dollar values for housing construction in new buildings but excluded dollar values for housing rehabilitation projects. This made it necessary to add a variable, G, to capture the effects of federal income tax incentives for rehabilitation which may have affected the flow of capital into housing in new relative to existing buildings.[15] In addition, extensive mortgage subsidy programs in

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[13] The period of study for Pittsburgh reflects the timing of significant tax rate changes which took place after the adoption of a home rule charter in 1976. Prior to home rule, Pennsylvania law required Pittsburgh to tax land at exactly twice the rate applied to improvements.

[14] Building permit data were obtained from the Bureau of Building Inspection, Department of Public Safety, City of Pittsburgh, and the Building Inspectors for McKeesport and New Castle. Public housing projects, which would not be affected by tax rates, were deleted from the data and the building permit series were smoothed in order to eliminate seasonal and irregular fluctuations. The building permit data were deflated using Boeckh's *Building Cost Index Numbers*, provided courtesy of American Appraisal Associates, Milwaukee, Wisc.

[15] Data were obtained from the Pennsylvania Historical and Museum Commission. The data consisted of the dollar value of residential rehabilitation projects for which application was made to take advantage of federal income tax credits. The expected project commencement date was used to assign projects to specific months. The monthly values were deflated and smoothed.

Pittsburgh suggested a need to add a variable, s, measuring the dollar value of mortgage subsidies.[16] The cost of housing capital variable, r, is defined as the difference between the nominal home mortgage rate and an appropriate risk-free rate, in this case the nominal three-year Treasury Bill rate.[17] As the difference between the nominal rates is the same as the difference between the real rates, there is no need to adjust for inflation. I will call this difference the 'real spread'. In all three cities, resident employment data were used as a convenient proxy, M, for the combined effects of average household income and number of households.[18] These data include the number of workers residing in each city regardless of place of work.

The proxies for average rent for existing housing services and the prices of other goods and services are fairly straightforward. The first is the consumer price index for shelter costs for the Pittsburgh area, lagged one month, while the second is the consumer price index for all items except shelter for that region.[19] The proxy for the price of operating inputs is the consumer price index for home heating fuels and other utilities. Finally, the proxy for the price of maintenance is an index of residential construction costs. These indexes were also used as proxies for variables in the McKeesport and New Castle models. Although McKeesport and New Castle

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16 Pittsburgh operated two housing subsidy programs during the study period which provided mortgage assistance for purchasers of new homes. The dollar value of assistance for new construction under each of these programs was obtained from the Department of Housing, Urban Redevelopment Authority, City of Pittsburgh.

17 Data for the Pittsburgh metropolitan area were obtained from the Federal Home Loan Bank Board. In this case, data for the Pittsburgh area are clearly applicable to McKeesport and New Castle, because most banks in the smaller cities are branches of Pittsburgh banks.

18 These were obtained from the Office of Employment Security, Department of Labor and Industry, Commonwealth of Pennsylvania.

19 Except for the construction cost indexes (which were derived from Boeckh's *Building Cost Index Numbers*), the consumer price indexes were obtained from the *CPI Detailed Report*, published by the Bureau of Labor Statistics, U.S. Department of Labor. Some interpolation and extrapolation was necessary because only bimonthly data are given for Pittsburgh, beginning with April 1978 (which can be calculated from the data published for June 1978).

are both near Pittsburgh (the former is a suburb, while the latter is outside the metropolitan boundaries), it is a rather bold assumption to suggest that indexes for the larger area are applicable to small communities in or near that area. In lieu of better data, however, it is hoped that the Pittsburgh indexes generally reflect trends occurring in the smaller communities.

The tax rates for Pittsburgh, McKeesport, and New Castle are shown in Tables 1, 2, and 3, respectively. The city, county, and school district all levy real estate taxes in Pittsburgh. Only the city, however, has a land value tax scheme, with heavier rates applicable to land. Since 1980, new residential improvements have been eligible for a three-year abatement of city, county, and school district improvement taxes. At first, use of the abatements was limited due to lack of knowledge about the abatement program. The number of abatements as a percentage of the number of building permits was quite low in 1980 (about 8 per cent) but has increased substantially since then (to approximately 75 per cent by 1983 [Department of City Planning and Urban Redevelopment Authority 1985, Table A4]). In order to take into account the abatements, the tax rates for 1980 and subsequent years have been adjusted.[20]

For McKeesport and New Castle, it was also necessary to take into account county and school district rates as well as city rates. As in the case of Pittsburgh, the counties and school districts do not have land value tax systems. It was also necessary to take into account changes and differences in assessment ratios and tax abatements for improvements which went into effect in 1979 in McKeesport and 1982 in New Castle.[21]

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[20] The procedure for making this adjustment was to treat the total structure tax rate as a perpetuity, calculate the present value of that perpetuity, and subtract from that the present value of a three-year annuity. The resulting value, expressed as a perpetuity, is the adjusted tax rate. In view of the initial lack of knowledge of the abatement program, the three-year annuities used in this calculation have been adjusted to reflect the level of participation in the program. This was accomplished by multiplying the values of the annuities by the percentage of participation.

[21] The abatements were taken into account in much the same manner as for Pittsburgh.

Table 1
Pittsburgh Real Estate Tax Rates, 1978-1984
(percentages)

Year	Land Tax Rate	Structure Tax Rate
1978	9.9875	7.5125
1979	14.5865	7.3115
1980	17.75	7.523
1981	19.45	8.542
1982	19.8	7.896
1983	21.65	7.492
1984	22.05	7.816

Sources: Pittsburgh City Treasurer's Office (city and school district rates) and County of Allegheny Deed Registry and Records Management Office (county rates).

Table 2
McKeesport Real Estate Tax Rates, 1978-1986
(percentages)

Year	Land Tax Rate	Structure Tax Rate
1978	8.6875	8.6875
1979	8.1865	7.5772
1980	15.9	8.4026
1981	17.9	10.4026
1982	18.85	11.3526
1983	19.05	11.5526
1984	19.05	11.778
1985	20.25	12.1283
1986	20.475	12.3533

Sources: City Treasurer's Office, City of McKeesport; Deed Registry and Records Management Office, County of Allegheny; and Business Office, McKeesport Area School District.

Table 3
New Castle Real Estate Tax Rates, 1979-1986
(percentages)

Year	Land Tax Rate	Structure Tax Rate
1979	5.446	5.446
1980	5.778	5.778
1981	6.586	6.586
1982	8.14	5.853
1983	7.87	5.583
1984	8.82	5.9584
1985	11.49	6.2878
1986	11.97	6.8016

Sources: City Treasurer's Office, City of New Castle; County Treasurer's Office, County of Lawrence; and Business Office, New Castle School District.

Expected Signs of Coefficients

As existing housing is a substitute for new housing, the coefficient of R_e should be positive. If new housing is a normal good, an increase in resident employment should result in an increase in the demand for new housing. Thus the coefficient of M should be positive. Since other goods are substitutes for new housing, the coefficient of P_x should be positive. Increases in the 'real spread' reflect increases in the relative cost of housing capital and, therefore, the coefficient of r should be negative. On the other hand, in the Pittsburgh model, the coefficient of s should be positive because mortgage subsidies reduce the cost of capital. Assuming that increases in the prices of operating and maintenance inputs will increase the cost of producing new housing, the quantity of new housing produced should fall. This implies that the coefficients of P_o and P_m should be negative. The coefficient of G, in the Pittsburgh model, should be negative to the extent that rehabilitation projects represent a diversion of capital from new construction to rehabilitation. The coefficient of b, the tax rate applied to land, should be positive or zero for the reasons given previously.

The coefficient of z, the tax rate applied to improvements, should be positive for Pittsburgh, zero for McKeesport, and for New Castle it should be somewhere between the values for the other two cities.

V. RESULTS

Pittsburgh

The empirical results for Pittsburgh are as follows:[22]

$$\ln Q = \underset{(0.99)}{-0.20} + \underset{(1.54)}{0.89 \ln R_e} + \underset{(2.12)*}{1.12 \ln M} + \underset{(2.69)**}{3.33 \ln P_x} - \underset{(1.19)}{0.73 \ln P_o}$$

$$- \underset{(8.23)**}{5.10 \ln P_m} - \underset{(0.29)}{0.003 \ln G} + \underset{(1.74)}{0.04 \ln r} + \underset{(5.37)**}{0.24 \ln s} - \underset{(1.76)}{0.41 \ln b}$$

$$- \underset{(4.29)**}{2.31 \ln z} + \underset{(13.86)**}{0.70 D}$$

where the absolute values of the t-statistics are given in parentheses and the estimates marked by * and ** are significantly different from zero at the five and one per cent levels, respectively. The high R^2 value of 0.98 indicates that virtually all of the variation in the dependent variable is explained by the independent variables. All of the coefficients have the expected signs except for the coefficients of the land tax rate and the real spread. Neither of those coefficients is significantly different from zero, however.[23]

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[22] Initial estimation of the model indicated a need to adjust for autocorrelation. This was accomplished using the first difference method, with ρ based on the Durbin-Watson d-statistic. In addition, it became evident that there was a need for a dummy variable, D, to capture the effect of an anomalous project that was distorting the Pittsburgh data.

[23] The general model proved to be very robust, as these basic results remained the same despite the various refinements which led up to the specific model for which estimates are shown.

The results show that changes in the land tax rate did not have a significant effect on the amount of housing development in Pittsburgh during the period of study. In contrast, the improvement tax rate is a highly significant determinant of the amount of new housing construction in Pittsburgh. Since the coefficients in the log-linear model are elasticities, a 1 per cent decrease in the improvement tax rate should result in a 2.31 per cent increase in the dollar value of new housing. This implies that a 5 per cent decrease in the improvement tax rate, such as that which occurred at the beginning of 1983, resulted in about an 11.6 per cent increase in the dollar value of new housing construction. Given the mean monthly amount of new housing construction during the study period ($1,076,042), this would represent an increase in construction activity of about $125,000 each month (in January 1978 dollars).

An increase in the dollar value of housing construction could reflect an increase in the number of new units, an increase in their average cost, or both phenomena. Estimating the model with a measure of the number of new units as the dependent variable yields an elasticity estimate of -2.62 for the improvement tax rate variable. Again, the estimated coefficient of the land tax rate is not significantly different from zero while that of the improvement tax rate is. Given the mean monthly number of new housing units during the study period (about 32.7), a 5 per cent decrease in the improvement tax rate would have resulted in about 4.3 additional units each month—a 13.1 per cent increase. Estimating the model with a measure of the average cost of new units as the dependent variable yields estimated coefficients for the improvement and land tax rates that are not significantly different from zero.

McKeesport and New Castle

The empirical results for McKeesport are as follows:

$$\ln Q = \underset{(1.11)}{-0.02} \underset{(0.30)}{- 0.17 \ln R_e} \underset{(1.20)}{+ 0.39 \ln M} \underset{(2.28)*}{+ 2.44 \ln P_x} \underset{(0.31)}{- 0.25 \ln P_o}$$

$$\underset{(2.80)**}{- 2.17 \ln P_m} \underset{(0.05)}{+ 0.001 \ln r} \underset{(0.30)}{+ 0.03 \ln b} \underset{(0.21)}{+ 0.05 \ln z}$$

where the absolute values of the *t*-statistics and the significances are given as before. In this case, only the coefficients for the prices of other goods and services and the price of maintenance inputs are significantly different from zero at the usual levels of significance. Both coefficients have the expected signs. Neither of the tax rate coefficients is significantly different from zero.

Similar results were obtained for New Castle:

$$\ln Q = \underset{(4.46)^{**}}{-0.05} + \underset{(0.14)}{0.02 \ln R_e} + \underset{(0.25)}{0.06 \ln M} + \underset{(2.95)^{**}}{2.30 \ln P_x} - \underset{(0.41)}{0.28 \ln P_o}$$

$$- \underset{(0.72)}{0.52 \ln P_m} - \underset{(1.15)}{0.01 \ln r} - \underset{(0.25)}{0.03 \ln b} + \underset{(0.53)}{0.10 \ln z}$$

where only the coefficient for the prices of other goods and services is significantly different from zero at the usual levels (it also has the expected sign). Again, neither of the tax rate coefficients is significantly different from zero. Both the McKeesport and New Castle estimations yielded high coefficients of determination—0.98 and 0.99, respectively. This fact, coupled with the low *t*-statistics for most of the variables, suggests that there is a problem with multicollinearity in the data for both cities. In other words, the estimation procedure is unable to determine which independent variables are actually having an influence on the dependent variable in each case. This is a rather intractable problem[24] which at best has the advantage of ensuring conservative conclusions.

VI. CONCLUSIONS

The results are consistent with theoretical expectations. The tax on improvements has a significant excise effect in Pittsburgh, a central city, but

[24] The commonly-cited solution of removing independent variables is unsatisfactory because it is likely to result in specification error. As Gujarati (1978, p. 186) notes: "[T]he remedy may be worse than the disease in some situations because while multicollinearity may prevent effective estimation of the parameters of the model, omitting a variable may seriously mislead us as to the true values of the parameters".

no detectable effect in McKeesport, a suburban city. Changes in the tax on improvements had no discernible effect in New Castle, a result which is consistent with the idea that the incentive effect would be less significant in a relatively isolated city than in a central city. The Pittsburgh results also showed that decreases in the improvement tax rate encouraged housing development in Pittsburgh in the form of additional units rather than in the form of increases in the average cost (quality) of new units. This is consistent with Mieszkowski's suggestion that changes in property tax rates should lead to shifts in the location of households. Changes in the tax on land had no significant effect in any of the three cities, suggesting that the impediments to development which could be offset by the liquidity effect were insignificant.

Given the results of this study, land value taxation seems to be a desirable strategy for central cities to employ in seeking to encourage development and attract households. Because households are relatively mobile within metropolitan areas, land value taxation may permit central cities to attract households that would otherwise locate in nearby suburban jurisdictions.

The results of this study should not be taken to imply that land value taxation is not or could not be a useful tool for cities such as McKeesport or New Castle.[25] As was mentioned, land value taxation may have different effects on different classes of property, and it is possible that studies of commercial or industrial properties in those places would yield positive results. Also, the various data problems—particularly the problem of multicollinearity—may have led to excessively conservative conclusions with respect to residential development. In addition, it is possible that changes in public expenditures offset the tax rate changes and skewed the results. Finally, as is true for the incentive effect, the liquidity effect may be significant for some classes of property but not for others or in some places and times but not others. This also suggests that it may not be valid to generalise from the results presented here.

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[25] It should also be noted that land value taxation may be desirable purely on equity grounds. See, for example, the argument put forth by George (1954, pp. 333-346).

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