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The Effect of Shifting the Property Tax Base from Improvement Value to Land Value: An Empirical Estimate

Richard L. Pollock and Donald C. Shoup*

INTRODUCTION

In the literature on property tax reform, one change that is often recommended is either a replacement of the general property tax by a land value tax, or at least a move in this direction by differentially heavier taxation of land than of improvements (a "graded" property tax).[1] Chief among the changes expected by supporters of site value taxation are lower housing costs and more efficient use of urban land. It has long been maintained that a land value tax is neutral in its effect on land development decisions, and that a general property tax discourages capital intensity in development. A change to site value taxation should therefore increase the capital intensity of real estate. However, even if the direction of the effect seems clear on theoretical grounds, the actual magnitude of the effect may be small.

The purpose of the present study is to estimate the effect on capital intensity of urban land development of a reduction in the tax rate on improvements accompanied by an increase in the tax rate on land value, with total property tax revenues held constant.

First, we briefly develop a model of investor decision making, which predicts the impact of land and improvement taxes on capital intensity of urban land development. Then we describe the sample of buildings which serves as the data base to estimate the parameters of the model. Finally, we predict the impact that a reduction in the property tax rate on improvements would have on the optimal capital investment in improvements for the sample of properties.

IMPACT OF PROPERTY TAXES ON REAL ESTATE INVESTMENT

Consider the revenue production function faced by a real estate investor contemplating the construction of a new building on an urban site,

$R = f(K,L,S)$

where:

- R = Annual Net Revenue (ANR) after deduction of operating, maintenance, and management expenses;
- K = capital (in \$) invested in improvements to the site;
- L = land area of the site in square feet;
- S = a vector of site location characteristics;

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[1] A recent example of such advocacy is found in Netzer [1973]

$\frac{\partial R}{\partial K}$ = Marginal Net Revenue Product of Capital (MNRPK);

$\frac{R}{K}$ = Average Net Revenue Product of Capital (ANRPK);

i = required rate of return on investment in real estate;

t_K = improvement tax rate as percent of K.

For any given site (where L and S are fixed), the curves relating ANR, MNRPK, and ANRPK to K might be as shown in Figure 1. If the ANR is assumed to be a constant stream of payments continuing from the date of construction to infinity, the profit-maximizing investment in improvements to a given site occurs where $\partial R/\partial K = i$. In Figure 1, this condition is fulfilled where the MNRPK curve intersects the horizontal interest rate curve at L, and the profit-maximizing investment in improvements is K'. The resulting ANR is R′, which is equal to the rectangle $OK'HJ$ in the lower panel of Figure 1. The annual interest on capital invested in improvements to the site is equal to the rectangle $OK'LE$, and the annual rental value of the site will be equal to the rectangle $ELHJ$.

Within the framework of this essentially Ricardian model of land use, we can analyze how the incentive to invest in improvements is affected by an equal yield ad valorem property tax on two alternative tax bases: (1) improvement value, and (2) land value.[2]

A Tax on Improvements

First, consider an annual property tax on the value of improvements to a site, $T_k = t_k K$, where t_k is the tax rate on improvements. As shown in the top panel of Figure 1, the tax as a function of investment in improvements is a ray from the origin. The ANR net of property taxes $(R - t_k K)$ is shown as the dashed line in the top panel of Figure 1. The MNRPK net of taxes is $\partial(R - t_k K)/\partial K = (\partial K/\partial K) - t_k$, and the ANRPK net of taxes is $(R - t_k K)/K = (R/K) - t_k$; both appear as simple downward shifts of their respective gross-of-tax functions, and are shown as dashed lines in the lower panel of Figure 1.

The profit-maximizing investment in improvements in the presence of the property tax in improvement value now occurs where the net-of-tax MNRPK is equal to the interest rate, $(\partial R/\partial K) - t_k = i$. This investment is shown as K'', which is less than K', confirming the belief that a tax on building value tends to reduce investment in construction of improvements below the level supplied in the absence of the tax. The resulting ANR, R'', is divided among interest payments $(iK'' = OK''FE)$, property tax payments $(t_k K'' = ABCD)$, and land rent $(EFCD)$. The magnitude of the reduction in investment from K' to K'' that would occur in any given case depends on the shape of the MNRPK schedule, and on the applicable tax and interest rates. If the MNRPK schedule is very elastic with respect to K in the vicinity of the optimal investment, even a moderate property tax rate on improvements may significantly reduce investment on the site, while if the MNRPK is inelastic near the optimum, the tax may have little effect on the investment decision.[3]

[2] For a more complete discussion of this model of land development, see Turvey [1957].

[3] The absolute value of the increase in the optimal value of K in response to a reduction in the tax rate on improvements will depend on the slope of the MNRPK schedule between the old and new optimum values of K. For instance, the MNRPK schedule derived from a

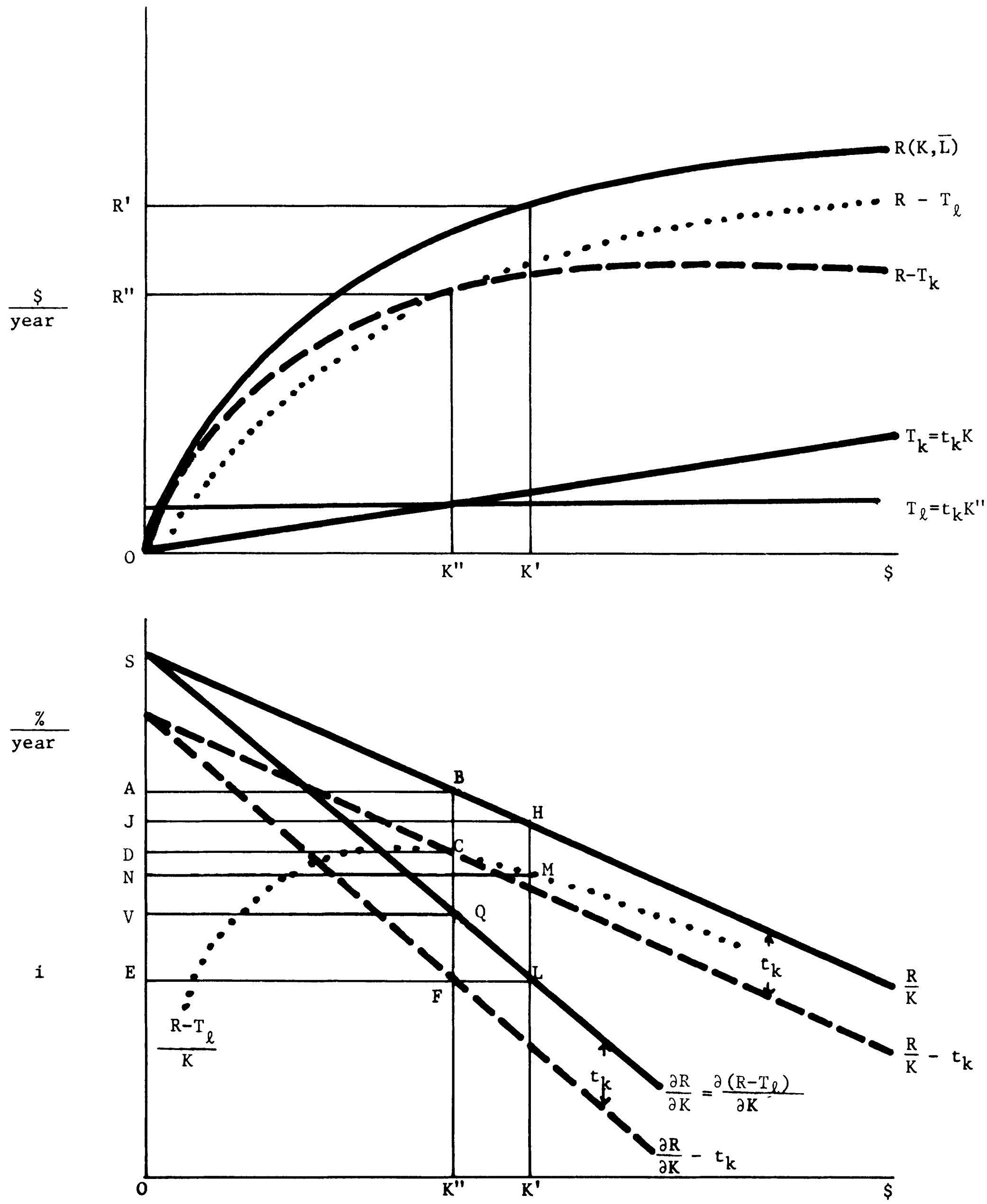
R(K,L̄)
R − Tℓ
R−Tk
Tk=tkK
Tℓ=tkK''
$/year
R'
R''
O
K''
K'
$
%/year
S
A
J
D
N
V
i
E
B
H
C
M
Q
L
F
R−Tℓ/K
tk
R/K
R/K − tk
∂R/∂K = ∂(R−Tℓ)/∂K
∂R/∂K − tk
0
K''
K'
$

FIGURE 1

In the next section we estimate empirically the MNRPK curve for one type of land use, and from this attempt to predict the response of investment to a decrease in the tax rate on that type of improvement. However, it should be noted here that the predicted reduction of capital investment from K' to K'' will overestimate the impact of the tax; in a general equilibrium framework, the decreased quantity of construction would cause an increase in the price of real estate services and a decrease in the price of inputs to the production of real estate services. This would tend to raise the gross-of-tax ANR and MNRPK curves. The reduction in construction would also reduce the demand for capital, and thus reduce its cost, i. Both the upward shift of the gross-of-tax MNRPK curve and the downward shift of the horizontal i curve mitigate the effect on investment of an increase in the tax rate on improvements. Only if there were a perfectly elastic demand for output and supply of inputs would the ANR and MNRPK curves and the opportunity cost of capital be unaffected by the tax. Thus, our model will normally overestimate the impact of taxes on investment.

A Tax on Land Value

The tax on improvement value yields a revenue of $T_k = t_k K''$. An equal-yield tax on land value, $T_\ell = t_K K''$, would not vary with the value of the improvement to the site and would therefore be represented by a horizontal line equal in value to $t_k K''$, as shown in the top panel of Figure 1. The ANR net of the land tax would be represented by a simple downward shift (dotted line) of the original gross-of-tax ANR, with the slope everywhere unchanged. Since T_ℓ is independent of K, $\partial(R - T_\ell)/\partial K = \partial R/\partial K$ and the MNRPK curve is unchanged. Since the MNRPK is unaffected by the land tax, the optimal investment in improvements is also unaffected, and is greater than the optimal investment that resulted from the equal-yield improvements tax.[4] The resulting ANR is divided between returns to capital ($iK' = OK'LE$) and returns to land ($ELHJ$), with the returns to land being further divided between tax payments ($T_\ell = HJNM$) and after-tax rent ($ELMN$).

If taxes on improvements were partially or wholly replaced by taxes on land value, the reduction in the tax rate on improvements should tend to increase investment in improvements, while the compensating increase in the tax rate on land value should have no effect on investment. The estimated impact of the tax change is thus due only to the reduction in the tax rate on improvements. We now proceed to estimate the impact on investment in improvements which would be produced by a reduction in the tax rate on building values, with revenue maintained constant by a commensurate increase in the tax rate on land value.

AN EMPIRICAL ESTIMATE OF THE REAL ESTATE PRODUCTION FUNCTION

The elasticity of the MNRPK schedule will determine the allocative impact of

Cobb-Douglas production function will have a constant elasticity and changing slope throughout the entire schedule, with a lesser slope for larger values of K. Thus, the increase in investment will depend not only on the elasticity of the MNRPK schedule, but also on the initial optimal value of K.

[4] A land tax may, however, alter the *timing* of urban land development, and through this the capital intensity. For a discussion of this issue, see Shoup [1970].

any untaxing of capital resulting from the partial conversion of the conventional property tax into a site value tax. If this schedule is highly elastic in the relevant range, any upward shift in the after-tax schedule resulting from the untaxing of improvement value will, ceteris paribus, tend to induce a significant increase in the amount of capital being applied to specific sites by the profit-maximizing developer. Conversely, if the MNRPK schedule is relatively inelastic over the relevant range, any upward shift of the schedule induced by an improvement tax rate reduction is not likely to lead to a pronounced increase in the amount of capital being applied to specific sites in the land development process.

Despite strong theoretical arguments in favor of site value taxation, most empirical studies on the effects of site value taxation [Richman 1965; Woodruff and Ecker-Racz 1969; Clark 1974] suggest that real estate investment decisions are surprisingly insensitive to changes in the property tax rates on improvements of a magnitude that might be expected to accompany a shift to site value taxation. Archer [1972] and Grieson [1974] provide a contrary view.

The scarcity of empirical work on production functions in the real estate sector is not surprising in view of the scarcity of necessary data. Many factors may affect the annual revenue of individual buildings in any cross-section study—the amount invested in construction of the improvement, size of the site, zoning, accessibility, quality of public services, neighborhood characteristics, etc. A regression equation with annual net revenue as the dependent variable and with appropriate measures of land, capital, and all other factors that affect revenue as the dependent variables would describe the desired relationship:

$$R = f(K, L, S_1, \ldots, S_n)$$

where K is the capital invested in improvements to a site; L is the land area (in square feet) of the site; and $S_1 \ldots S_n$ are measures of site characteristics other than size. Unfortunately, it is difficult to find a sample of buildings for which it is possible to obtain appropriate measures of all the relevant variables. Several preconditions may be mentioned.

First, there is the problem of measuring capital. If the capital input is measured by the dollar amount invested in construction, construction technology and construction input prices should be uniform for the sample of buildings; otherwise, the same dollar amount invested in construction on similar sites but with differing technology or input prices could produce differing quantities of physical capital, and an error in the measurement of capital would be introduced. Because construction costs generally increase over time and may vary from one location to another, this assumption of uniform technology and input prices would be most nearly met if all buildings in the sample were constructed in the same area, for the same use, and at roughly the same time.

Second, since the model refers to the effect of property taxes on the equilibrium capital intensity of land development, all improvements in the sample should be optimal for their sites in relation to the current demand and supply conditions at those sites. If, because of changed demand and supply conditions since the date of construction, an existing building is no longer of the appropriate type for its site (e.g., if an office building of the same initial cost would now yield a higher annual net revenue than the existing apartment building), then its annual net revenue as a function of the capital and land inputs will not lie on the envelope curve of Figure 1. The assumption that a building is the optimal one for its site is most nearly met for newly constructed buildings, because in the putty-to-clay new construction decision the developer is able to choose exactly what to build, while subsequent changes in building design or use are generally much more difficult to make.[5]

A third difficulty concerns the definition and measurement of the land input. In this model, land rent (and therefore land value) is derived as a residual that remains when all other factors have been paid, and it would therefore be circular reasoning to use land value as as independent variable to explain annual net revenue. However, if site *size* is used as the measure of land input, it is clear that the annual net revenue as a function of capital and site size depends greatly on the site characteristics such as accessibility, neighborhood composition, zoning, slope, drainage, etc. Thus, if the area of the site is to be the measure of land input, these other site characteristics must be controlled for, either by including each characteristic as an independent variable (a difficult task of data collection) or by selecting a sample of sites for which all site characteristics other than size are uniform. In the following empirical work we employ this second method of controlling for the effect of site characteristics by using a sample of sites located within an area small enough to be homogeneous with respect to all important site characteristics.

The preconditions for an empirical estimation of a real estate revenue production function appear to have been satisfied in the case of tourist hotel investments in Waikiki in the 1965 to 1973 period. A Hawaiian tourist boom in the latter half of the 1960s stimulated a boom in hotel construction in the primary tourist destination area of Waikiki. Since the Waikiki "island" is a relatively small and well-defined area of about one square mile in size, the site characteristics under the new hotels are relatively homogeneous. This set of circumstances affords an opportunity to estimate a real estate revenue production function, $R = f(K, L, S)$, since a significant number of different capital improvements in the same industry were made on sites in a relatively small homogeneous land area within a short period of time. Moreover, the Hawaii graded property tax assessment procedure, in which accurate separation of land and improvement value is required, makes available a significant amount of reliable empirical cost and revenue data for the outside analyst.

Overview of the Estimation of a Revenue Production Function

The derivation of the desired MNRPK schedule requires the cross-section estimation of a revenue production function to identify the relative roles of capital and land in explaining the revenue of hotels built in Waikiki between 1965 and 1973. Since we are trying to explain the *net* revenue available to capital and land, the revenue variable used as the dependent variable in the production function is net of all out-of-pocket, noncapital operating expenses. The net revenue before property taxes then includes depreciation, interest payments, profit, and land rent. Taking land and capital as

[5] However, even some new buildings may not be currently optimal for their sites. Because building changes are hard to make once construction is finished, developers may over-build in relation to current conditions if they anticipate future growth in demand.

the independent variables, and annual net revenue as the dependent variable, a Cobb-Douglas revenue production function is estimated by a linear regression analysis. The resulting coefficients for land and capital are then used to derive an MNRPK schedule: for any assumed fixed site, the marginal rate of return to successive increments of capital to the site can be calculated for the prevailing cost and revenue conditions.

This revenue production function approach to the determination of productivity or profitability of capital applied to a given site thus requires several crucial types of data input for each hotel for some common point or period of time: (a) a measure of the annual revenue net of operating and maintenance expenses; (b) a measure of the construction cost of the hotel; and (c) a measure of the land input for each hotel.

The sample of hotels being used in this inquiry consists of 30 large resort hotels constructed in Waikiki after 1965.

The Measure of Annual Net Revenue

As indicated in the discussion of the model, the dependent variable is Annual Net Revenue (ANR), the expected return to capital and land net of all operating expenditures. An estimate of this was obtained by first calculating the gross revenue of each hotel from data on the number of rooms and 1973 room rates for each hotel, and from average 1973 occupancy rates. The gross revenue of each hotel was then multiplied by the average operating expenses, as a percent of gross revenue, for all Hawaiian tourist hotels.[6] The estimated operating expenses for each hotel are then subtracted from gross earnings to obtain an estimate of ANR for each hotel. This is an admittedly imperfect method of estimating ANR, but it is made necessary by the general unavailability of more appropriate data.

Measure of Land Input

The measure of land input is the land area of the site on which the hotel has been constructed. In view of the homogeneous confined nature of the Waikiki area, any site differences, other than site size, which might account for significant differences in the revenue-generating capacity of hotels should be slight. The land area in square feet assigned to the site under each hotel is determined by data from the Hawaii Tax Office.

Measure of Capital Input

The construction cost (in 1973 dollars) of the hotel on each site is the measure of the capital input applied to that site. Except for a 70 percent assessment ratio adjustment, the initial tax assessment of the building portion of each hotel is the construction cost of the new building. An adjustment of the original construction cost by the Hawaii Tax Office's construction cost and depreciation index provides an estimate of the construction cost of each hotel in 1973 dollars.

Estimation of Revenue Production Function and MNRPK Schedule

The cross-section data described in the preceding sections provide the empirical

[6] Data on operating expenses are found in Harris, Kerr, Forester and Company [1973]. If the ratio of operating expenses to gross revenue increases systematically with the age of the structure, this procedure will bias upward the estimate of operating expenses, for this sample is newer than the average Hawaiian tourist hotel.

basis for estimating a Cobb-Douglas revenue production function with land and capital as the two inputs. Revenue is gross of property taxes,

$$R = AL^{\alpha}K^{\beta}$$

where:

R = Annual Net Revenue of the hotel (in thousands of dollars);
L = land input (site area in square feet);
K = capital input (construction cost in thousands of dollars);
A = constant term;
α = elasticity of net revenue with respect to land input;
β = elasticity of net revenue with respect to capital input.

When this function is fitted to the data, the following specific revenue production function is estimated (t-values in parentheses):

$$\log R = -.91750 + \underset{(2.08)}{0.27303} \log L + \underset{(5.936)}{0.7329} \log K$$

$$R^2 = .926 \quad SEE = 0.09552 \quad F\text{-value} = 168.86 \quad N = 30$$

The estimated coefficients for both site area and construction cost are significant at the 5 percent level. The sum of the capital and land coefficients is 1.06, which suggests that the production function exhibits no significant economies of scale.

By partial differentiation of the revenue production function and substitution of the estimated parameters, the equation for the MNRPK is

$$\frac{\partial R}{\partial K} = A\beta L^{\alpha}K^{\beta-1} = .293L^{.273}K^{-.268}$$

This equation is used below to estimate the impact of changes in the tax rate on improvement value.

ESTIMATED IMPACT OF PROPERTY TAXES ON REAL ESTATE INVESTMENT

In equilibrium, the developer will invest in improvements to land up to the point where the MNRPK is equated to the interest rate plus the tax rate:

$$\text{MNRPK} = A\beta L^{\alpha}K^{\beta-1} = i + t \qquad [1]$$

The optimal investment in improvements in the presence of a property tax is:

$$K'' = \left(\frac{i+t}{A\beta L^{\alpha}}\right)^{\frac{1}{\beta-1}} \qquad [2]$$

and the partial derivative of investment with respect to the tax rate is:

$$\frac{\partial K''}{\partial t} = \frac{1}{A\beta L^{\alpha}(\beta-1)} \cdot \left(\frac{i+t}{A\beta L^{\alpha}}\right)^{\frac{1}{\beta-1}-1} \qquad [3]$$

The elasticity of capital investment with respect to the property tax rate is therefore:

$$\epsilon_{Kt} = \frac{\partial K''}{\partial t} \cdot \frac{t''}{K} = \frac{1}{A\beta L^{\alpha}(\beta-1)} \cdot \left(\frac{i+t}{A\beta L^{\alpha}}\right)^{\frac{1}{\beta-1}-1}$$

$$\cdot \frac{t}{\left(\frac{i+t}{A\beta L^{\alpha}}\right)^{\frac{1}{\beta-1}}} = \frac{-t}{(i+t)(1-\beta)} \qquad [4]$$

The extent of the capital investment response to a change in the property tax rate thus depends not only on the value of the coefficient β in the MNRPK schedule, but also on the required rate of return, i, to which the MNRPK is equated and on the size of the initial property tax rate, t, on improvements.

When the MNRPK equation derived from the revenue production function estimated for our sample of sites is evaluated with the actual values of L and K for each hotel, the mean value of MNRPK before property taxes is 15 percent and the standard deviation is 4 percent. This is taken as the estimate of the required marginal rate of return before corporation income taxes. When corporation income taxes are deducted, the after-tax rate of return to investors would, of course, be lower.[7] To show the sensitivity of investment response to other assumptions we also show results based on several other rates of return which bracket the mean.

In Honolulu, the effective property tax rate on hotel buildings was 1.07 percent of market value in 1973. The maximum possible reduction in tax rate is thus 1.07 percent, and a graded property tax would result in smaller reductions in the tax rate on improvements.

With the observed value for t and the estimated values for i and β for our sample of buildings, the estimated elasticity of investment with respect to the tax rate from equation [4] is:

$$\epsilon_K = \frac{-.0107}{(.15 + .0107)(1 - .7329)} = -.25$$

If the actual elasticity were of this size, a complete elimination of the property tax on improvements would in long-run equilibrium lead to approximately a 25 percent increase in optimal capital investment. The elasticity of investment with respect to the tax rate for a variety of assumptions concerning t and i are shown in Table 1. It can be seen that at lower interest rates, changes in taxes would have a greater influence on the optimal capital intensity of land development. At higher interest rates, property taxes constitute a smaller proportion of the total cost of capital, and thus reductions in the tax rate would have a relatively smaller effect on investment.

TABLE 1
ELASTICITY OF INVESTMENT WITH RESPECT TO TAX RATE

$$\epsilon_{Kt} = \frac{-t}{(i + t)(.2671)}$$

	t		
i	.005	.010	.015
.18	−.10	−.20	−.29
.16	−.11	−.22	−.32
.14	−.13	−.25	−.36

CONCLUSIONS

The findings of this study lend tentative support to the view that a shift from general property taxation toward site value taxation can have a significant impact on the degree of capital intensity of improvements to land. For the real estate revenue production function estimated here, elimination of the tax rate on improvements would increase the long-run equilibrium investment in improvements by a maximum of 25 percent.[8] This increase in investment is,

[7] Because property taxes are deductable in computing taxable corporate income, the real property tax rate facing corporate decision makers can be considerably lower than the conventionally measured effective property tax rate. The sensitivity of our results to assumptions about the property tax rate is shown below.

[8] Since most real estate services are produced by the existing stock of improvements, in the short run the overall supply of improvements is considerably less elastic than is the supply of new construction. Muth [1960] suggests that in the housing market 90 percent of any deviation from equilibrium will be adjusted in six years, while Mills' [1972] investigation of urban density functions suggests that only about one-fourth of any deviation from equilibrium is corrected in any five-year period.

however, very much of an upper-bound estimate because it ignores several general equilibrium effects that are omitted in this analysis, but which should be mentioned. Increased capital investment will increase the cost of construction and operating inputs if the supply of construction is less than perfectly elastic, and will reduce the gross revenue generated by any investment if demand for hotel space is less than perfectly elastic. Both of these supply and demand effects will tend to make the MNRPK schedule less elastic than here estimated, and will thus tend to reduce the investment response to a tax rate change. Further, if the supply of capital is less than perfectly interest elastic, the increase in investment resulting from a tax reduction will raise the interest rate, and this too would reduce the investment response below what was estimated from our data. This effect on interest rates may not be of great importance if only one community is introducing the graded property tax, but would have to be considered if this were a national policy. Finally, this estimate refers to only one particular form of improvement in one location, and the adoption of a graded property tax would almost certainly have further effects on the location, composition, and timing of all forms of new construction in urban areas. At the very least, the partial equilibrium production function approach to this question does not demonstrate that untaxing improvements would have an insignificant effect on the supply of improvements.[9]

The generality of the present results must be qualified by the restricted nature of the location and industry that serve as the data source. The large number of recently constructed buildings on similar sites provided an opportunity to estimate a production function for one type of real estate service, but the specificity of the data requires that the policy conclusion be correspondingly restricted. However, the results do imply that in some circumstances there is empirical evidence for the theoretically expected effect of land value taxation on capital intensity of development.

[9] It is interesting to compare our results with those of Grieson [1974]. Using a general equilibrium model and aggregate data, Grieson estimated that a total elimination of the property tax on improvements would increase the supply of structures by 23 percent. Though the approaches in his and the present studies are entirely different, one using aggregate data in a general equilibrium model and the other using microdata in a partial equilibrium model, both suggest that the impact on new construction may be quite significant.

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