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Symposium on "Factor Mobility and Local Taxation", October 17, 1985

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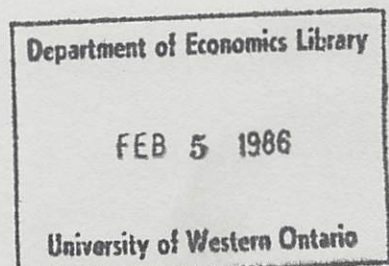
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Department of Economic History
FEB 2 1986
University of Western Ontario

Factor Mobility and Local Taxation

This one-day symposium was held on October 17, 1985 in the Department of Economics at The University of Western Ontario. Four excellent papers were presented. Anwar Chaudry-Shah (Department of Finance, Ottawa) presented some results from an empirical study on the capitalization of net fiscal benefits, arguing that a capitalization approach to measuring net fiscal incidence is superior to other, ad hoc, methods which appear in the literature. John Wilson (University of Indiana) presented some novel, and intriguing results derived from a multi-jurisdictional model of tax competition. Extending the conventional model in which only one good is produced to a two-good setting, Wilson's analysis uncovers an inefficiency associated with tax competition that has hitherto remained unrecognized; namely, an inefficient distribution of public goods supplies across jurisdictions and corresponding inefficient trade. Jan Brueckner (University of Illinois) presented some results, based on a static model of a single tax jurisdiction, on the effects of moving to a split rate property tax system in which land is taxed relatively more heavily than capital. Bernd Gutting (University of Western Ontario and Mannheim University) concluded the presentations with an analysis of the effects of conventional property taxes and of site value taxes on the time path of urban land development using a dynamic model in which land is treated as a non-renewable resource. Finally, a joint session was held with the International Trade Workshop.

At least as important as the papers themselves was the discussion among the participants before, during and after the symposium. These included Kul Bhatia (Western), Sam Bucovetsky (Western), Jim Davies (Western), Paul Hobson (Western), Dondon Paderanga (Western and University of the Philippines), David Pines (Western and Tel Aviv University), Mike Veall (Western), and John Whalley (Western).

The diversity in the issues addressed and in the interests of the participants is indicative of the broad range of issues which arise in the analysis of local government; researchers in this area must draw on the literature of both public finance and international trade in pursuing their research.

The workshop was co-sponsored by the Centre for the Study of International Economic Relations (CSIER) and the Centre for the Analysis of National Economic Policy (CANEP). Financial support from these two Centres is gratefully acknowledged. The workshop was organized by Sam Bucovetsky and Paul Hobson with the assistance of Barb Ross.

A CAPITALIZATION APPROACH TO
FISCAL INCIDENCE AT THE LOCAL LEVEL

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ABSTRACT

This paper notes the limitations of conventional approaches to fiscal incidence at the local level notably the "reasonable assumptions" and the "Aaron and McGuire" approaches and suggests an alternate objective methodology to measure redistribution based on an analysis of the capitalized burdens and benefits of the local public sector. The empirical analysis presented in this paper implies that the overall impact of the local public sector in Edmonton, Canada is to redistribute income from the middle class to the poor and the rich homeowners.

* This article is based on the author's doctoral dissertation which received a prize in the Outstanding Doctoral Dissertation Awards Competition sponsored by the National Tax Association - Tax Institute of America in 1983. The author is grateful to Professors Melville McMillan, Wallace Oates, Carl Shoup, Dick Netzer, Roger Smith, Sam Wilson, Bev Dahlby and Dr. Saleh Nsouli for encouragement and helpful comments and suggestions. The errors that still remain are the sole responsibility of the author alone.

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A CAPITALIZATION APPROACH TO
FISCAL INCIDENCE AT THE LOCAL LEVEL

1. INTRODUCTION AND AN OVERVIEW OF APPROACHES TO FISCAL INCIDENCE

This paper argues that an analysis of the capitalized burdens and benefits of the local public sector offers a simple, straightforward and objective computational methodology to fiscal incidence at the local level. This (capitalization) approach represents a major departure from the highly discretionary and imprecise computational environment of the "reasonable assumptions" and Aaron and McGuire approaches. Section 1 provides an overview of approaches to fiscal incidence. The capitalization approach is discussed both from conceptual and operational points of view in sections 2 and 3 respectively. Section 4 and 5 present results using alternate procedures and section 6 notes major limitations of the approach. Section 7 provides a summary of the conclusions. An appendix to the paper estimates the distribution of net fiscal incidence among communities in Edmonton, Canada.

During the past two decades several important studies have been published which investigate the redistributive implications of federal, provincial and local government finances in Canada.¹ All the Canadian studies on the subject in general follow the methodology used for similar studies in the U.S. These studies differ as to the shifting of tax burden assumptions and the concept of income employed and understandably their results also vary accordingly. A major common criticism of these approaches is that their "distribution conclusions depend crucially on what incidence hypothesis is chosen".² Bird and Slack (1978) correctly note that all these studies merely illustrate what the

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1. See Ross (1980) and Reuber (1978) for summaries of Canadian studies on fiscal incidence. See also Ballentine, Thirsk and Dean (1978), Gillespie (1965, 1976) and Clayton (1966).
 2. Musgrave and Musgrave (1976), p. 394.

distribution of fiscal incidence would be if the incidence assumptions were true.³ The numerical estimates thus derived have limited significance although they are often used to support the assumptions from which they are derived.

Musgrave, Case and Leonard (1974), for example, illustrate property tax incidence using broad income (money income plus accrued asset gains) as a measure of income and assuming that the tax on owner-occupied housing is borne by owners and on rental housing by tenants; and non-residential portion of the tax is shifted one-half to consumers and one-half borne by all asset holders in proportion to capital income (the "traditional" incidence hypothesis). Using these assumptions they find support for the "traditional" view of the property tax incidence i.e. the tax is regressive. However, when the allocation basis is changed and all property taxes are allocated in proportion to total income from capital, they find support for the "new view" i.e. the incidence of the local real property tax is progressive.

The approaches to benefit incidence are no less controversial. Gillespie (1965) pioneered the reasonable assumptions approach to benefit incidence. This approach identifies beneficiary groups for each public good and then makes reasonable assumptions as to the distribution of benefits using one or more concepts of income. Aaron and McGuire (1970) sought to improve upon Gillespie's work by deriving benefits allocation implications for public goods by postulating a utility function and placing reasonable restrictions on it.⁴ They theoretically

3. See Bird and Slack (1978), p. 152-154.

4. Aaron and McGuire assume that (i) identical preference maps for all individuals; (ii) utility functions additively separable in public and private goods; (iii) output of public goods is efficient; and (iv) perfect information.

establish the rule that imputed benefits of public goods should be allocated in inverse proportion to the marginal utility of income.⁵

The Aaron and McGuire approach was initially thought to be superior to Gillespie's approach as it provided a more rigorous framework for empirical estimation. Brennan (1976), however, quite persuasively argued and Aaron and McGuire (1976) agreed that the elasticity of marginal utility of income could not be empirically estimated. Ballentine et al. (1978) discuss alternate assumptions under which both the approaches reach similar conclusions. Table 1 highlights these similarities using alternate incidence hypotheses.

Without going into a detailed critique of the approaches to the benefit incidence, it is obvious that the accepted doctrines are equally imprecise as those adopted for tax incidence due to the use of highly discretionary procedures.⁶

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5. At first it was thought that the elasticity of marginal utility of income could be estimated and researchers used as a proxy for this magnitude the reciprocal value of the overall elasticity of substitution among consumer goods. Based on Powell (1965) Maital placed an estimate of the elasticity of marginal utility of income for Canada at 1.55. It followed that the imputed benefits from public goods operates to make income distribution less equal. Maital (1975) using 1960 data for the U.S. demonstrates that the distribution of net fiscal incidence will be pro-poor if Gillespie's methodology is followed and pro-rich if the Aaron and McGuire approach is adopted. Neenan (1972) proposed that the elasticity of the marginal utility of income could be inferred from empirical studies on the determinants of public expenditures and the demand for public goods. From a review of these studies, he concluded that the benefits from public goods are distributed proportionally to income. See also Martinez-Vazquez (1982).
 6. For an overview of criteria and procedures used for benefit imputation see Pfaff and Asam (1978).

Table 1 DISTRIBUTIONAL IMPLICATIONS OF APPROACHES TO BENEFITS INCIDENCE

<u>BASIC ASSUMPTIONS</u>		<u>DISTRIBUTIONAL RESULT</u>
<u>Gillespie</u>	<u>Aaron and McGuire</u>	
Allocation of Benefits by:		
Families	$\phi < 1$	PRO-POOR
Disposable Income	$\phi = 1$	NEUTRAL
Wealth	$\phi > 1$	PRO-RICH

Symbol ϕ = elasticity of the marginal utility of income.

Sources: Ballentine et al. (1978), p. 147.

2. AN ALTERNATE APPROACH TO DERIVE THE NET FISCAL INCIDENCE OF THE LOCAL PUBLIC SECTOR

A simpler and more straightforward approach to local budget incidence is possible with the help of disaggregated data on real estate transactions. Current tax payments and expenditures do not provide an adequate guide to the burdens and benefits of the local public sector. Residential property taxes lower residential property values, and public expenditures enhance residential property values. The net effect of these two opposing influences would constitute net fiscal incidence of the local public sector. Capitalization studies use a hedonic index approach to investigate the impact of local public sector on housing prices. Typically, the price of a house is depicted as a function of the valuation of the various characteristics of the house namely structure, site, neighbourhood, public services and taxes. The correct specification of the tax price term in this equation is the subject of an ongoing debate. Oates (1969) used effective tax rate (taxes/house price) as the tax price term in his empirical investigation and until recently most subsequent studies followed suit. King (1977) and Reinhard (1981) have recently argued that the tax effect is incorrectly treated in an Oates type equation and have advocated an alternate approach using annual property tax payments (\$) per household as the tax price term. Chaudry-Shah (1983) finds that both specifications yield comparable estimates if intrajurisdictional variations in taxes is also captured by the model. We, therefore, modify both Oates and King-Reinhard approaches to distinguish empirically intrajurisdictional capitalization of taxes due to random assessment errors within each jurisdiction and interjurisdictional capitalization due to differences in the effective tax rates among jurisdictions. Our respecification of these models to capture the separate effects of the two above mentioned influences is reported below.

Oates Approach

$$P = \alpha_0 + \beta_1 X_1 + \delta PS + \gamma_1 TMT + \gamma_2 MT + \epsilon_1 \quad (1)$$

- where
- P = House sales price.
 - X_1 = Structural, side and public services characteristics of a house.
 - PS = Output or expenditure measures of local public services.
 - MT = Municipal effective tax rate.
 - TMT = T-MT = Difference between house effective tax rate and municipal effective tax rate.

The MT variable in the above equation captures interjurisdictional influences, TMT will measure the effect of intrajurisdictional property tax differentials for the sample communities and the measures of local public services estimate the influence of alternate mix and level of local public sector output.

King-Reinhard Approach

$$P + (b_1/r) TAXDIF + (b_2/r) MTAX = \alpha_0 + \sum \beta_i X_i + \delta PSI \quad (2)$$

- where
- MTAX = Municipal mean property tax per household (\$).
 - TAX = House property tax bill (\$).
 - TAXDIF = TAX - MTAX

MTAX is used to estimate interjurisdictional influences whereas TAXDIF captures random assessment differentials within jurisdictions.

3. OPERATIONALIZING THE CAPITALIZATION APPROACH TO FISCAL INCIDENCE

The capitalization approach is empirically implemented by analyzing the variations in residential property values due to the provision and financing of local public goods in the City of Edmonton as revealed by the house price regressions. For this purpose disaggregated data on house sales based on a stratified random sample of 875 residential properties sold in the summer of 1977 in twenty-seven communities within the city of Edmonton and eight neighbouring municipalities in the Edmonton metropolitan region was collected. Basic data on house characteristics and property taxes were obtained from the Multiple Listings Service. Supplementary data on spending and output measure of local public services were assembled from a variety of sources. The original data set was collinear and application of ridge regression did not offer any significant improvement. Therefore, in our analysis, as a possible solution to the multicollinearity problem, at the first stage we utilize canonical analysis to form composite variates.⁷ In subsequent regression analysis these variates replace the original variables. The canonical analysis was used to reduce the number of original independent variables to a subset of a manageable size. Three composite indexes comprising structure, side and public services characteristics were obtained. With this procedure, we were able to utilize some valuable data which could not be used in regressions ignoring multicollinearity correction. PSI index is composed entirely of output indicators of

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7. What if one of the independent variables not in the subset is correlated with original variables in the subset replaced by the composite variate? This poses no difficulty so long as the independent variable in question is not strongly correlated with the new composite variate. In fact, in such a situation the regression equation using canonical estimators would have a smaller mean square error than the one with OLS estimators in their original form. If on the other hand, the independent variable in question is more strongly correlated with the composite variate than the original variable set in pairwise relation, then the technique is not helpful for it would lead to imprecise estimates. This problem is not encountered in our analysis. Much work remains to be done on the efficiency and unbiasedness of canonical estimators but McCallum (1970) has shown that under certain conditions the composite estimators will have smaller mean square error than OLS estimators.

public services. The index is positively related to AS (achievement score), PARK (park area), PKIS (park and recreation subprogram index), PBT (per capita bus trips per week by each neighbourhood) and negatively to RFR (residential fire rate) and PTC (per capita total crimes by each neighbourhood). Thirty-five canonical indices representing composite public services output characteristics for twenty-seven communities within the city of Edmonton and eight neighbouring municipalities were formed. These indices proved useful in deriving improved estimates of public sector capitalization within and across the sample municipalities. It may be noted that 13.2% of the variance in the price of housing is explained by the public services index. Similarly 53.3% and 23.2% of the variance in the price of housing is explained by structure and site composite indexes.

In investigating public sector capitalization based on the effective tax rate variable (the Oates approach) we estimated several equations using a variety of models and data. Of these models Equation 1 (see Table 2) appears to be most satisfactory based on theoretical considerations and empirical results. It distinguishes between intra- and inter-jurisdictional aspects of property tax capitalization. It also incorporates quality indices for public sector output which are theoretically preferable over expenditure measures. Moreover, these measures are neighbourhood specific as opposed to expenditure measures of public services which are only available at the municipal jurisdiction level. Empirically, the equation overcomes the multicollinearity problem by incorporating a composite measure of public services which is not collinear with other regressors. All the independent variables appear with statistically significant coefficients having sizes and signs consistent with a priori expectations.

As an alternate approach to tax capitalization, we also estimated models using the annual property tax bill (\$) per household as an explanatory variable (the King-Reinhard approach). These models also differed as to the choice of public sector variables and econometric technique employed. Of these models, Equation 2 (see Table 3) presents superior results than alternate estimating equations. Recall that the

model incorporating the King-Reinhard suggestions is non-linear both in variables and parameters. Equation 2 estimated this model by non-linear method based on a Quasi-Newton algorithm. This procedure enabled us to obtain more precise estimates of all regressors without encountering the heteroskedasticity problem often encountered with the use of iterative linear methods. Furthermore, the equation utilized composite indices of structure, site and public services characteristics and thus a very small set of significant regressors explained most of the variations in the house price. All the regressors appear with the expected signs. Like Equation 1 it also enables us to estimate the extent of both within and across jurisdiction tax capitalization.

The above mentioned equations are used to determine the net fiscal incidence of the local public sector in Edmonton. The mechanics of this approach is described in the following paragraphs.

Table 2
 ESTIMATION OF WITHIN AND ACROSS JURISDICTIONS PUBLIC SECTOR CAPITALIZATION - MODIFIED OATES APPROACH
 (875 Observations)
 Dependant Variable=P (house price)

EQUATION 1			
	METHOD	OLS	
	INTERCEPT	17180.0	(1.6)
Number of rooms	ROOMS	309.5	(1.0)
Dwelling size (square feet)	DSIZE	1611.0	(14.5)
Living room area (square feet)	LRA	36.8	(5.0)
Age of dwelling	AGE	-206.2	(-8.6)
Fire Place Dummy	FP	1986.1	(2.0)
Family Room Dummy	DFR	2539.0	(3.6)
Number of bathrooms	BATH	1669.1	(2.4)
Garage size	GAR	2868.9	(4.9)
Brick-Stone Exterior Dummy	BRST	6818.1	(4.0)
Lot size (square feet)	LSIZE	2.8	(9.3)
General Accessibility Index	GAI	19.3	(1.0)
Income (\$)	Y	188.9	(1.6)
Effective tax rate minus MT	TMT	-1850.0	(-7.4)
Mean Municipal Effective Tax Rate	MT	-1691.6	(-2.3)
TMT Dummy for St. Albert	TMT241	-3950	(-.99)
MT Dummy for St. Albert	MT241	-610.4	(-2.0)
Public Services Index	PSI	7196.5	(8.8)
	R ²	.6576	
	S.E.E.	10800	

Table 3
PUBLIC SECTOR CAPITALIZATION ESTIMATION BASED ON MODIFIED KING-REINHARD APPROACH

EQUATION 2

METHOD		NON-LINEAR	
INTERCEPT		29945.0	(1006.0)
STRUCI	Structural Characteristics Index ¹	25877.0	(56.0)
SITEI	Site Characteristics Index ²	10284.0	(27.3)
Y	Income	177.5	(1.8)
PSI	Public Services Index ³	6661.2	(9.4)
TAXDIF	House tax bill minus mean municipal tax bill	-41.8	(-9.7)
MTAX	Mean Municipal tax bill	-19.9	(-7.8)
TAXDIF21	TAXDIF Dummy for St. Albert	-66.2	(-2.0)
MIAX21	MTAX Dummy for St. Albert	-25.4	(-4.1)
LF*		-9340.9	

Notes:

- 1 Canonical composite index based on Number of rooms, Dwelling size, Living room area, Age, Fireplace dummy, Recreation or Family room dummy, Number of 3 or 4 piece bathrooms, Garage size and brick/stone exterior dummy.
 - 2 Canonical composite index based on lot size, general accessibility index, distance from Central Business District, distance from a bus stop and population density.
 - 3 Canonical composite index based on achievement score, park area, recreations programs index, residential fire rate, per capita weekly bus trips and neighbourhood crime rate.
- * Log-likelihood function.

To derive the incidence of the residential property tax, the empirical procedure involves the following steps:

Step I: The mean capitalized tax burden for each neighbourhood is obtained by multiplying the regression coefficient of the tax variable with the mean value of that variable for each neighbourhood.⁸ We obtain 27 observations this way. This assumes that the marginal tax effects across neighbourhoods are the same whereas average effects vary due to differential effective tax rates and mean tax payment per household for various subareas within the City of Edmonton. These values are then annualized by applying a factor obtained from standard mathematical tables based on assumed values of the discount rate and the time horizon.

Step II: The resulting tax burden estimates are then classified by family income class (Table 4) using median family income of each neighbourhood (Table A1) as a criterion. These figures are then averaged for each class.

Exactly the same procedure is used for benefit estimation except that the mean neighbourhood tax variable values in step I are replaced by the neighbourhood public services indices (PSI). As the public services included in the index account for only 59 per cent of total local public expenditure, benefit estimates are inflated by a factor of 1.7 ($=1/0.59$) to account for excluded services. This assumes that benefits from omitted services are capitalized in the same manner as benefits from included services.

This approach is implemented in the remainder of this paper and, where appropriate, incidence results are compared with the other Canadian studies. The focus of this approach is on total benefits and

8. Danziger (1976) evaluates regression results at mean values in a study of the determinants of the level and distribution of family income. Goodman (1983) follows the same procedure to work out a geographic distribution of capitalized burdens of property taxes.

burdens as these are more easily perceived and enable us to compare our results with traditional studies on the subject. However, calculations based on a marginal analysis are also presented and substantiate the conclusions reached using the basic approach. Major limitations of this approach are discussed in section 7. It should be noted that our empirical analysis ignores renters and derives conclusions based on homeowners only. No claim can, therefore, be made for the universality of these results. Furthermore, only aggregate income data is available to us for each subarea. Our analysis could be further refined if micro-data on family income distribution becomes available at a future date. Special notice must also be taken of the fact that the residential property taxes financed only 27.8 per cent of municipal expenditure for sample communities in 1977. Thus if both the residential taxes and the local expenditures were completely capitalized, capitalized tax burdens would not offset capitalized benefits and a substantial fiscal surplus would result. Our empirical results, however, indicate nearly complete capitalization of taxes but capitalization of only a very small portion of expenditures. Thus fiscal surplus, if any, would be small.

4. EMPIRICAL RESULTS

4.1 THE DISTRIBUTION OF THE REVEALED BURDENS OF THE URBAN RESIDENTIAL PROPERTY TAX

Following the approach outlined in section 3, regression equations 1 and 2 (see Tables 2 and 3) are evaluated at mean values for each of the twenty-seven communities within the City of Edmonton. The capitalized tax burden estimates based on the coefficients of these regressions are then classified by family income class using median family income of each neighbourhood as a criterion. Table 4 describes the family income group classification used for this purpose. It also provides information on the distribution of households by income class in Edmonton. The resulting distribution of tax burdens is annualized using a discount rate of 2 per cent and a time horizon of forty years and is presented in Table 5 and is also graphed in Figure 1.⁹

From Table 5, the absolute annualized tax burden per household increases with income for households having family income less than or equal to \$20,000 and decreases with income for the remaining groups under Equation 1. Using Equation 2 the absolute burden can be approximated by an inverted U-Shaped function of family income.

The progressivity of a tax is generally defined in terms of average rate of tax along income scale.¹⁰ A tax is said to be

- a. progressive when the average rate of tax rises with income;
- b. proportional when the average rate remains constant and
- c. regressive when it falls with rising income.

The concept of tax progressivity used here was initially proposed by Slitor (1948). Slitor stated that a tax system would be progressive,

9. Appendix K in Chaudry-Shah (1983) provides similar calculations for a dozen selected regressions.
10. See Kakwani (1980), p. 245.

Table 4 FAMILY INCOME DISTRIBUTION IN EDMONTON - 1977

<u>Classification</u>	<u>Family Income (\$)</u>		<u>Percentage Households</u>
	<u>Range</u>	<u>Median</u>	
1	Under 15,999	14,934	30.2
2	16,000 - 17,999	17,200	6.2
3	18,000 - 19,999	19,356	7.3
4	20,000 - 21,999	20,954	7.6
5	22,000 - 23,999	23,766	
6	24,000 - 25,999	25,196	14.0
7	26,000 - 27,999	27,466	
8	28,000 and over	39,416	34.7
All Groups		21,663	100.0

a - based on sample values

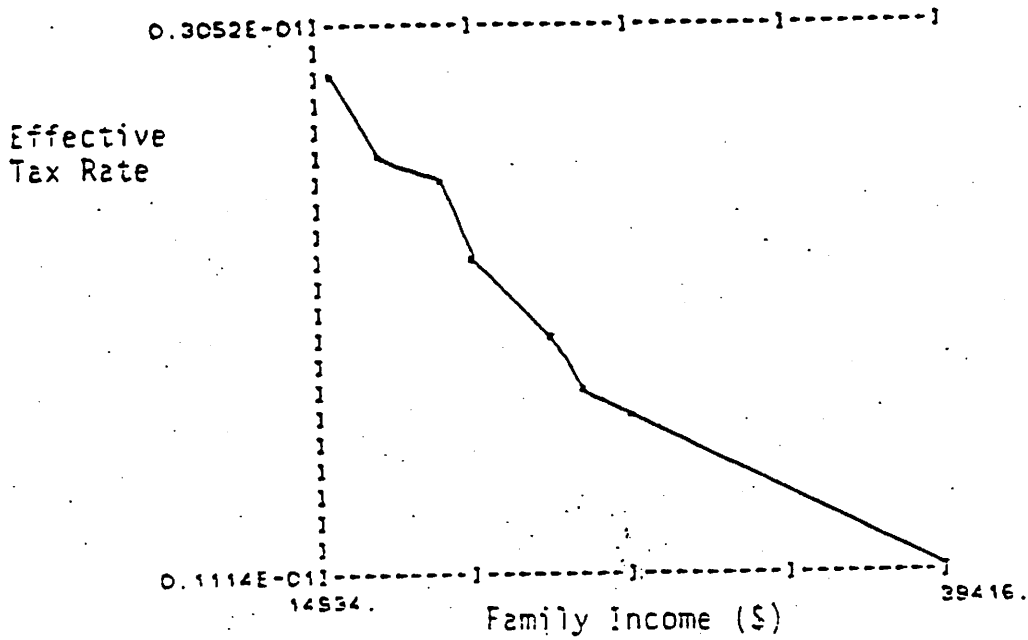
Source: Statistics Canada (1979)

Table 5 REVEALED TAX BURDENS AND EFFECTIVE TAX RATES BY FAMILY INCOME CLASS

<u>Family Income (\$)</u>	<u>Annualized residential property tax burden per household (\$)*</u>		<u>Residential property tax burden as a proportion of household income</u>	
	<u>Equation 1</u>	<u>Equation 2</u>	<u>Equation 1</u>	<u>Equation 2</u>
Under \$15,999	455.77	384.28	.0305	.0257
\$16,000 - \$17,999	457.77	297.67	.0266	.0173
\$18,000 - \$19,999	492.30	342.52	.0254	.0177
\$20,000 - \$21,999	473.73	345.62	.0226	.0165
\$22,000 - \$23,999	477.10	494.09	.0201	.0208
\$24,000 - \$25,999	441.10	410.57	.0175	.0163
\$25,000 - \$27,999	451.63	458.52	.0164	.0167
\$28,000 and other	<u>438.91</u>	<u>426.04</u>	<u>.0111</u>	<u>.0108</u>
Mean	461.13	394.91	.0213	.0177

* Assumes a discount rate of 2% and life of housing stock as 40 years.

Equation 1



Equation 2

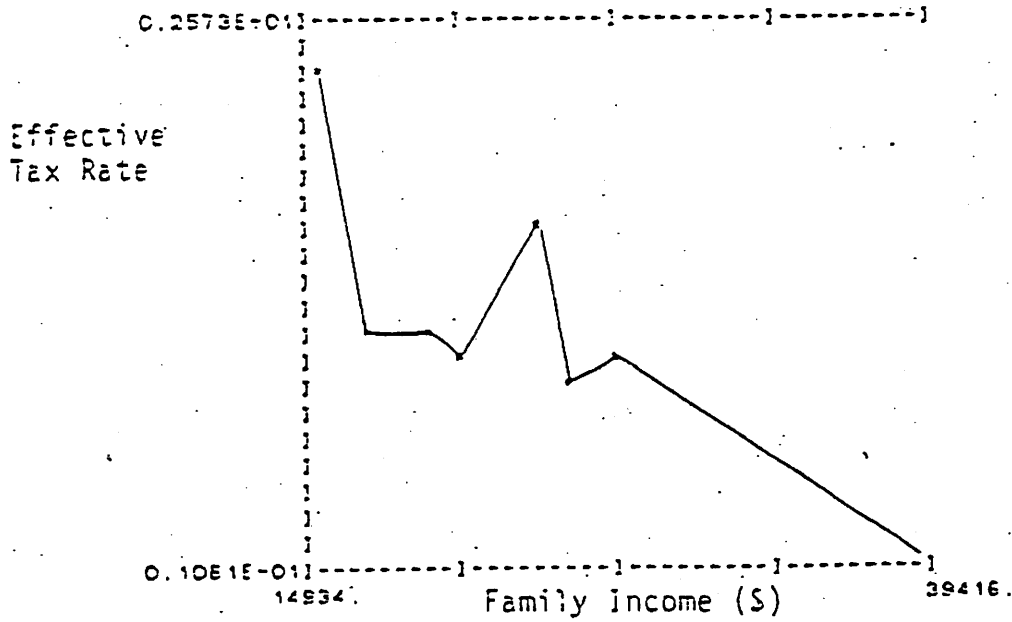


Figure 1 DISTRIBUTION OF TAX BURDENS BY FAMILY INCOME CLASS
(Effective Tax Rates)

proportional or regressive if the first derivative of the effective tax rate with respect to income was greater than, equal to or less than zero respectively. This concept of progressivity implies that a tax system is progressive, proportional or regressive if the marginal tax rate is greater, equal to or less than the average tax rate respectively. Although other measures of tax progression are also available, this measure is most commonly used in fiscal incidence studies.¹¹

The progressivity of revealed tax burdens using this measure is investigated quantitatively and graphically. Table 5 and Figure 1 show that the effective incidence of the tax burden falls with rising income lending support to the traditional view of the residential property tax.¹² Appendix K in Chaudry-Shah (1983) shows that the tax burden distribution shown by Equation 1 is typical of the incidence pattern implied by the Oates model. Similarly Equation 2 indicates a distribution pattern which is typical of the results based on the King-Reinhard approach although the incidence curve derived from this equation is somewhat flatter than those from other equations.

Two reasons are often cited for the regressivity of tax burdens on home-makers:¹³

1. assessors tends to underassess higher value homes; and
2. higher income families spend a smaller proportion of their income on housing relative to lower income families.

The first reason is borne out by the data for this study as the average effective tax rate is lower on higher priced homes compared to low priced homes. The second reason is supported by consumer expenditure surveys.¹⁴

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11. See Suits (1977), Guthrie (1979) and M. Kienzle (1981, 1982) for recent contributions to the measurement of progressivity of the public budget.
 12. See Dahlby (1982).
 13. See Auld and Miller (1975), Netzer (1966) and Clayton (1966), p. 76.
 14. See Reid (1962), p. 1.

4.2 THE DISTRIBUTION OF REVEALED BENEFITS OF THE LOCAL PUBLIC SECTOR

Slitor's (1948) concept of average rate progression is also applicable to an analysis of the degree of progressivity of expenditure benefits. Table 6 presents, in both absolute terms and as a proportion of family income two series of estimates of distribution of expenditure benefits by income class based on regressions 1 and 2. The effective rate of benefits is also graphed in Figures 2.

The absolute levels of benefits indicates a pro-poor distribution for family incomes up to \$20,000 and pro-rich beyond (see Table 6). The annualized benefits per household have the highest value for the lowest income group. This occurs because the downtown areas in Edmonton represent the largest single concentration of low income families but the same areas receive the highest ranking on the public services index (PSI) due to greater access to all amenities.

The graphic presentation of Figure 2 indicates that the incidence of benefits is regressive (pro-poor) for family incomes less than \$22,000, progressive (pro-rich) over family income range \$22,000 to \$28,000 and regressive (pro-poor) beyond.¹⁵

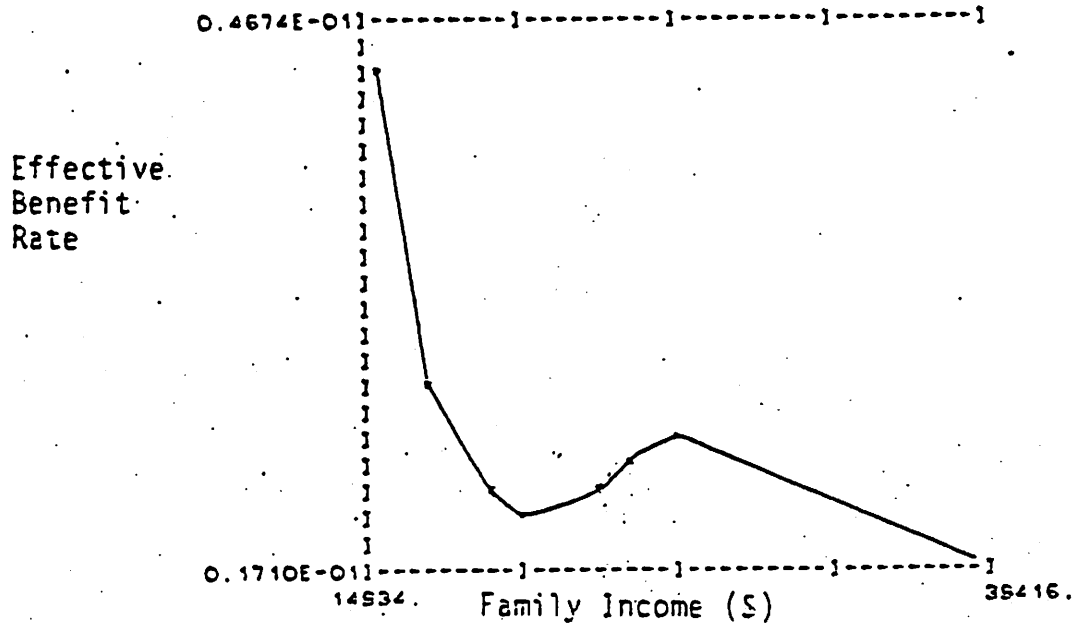
The above results provide an interesting comparison with the conclusions of the traditional view of public expenditure benefit incidence espoused by Musgrave and Musgrave (1976) and Gillespie (1965) and a 'new view' presented by Gramlich and Rubinfeld (1982). The traditional view states that the benefits of public services are not distributed in a pro-rich manner. Gillespie finds a neutral distribution

15. This result is representative of all equations in Chaudry-Shah (1983) except those using expenditure measures of public services. We derived strictly regressive (pro-poor) distribution of expenditure benefits when results are evaluated for regressions incorporating an expenditure measure of public services (see Chaudry-Shah (1983), Appendix K). These latter equations do not allow for intrajurisdictional variations in public services and are not helpful in our analysis.

Table 6 REVEALED PUBLIC SECTOR BENEFITS AND EFFECTIVE RATES BY FAMILY INCOME CLASS

<u>Family Income (\$)</u>	<u>Annualized Local</u>		<u>Annual local Public</u>	
	<u>Public Sector Benefits (\$)</u>		<u>Sector Benefits</u>	
			<u>As a Proportion of</u>	
	<u>Equation 1</u>	<u>Equation 2</u>	<u>Equation 1</u>	<u>Equation 2</u>
Under \$15,999	698.00	646.08	.0467	.0433
\$16,000 - \$17,999	462.62	428.21	.0269	.0249
\$18,000 - \$19,999	392.46	363.26	.0203	.0188
\$20,000 - \$21,999	422.33	390.92	.0201	.0187
\$22,000 - \$23,999	505.62	468.01	.0213	.0197
\$24,000 - \$25,999	556.32	514.9	.0221	.0204
\$25,000 - \$27,999	<u>675.37</u>	<u>625.13</u>	<u>.0246</u>	<u>.0158</u>
Mean	548.34	507.55	.0249	.0230

Equation 1



Equation 2

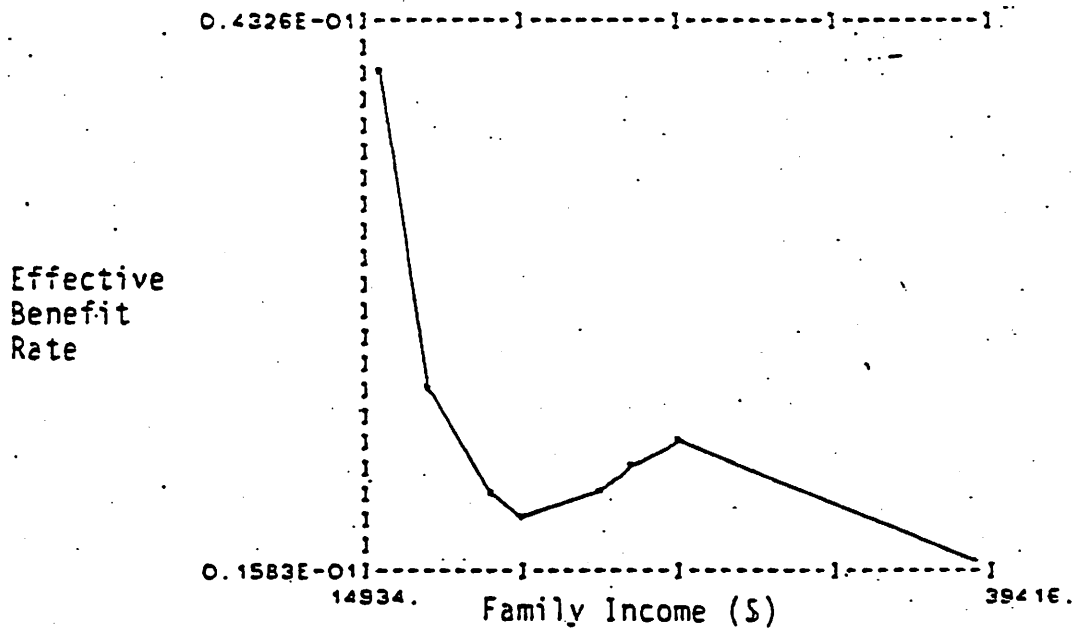


Figure 2 THE DISTRIBUTION OF LOCAL PUBLIC SECTOR BENEFITS BY FAMILY INCOME CLASS (Effective Benefit Rates)

whereas Musgrave and Musgrave find pro-poor distribution of educational benefits. It may be noted that the illustrative calculations of Gillespie and Musgrave and Musgrave are based solely on expenditures made and do not consider quality differentials within the community or the value at which public goods are assessed by the recipients of those services.¹⁶ In the light of these conclusions high income individuals are more likely to emigrate from the community for fiscal reasons.¹⁷ Gramlich and Rubinfeld (1982) on the other hand infer pro-rich distribution from the income elasticity of demand for public spending based on survey results.¹⁸ Gramlich and Rubinfeld also do not consider public services quality differentials within a community.

The traditional view of expenditure benefit incidence is sustained in our estimates using dollar values of public expenditures. On the other hand when we consider quality differentials in public services provision within a jurisdiction, our results indicate pro-poor distribution (Musgrave and Musgrave result) over the poor and the lower middle class ranges, pro-rich (Gramlich and Rubinfeld findings) for upper middle class and pro-poor over the upper end of the family income scale. Thus our results suggest that whereas low income households are advantaged both absolutely and relatively, the high income individuals are advantaged absolutely but not relatively.

4.3 THE NET FISCAL INCIDENCE OF THE LOCAL PUBLIC SECTOR

In the previous sections we examined the incidence of the local public sector burdens and benefits. Here we combine the two influences to obtain the net fiscal residue (defined as benefits minus tax burdens) of the local public sector for eight income groups based on two alternate approaches. The absolute values of the net effect as well as the effective rate of fiscal incidence by income classes are presented in Table 7. The net incidence is also graphed in Figure 3.

16. See Gramlich and Rubinfeld (1982), p. 549.

17. See Gramlich and Rubinfeld (1982), p. 548.

18. Katzman (1968) also reaches the same qualitative conclusion for education spending - a pro-rich distribution within cities.

The annualized value of fiscal residuals per household in absolute dollar terms show a regressive (pro-poor) trend for family incomes up to \$20,000 from Equation 1 and up to \$24,000 from equation 2 and progressive (pro-rich) beyond.

The net fiscal incidence according to the two series shares a pro-poor bias for family incomes less than \$20,000, pro-rich distribution for income range \$22,000 to \$28,000 and pro-poor beyond. Mean net benefits are estimated to be less than one-half of one percent of household income.

We conclude that the overall fiscal incidence could be represented by an elongated U-shaped curve indicating a redistribution from the middle class to lower and upper income groups both absolutely and relatively. Our results contrast with Gillespie's findings based on an aggregative study (1976) that local fiscal residue is negative for lower income groups and positive for the remaining groups. The distribution of this residue, according to him, is pro-rich over the lower end and then proportional throughout along the family income scale.¹⁹ Thus Gillespie results suggest a redistribution of income from the poor to the middle class and the rich. His result, derived from aggregate data, however, critically depends upon his concept of income and the assumptions underlying allocation basis.

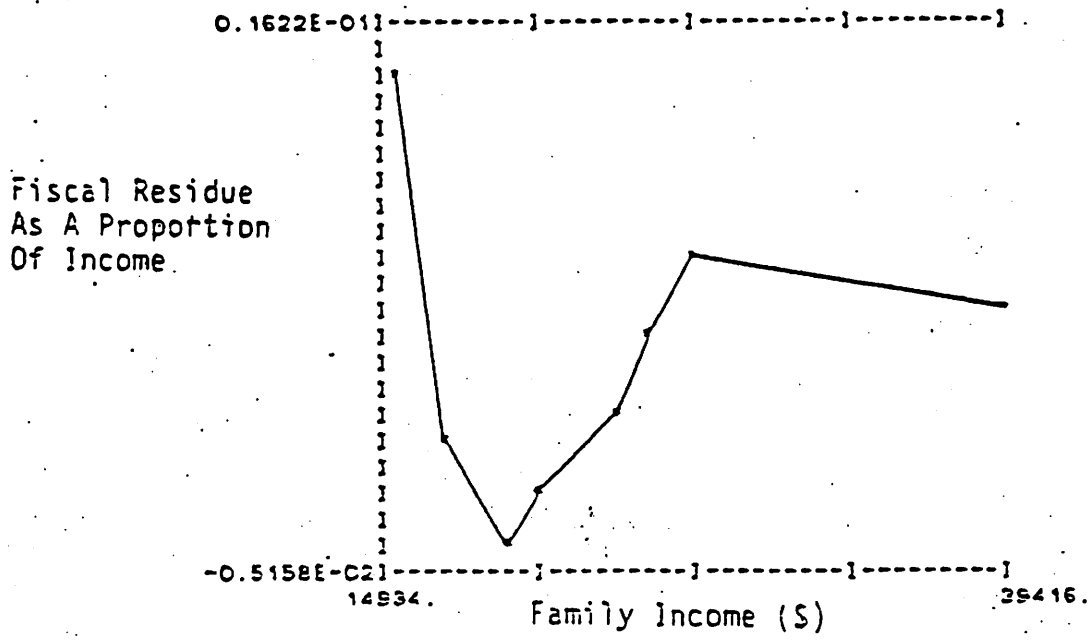
19. Dodge (1975) results cannot be compared as he works out the combined effects of local and provincial governments nationwide. No clear pattern of fiscal incidence emerges from Clayton's (1966) work. Local fiscal incidence changes drastically from one allocative series to another.

Table 7 FISCAL RESIDUALS AND EFFECTIVE INCIDENCE RATE BY FAMILY INCOME CLASS

<u>Family Income (\$)</u>	<u>Net Local Public Sector Benefits (= Benefits - Tax Burdens) (\$)</u>		<u>Net Benefits as a Proportion of Household Income</u>	
	<u>Equation 1</u>	<u>Equation 2</u>	<u>Equation 1</u>	<u>Equation 2</u>
Under \$15,999	242.23	261.80	.0162	.0175
\$16,000 - \$17,999	4.9251	130.53	.0003	.0076
\$18,000 - \$19,999	-99.842	20.74	-.0052	.0011
\$20,000 - \$21,999	-51.402	45.30	-.0025	.0022
\$22,000 - \$23,999	28.525	26.08	.0012	.0011
\$24,000 - \$25,999	114.43	104.36	.0045	.0041
\$25,000 - \$27,999	223.74	166.61	.0081	.0061
\$28,000 and other	<u>235.10</u>	<u>197.84</u>	<u>.0060</u>	<u>.0050</u>
Mean	87.212	112.64	.0036	.0053

Note: This table is derived from Tables 5 and 6.

Equation 1



Equation 2

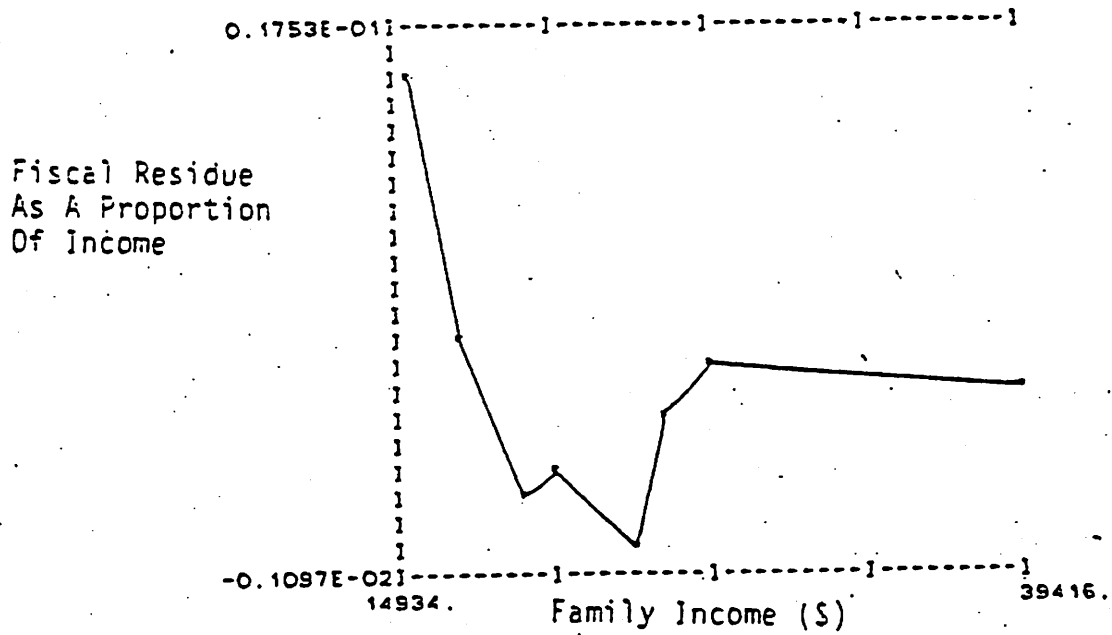


Figure 3 EFFECTIVE RATES OF NET FISCAL INCIDENCE BY FAMILY INCOME CLASS

5. THE NET INCIDENCE: SOME FURTHER EXPERIMENTS

In this section the net fiscal incidence of the local public sector will be derived using two alternate approaches.

5.1 Method A

Here we compare the actual residential property tax bills with the annualized benefits determined from the capitalization of the benefits side only, assuming a discount rate of 2 per cent and a time horizon of 40 years. Equation 2 (King-Reinhard) is evaluated to derive annualized benefits of the local public sector.

Table 8 presents tax bills, annualized value of public service benefits and the net gain per household by family income class. The table also presents the effective rate of net fiscal incidence.

The table shows that average tax bill is almost \$508 and class average annualized benefit per family is also almost \$508 based on equation 2. In absolute terms benefits per household first decline with income and beyond income group \$20,000-\$21,999 show a consistent upward trend. Average net incidence is zero. The net fiscal incidence (see Figure 4) has a pro-poor bias over the family income range of up to \$24,000, pro-rich for incomes in the range \$24,000 to \$28,000 and pro-poor beyond. The effective rate is 1 per cent of family income for the lowest income group and 0.2 per cent for families having incomes exceeding \$28,000. It is best represented by an elongated U-shaped curve (see Figure 4(i)).

5.2 Method B

So far our analysis has been carried out in terms of total burdens and benefits of the local public sector. Now we look at the distributional effects of a marginal change.

Table 8 THE NET FISCAL INCIDENCE: SOME FURTHER EXPERIMENTS

(i) Method A

<u>Family Income (\$)</u>	<u>Residential Property Tax Per Household (\$)</u>	<u>Public Service Benefits (\$)</u>	<u>Fiscal Residue (\$)</u>	<u>Fiscal Residuals as a Pro- portion of Household Income</u>
Under \$15,999	501.0	646.08	145.08	+ .0097
\$16,000 - \$17,999	445.0	428.21	-16.79	- .0010
\$18,000 - \$19,999	474.0	363.26	-110.74	- .0057
\$20,000 - \$21,999	476.0	390.92	-85.08	- .0041
\$22,000 - \$23,999	572.0	468.01	-103.99	- .0044
\$24,000 - \$25,999	518.0	514.94	-3.06	- .0001
\$25,000 - \$27,999	549.0	625.13	76.13	+ .0028
\$28,000 and over	<u>528.0</u>	<u>623.88</u>	<u>95.87</u>	<u>+ .0024</u>
Mean	507.9	507.6	-0.3	-0.00004

(ii) Method B (Marginal Analysis)

<u>Family Income (\$)</u>	<u>Non-Annual- ized Change in Total Tax Burden (\$)</u>	<u>Non-Annual- ized Change in Public Sector Benefits (\$)</u>	<u>Non- Annual- ized Fiscal Residue (\$)</u>	<u>Non- Annualized Fiscal Residuals as a Pro- portion of Household Income</u>
Under \$15,999	1938.6	3321.5	1382.9	+ .0926
\$16,000 - \$17,999	1767.6	1601.3	-166.3	- .0097
\$18,000 - \$19,999	1882.8	1358.4	-524.4	- .0271
\$20,000 - \$21,999	1890.7	1461.8	-428.9	- .0204
\$22,000 - \$23,999	2272.1	1750.1	-522.0	- .0220
\$24,000 - \$25,999	2057.6	1925.3	-132.3	- .0052
\$25,000 - \$27,999	2181.7	2337.6	+155.9	+ .0056
\$28,000 and over	<u>2097.3</u>	<u>2333.0</u>	<u>+235.7</u>	<u>+ .0060</u>
Mean	2011.1	2011.1	0.0	.000

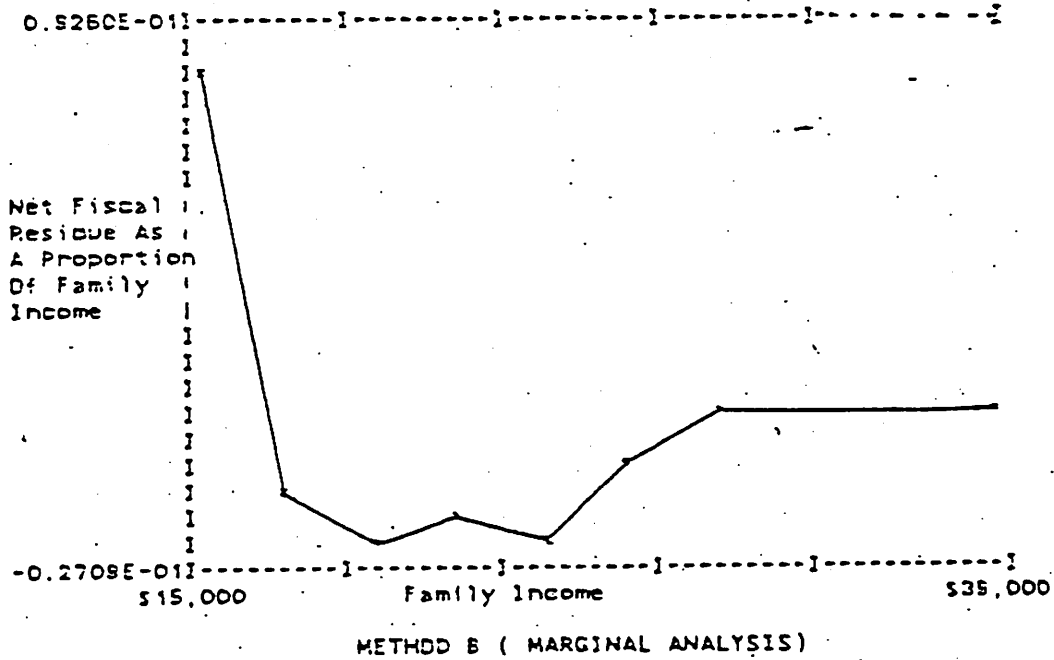
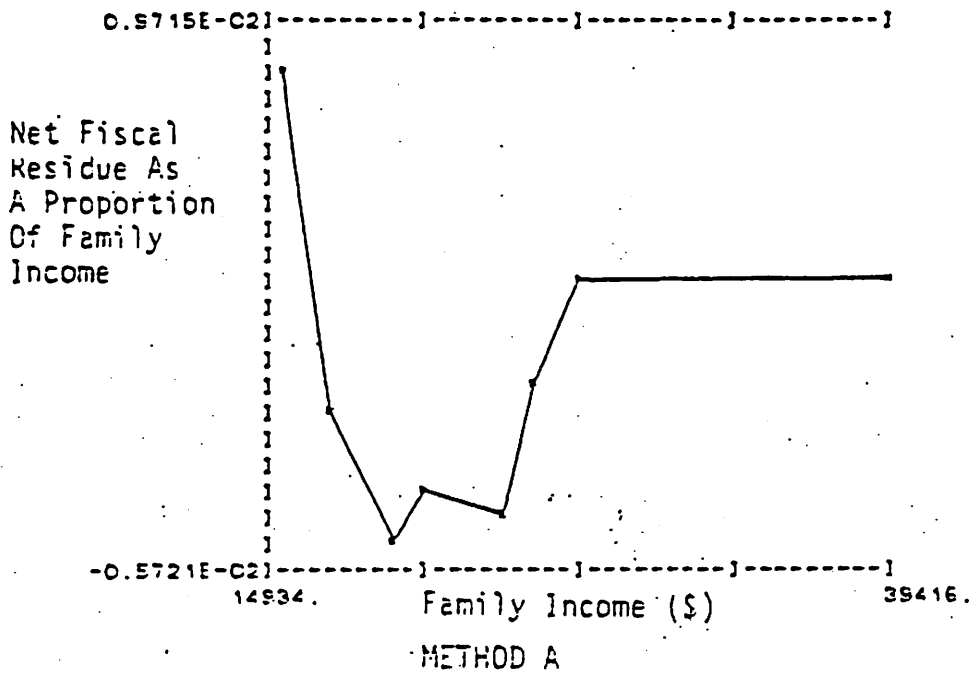


Figure 4 EFFECTIVE RATE OF NET FISCAL INCIDENCE USING ALTERNATE METHODS

Assume that there is a 10 per cent increase in property taxes per household. This is accompanied by an increase in the level of public services that such revenue would finance. We further assume that:

$$dPSI/dLOCAL = .0011854$$

where

LOCAL = local expenditures for services included in PSI

and that the increase in PSI would be distributed as PSI now.²⁰ We further impose the constraint that the net change in dollar values of all properties as a whole due to the assumed change in property and public services is zero. This implies that the marginal cost of additional tax dollar equals marginal benefits of additional local public expenditure. This scenario allows us to compare the pattern of net impact or the distributional effects of the local sector without the difficulty of any overall surplus or deficiency.

Table 8 presents evaluations of Equation 2 for the marginal change specified above. The values are not annualized. The distribution of tax burdens and public services benefits is consistent with estimates obtained under Method A. Once again the net fiscal incidence could be approximated by an elongated U-shaped curve (see Figure 5(ii)).

20. This is approximated from the following equation:

$$PSI = 0.25436 + 0.0011854 LOCAL$$

$$(R^2 = .1743 \quad S.E.E. = .22238 \quad N=9)$$

6. VALIDITY AND LIMITATIONS OF THE APPROACH

Our redistributive estimates are based on capitalization. Thus our method is legitimate for small and open areas where communities have been sorted out by income class and taste.²¹ The study area fulfills the small and open area condition but our community zones are not strictly consistent with income sorting. Thus homogenous incomes and taste condition would not be satisfied. Also preferences for local public services may vary significantly within the specified subareas in the City of Edmonton. The public services indices used for various Edmonton communities do not reflect intra-community variations in service levels. Thus the fiscal residuals may be different for different households within the subareas studied. Another major limitation of these indices is that they do not capture variations of all locally provided services. Even for the included services, there may be large measurement errors. Income data is also aggregated to community level and subject to error. Also, within community income distribution data is simply not available. Any imperfections in the local housing market also work to make our estimates less precise. For example, a shortage of high income oriented housing compared to say middle income housing would force a high income household to buy housing services at the market price in middle income jurisdiction. This individual will thus experience a negative fiscal residual as he may not usually be willing to pay as much as a middle income household for a high level of middle income oriented local public services say public schools and public transit, etc.

21. These conditions have been specified by Polinsky and Shavell (1976) who demonstrate that a capitalization approach would be valid only "if the area affected is small (in which case the property value at location i depends only on amenities at i) and open (that is, there is full mobility). In that case competitive bidding by households for preferred locations will result in land values fully reflecting the value of differences in environmental quality (McMillan, Reid and Gillen" (1980), p. 315).

Starrett (1981) clarifies the capitalization mechanism in a system of local governments. His arguments are summarized in Chaudry-Shah (1983).

A major limitation of our approach arises from the fact that changes in property values may reflect the tax burdens and service benefits but if these were expected and capitalized into property values when the property was purchased it would not adversely affect or benefit existing owners.²²

In spite of the above limitations the approach adopted in this chapter provides useful insights relating the distributional implications of local public goods provision in Edmonton and merits consideration for empirical application elsewhere.

7. SUMMARY AND CONCLUSIONS

Almost two decades ago Aaron Director proposed a law of public expenditure:

"Public expenditures are made for the primary benefit of the middle class, and financed with taxes which are borne in considerable part by the poor and the rich" (Stigler 1970, p. 1).

An empirical verification of this law at the local level could be carried out by examining the income redistributive effects generated by the economic activities of local governments. Economists have just begun to address this question. Gillespie (1976) employs the 'reasonable assumptions' approach and concludes that the local government sector at the national level of aggregation appears to redistribute income from the poor to the rich and middle class. If the pro-rich local public services benefits distribution inferred by Gramlich and Rubinfeld (1982) is combined with a regressive incidence of the real property tax, the net redistributive impact of the local public sector would be to favour the rich at the expense of the poor and the middle class residents. The present study avoids difficulties associated with

22. See Hamilton (1976).

the reasonable assumptions approach and approximates the net fiscal incidence from changes in residential property values. Thus the estimated redistributive effects are not illustrative but real and cast a considerable shadow of doubt on the pattern of income redistribution derived from earlier studies. Our empirical results refute Director's law and imply that the local public sector redistributes income from the middle income families to the poor and the rich.

The following overall conclusions emerge from the analysis of this chapter.

1. The incidence of the residential property tax is highly regressive (pro-rich). The absolute burden, on the other hand, initially increases with income and then decreases with income. It can be approximated by an inverted U-shaped function of family income.
2. The incidence of expenditure benefits is regressive (pro-poor) for those earning less than \$22,000 and progressive (pro-rich) for family incomes in the range \$22,000 to \$28,000 but regressive (pro-rich) for the richest class (family incomes \$28,000+).²³
3. The overall impact of the local public sector in Edmonton is to redistribute income from the middle class to the poor and the rich.
4. The local public sector aggravates income inequality in Edmonton. The overall impact on the distribution of income, however, is very small.²⁴

23. These estimates are consistent with Weicher's (1971) estimates for police expenditures using Chicago (1959) data.

24. This effect is statistically insignificant. See Appendix L in Chaudry-Shah (1983).

The above results also help explain the rapid growth of two middle class suburbs namely the City of St. Albert and the Hamlet of Sherwood Park just at the boundary of the City of Edmonton. Many middle income people living in or moving to Edmonton may have found those more attractive in view of the fiscal deficiency perceived by these groups in Edmonton.²⁵ Since these communities have very few poor families and high concentration of middle income groups there would be very little if any income redistribution or cross-subsidization. This helps explain the strong opposition voiced by these communities to Edmonton's annexation bid in 1980. Thus a very small dollar amount of redistribution affected by the local public sector is perceived to be marginally very important indeed by local residents.²⁶

25. Muth (1969) has found that the growth of low income population in a central city tends to increase the size of suburban population. He attributes this result to aversion of rich families to rising health and welfare expenditures. The present study suggest that the same result may occur due to all local expenditures. See also Weicher (1971), p. 219.

26. Public opinion polls conducted in the region from time to time have never addressed this question.

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APPENDIX A

THE DISTRIBUTION OF RESIDENTIAL PROPERTY TAXES, PUBLIC SERVICES AND THE NET FISCAL INCIDENCE OF THE LOCAL PUBLIC SECTOR AMONG NEIGHBOURHOODS WITHIN THE CITY OF EDMONTON

Here we examine interneighbourhood effects of the local public sector in the City of Edmonton based on an analysis of data on property taxes, public services, median family incomes and regression results repeated earlier in this paper. To study these effects, first the communities are ranked by property tax per household (TAX), the public services index (PSI) and median family income of the community (Y). A rank of one is assigned to an area having the highest value of a particular variable. Table A1 displays these ranks. Spearman's ρ and Kendall's τ coefficients of rank correlation are then calculated to determine the magnitude and direction of association between any two variables at a time. Values of ρ and τ can vary from plus one to minus one. A value of plus one would indicate a perfect positive correlation between the ranks of two variables and a value of minus one indicates perfect negative correlation. The coefficients would be equal to zero if there was absolutely no association between the two measures.

Table A1 shows that central city areas in real estate zones 13 (Downtown), 26 (Clifton Place), 15 (Garneau), and 11 (Windsor Park) receive higher rankings on both the TAX and PSI variables. Among the suburbs, Mill Woods (#29) and Castle Downs (#27) are ranked 10th and 11th respectively by the public services index.

The ranking of the communities by the two variables is consistent as is shown by Kendall's τ and Spearman's ρ rank correlation coefficients (see Table A2). Table A2 further shows that there is a weak positive relationship between median family income and the public services index. An inverse ranking of communities by the effective tax rate (T) and the house sales price (P) indicates that higher priced residences are underassessed.

Table A1 RANKING OF EDMONTON COMMUNITIES BY THE LEVEL OF PROPERTY TAXES,
PUBLIC SERVICES AND MEDIAN FAMILY INCOME

Community	Property Tax/ Household (TAX)		Public Services Index (PSI)		Median Family Income (Y)	
	\$	Rank	Index	Rank	\$	Rank
	1. Calder	453	20	.69226	22	19,400
2. Baldwin	467	16	.56804	26	19,596	17
3. Northwest	544	6	.52752	27	20,596	11
4. Sherbrooke	460	18	.92452	16	20,458	12
5. Parkdale	496	12	.93197	15	15,548	25
6. Newton	398	25	.86699	20	14,912	26
7. North Glenora	417	24	1.14730	9	20,348	14
8. Queen Mary	387	26	.89240	18	17,346	23
9. Bellevue	345	27	1.05640	12	20,410	13
10. Crestwood	529	8	1.57190	4	41,342	1
11. Windsor Park	527	9	1.40700	5	37,342	2
12. Oliver	577	4	1.30260	6	21,056	10
13. Downtown	634	2	3.78230	1	13,508	27
14. Lendrum	518	10	1.22900	8	25,196	5
15. Garneau	675	1	1.60040	3	23,808	6
16. McKernan	451	21	.86643	21	19,662	15
17. Avonmore	435	23	1.00920	14	19,338	19
18. Bonnie Doon	450	22	.87757	19	21,880	9
19. Capilano	470	15	.63436	25	23,724	7
20. Callingwood	459	19	1.27350	7	16,326	24
21. Jasper Place	490	13	.90049	17	17,926	22
22. Meadowlark	503	11	1.02290	13	27,336	4
23. Beverly Heights	476	14	.67169	26	19,624	16
26. Clifton Place	595	3	1.96170	2	27,598	3
27. Castle Downs	462	17	1.11150	11	19,598	20
28. Londonderry	543	7	.69122	23	21,890	8
29. Mill Woods	576	6	1.14700	10	18,776	21

Table A2 RANK CORRELATIONS AMONG PAIRS OF SELECTED VARIABLES
(1977 Data for 27 Communities in Edmonton)

<u>VARIABLE PAIR</u>	<u>Kendall's Tau (τ)</u>		<u>Spearman's Rho (ρ)</u>	
	<u>Coefficient</u>	<u>Signifi- cance Level</u>	<u>Coefficient</u>	<u>Signifi- cance Level</u>
TAX WITH PSI	0.2936	0.016	0.4158	0.016
P WITH PSI	0.3732	0.003	0.5317	0.002
T WITH PSI	-0.2593	0.029	-0.4689	0.007
Y WITH PSI	0.1168	0.196	0.1893	0.172
T WITH P	-0.1225	0.185	-0.3608	0.032

Symbols: P = House price (\$)
T = TAX/P = Effective tax rate
Y = Median Income (\$)

A small degree of inequality in the geographical distribution of the local public services is revealed by the Gini coefficient of 0.33 (Pareto's α is 2.0051 and the standard error of α is .10288).¹

With this brief analysis of the basic data we can now proceed to determine the net surplus (or deficiency) of a representative household (homeowner only) in different areas of the city. Our analysis ignores renters and hence our results would be less precise for the city areas with greater concentration of rental properties.

Fiscal Residuals By Neighbourhood

To determine the net impact of the local public sector for each community we determine the mean annualized value of public services benefits (assuming a discount rate of 2 per cent and a time horizon of 40 years) for each community from the regression results of Equation 1 and then subtract the residential property tax per household from benefit estimates. The net fiscal incidence derived in this way is reported in Table A3. The table shows that southwest areas of the city in general experience a net surplus and suburbs a net deficiency from the local public sector in Edmonton. The local public sector appears to favour central and southwest city residents at the expense of dwellers in the northeast, northwest and southeastern areas of the city. The areas in the east and the west side of the city have a relatively higher

1. α is based on the following function proposed by Cowell (1977).

$$P_i = A x_a^{-\alpha}$$

where $P_i = \log(1 - (n-1)/n)$
 n = Number of observations.
 A = A constant
 x_a = Array of public services indices in ascending order
 α = Pareto distribution parameter.

Gini Concentration ratio is defined as:

$$G = 1/(2^\alpha - 1)$$

See Cowell (1977), p. 153

Table A3 FISCAL RESIDUALS BY COMMUNITY - CITY OF EDMONTON

		Residential Property Tax per Household (\$)(TAX)	Public Services Benefits Per Household (\$)(PSB)	FISCAL RESIDUE = (PSB) - (TAX)
	<u>Community</u>			
1.	Calder	453.00	304.89	-148.11
2.	Baldwin	467.00	250.18	-216.82
3.	Northwest	544.00	232.33	-311.67
4.	Sherbrooke	460.00	407.18	-52.81
5.	Parkdale	496.00	410.46	-85.53
6.	Newton	398.00	381.84	-16.15
7.	North Glenora	417.00	505.30	88.30
8.	Queen Mary	387.00	393.04	6.03
9.	Bellevue	345.00	465.27	120.27
10.	Crestwood	529.00	692.31	163.31
11.	Windsor Park	527.00	619.68	92.67
12.	Oliver	577.00	573.70	-3.30
13.	Downtown	634.00	1665.80	1031.80
14.	Lendrum	518.00	541.28	23.28
15.	Garneau	675.00	704.86	29.85
16.	McKernan	451.00	381.60	-69.40
17.	Avonmore	435.00	444.48	9.47
18.	Bonnie Doon	450.00	386.50	-63.49
19.	Capilano	470.00	279.39	-190.61
20.	Callingwood	459.00	560.88	101.88
21.	Jasper Place	490.00	396.60	-93.40
22.	Meadowlark	503.00	450.51	-52.48
23.	Beverly Heights	476.00	295.83	-180.17
26.	Clifton Place	595.00	863.98	268.98
27.	Castle Downs	462.00	489.53	27.53
28.	Londonderry	543.00	304.82	-238.18
29.	Mill Woods	576.00	505.17	-70.83
	Mean	493.96	500.28	6.31
	Standard Deviation	75.15	276.16	242.86
	Minimum	345.00	232.33	-311.67
	Maximum	675.00	1665.80	1031.80

concentration of commercial and industrial properties vis-à-vis residential properties so these areas likely have lower aggregate demand for local public goods measured by PSI e.g. education and recreation. This may explain the net deficiencies observed in those areas. The above results based on an analysis of fiscal residuals reinforce our overall conclusions regarding the net redistributive impact of the local public sector by family income class as the data reveals a greater concentration of middle income families in the suburbs.

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TRADE, CAPITAL MOBILITY
AND TAX COMPETITION

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8505

Tatsuo Hatta and David Wildasin read earlier drafts and provided many useful comments.

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Abstract

This paper examines a system of governments (national, state, or local) which finance public expenditures with taxes on mobile capital (e.g., a property tax). Unlike previous research on "tax competition," explicit consideration is given to the general equilibrium determination of the prices at which goods are traded between regions. The analysis identifies inefficiencies in government behavior which are not apparent in models where the terms of trade are exogenously given. Capital taxation is shown to create an inefficient distribution of public good supplies across regions, accompanied by an inefficient pattern of trade. A model is presented where the chosen levels of public good outputs differ across regions containing identical residents and production possibilities; there is a wasteful diversity of public good supplies.

1. Introduction

The theoretical literature in both international trade and local public economics has devoted a significant amount of attention to issues concerning factor mobility. A key issue in local public economics is the relation between interregional (or intercommunity) factor mobility and the efficiency properties of decentralized decision-making by local governments. Several forms of inefficient government behavior have been identified under various assumptions about the mobility of labor and capital.¹ But whereas international commodity trade is the central concern of trade theory, the local public economics literature has devoted little attention to the relation between commodity trade and government behavior. While it is often assumed that goods are traded between regions, explicit consideration is not normally given to the general equilibrium determination of the terms of trade.² The present paper brings together the fields of international trade and local public economics in an attempt to correct this omission and thereby identify inefficiencies in government behavior which are not apparent in models where the terms of trade are exogenously given.

I shall be concerned specifically with the inefficiencies which arise under the common practice of local governments to include mobile capital in their property tax base. Wallace Oates (1972, p. 143) argues that this practice may lead to an under-provision of local public goods and services. Using the term "tax competition" to describe this under-provision, he states: "The result of tax competition may well be a tendency toward less than the efficient levels of outputs of local public services. In an attempt to keep tax rates low to attract business investment, local officials may hold spending below those levels for which marginal benefits equal marginal costs."

Both Zodrow and Mieszkowski (1984) and Wilson (1984b) have examined tax competition in formal models without commodity trade. In their analysis, the economy consists of many small regions (which may be interpreted as communities, states, or nations). Each region's government finances its public expenditures with a tax on mobile capital (e.g., a property tax), and the objective of the government is to maximize the welfare of its residents. From a single region's viewpoint, this tax distorts private production decisions by causing firms to produce where the value of their marginal product of capital exceeds the opportunity cost of capital to the region. As a result, an outflow of capital from the region makes residents worse off. The region's government therefore treats the capital outflow induced by a rise in its tax rate as an additional cost of public good provision. But this outflow represents an inflow of identical magnitude for the rest of the nation, since the nation's total capital stock is taken to be fixed in supply. And this inflow represents a positive externality: when one region raises its tax rate to finance additional public expenditures, other regions benefit through the resulting rise in their capital supplies. Since the government ignores this positive externality associated with additional public good provision, it provides an inefficiently low level of public goods.³

By incorporating interregional commodity trade into the analysis, I demonstrate that the inefficiencies resulting from taxing mobile capital cannot be adequately described as an under-provision of public goods. In fact, the equilibrium public good output for the whole economy may actually exceed the efficient output level. What can be said, however, is that capital taxation creates an inefficient distribution of public good outputs across regions, and this inefficient distribution is accompanied by an inefficient pattern of trade. In my simplest model, the levels of public good outputs chosen by local governments differ across regions with

identical residents and production possibilities. Thus, the equilibrium is characterized by a wasteful diversity of public good supplies. I also present a model where there is not enough diversity. These results contrast sharply with the Tiebout Hypothesis, which emphasizes the ability of local governments to tailor local tax and expenditure policies to the particular preferences of residents. In a Tiebout equilibrium, the migration of individuals between regions, combined with the decentralized decision-making by local governments, leads to an efficient diversity of public good supplies across regions. Even when I include both labor and capital mobility in the model, the level of diversity remains inefficient.

The plan of this paper is as follows. I present the basic model in the next section and describe the unusual properties of the equilibrium in Section 3. Section 4 characterizes the various inefficiencies which exist when the economy is in equilibrium. The model is deliberately kept simple in order to make the arguments as transparent as possible. Sections 5 and 6 discuss how the results generalize to more complicated settings. Section 7 relates the results to the trade-theoretic literature on factor mobility, and some concluding remarks are made in Section 8.

2. The Model

The economy contains a large number of regions and two primary factors. The first factor, capital, is perfectly mobile across regions. Thus, the equilibrium after-tax return to capital is equated across regions. Each region is small in the sense that it has a negligible impact on this return.

The second factor, which I call labor, is supplied in fixed amounts by each region's residents to firms located within the region. To concentrate on capital mobility, residents are assumed to be immobile between regions. But Section 5 argues that this assumption is not essential. Both capital and labor are fixed in supply for the nation as a whole, but perfectly mobile across firms within any given region

To emphasize the implications of interregional commodity trade, I assume that all goods in the economy are tradeable between regions. Leaving generalizations to Section 6, I also assume that there are only two private goods, 1 and 2. Each region is small in the sense that it has a negligible impact on the equilibrium prices at which these two goods are traded.

The two goods are produced by competitive private firms using technologies which exhibit constant returns to scale. Good 2 is always capital intensive relative to good 1. This means that the cost-minimizing capital-labor ratio is higher in good 2 production than in good 1 production whenever the two industries face the same rental-wage ratio.

Both goods are purchased directly by residents and utilized as final consumption goods. However, one of the goods is also purchased by each region's government and used as the sole input in the production of a public good. The production technology is linear, with one unit of the private good producing one unit of the public good. The government distributes the public good uniformly across the

region's residents. Since each region's population is fixed, the analysis in no way depends on whether the public good has the attributes of a private good or is pure in the Samuelson sense (zero marginal cost of provision to additional residents).

Each individual's utility is a strictly quasi-concave function of his consumption of the two private goods and the public good, and consumer demands for all three goods are always positive (i.e., indifference surfaces are strictly convex and converge asymptotically to each of the three axes). I assume initially that all individuals possess identical utility functions and factor endowments, but the implications of consumer heterogeneity are later explored. The objective of a single region's government is to maximize the representative resident's utility. All regions are identical in the sense that they possess identical production technologies and contain identical numbers of residents. For notational simplicity, each region's population is normalized to equal one.

Public good expenditures in each region are financed by a uniform tax on the capital employed in the region. The government budget constraint may be written

$$tK = p_G G, \tag{1}$$

where t is the tax rate, K is the region's total capital supply, G is the total output of the public good, and p_G is the unit cost of the public good (which equals the price of the private good used to produce it). The tax and expenditure policy which maximizes the utility of the region's resident is referred to as "optimal." But it will soon become clear that this policy is inefficient from the viewpoint of the nation as a whole.

I next describe some important properties which any equilibrium must possess, and I address the issue of whether an equilibrium always exists.

3. The Equilibrium

The surprising conclusion from this model is that the economy is in equilibrium only when each of the identical regions specializes in the production of a single private good. Thus, goods are traded between regions, even though all regions are completely identical. Furthermore, public good outputs differ between regions which produce different private goods.

These claims can be demonstrated graphically. First consider Fig. 1, which depicts the isoquants, $I_1|_1$ and $I_2|_2$, corresponding to one dollar of good 1 and one dollar of good 2. The isocost curve $C_1|_1$ corresponds to the rental-wage ratio, r'/w' , where profits equal zero in the production of both goods; and the tangencies of this isocost curve with the two isoquants give the cost-minimizing input combinations. Under r'/w' , firms are willing to produce positive outputs of both goods. However, no region's government would tolerate production of both goods. By lowering its tax rate on capital slightly, the government could lower slightly the rental rate (recall that the after-tax return to capital is fixed from the region's viewpoint). As a result, the wage rate would rise slightly to maintain zero profits in industry 2, which is capital intensive. Profits would become negative in industry 1, causing output of good 1 to drop to zero. As illustrated in Fig. 1, the slight fall in the rental-wage ratio from r'/w' reduces the slope of the isocost curve so that new curve, $C_3|_3$, is tangent only to the isoquant for good 2. With the labor intensive industry eliminated from the region, a discrete jump occurs in the total quantity of capital utilized with the region's fixed stock of labor. As a result, tax revenue rises discontinuously, causing a jump in the budget-balancing public good supply. With the wage rate having risen slightly, it is clear that the small decline in the tax rate must raise utility. The original policy must therefore not have been optimal.

Thus, each region produces only one good. By assumption, however, the total demand for each good is always positive. An equilibrium can only be established when there exist regions which produce only good 1 and regions which produce only good 2. For this to be possible, the maximum utility that can be obtained by choosing a tax rate at which industry 1 is willing to produce must exactly equal the maximum utility obtainable with a tax rate where industry 2 is willing to produce. These two maximum utilities are functions of the product prices and after-tax return to capital, both of which are taken as given by a single small region: $u_1 = u_1(b,p)$ and $u_2 = u_2(b,p)$, where b is the after-tax return, p is the price of good 2, and good 1 serves as the numeraire with its price set equal to one. Stated in symbols, b and p can only be at their equilibrium values when

$$u_1(b,p) = u_2(b,p). \quad (2)$$

I shall refer to a region where good i is produced as a "type i " region.

A region's tax rate determines its rental-wage ratio, and this ratio determines the one industry that produces there. In order to attract the labor intensive firms, type 1 regions will possess high tax rates, high rental rates on capital, but low wage rates. In contrast, type 2 regions will attract the capital intensive firms by possessing low tax rates, low rental rates on capital, and high wage rates. To offset this difference in wage rates so that utilities remain equal, type 1 regions will have a greater public good supply than type 2 regions.

Figure 2 illustrates the equilibrium. On the vertical axis is a resident's private expenditures on the two goods, E , defined as

$$E = C_1 + pC_2, \quad (3)$$

where C_i is the private demand for good i . By the resident's budget constraint, E satisfies

$$E = w\bar{L} + b\bar{K} \quad (4)$$

where w is the wage rate, \bar{L} is the total labor supplied by the region's resident and \bar{K} is his ownership of capital (recall that each region's population is normalized to equal one). In equilibrium, residents of type 1 regions trade some of their capital to type 2 regions, where production is most capital intensive. Consequently, \bar{K} does not equal the total quantity of capital (K) used by firms within a given region.

On the horizontal axis of Fig. 2 is the level of public good output in a region, which I label G . For a given b and p , a "consumption possibility frontier" (CPF) is drawn and labeled aa . This CPF depicts the feasible (G,E) 's for the region. Each point on it corresponds to a different tax rate, and, therefore, to a different rental-wage ratio. A small reduction in the tax rate lowers the rental rate by the same amount (since the after-tax return to capital is fixed for the region). To maintain zero profits, the wage rate then rises. Thus, a fall in the tax rate reduces r/w and moves the economy along the CPF towards higher levels of E .

I have drawn the CPF so that it bends back toward the E -axis at low levels of E . This reflects the observation that, when the tax rate becomes sufficiently high, further increases in the tax rate reduce total tax revenue through their negative impact on the region's capital supply. As 100% capital taxation is approached, the capital stock and equilibrium wage rate both converge to zero, leaving the region with no tax revenue or wage income; E is then financed entirely from after-tax earnings on capital.

A crucial property of the CPF is that it becomes horizontal at the private expenditures level, E' , corresponding to the rental-wage rate where both firms earn

zero profits (r'/w'). There is a continuum of equilibrium capital supplies at this factor price ratio, each corresponding to a different division of production between the labor intensive and capital intensive industries. Consequently, there is a continuum of equilibrium public good supplies, each satisfying the government budget constraint for a different capital supply. Points on the CPF above (below) E' correspond r/w 's below (above) r'/w' . Consequently, regions with E 's above (below) E' specialize in producing good 2 (1), which is capital (labor) intensive. The discontinuous jump in the public good supply as E rises above E' reflects the change in specialization towards the capital intensive good.

Each government maximizes utility subject to the constraint described by the CPF. Given the discontinuity at E' , there can never be a unique optimum when the economy is in equilibrium. In Fig. 2, there are two optima, as illustrated by the two points, 1 and 2, where indifference curve JJ touches the CPF (as with the CPF, indifference curves depend on product prices, which are fixed from a single region's viewpoint). Policy 1 is to choose a high tax rate and attract only labor intensive firms. Policy 2 is to choose a low tax rate, thereby attracting capital intensive firms. Fig. 2 illustrates the case where the tax rate under policy 2 is at the highest level where capital intensive firms are willing to produce. Labor intensive firms are also willing to operate under this tax rate, but, in equilibrium, the regions following policy 2 (type 2 regions) contain only the capital intensive firms. If both labor and capital intensive firms operated in one of these regions, utility could be raised by slightly lowering the tax rate, as argued above (recall Fig. 1). Other examples can be constructed where labor intensive firms strictly prefer not to operate in type 2 regions (in which case the indifference curve in Fig. 2 is tangent to the CPF at points above E'). And examples can be found where there are more than two optima.

Some readers may question whether an equilibrium can ever exist. For

condition 2 appears to represent an extra equilibrium condition which is not normally found in general equilibrium models. This observation is accurate. But it does not imply that the number of equilibrium conditions exceeds the number of "unknowns", because the presence of two types of regions essentially adds another "unknown" to the model; namely, the fraction of regions producing each good. Although the existence of an equilibrium cannot be verified simply by counting equations and unknowns, an equilibrium can be shown to exist for this economy. Since the proof is long and slightly technical, I shall only outline the important steps with the aim of further illustrating how the model works.⁴

Condition (2) produces a dependence between p and b : for each b , p must adjust so that type 1 and 2 regions have the same maximum utility. That this is possible, at least for some b , is easily understood. A sufficiently high p represents a terms of trade which is so favorable for regions producing good 2 that every region sets its tax rate at a level which attracts only industry 2. Similarly, a sufficiently low p induces all regions to attract only industry 1. There is then an intermediate p at which each region is indifferent about which industry to attract.

Given this relation between p and b , there remain two independent variables to clear the capital and product markets: b and the fraction, s , of regions producing good 1.⁵ A rise in s lowers the total demand for capital in the economy by increasing production of the labor intensive good relative to the capital intensive good. For each b lying in some interval of b 's (with p determined by (2)), it is possible to find an s where demand equals supply in the nation's capital market. Given this relation between b and the market-clearing s , the excess demand for good 1 can be written as a function of b alone: $Z_1 = Z_1(b)$. At any b where this excess demand equals zero, Walras Law implies that the excess demand for good 2 is also zero.

Some rough intuition can be given to explain why there is some b where $Z_1(b) =$

0. If b is high, then both industries will face high rental-wage ratios and choose low capital-labor ratios. Given the nation's fixed stock of capital, equilibrium in the capital market will then be obtainable, if at all, only if a large share of the nation's labor force resides in type 2 regions, where the capital intensive good is produced. In fact, it is possible to find a b under which the capital market clears only when everyone resides in type 2 regions.. The supply of good 1 then equals zero, implying a positive $Z_1(b)$.

Similarly, there exists a low b under which the capital-labor ratios chosen by firms are sufficiently high for the capital market to clear with everyone residing in the region producing the labor intensive good. In this case, there is excess demand for good 2, implying an excess supply of good 1: $Z_1(b)$ is negative. Once $Z_1(b)$ is shown to be continuous between these two b 's, it can be concluded that there is some intermediate b where the market for good 1 clears. With all other markets clearing, the economy is in equilibrium.

4. Wasteful Diversity

The surprising conclusion from the previous section is that different regions choose different public good supplies, even though all regions and individuals are identical. Since Pareto efficiency requires that identical individuals consume identical bundles of goods, the equilibrium is characterized by a wasteful diversity of public policies.

The various inefficiencies which arise in equilibrium are illustrated by Fig. 3. The horizontal axis measures total public good output, summed across all regions, while the vertical axis measure total private expenditures. For the purpose of this graphical illustration, the model is specialized by assuming that one of the two private goods is used only as a final consumption good by residents, while the other

good is used only as the sole input in the production of the public good. Since there is essentially no difference between the second good and the public good, I can assume that private firms produce the public good directly and then sell it to the regions' governments. Given the total quantities of labor and capital available in the whole economy, curve dd gives the economy's production possibility frontier (PPF) for the two goods. To produce on the PPF, all regions should choose the same tax rates and public good outputs. Since, however, tax rates differ in equilibrium, capital is missallocated between regions, and the equilibrium total outputs of the public and private goods, G_T and E_T , lie below the PPF, as illustrated. The Edgeworth box associated with these outputs is also drawn, with the type 2 regions' allocation measured from the southwest corner and the type 1 regions' allocation measured from the northeast corner. The equilibrium allocation is labeled A. As illustrated by the indifference curves passing through this point, the equilibrium division of G_T and E_T between regions lies off the contract curve (i.e., it is Pareto inefficient) because identical individuals do not receive identical bundles of goods. Thus, the equilibrium is characterized by both "production inefficiency" and "exchange inefficiency."

Another way to describe the inefficiencies in the model is to compare the marginal rate of substitution between G and E (MRS_{GE}) with the "resource cost" of the public good, as measured by p_G . This can be done by examining the first-order condition for a type 1 region's optimal policy. Since the slope of the CPF in Fig. 2 is not defined at E', there does not exist a first-order condition for a type 2 regions' optimal policy. But this slope is defined under the optimal policy for a type 1 region, and its absolute value equals the marginal rate of transformation between G and E (MRT_{GE}).

The first-order condition for the type 1 optimal policy is obtained by equating MRT_{GE} with MRS_{GE} . To obtain the MRT_{GE} , I increase the tax rate by a differential

amount dt . With b fixed, the rental rate rises by $dr=dt$. To maintain zero profits in the labor intensive industry (the only industry in type 1 regions), the wage rate then falls by

$$dw = -k_1 dt, \quad (5)$$

where k_1 is the capital-labor ratio for the labor intensive good. By the consumer budget constraint, this change in w lowers E by

$$dE = -K dt. \quad (6)$$

Equation (6) and the government budget constraint (eq. (1)) yield

$$-dE = p_G dG - t dK. \quad (7)$$

At the optimum, this feasible policy change has a zero first-order impact on utility. Thus, I can rewrite (7) as

$$MRS_{GE} = p_G - t(dK/dG), \quad (8)$$

where dK/dG is the marginal impact of G on the region's capital supply. The right side of (8) gives the MRT_{GE} under the type 1 regions' optimal policy (point 1 in Fig. 2). It is easily shown that dK/dG must be negative here: the tax rate rises to finance additional G , and the resulting rise in the rental-wage ratio causes an outflow of capital. Thus, the type 1 regions choose a public good supply where MRS_{GE} exceeds p_G . The same inequality must also hold for type 2 regions, since their chosen public good supplies are lower than those in type 1 regions, implying

that their MRS_{GE} 's are also higher (by the strict convexity of indifference curves). In symbols,

$$MRS_{GE} > p_G \quad \text{in all regions.} \quad (8)$$

Thus, each region chooses a public good supply where the social marginal benefit of the public good exceeds the "resource cost" of providing another unit of the public good. This is the same conclusion obtained from the model discussed in the introduction, where there is no trade in equilibrium; and the intuition is basically the same. Contrary to the model without trade, however, the equilibrium allocation is not located on the PPF (see Fig. 3). This means that p_G cannot be interpreted as the nation's marginal rate of transformation between G and E . In fact, this MRT_{GE} is not well-defined. Thus, the difference between MRS_{GE} and p_G does not imply anything about how G_T differs from the Pareto efficient total public good output for the economy. This difference can have any sign. Figure 3 illustrates a situation where the efficient output is less than the equilibrium output. The equilibrium output is represented by the tangency between the PPF and a social indifference curve, which is defined when all residents receive equal amounts of the total outputs of the private and public goods.

5. Insufficient Diversity

In the models discussed so far, any difference across regions in the supply of public goods must be wasteful because the population is homogeneous. If consumer heterogeneity is introduced into the analysis, then a surprising new possibility emerges: the equilibrium may be characterized by too little diversity in public good supplies. In particular, there may exist an equilibrium where a group of individuals

consume the same quantities of public goods but possess different marginal rates of substitution (MRS_{GE}).

In order to isolate the implications of commodity trade for diversity, it is useful to abstract from other factors which might produce an equilibrium with dissimilar individuals residing in the same region. Thus, I now explicitly incorporate labor mobility into the analysis, so that it is possible for individuals to segregate themselves across regions according to preferences and incomes. Furthermore, I assume that the public good has the attributes of a private good (i.e., the marginal cost of providing the current output to an additional resident is constant and equal to the average cost of provision). This last assumption gets rid of the possibility that individuals with different preferences or incomes might reside in the same region in order to take advantage of scale economies in public good consumption. Hamilton (1983) argues that it is empirically reasonable.⁶

Turning to government behavior, I assume that each region's tax and expenditure policy is chosen to maximize the utilities that its current residents can receive by residing there. Given my assumptions of constant returns to scale, any disagreement among residents about what is the utility-maximizing policy would imply that some residents could be made better off without anyone being made worse off, if the region was split into two separate regions, each with their own separate tax and expenditure policy. Since I wish to abstract for inefficiencies which arise from constraints on community formation, I shall assume that regional borders can be altered in this way. Then an equilibrium emerges where all individuals in any given region agree unanimously about the particular public policy to follow.

Suppose now that my previous model with identical individuals is modified to include labor mobility. Then the allocation of labor across regions becomes both indeterminate and irrelevant, because the maximum utility received by a region's

residents does not depend on the region's population size.⁷ The optimal public policy for a region is completely independent of the region's population size. Consequently, the mobility of labor does not alter my previous conclusions. In particular, the economy is in equilibrium only when public good supplies differ across regions. There is too much diversity in public good supplies.

To demonstrate the possibility of too little diversity, assume next that individuals possess different preferences (i.e., utility functions). They may also possess different factor endowments, but I assume that there exists a subset of individuals with identical factor endowments but different preferences. All individuals in this subset face the same consumption possibility frontier (CPF), which I draw in Fig. 4, along with indifference curves for three individuals with different preferences. As illustrated, one individual chooses to reside in a type 1 region, where good 1 is produced and the tax rate and public good supply are relatively high. But the other two individuals can maximize utility by residing in a type 2 region. The tax rate in this type 2 region is at the highest level at which industry 2 is willing to produce. And both of the individuals agree unanimously to consume the same amount of the public good, even though they possess different MRS_{GE} 's. This situation is made possible by the discontinuity in the CPF, which I have discussed at length above. The MRS_{GE} 's differ because the optimal tax and expenditure policies for the type 2 region represent a "corner solution:" any further rise in the tax rate would immediately turn the type 2 region into a type 1 region, with industry 1 replacing industry 2 and the region's capital-labor ratio thereby dropping discontinuously.

In contrast to this equilibrium, a requirement for an efficient allocation is that both factor and product prices be equalized across regions. Thus, all individuals should possess the same MRS_{GE} 's, regardless of how their preferences and endowments differ. And if two individuals always possess different MRS_{GE} 's under

the same (G,E), then they should possess different (G,E)'s in equilibrium. The example depicted in Fig. 4 can therefore be viewed as illustrating a situation where there an insufficient degree of diversity in public good supplies.

It should be apparent that a necessary condition for there to be too little diversity is that the number of different types of individuals exceed the total number of traded goods with different factor intensities. (Section 6 extends the analysis to more than two traded goods.) But this condition is by no means sufficient. Examples can be constructed where the number of different public good supplies exactly equals the number of different types of individuals, even if individuals differ only in preferences, rather than factor endowments (e.g., fig. 4 can be altered so that one of the indifference curves is tangent to the CPF at a point above the discontinuity.) And examples can also be given where there is again wasteful diversity in the sense that identical residents residing in different regions consume different quantities of the public good. However, only in the case where the number of traded goods exceeds the number of different types of individuals can it be concluded that the equilibrium must be characterized by too much diversity in the sense that identical individuals consume differ public good supplies.

Since my model represents an extremely high degree of abstraction, it would be foolish to draw conclusions based on the empirical reasonableness of various assumptions about the relative numbers of goods and types of individuals. However, the model does call into question the usefulness of one-good, identical-jurisdiction models, which are widely used in local public economics as a means of isolating efficiency considerations from equity considerations. Such models may ignore important efficiency issues concerning the allocation of goods across individuals.

6. Specialization and Nontraded Goods.

My argument that each region specializes in the production of only one traded good does not depend on the number of traded goods in the economy. If any two traded goods with different factor intensities are produced in a single region, then a slight reduction in its tax rate shifts all production to the capital intensive industry, thereby causing a discontinuous rise in the tax base. Thus, no local government will tolerate more than a single industry in the region. In the limit, when the number of traded goods becomes a continuum, there will be a continuum of regions, each producing a single traded good. This is illustrated by Fig. 5, where isoquants for a dollar of output are drawn for several goods with different factor intensities. The envelope of all of the isoquants is labeled II. In equilibrium, product prices and the after-tax return to capital adjust so that each of the traded goods is produced by some subset of regions. In the case where all individuals are identical, every region will be completely indifferent about which traded good to produce, and the public good supply will be higher and the wage rate lower the more labor intensive the good produced in a region.

If nontraded private goods are introduced, or the public good is nontraded, then it is still the case that each region produces only one traded good. With each region producing both traded and nontraded goods, however, there is now the issue of whether a local government would want to tax the capital used to produce traded goods at different rates than the capital used to produce nontraded goods. This issue has been studied in detail by Wilson (1984a) using a model with only one traded good. He concludes that local governments normally have an incentive to impose

relatively low tax rates on nontraded goods. Furthermore, the introduction of additional traded goods strengthens this conclusion. Briefly, when the tax rate is increased on the capital in traded good production, the equilibrium capital-labor ratio there falls, not only because producers switch to less capital intensive production techniques, but also because there is a shift in specialization toward less capital intensive goods. In contrast, while a rise in the tax rate on the capital used to produce a nontraded good also leads to less capital intensive production techniques, it does not eliminate the production of the nontraded good in the region (assuming consumer demand stays positive). Consequently, the specialization of regions in traded good production provides a justification for assuming that the elasticity of substitution between capital and labor in traded good production (defined to include switches in specialization) is greater than the substitution elasticity in the production of any nontraded good. And the general intuition developed from the optimal tax literature is that high elasticities imply low optimal tax rates. Wilson (1984a) confirms this intuition for the the case of property taxation: a relatively high substitution elasticity in traded good production provides an incentive for the local government to tax capital in traded good production at relatively low rates. By explaining why this elasticity might be relatively high, the present extension of the analysis provides one explanation of why local governments tend to provide tax advantages to industrial firms producing goods sold on the national market.

A useful extension of the analysis would be to construct a model where each region contains a fixed amount of land, but both labor and capital are mobile. Here a natural government objective to consider is land value maximization, which has been shown by past research on models without capital mobility to possess desirable efficiency properties.⁸ Wilson (1984a) analyzes one such model but assumes that there is only a single traded good. His analysis suggests, however,

that the results from a land value maximization model with two or more traded goods would be quite similar to the results from the present study.

One extension which would change the results somewhat would be to include more than one immobile factor in the model. If there are $n > 1$ immobile factors, then n factor prices are free to adjust when a region changes its tax rate on mobile capital. Consequently, zero profits can be maintained in n traded good industries as the tax rate changes. However, as long as the economy contains more than n traded goods with different factor intensities, there can still be some specialization in traded good production, even when all individuals in the economy are identical. An equilibrium can be expected to emerge where each region produces only n traded goods. Although this specialization is longer be complete, regions specializing in the production of different sets of traded goods will usually choose different public good supplies. Thus, there still exists the possibility of a wasteful diversity of public good supplies.

A new problem created by this last extension is that the owners of different immobile factors in a single region are likely to disagree over which tax and expenditure policy to implement. Thus, the politics of the model are no longer trivial, and an explicit political model is needed to complete the analysis. Of course, this lack of unanimity also arises in the empirically relevant case where factors are only partially mobile, due to either "moving costs" or "adjustment lags." An important task for future research is to investigate the properties of decentralized government decision-making in models with partial factor mobility.

7. The International Trade Literature

There is an interesting connection between the results reported here and the international trade literature on factor mobility. A key concern of the trade literature has been the relation between factor movements and commodity trade. The modern discussion of this relation begins with the classic article by Mundell (1957), which demonstrates that factor movements and commodity trade are substitutes, in both the sense that the existence of the former reduces the latter, and the sense that the welfare gains from international trade can be realized either from movements of commodities or movements of factors.

It is perhaps a distinguishing feature of local public economics that labor mobility and commodity trade can never be viewed as substitutes, at least in the welfare sense. Labor mobility serves a role which cannot be served by commodity trade alone: namely, it provides a mechanism by which individuals can "vote with their feet" and obtain tax-expenditure packages which are tailored to their preferences and incomes.

Although capital mobility does not also serve this role, the present research still casts doubt on accuracy of the claim that capital mobility and commodity trade may generally be viewed as substitutes. In particular, my simplest model provides an example where there is a complementary relation between capital movements and commodity trade. Since all individuals are identical in this model, the absence of capital movements would imply an absence of trade (assuming that each region's capital is owned entirely by its residents). In fact, the equilibrium would be efficient, because each region's tax on its immobile capital stock would be completely capitalized into the after-tax return to capital, causing the region's residents to bear the true social cost of public good production. All regions would choose the same tax rates and public good supplies, and their rental-wage ratios

would be identical. Once capital mobility is allowed, however, tax rates differ and each region produces only one traded good while importing all other traded goods. Thus, capital mobility produces net movements of different goods between regions. In this sense, decentralized decision-making by regional governments causes capital movements and commodity trade to be complements.

Recent research in trade theory has also produced conditions under which capital movements and commodity trade are complements in the volume-of-trade sense (i.e., capital movements resulting from international factor price differences lead to a rise in the volume of trade). These conditions include differences in technologies across countries, scale economies, production taxes, factor market distortions, and monopoly; all of which are absent from Mundell's (1957) classic demonstration that trade and capital mobility are substitutes (see Markusen (1983)). The distinguishing feature of my analysis is that the relation between trade and capital mobility is the direct result of government behavior. Although the capital taxes in my model represent factor market distortions, it would be misleading to say that these distortions are the cause of the complementary relationship between trade and capital movements. Rather, this relation is the direct result of the decentralized decision-making by the regions' governments.

8. Concluding Remarks

In this paper, I have introduced interregional commodity trade into the study of tax competition. The presence of trade leads to new conclusions about decentralized decision-making by a system of governments. Perhaps the most surprising portion of the analysis is the presentation of a model where the equilibrium public good supplies differ across regions containing identical

individuals and production technologies. In general, the inefficiencies introduced by taxes on capital are varied and complex, and cannot be adequately described in terms an "under-provision" in the overall supply of public goods. In fact, the analysis produces as a possibility the "conservative view" that the overall supply of public goods exceeds the efficient level.

I view the results of this paper as an argument against the present system of property taxation in the U.S. The usual arguments for taxing mobile capital concern the difficulty of distinguishing between the values of land and its improvements at a particular site. I find these arguments unconvincing. In any case, it is not clear that commodity taxes or an income tax might not be preferable to the present property tax system, despite the inefficiencies which they create. Just as my results dramatize the inefficiencies resulting from the taxation of mobile capital by local governments, it is also quite possible that decision by local governments to rely heavily on capital taxation rather than some other administratively feasible form of taxation is undesirable from the viewpoint of national welfare.

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Footnotes

1. Much of the local public economics literature is motivated by Tiebout's (1957) classic paper, which argues that the ability of individuals to "vote with their feet" will produce an efficient provision of local public goods. Bewley (1981) and Gordon (1983) synthesize and extend the research on the many potential inefficiencies which may arise in a Tiebout equilibrium. For a review of the trade-theoretic literature on factor mobility, see Ruffin (1984).
2. An exception is the insightful analysis by Berglas (1976) of the pattern of production specialization which emerges across communities in an economy with commodity trade and labor mobility.
3. A crucial assumption underlying this analysis is that governments are unable to implement an efficient zoning policy. Hamilton (1975, 1976) demonstrates that efficient zoning turns the property tax into a nondistortive head tax. Mieszkowski (1984) questions the empirical reasonableness of the assumption that efficient zoning policies are feasible. The present paper is concerned with the inefficiencies which arise from taxes on capital when efficient zoning is not possible.
4. The proof is available from the author upon request. I have not constructed general existence proofs for the extensions of the model discussed later in the text. In fact, well-known problems for existence arise when the model is extended to include heterogeneous individuals who are perfectly mobile between regions. It is possible, however, to find examples of equilibria with the properties discussed in the text.

5. I treat s as a continuous variable, thereby ignoring the fact that the number of regions providing each good is an integer. This approximation appears reasonable, since I have already assumed that regions are small enough to be "price-takers."
6. For some recent evidence, see also Gramlich and Rubinfeld (1983).
7. Note, however, that the assumption that regions are "price-takers" becomes problematic if the economy's entire population resides in only a few regions. Thus, the equilibria discussed in this section should be interpreted as those for which the number of occupied regions is large. Interestingly, the conclusion that each price-taking region chooses to produce only one of the two goods implies that there cannot exist an equilibrium with only a single occupied price-taking region. With two or more regions, an equilibrium can be obtained through adjustments in both the fraction of regions producing each good and the number of individuals residing in each region.
8. See, for example, Sonstelie and Portney (1978).

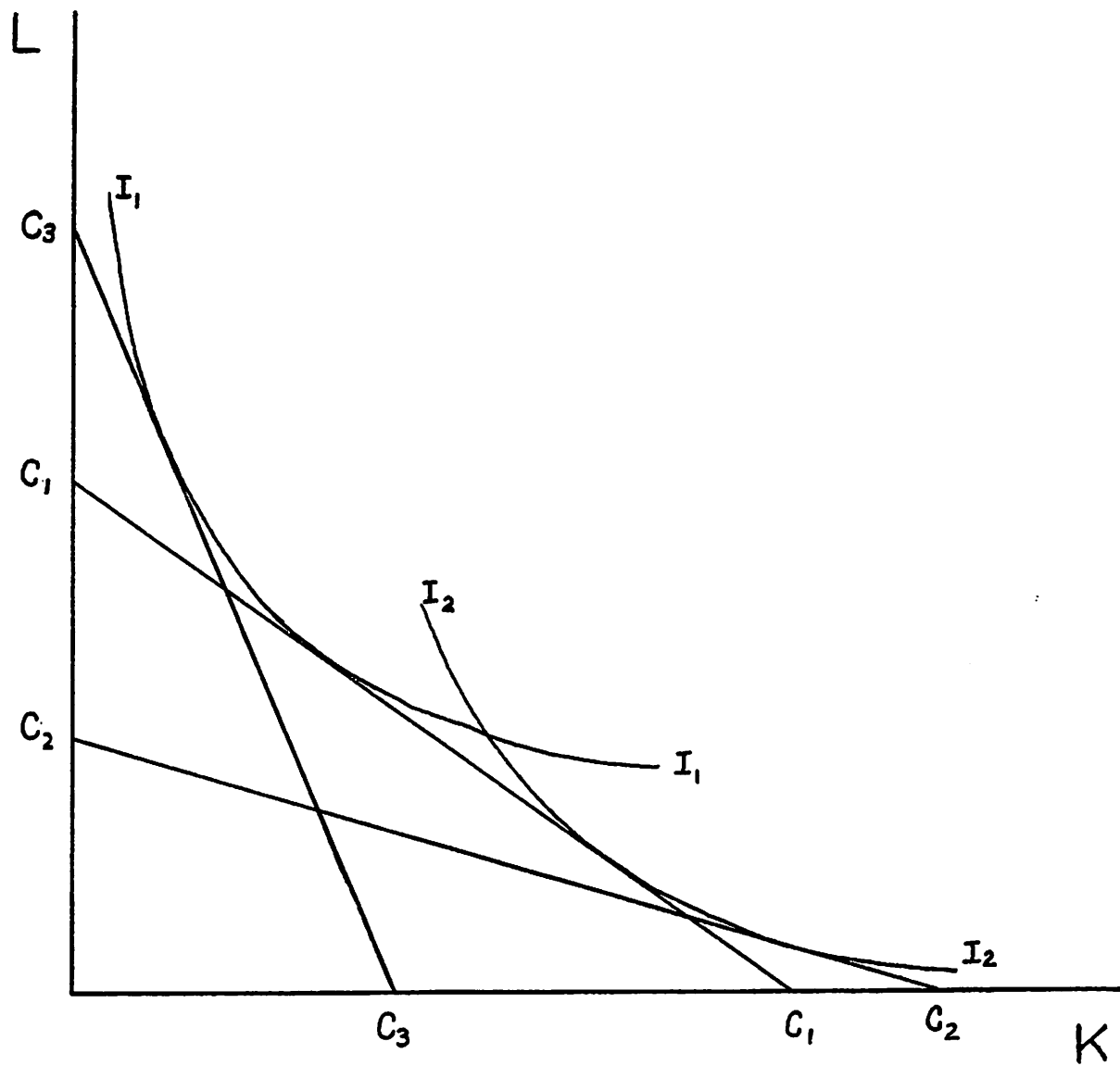


Fig. 1

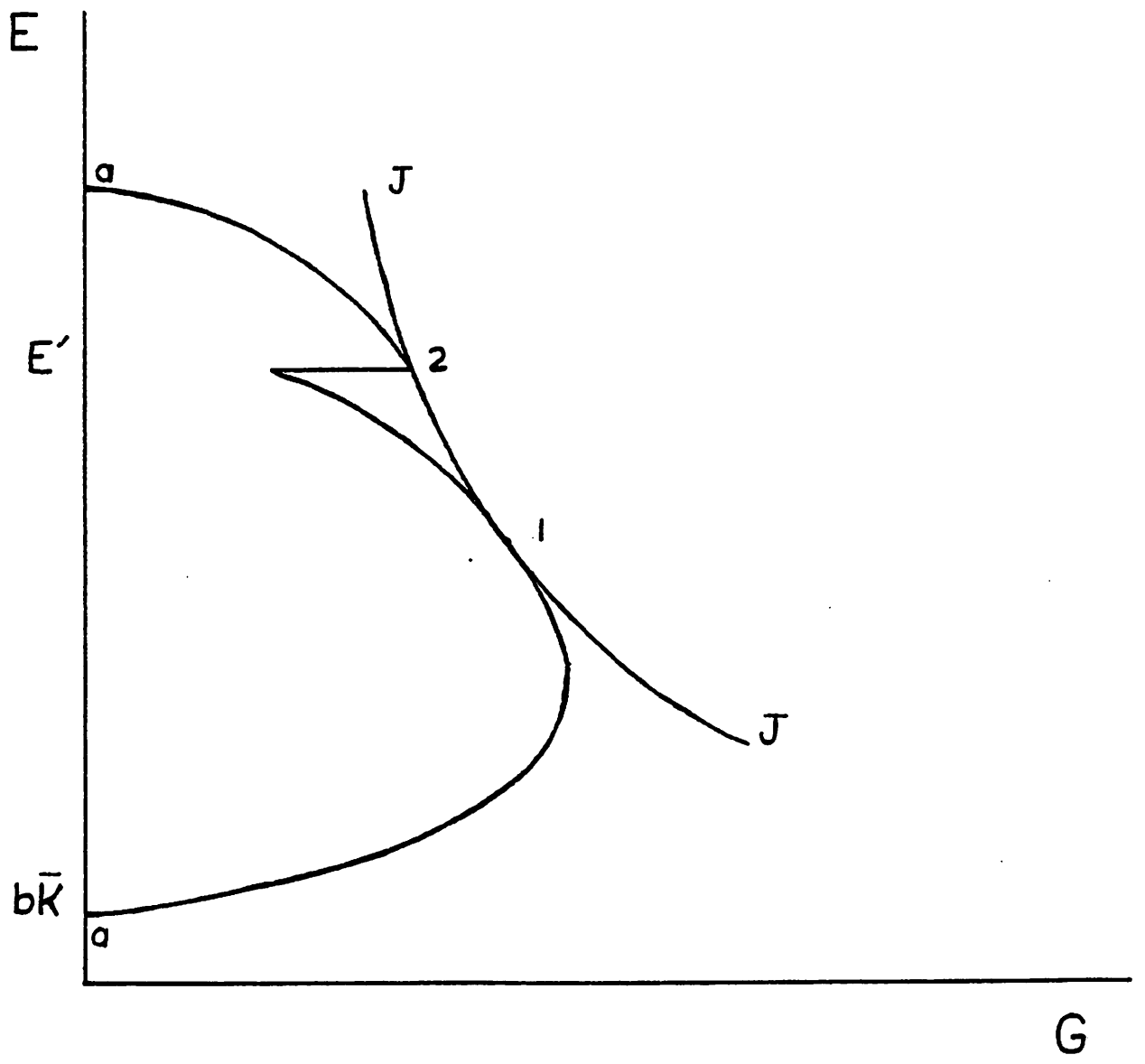


Fig. 2

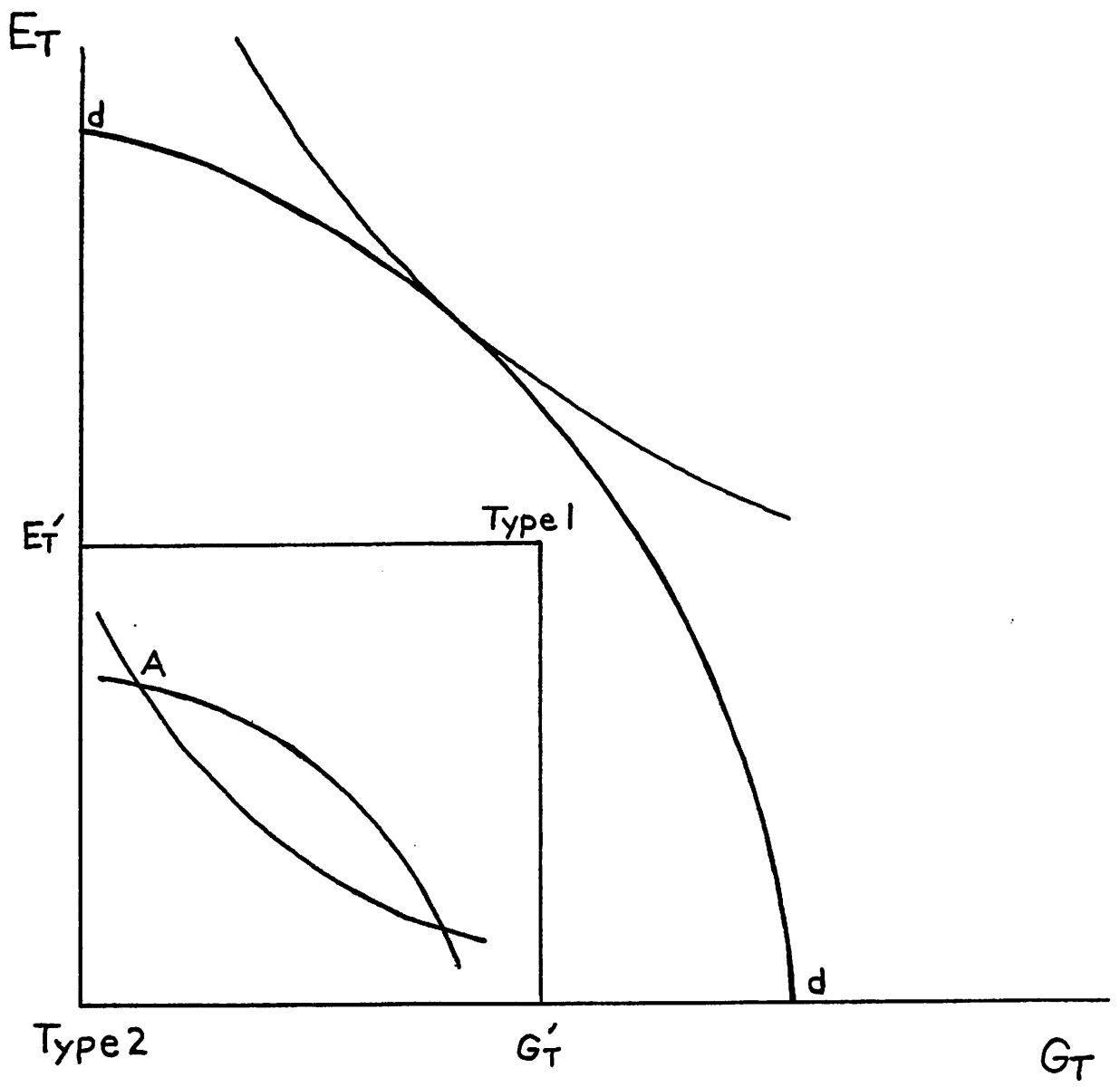


Fig. 3

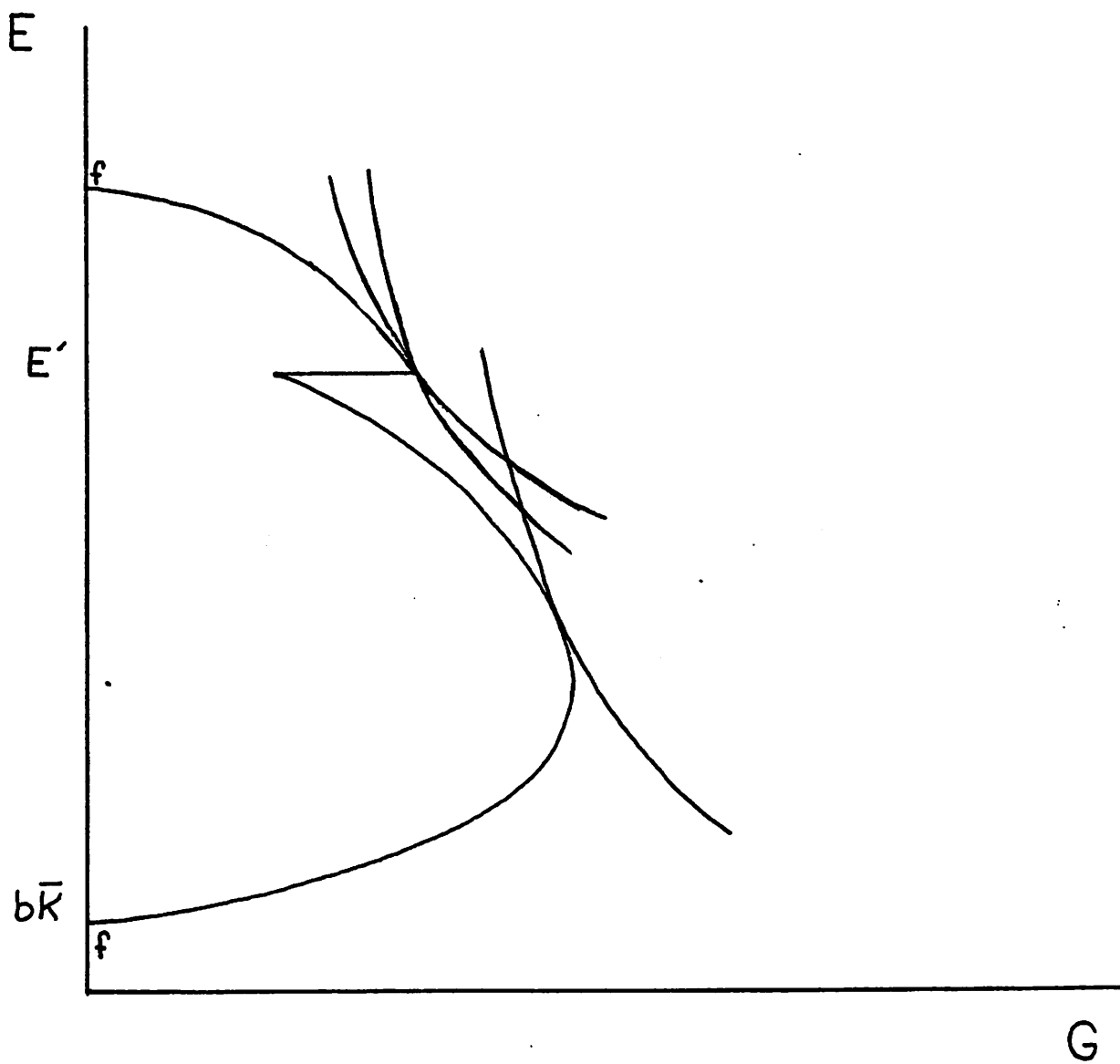


Fig. 4

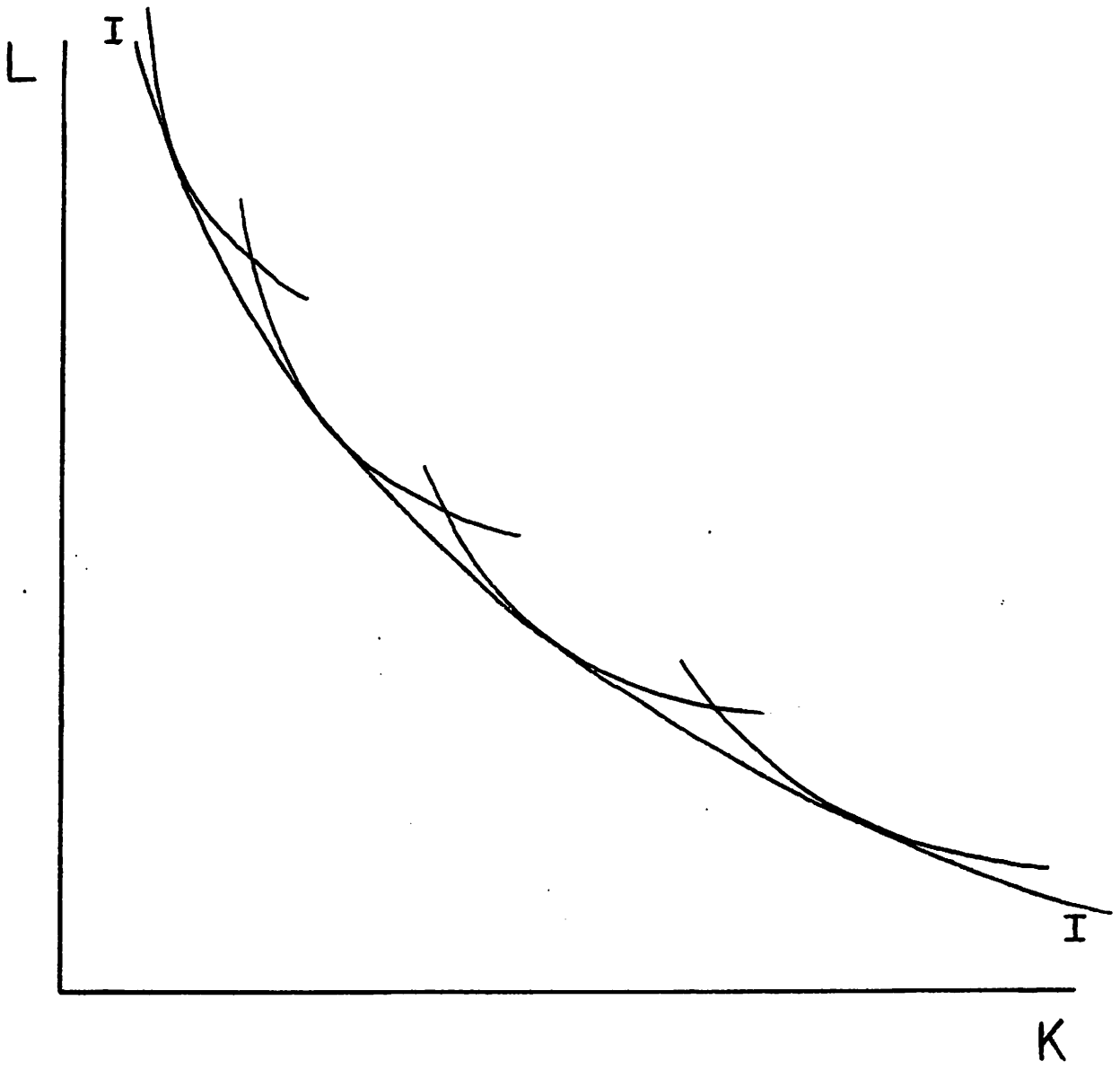


Fig. 5

**A Modern Analysis of the Effects
of Site Value Taxation**

by

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Abstract

Formal analysis is generally absent from the previous literature on site value taxation. This paper analyzes the impact of such a system (under which the property tax on improvements is eliminated, with the tax burden shifted toward land) using standard modern methods. Specifically, the analysis derives the long-run impacts on the level of improvements, the value of land, and the price of housing of a shift to a graded tax system (where the improvements tax rate is lowered and the land tax rate is raised). The paper also analyzes the incidence of the short-run windfall gains and losses that result from gradation of the tax system.

The Effects of Site Value Taxation:
A Modern Analysis

by

Jan K. Brueckner*

Ever since the publication of Henry George's "Progress and Poverty" in 1879, the possibility of using land value taxation as a source of government revenue has intrigued economists and other social commentators. While George's ideas have had little general impact, land value taxation is practiced in Jamaica and in certain cities in Australia and New Zealand. In addition, graded property tax systems (where land is taxed at a higher rate than improvements) are in use in some Canadian provinces as well as in the city of Pittsburgh and several smaller Pennsylvania communities.¹

The literature dealing with land (or site) value taxation is vast (for an excellent bibliography, see Carmean (1980)). Most writers have been concerned with predicting the effects of a shift from a typical property tax system, where land and improvements are taxed at the same effective rate, to a system of pure site value taxation, where the improvements tax is eliminated and land is taxed at a higher rate (tax revenue is held constant). Others deal with the effects of transition to a graded system (where the improvements tax rate is lowered but remains positive), recognizing that pure site value taxation is simply an extreme case of gradation. Consensus has emerged on a number of points. First, nearly all writers agree that reduction or elimination of the improvements tax will raise the level of improvements in the long run, leading to more intensive land-use. Second, there is

agreement that in the short run, windfall gains and losses will result from a movement to a graded system as tax bills rise for certain properties and fall for others.² Additional interest centers on the effect of site value taxation on land speculation³ and on the problem of obtaining the accurate land value assessments required under a site value system in the absence of frequent sales of vacant land.⁴ The best general discussions of these and other issues are provided by Becker (1969), Harriss (1970), and Peterson (1978).⁵

What is remarkable about this large literature is the almost complete absence of modern analysis. Most studies rely on verbal arguments or simple diagrams, and the few analytical efforts (McCalmont (1976) and Cuddington (1978)) are marred by ad hoc assumptions or misplaced emphasis. While several correct predictions have been derived without the aid of rigorous methods (the predicted increase in land-use intensity, for example), the lack of precision of past studies has led to substantial confusion on certain points. A prime example is the question of land value impacts. As is shown below, the improvements tax reduction accompanying a shift to a graded system raises land value while the corresponding land tax increase lowers value. Only two of the many previous writers in this area (Becker (1969) and Harriss (1970)) recognize the existence of these opposing effects, and both identify the net impact as ambiguous.⁶ The analysis presented below shows, however, that the land value change is in fact determinate and has a rather surprising direction. The results of the paper therefore invalidate McCalmont's claim that "not even the direction, let alone the amount, of the change in land rent

can be ascertained from theory alone..." (1976, p. 928). Another important question on which the literature is virtually silent is the impact of site value taxation on housing prices. Modern analysis gives an immediate answer, as will be seen below.

The remainder of this paper will elaborate on the above points by conducting an analysis of the effects of site value taxation using standard modern methods. Sections 1 and 2 investigate the long run impacts of a revenue-preserving shift from a standard property tax system to a graded system under two different scenarios. In the first case, the graded tax system is imposed in only a small part of a housing market, so that the price of housing is unaffected. In the second case, implementation occurs market-wide, so that price effects emerge. In both cases, the analysis derives the impacts of gradation on the level of improvements and the value of land. The impact on the price of housing is also derived for the second case.

While Sections 1 and 2 assume that the price of housing is spatially uniform, Section 3 allows spatial variation. In this setting, improvements and land value vary with location, and short-run windfall gains and losses result from a switch to a graded tax system. The analysis investigates the spatial pattern of gains and losses under the assumption that the housing price contour is exogenous. The last section of the paper offers conclusions.

1. Long-run effects with an exogenous housing price

In reality, property taxes are levied on a wide variety of types of structures: residential, commercial, and industrial. Typically,

the interior space in one type of structure is unsuitable for any other use. In the following analysis, this fact is ignored and the property tax base is assumed to consist of a homogeneous class of structures called "housing." In the model, housing floor space is rented at price p per square foot and is produced using inputs of capital (N) and land (l) under a neoclassical constant returns technology represented by the production function $H(N, l)$. Since output is indeterminate under constant returns, the analysis focuses on levels of output and capital input on a per-acre-of-land basis. Housing output per acre is $H(N, l)/l = H(N/l, 1) \equiv h(S)$, where S is capital per acre of land (hereafter improvements per acre), a measure of land-use intensity, and $h(S) \equiv H(S, 1)$. Note that $h' = H_1 > 0$ and $h'' = H_{11} < 0$ by the concavity of H .

The net-of-tax rental prices of capital and land are represented by i and r respectively, and the tax rates on improvements (capital) and land are τ and θ respectively. The gross-of-tax capital and land prices are therefore $(1+\tau)i$ and $(1+\theta)r$ respectively. Note that since taxes are expressed as a fraction of net rental price instead of value, conversion to value terms would require multiplication of the tax rates by the discount rate. Note also that $\tau = \theta$ will hold under a standard property tax system.

The shift to a graded property tax system is assumed to occur over a land area of size \bar{l} (referred to subsequently as the "tax zone"). Locational advantages are absent within the tax zone, so that the housing price p is spatially uniform. Furthermore, in this section of the paper, the tax zone is viewed as representing a small portion of the

relevant housing market. For example, the zone can be thought of as a single small city imbedded in a much larger metropolitan area. This means that a change in the tax system will have a negligible effect on the total supply of housing in the market, with the result that the price p can be viewed as exogenous. Finally, given that the analysis deals with the effects of a localized rather economy-wide tax change, the net return to capital is also taken to be exogenous (the locality faces a perfectly elastic supply of capital).

Profit per acre for a housing producer operating in the tax zone is given by $ph(S) - (1+\tau)iS - (1+\theta)r$. The equilibrium conditions for the producer require that profit per acre is maximal and that the maximized value equals zero. The appropriate conditions are

$$ph'(S) = (1+\tau)i$$

$$ph(S) - (1+\tau)iS - (1+\theta)r = 0.$$

$\theta = \text{land tax}$
 $\tau = \text{cap. tax}$ (1)
 $i = \text{cap. return}$
 $r = \text{land rent}$ (2)

Together, eqs. (1) and (2) determine equilibrium values of improvements per acre S and net land rent r . The impacts on S and r of changes in the tax rates τ and θ , which are used to derive the effects of a shift to a graded tax system, are computed by totally differentiating the system (1)-(2). The results are

$$\frac{\partial S}{\partial \tau} = \frac{i}{ph''} < 0 \tag{3}$$

$$\frac{\partial S}{\partial \theta} = 0 \tag{4}$$

$$\frac{\partial r}{\partial \tau} = \frac{-iS}{1+\theta} < 0 \quad (5)$$

$$\frac{\partial r}{\partial \theta} = \frac{-r}{1+\theta} < 0 \quad (6)$$

By increasing the cost of capital, an increase in the improvements tax rate τ reduces improvements per acre, as seen in (3). By reducing the profitability of development, the higher improvements tax also depresses land rent, as seen in (5) (rent serves to exhaust residual profit). Eqs. (4) and (6) indicate that while an increase in the land tax rate has no effect on the level of improvements, the higher θ lowers land rent. The higher tax is in fact fully capitalized, leaving $(1+\theta)r$ unchanged.

The goal of the analysis is to derive the impacts on S and r of a revenue-preserving shift to a graded tax system. Starting with a standard tax system (where $\tau = \theta$), gradation results from an increase in θ combined with a revenue-preserving change in τ (pure site value taxation emerges when $\tau = 0$). The first step in the derivation is the computation of the derivative $\partial \tau / \partial \theta$, which gives the revenue-preserving change in τ accompanying an increase in θ . Noting that tax revenue originating from the tax zone equals $\bar{x}(\tau i S + \theta r)$, $\partial \tau / \partial \theta$ must satisfy $d(\tau i S + \theta r) / d\theta = 0$, or

$$\frac{\partial \tau}{\partial \theta} i S + \tau i \left(\frac{\partial S}{\partial \theta} + \frac{\partial S}{\partial \tau} \frac{\partial \tau}{\partial \theta} \right) + r + \theta \left(\frac{\partial r}{\partial \theta} + \frac{\partial r}{\partial \tau} \frac{\partial \tau}{\partial \theta} \right) = 0 \quad (7)$$

Substituting from (3)-(6) and rearranging, (7) yields

$$\frac{\partial \tau}{\partial \theta} = \frac{-r}{iS} \left\{ 1 - \frac{(1+\theta)\tau\sigma}{(1+\tau)\mu_2} \right\}^{-1}, \quad (8)$$

where σ is the elasticity of substitution between capital and land in housing production and μ_l is land's factor share.⁷

Inspection of (8) shows that the sign of $\partial\tau/\partial\theta$ is ambiguous, so that a revenue-preserving change in τ may involve either a decrease or an increase. The outcome depends crucially on the magnitude of the elasticity of substitution, which, for given values of τ , θ , and μ_l , determines the sign of the expression in braces in (8). Inspection of (8) indicates that for σ sufficiently close to zero, $\partial\tau/\partial\theta$ will be negative, while for σ sufficiently large, $\partial\tau/\partial\theta$ will be positive. To gain an intuitive understanding of this result, the first step is to note that (8) equals minus the ratio of the derivative of tax revenue with respect to θ ($r+\theta\partial r/\partial\theta$) and the derivative of revenue with respect to τ ($iS + \tau i\partial S/\partial\tau + \theta\partial r/\partial\tau$). Since the first derivative is always positive (revenue is always increasing in θ),⁸ the sign of $\partial\tau/\partial\theta$ depends on the sign of the latter derivative, which depends in turn on two separate effects. First, since $\partial r/\partial\tau < 0$ by (5), an increase in τ indirectly depresses revenue from the land tax, making the last term in the derivative negative. The effect of a higher τ on improvements tax revenue (captured by $iS + \tau i\partial S/\partial\tau$) is ambiguous, however, and depends on the magnitude of σ . A low (high) value of σ means that improvements tax revenue is increasing (decreasing) with τ due to weak (strong) substitution away from capital as τ rises.⁹ Since a higher τ will therefore depress revenue from both the improvements and land taxes when σ is large, it follows that cancellation of the revenue gain from an increase in θ can be achieved by raising τ . As a result, $\partial\tau/\partial\theta$ will be positive when σ is large. When σ is sufficiently small, however,

the increase in improvements tax revenue resulting from a higher τ dominates the decline in land tax revenue, and total revenue rises with τ . In this case, τ must fall as θ rises to keep total revenue constant.¹⁰

Whether $\partial\tau/\partial\theta$ is negative or positive for plausible values of σ depends on the magnitudes of the other parameters in (8). To make matters simple, suppose first that $\partial\tau/\partial\theta$ is evaluated under a standard property tax system, so that $\tau = \theta$ holds. In this case, the sign of (8) is the same as the sign of $\sigma - (\mu_\ell/\tau)$. Focusing first on land's share, published (or implied) estimates of μ_ℓ range from 20% to 50%, with most values lying in the middle or lower end of this range.¹¹ In addition, data compiled by the Advisory Council on Intergovernmental Relations (1983, Table 37) show that the average effective property tax rate in the U.S. in 1981 for single family homes with FHA insured mortgages was 1.26%. With a value-to-rent ratio between 10 and 20 (a discount rate between 5% and 10%), this yields a τ between 12% and 26% (recall that τ is the tax rate on net rent, not value). Together, these μ_ℓ and τ values imply that μ_ℓ/τ lies between .8 and 4.2, with a plausible value falling near the middle of this range. Since published estimates of the elasticity of substitution in housing production are almost always smaller than unity (see McDonald (1981) for a survey), it follows that $\sigma - (\mu_\ell/\tau)$ is almost certainly negative, implying $\partial\tau/\partial\theta < 0$. Thus, the initial shift toward a graded tax system will require a decline in τ , as intuition would suggest. It should be noted that while this analysis does not guarantee that $\partial\tau/\partial\theta$ remains negative after τ falls below θ , such an outcome seems likely. In this

case, τ falls monotonically as θ increases, reaching zero in the case of pure site value taxation.

Having computed $\partial\tau/\partial\theta$, it is now possible to derive the impacts on S and r of a shift to a graded property tax system. Since $\partial S/\partial\theta = 0$ by (4), the impact on S is simply $dS/d\theta = (\partial S/\partial\tau)(\partial\tau/\partial\theta)$. Given that $\partial S/\partial\tau < 0$ by (3), $dS/d\theta$ will be positive in the normal case where $\partial\tau/\partial\theta$ is negative. This is the outcome recognized in the earlier literature: a shift in the property tax burden toward land and away from improvements will raise the level of improvements.¹² While earlier writers were correct on this point, they never successfully analyzed the effect of gradation of the tax system on land value. The present analysis gives an immediate answer since it follows (using (5), (6), and (8)) that

$$\begin{aligned} \frac{dr}{d\theta} &= \frac{\partial r}{\partial\theta} + \frac{\partial r}{\partial\tau} \frac{\partial\tau}{\partial\theta} \\ &= \frac{\Lambda r}{(1+\theta)(1-\Lambda)}, \end{aligned} \quad (9)$$

where $\Lambda \equiv (1+\theta)\tau\sigma/(1+\tau)\mu_g$ is the expression inside the braces in (8).

Since $\partial\tau/\partial\theta \lesseqgtr 0$ as $1 - \Lambda \gtrless 0$, (9) implies that

$$\frac{dr}{d\theta} \gtrless 0 \text{ as } \frac{\partial\tau}{\partial\theta} \lesseqgtr 0. \quad (10)$$

In other words, land value (which is proportional to r) rises (falls) with θ in the normal (perverse) case where $\partial\tau/\partial\theta$ is negative (positive). Thus, in the normal case where gradation involves a decline in τ , land value rises. This effect is magnified as the tax burden on land increases, with land value reaching a maximum under pure site value taxation.

r rise as land tax increases.

While the land value impact is straightforward in the perverse case (where higher values of τ and θ both serve to depress r), the outcome in the normal case is by no means obvious. In this case, a lower τ raises land value at the same time that the higher θ depresses it, yielding an apparently ambiguous net effect. The surprising implication of the analysis is that the positive effect of the lower improvements tax dominates, so that gradation unambiguously raises the value of land.

While the algebraic approach pursued above is indispensable in identifying (and ruling out empirically) the perverse $\partial\tau/\partial\theta > 0$ case, a simple diagrammatic approach can in fact be used to derive the signs of $dS/d\theta$ and $dr/d\theta$ in the normal case.¹³ Figure 1, which graphs the downward sloping curve $ph'(S)$, illustrates the effect of gradation in the case where the improvements tax rate falls from τ_0 to τ_1 . Improvements tax revenue changes from $B+D$ to $D+E$ as S rises from S_0 to S_1 , while gross-of-tax land cost rises from A to $A+B+C$ ($(1+\theta)r$ equals the area under ph' minus $(1+\tau)iS$ from (2)). Land tax revenue, which equals gross-of-tax land cost minus r , changes from $A-r_0$ to $A+B+C-r_1$. Since total revenue from the two taxes must remain constant, it follows that $B+D+A-r_0 = D+E+A+B+C-r_1$. This equality yields $r_1-r_0 = C+E > 0$, establishing that gradation raises land value.¹⁴ While the diagrammatic approach offers a short path to this result, it should be noted that the approach works only because of the simplicity of the present model. In the more complex model considered in the next section, where the housing price p is endogenous rather than fixed, diagrammatic analysis is not feasible.

2. Long-run effects with an endogenous housing price

In this section, the tax zone is assumed to encompass the entire housing market (an entire metropolitan area, for example). The assumption that locational advantages are absent is maintained, however.¹⁵ In this case, a change in the property tax system will have an impact on the price of housing, and a market-clearing equation must be added to the previous equilibrium system (1)-(2). Letting $D(p)$ denote the aggregate demand function for housing,¹⁶ which satisfies $D' \leq 0$, the expanded equilibrium system consists of the earlier equations together with $\bar{h}(S) = D(p)$.

The separate impacts of τ and θ on p , S , and r are derived by totally differentiating the new equilibrium system (detailed results are available on request). As before, a higher land tax is fully capitalized and has no effect on S . As a result, there is no impact on p ($\partial p / \partial \theta = 0$). A higher improvements tax once again lowers the level of improvements ($\partial S / \partial \tau < 0$), but its effect on land rent is ambiguous. The latter result is due to the fact that the improvements tax is shifted forward, raising the price of housing ($\partial p / \partial \tau > 0$). Since the higher p tends to increase the profitability of development at the same time that the higher τ reduces it, the net impact on r is indeterminate.

Eq. (7) is once again used to compute $\partial \tau / \partial \theta$. The calculation yields

$$\frac{\partial \tau}{\partial \theta} = \frac{-r}{iS} \left\{ 1 - \frac{\sigma [(1+\theta)\tau\epsilon + \theta(1+\tau)]}{(1+\tau)\mu_g(\epsilon-\eta)} \right\}^{-1}, \quad (11)$$

where $\eta \equiv (p/h)(\partial h / \partial p) > 0$ is the elasticity of housing supply per acre and $\epsilon \equiv pD' / D \leq 0$ is the elasticity of housing demand. To see that the earlier solution for $\partial \tau / \partial \theta$ is just a special case of (11), note that

(11) reduces to (8) when $\epsilon = -\infty$ (when p is exogenous). As in the previous case, a negative sign for $\partial\tau/\partial\theta$ is likely when the derivative is evaluated at $\tau = \theta$. This follows because the expression in braces in (11) (call it $1-\Lambda'$) is larger than the corresponding expression in (8). Since the latter expression was shown to be positive under reasonable parameter values when $\tau = \theta$, it follows that $1-\Lambda'$ is also positive under the same assumptions. While this implies that the initial shift toward a graded tax system will require a reduction in τ , it is again likely that $\partial\tau/\partial\theta < 0$ will continue to hold as θ rises.

Computation of the impacts of gradation proceeds as before. First, since $\partial p/\partial\tau > 0$ and $\partial p/\partial\theta = 0$, it follows that $dp/d\theta = (\partial p/\partial\tau)(\partial\tau/\partial\theta)$, which is negative when $\partial\tau/\partial\theta < 0$. Thus, the effect of gradation is to reduce the price of housing. Similarly, since $\partial S/\partial\tau < 0$ and $\partial S/\partial\theta = 0$, $\partial\tau/\partial\theta < 0$ yields $dS/d\theta > 0$. Once again, gradation raises the level of improvements per acre. The impact of gradation on land value is again computed using the first line of (9). The result is:

$$\frac{dr}{d\theta} = \frac{\sigma[1+\tau(1+\epsilon)]}{(1+\tau)\mu_\ell(\epsilon-\eta)} \frac{r}{1-\Lambda'} \quad (12)$$

Since $\epsilon-\eta < 0$, $dr/d\theta$ from (12) has the sign of $-[1+\tau(1+\epsilon)]$ in the normal case where $1-\Lambda' > 0$. The elasticity of housing demand ϵ therefore plays a crucial role in determining the direction of the land value impact. If housing demand is highly elastic, then $1+\tau(1+\epsilon)$ is negative and gradation raises the value of land. This outcome shows that an infinite demand elasticity is not required for the surprising result of the last section to emerge. The conclusion is reversed, however, when ϵ is closer to zero, in which case $1+\tau(1+\epsilon)$ will be positive

and $dr/d\theta$ negative. In fact, a simple sufficient condition for $dr/d\theta$ to be less than zero is that housing demand is inelastic ($-1 \leq \epsilon \leq 0$). When this condition holds, gradation of the tax system depresses land value. Since there is overwhelming empirical evidence showing that housing demand is actually inelastic (see Mayo (1981) for a survey), a fall in land value appears to be the realistic outcome.

This result is clearly the opposite of the one reached in the earlier analysis, and the reason for it lies in the behavior of the housing price. Since p falls with θ in the present situation, a new force that reduces the profitability of development (and hence the value of land) enters the analysis. The specific results above are due to the fact that the price of housing falls faster with θ the less elastic is demand (the absolute value of $dp/d\theta$ is larger when ϵ is closer to zero). When demand is inelastic (or moderately elastic), an increase in θ leads to a sharp decline in p and a correspondingly large depressing effect on r . This effect, which was not present before, is sufficient to reverse the previous outcome and lead to a decline in land value. When demand is highly elastic, the decline in p is moderate and the depressing effect on r is not sufficiently strong to reverse the earlier positive impact, so that land value rises.

3. Short-run gains and losses

In long-run equilibrium, housing producers are indifferent to the features of the property tax system since profit is identically zero. Before full market adjustment occurs, however, producers can experience windfall gains or losses from a change in the tax system. The purpose of this section is to analyze the spatial incidence of such

gains and losses in a model where the price of housing (and thus the levels of S and r) varies within the tax zone. The analysis focuses on the short-run case in which S and r are frozen at their equilibrium levels under the preexisting tax system.¹⁷

The housing price p (which is taken to be exogenous) is assumed to be a decreasing function of a single location variable x . This variable could measure radial distance to a downtown employment center (as in monocentric city models) or the distance to an amenity such as a shoreline. Spatial variation in p induces corresponding variation in S and r , with improvements per acre and land rent sympathetically declining over distance. This can be seen by totally differentiating (1) and (2), which yields $\partial S/\partial x = -(h'/ph'')(\partial p/\partial x) < 0$ and $\partial r/\partial x = (h/(1+\theta))(\partial p/\partial x) < 0$. Spatial variation in S and r leads to spatial variation in the impact of gradation of the tax system, as will be seen below.

Since S and r are fixed in the short run, revenue and net-of-tax input costs are also fixed. As a result, gains and losses will be due entirely to changes in tax liabilities. Letting \bar{S} and \bar{r} denote the levels of S and r prevailing prior to the change in the tax system, the tax payment at a given location equals $\tau i \bar{S} + \theta \bar{r}$ (the x argument of \bar{S} and \bar{r} is suppressed). Total revenue from the tax zone is then $\int (\tau i \bar{S}_A + \theta \bar{r}_A)$, where \bar{S}_A and \bar{r}_A are the average levels of improvements per acre and land rent in the zone. Differentiation of this expression shows that for total revenue to remain constant, $\partial \tau / \partial \theta = -\bar{r}_A / i \bar{S}_A$ must hold. Using this result, the change in the tax liability at a particular location (which equals $i \bar{S} \partial \tau / \partial \theta + \bar{r}$) becomes

$$\bar{S}[(\bar{r}/\bar{S}) - (\bar{r}_A/\bar{S}_A)]. \quad (13)$$

Eq. (13) indicates that parcels with above-average ratios of land value to improvements face higher taxes as θ rises and τ falls, with taxes declining for parcels with below-average \bar{r}/\bar{S} ratios. Note that if land-use is uniform within the tax zone, so that $\bar{r} \equiv \bar{r}_A$ and $\bar{S} \equiv \bar{S}_A$, then (13) is zero and the tax liability is unchanged at each location.

Since both improvements and land value are decreasing functions of x , the spatial behavior of \bar{r}/\bar{S} (which provides the key to the spatial incidence of gradation) is not immediately obvious. However, since $\partial p/\partial x < 0$ and

$$\frac{\partial \bar{r}/\bar{S}}{\partial x} = \frac{(1-\sigma)\bar{h}}{(1+\theta)\bar{S}} \frac{\partial p}{\partial x}, \quad (14)$$

it follows that \bar{r}/\bar{S} is a decreasing function of x in the realistic case where $\sigma < 1$. This in turn implies that parcels with above average (below average) \bar{r}/\bar{S} ratios are found at low (high) x 's. Eq. (13) then implies that parcels with low x 's face higher taxes, while lower taxes are enjoyed by parcels at more remote locations. A shift to graded property tax system thus imposes short-run losses (gains) on the most (least) intensively developed parcels. This result might at first appear counterintuitive since parcels with high improvements per acre stand to gain the most from a lower improvements tax. This observation, however, ignores the fact that such parcels also have high land value, which makes an increase in θ especially burdensome. When $\sigma < 1$, the latter effect dominates and the total tax liability rises.¹⁸

Although the above analysis applies to a tax zone with a single type of real estate, the conclusions based on (13) apply even in the

case of mixed land uses. That is, regardless of what types of property are located in the tax zone, comparison of the \bar{r}/\bar{S} ratio for a given parcel to the ratio of average values for the zone tells whether taxes rise or fall for that parcel in the short run. Using this principle, the impact analyses cited earlier attempt to predict the short-run incidence of a shift to pure site value taxation for various municipalities. Typical findings show that many commercial and industrial properties would face higher taxes, while single family homes would generally benefit from lower tax bills.

4. Summary and conclusion

This paper has analyzed two of the principal questions treated by the previous literature on site value taxation: long-run effects and the incidence of short-run gains and losses. Long-run effects were shown to depend crucially on the relative sizes of the tax zone and the housing market. When the tax zone comprises a negligible portion of the market, gradation of the tax system leaves the price of housing unchanged while raising both the level of improvements per acre and the value of land. The positive land value impact is surprising since gradation increases the direct tax burden borne by land. When the tax zone encompasses the entire housing market, the outcome is different. In this case, gradation reduces the price of housing, again raises the level of improvements, and (under a realistic elasticity assumption) lowers the value of the land. The negative land value impact is due to the depressing effect of the lower housing price, which reduces the profitability of development. These results suggest that while a small

city in a large metropolitan area will generate capital gains for landowners by grading its tax system, metropolitan-area-wide gradation will leave landowners with capital losses while benefitting the ultimate consumers of housing. It should be noted that since pure site value taxation is simply an extreme form of gradation, the above results can be used to predict the impact of such a system.

The contribution of the short-run analysis is to show that the windfall gains and losses resulting from gradation of the tax system have a rather surprising spatial incidence. Contrary to a common impression, the most intensively developed parcels suffer windfall losses in the form of higher taxes, while the least intensively developed parcels benefit from windfall gains.

In conclusion, it should be noted that while the issues addressed in this paper have been debated for decades, the results on the land value and housing price impacts of a graded tax system are new. Their existence shows that modern methods can provide answers to questions left unresolved by the less precise techniques used in earlier research in this area.

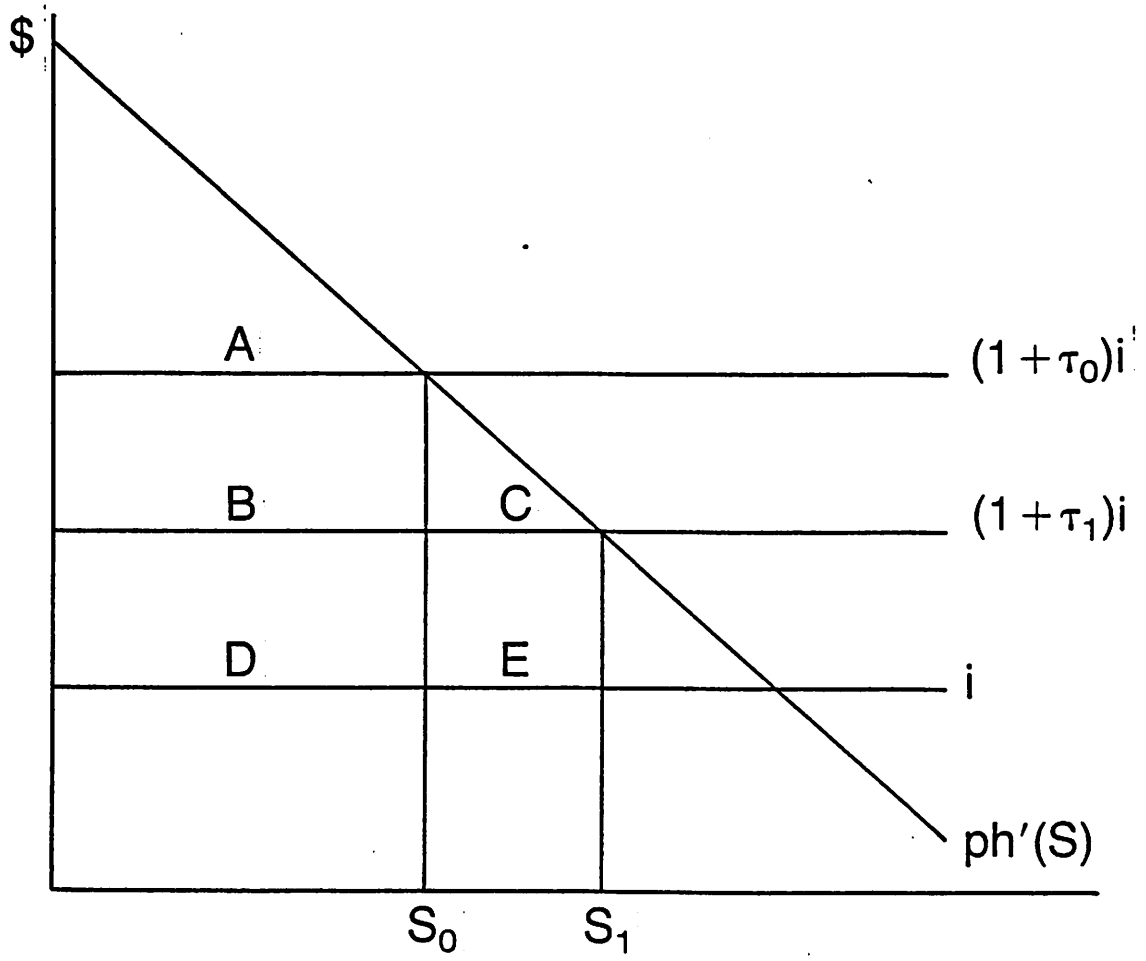


Figure 1

Footnotes

*I wish to thank Jon Sonstelie, James Follain, Chuan Lin, and David Wildasin for comments. Errors are mine.

¹Lent (1967) provides a complete list of countries using variants of land value taxation. Holland (1969) gives a lengthy description of the institutional aspects of Jamaica's tax system, while Breckenfield (1983) discusses Pittsburgh's system.

²The list of studies that attempt to quantify such impacts includes Schaaf (1970), Smith (1970), Neuner et al. (1974), Lusht (1975), Killoren and Casey (1981), and Stoddard and Fry (undated).

³See Brown (1927) for an early contribution.

⁴Many writers claim that accurate assessment is possible (see Back (1970), for example).

⁵Another concern in the literature is whether land alone is an adequate revenue base for the property tax system (see, for example, Stone (1975)).

⁶Turvey (1955) also claims that the impact of site value taxation on land values is ambiguous, but his reasoning is unclear.

⁷With the production function in intensive form, $\sigma = -h'(h-Sh')/Shh$ ". Also, μ_g , which equals $(1+\theta)r/pH$, can be written $(h-Sh')/h$.

⁸Using (6), $\partial\theta r/\partial\theta = r/(1+\theta) > 0$.

⁹Using (3), $\partial\tau iS/\partial\tau = iS(1-\tau\sigma/(1+\tau)\mu_g)$.

¹⁰Another way of expressing this result is that a necessary (but not a sufficient) condition for $\partial\tau/\partial\theta < 0$ to hold is that the relevant range of the improvements tax "Laffer curve" is upward sloping.

¹¹Direct μ_g estimates can be found in Richman (1965), Gottlieb (1969), and Harriss (1970). Implied μ_g estimates can be computed from data contained in the impact studies cited in the introduction.

¹²Pollock and Shoup (1977) provide an empirical estimate of the magnitude of the impact on improvements using a model which posits a value for $\partial\tau/\partial\theta$ and makes use of a particular parameterization of eq. (1).

¹³I wish to thank Jon Sonstelie for suggesting this diagrammatic approach.

¹⁴In order for Figure 1 to illustrate the normal case, σ must be small. This means that h'' must be large in absolute value, which implies that the ph' curve is steep. In this case, the change in θ accompanying the decline in r (which, by the way, has no simple representation in the Figure) will be positive, as required.

¹⁵Since \bar{l} is exogenous, the analysis ignores the possibility that a change in the tax system could affect the spatial size of the city. Analysis of such an effect, which requires use of a monocentric city model, proved to be intractable.

¹⁶The fact that housing demand does not depend on net land rent r (which determines the income of land owners) reflects the implicit assumption that land owners are absentee, living outside the tax zone.

¹⁷While the longevity of housing capital implies a long adjustment period for S , the short-run impact of a new tax system on gross- and net-of-tax land costs requires some explanation. First, net-of-tax land cost (r) will not change until the property is sold (or, if the land is rented, until a new lease is negotiated). Similarly, the land tax liability (θr) will stay the same until the land is reassessed for tax purposes. Note that while the land will not be reassessed immediately, reassessment may occur prior to redevelopment (see footnote 18).

¹⁸It can be shown that the qualitative results of this analysis also hold for the medium-run case, where land is reassessed for tax purposes at its value in new development. In this case, S is frozen at S and net-of-tax land cost is frozen at r , but the land tax liability is given by θr , where r comes from the solution to (1)-(2) with S freely variable.

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NEUTRALITY AND NON-NEUTRALITY OF LAND TAXATION:

AN INTERTEMPORAL ANALYSIS

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1. INTRODUCTION

Ever since Ricardo presented his thoughts concerning the taxation of the rental value of land, this tax has been of little concern to most economists. On the contrary, it has been the classic example of an unshiftable, hence neutral, tax. Feldstein (1977) was one of the first to point out that Ricardo's proposition is subject to the requirement that the supplies of non-land factors of production do not respond to the introduction of a tax on land rents. This condition is not necessarily fulfilled when one departs from the static framework of Ricardo's analysis and the possibility of capital accumulation processes is introduced. Using the traditional overlapping-generations model, Feldstein was able to show that the introduction of a tax on the pure rental value of land induces an increase in the accumulation of capital and thus leads--given the supply of land--to a higher capital/labor ratio and to a lower net-yield on capital and a higher wage rate.

Commenting on Feldstein's article, Calvo et al (1979) shows that these results do not hold when bequests are introduced into the model. Extending the two-period planning horizon of a single household to an infinite one, there is no tax induced incentive for the economy's decision makers to change their before-tax consumption-savings decision; the tax is fully capitalized in the price of land.

While their analysis of the model is correct, their results depend upon the assumptions that (1) there is only one use of land in the economy and (2) land is fully employed at every point of time. Because of the assumed non-existence of vacant land there is no rational reason for the land-owner to react to the capital owner's attempt to shift the burden of the tax. When the existence of vacant land is taken into account, however, it is possible to

show that a tax on the rental value of land is not neutral; that it is impossible to say how the economy responds to the introduction of such a tax in the short run; and that a per-unit-tax on land is neutral. Section 2 provides an intuitive example to illustrate the significance of vacant land for investment decisions. Section 3 contains the formal treatment of this example and the derivation of the laissez-faire optimality conditions and time paths.¹ In Section 4 alternative methods of land taxation are introduced. The taxes under consideration are (1) a tax on the value of land either as a tax on the value of land and developments or as a tax on the site value, and (2) a per-unit land tax which is assessed independent of the actual use of the taxed item.

2. THE ECONOMIC INTUITION OF THE MODEL

Consider the decision problem of a landlord who wishes to acquire vacant land on which to provide newly constructed rental accomodation. The investment decision is assumed to be irreversible and demolition costs are assumed to be prohibitively high. Suppose also that there will be a once and for all increase in the demand for housing services in some future period. Knowing this, the landlord has three alternatives:

¹The model used in Section 3 is adopted from Sinn (1984). Section 3 therefore features only the most important parts of the model's formal background. Readers who are interested in a more detailed explanation are referred to Sinn (1984).

1. to buy the building lot today and build a small structure on it in accordance with the present demand situation, foregoing higher future rental receipts;
2. to buy the building lot today and build on it a larger structure with a view to the future demand situation, accepting the possibility of vacant housing units today;
3. to postpone the purchase of the building lot and its development until the future increase in demand has occurred, thus foregoing the rental receipts he would have otherwise received as well as avoiding the opportunity cost of housing investment during this time period.

A priori it is not clear which one of these alternatives the landlord will prefer; in the individual case this decision will depend upon the level of the interest rate, on how soon the demand change will occur, on the size of the change in the demand for housing services and on the level of the per-unit rent. But one statement can be made with certainty:

The greater is the future jump in housing demand, the more likely it is that alternative three will be chosen.

In what follows we will deal not with a once-and-for-all shift in the demand for housing services but with a continuously increasing demand for those services which is large enough to make it profitable for the landlord to postpone some proportion of his housing investment into the future.

Obviously, the postponement of the investment presumes the landowner's willingness to hold the required stock of vacant land. This is not without cost to the landlord. The price of building land in future periods has to be higher than in the present in order to compensate the landowner for any opportunity cost incurred in land speculation.

This intuitive example provides a first impression about the extent to which the time-path of housing investment depends on the selling plan of the landowner. It will be of interest to see how both the landowner and the landlord change their plans in response to the imposition of alternative forms of land taxation.

3. AN OUTLINE OF THE MODEL²

In this model there are two groups of market agents, landowners and landlords. Each group can be described by a representative agent who is endowed with perfect foresight and rational behavior. The representative landowner owns and sells land, but does not build. The representative landlord buys vacant land, builds on it and rents out the produced housing units. Both agents behave competitively and take the time paths of market prices as given in their decision problems. Nevertheless, the time paths of the rent on housing, the price of a housing unit and the land price are endogenously determined by market clearing conditions.

3.1 THE DECISION PROBLEM OF THE LANDLORD IN THE TAX-FREE SITUATION

We assume an urban area where, as the result of an irrevocable decision of a public authority made in the planning period t_0 , there is initially a homogeneous stock of vacant land

$$(1) B_0 \equiv B(t_0) > 0,$$

which by assumption yields no intermediate benefits. In the same period the landlord owns a given stock of homogeneous housing units,

$$(2) H_0 \equiv H(t_0) > 0.$$

These housing units are rented out for a rental price m per unit per period.

²See Sinn (1984)

New housing units, \dot{H} , can be produced from a flow of investment goods, I , and a flow of vacant land, F^d , by means of a linear homogeneous, strictly quasi-concave production function

$$(3) \quad \dot{H} = f(I, F^d) = F^d f\left(\frac{I}{F^d}, 1\right) \equiv F^d \varphi(\epsilon),$$

with constant partial production elasticities $\alpha = \varphi' \cdot \epsilon / \varphi$ (for housing capital) and $\beta = 1 - \alpha = -\varphi'' \epsilon / \varphi'$ (for land); ϵ indicates the marginal capital intensity of land, and $\varphi(\epsilon)$ can be interpreted as the marginal structural density of housing investment. The production process is irreversible, and for simplicity it is assumed that there is no depreciation.

The price of the flow I , which covers all commodities and services provided by the exogenous construction industry, is used as numeraire. Let P_B denote the price the landlord has to pay for every unit of vacant land. The market value M_H of the housing stock can be described by the present value of the net cash flow out of building and renting housing units:

$$(4) \quad M_H(t_0) \equiv \int_{t_0}^{\infty} [z m(t) H(t) - P_B(t) F^d(t) - \epsilon(t) F^d(t)] e^{-zr(t - \min(t, t_0^*))} dt,$$

where r is the (constant) real market interest rate. In (4), the parameter z refers to a meta-time period (t_0, t_0^*) , indicating jumps in the state variables H and B . The introduction of the meta-time is necessary to allow the possibility that all vacant land can be built upon at the planning date in accordance with alternatives one and two mentioned in section 2. Otherwise the 'preference' for alternative three would be trivial because of the

³ In what follows, \dot{X} stands for the first derivative of the variable X with respect to time and X for the relative change of X over time.

requirement that state variables be continuous functions of time. Employing the meta-time period (t_0, t^*) , a possible jump in the state variables can be transformed in a continuous process. For $z = 1$ real time runs and meta-time stands still, for $z = 0$ meta-time runs and real time stands still, so that, expressed in real time, $t_0 \equiv t^*$. There are no rent revenues and the flows of land and investment expenditures are not discounted during the meta-time period.

Assuming rationality, the landlord chooses the time paths of land consumption, $\{F^d\}$, and of marginal capital intensity, $\{\epsilon\}$, so as to

$$(5) \quad \text{Max}_{\{F^d, \epsilon\}} \int_0^t M_H \, dt$$

under the constraints (1), (4) and

$$(6) \quad \dot{H} = F^d \varphi(\epsilon).$$

The state variable of this problem is H . The Hamiltonian corresponding to (5) then is

$$(7) \quad \mathcal{H}_H = z\pi H - P_B F^d - F^d \epsilon + P_H F^d \varphi(\epsilon),$$

where P_H is the shadow price of the state variable, i.e. by definition, the implicit market price of a housing unit.

3.2 THE DECISION PROBLEM OF THE LANDOWNER IN THE TAX-FREE SITUATION

The landowner knows the market rate of interest and takes the time path of the price of land, $\{P_B\}$, as given. His goal is to choose the time path of land supply, $\{F^s\}$, in order to maximize the present value of his land sale revenues; therefore, his decision problem reads

$$(8) \quad \text{Max}_{\{F^s\}} M_B \equiv \int_{t_0}^{\infty} P_B(t) F^s(t) e^{-zr(t-\min(t, t^*))} dt,$$

z again indicating the meta-time. The state variable of this problem is B, with

$$(9) \quad \dot{B} = -F^S$$

The Hamiltonian for this problem is

$$(10) \quad \mathcal{H}_B = P_B F_B^S - \lambda_B F_B^S,$$

with λ_B symbolizing the shadow price of vacant land.

3.3 CONDITIONS FOR THE MARKET EQUILIBRIUM

The intertemporal market equilibrium requires that the time paths $\{m\}$ and $\{P_B\}$ adjusts so that the land market and the rental market clear at all points of time, i.e.

$$(11) \quad F^d = F^S = F \quad \text{for all } t \geq t^*,$$

$$(12) \quad m = m\left(\frac{a}{H}\right) \quad \text{for all } t \geq t^*,$$

and that the individual optimization conditions derivable from (7) and (10) are fulfilled simultaneously, i.e.

$$(13) \quad \epsilon = \epsilon^* \quad \text{for all } t \geq t^*,$$

where ϵ^* is implicitly defined through⁴

$$(14) \quad P_H \varphi'(\epsilon^*) = 1 \quad \text{for all } t \geq t^*,$$

$$(15) \quad \frac{\beta}{\alpha} \epsilon^* < P_B \Rightarrow F \geq 0 \quad \text{for all } t \geq t^*,$$

$$(16) \quad \hat{P}_H = \hat{P}_B = 0 \quad \text{for } t_0 \leq t < t^*,$$

$$(17) \quad \hat{P}_H = -\frac{m}{P_H} + r \quad \text{for all } t \geq t^*,$$

$$(18) \quad \hat{P}_B = r \quad \text{for all } t \geq t^*,$$

⁴ See Appendix 1.

$$(19) \lim_{t \rightarrow \infty} [P_X(t)X(t)e^{-r(t-t^*)}] = 0 \quad \text{for } X = H, B.$$

Condition (14) requires that in equilibrium the marginal value product of capital must equal the price for capital. Condition (15) requires the same for the use of land; the case where the marginal value product of land, which represents the landlords marginal willingness to pay for land, exceeds P_B can be ruled out, because it is not compatible with the maximum of the Hamiltonian in (7). Condition (16) is simply the statement that neither the house price nor the land price change during the meta time period (t_0, t^*) . Condition (17) is the familiar user-cost-of-capital formula, requiring that in equilibrium the effective rate of return from the housing stock must cover the opportunity cost of this stock. Condition (18) is similar to the Hotelling-rule for the depletion of exhaustable resources, requiring that in equilibrium the price of vacant land has to grow at a rate which is equal to the market rate of interest, in order to compensate the landowner for the opportunity cost involved in the speculation with land. The transversality conditions for the optimization problems (5) and (8) are described in (19).

3.4 THE DYNAMICS OF THE MODEL IN THE TAX-FREE SITUATION

In Condition (11) the supply price m equals the demand price m_H^a . The demand price stands for the (representative) household's marginal willingness to pay rent, which depends on the level of demand for housing units, a , ($m_a > 0$) and on the stock of housing units, H , ($m_H < 0$) at a given point of time. The absolute price elasticity of demand, η , is assumed to be constant and greater than one. The parameter a is allowed to

grow at some rate $\hat{a} = \text{constant} \begin{matrix} > \\ < \end{matrix} 0$ over time. It is this change in demand which is crucial for the dynamic behavior of the model under consideration. Proceeding on the assumption that parameter a grows at some minimum rate

$$(21) \quad \hat{a} > \eta\beta \hat{P}_B = \eta\beta r \quad 5$$

the dynamic behavior of the endogenous variables after some finite point of time $\tilde{t} \geq t^*$ can be described by the following equations: ⁶

$$(22) \quad \hat{P}_H = \beta \hat{\epsilon} = \frac{m}{P_H} + r = \text{constant} > 0 \quad \text{for all } t \geq \tilde{t},$$

$$(23) \quad \hat{\epsilon} = \hat{P}_B = \text{constant} > 0 \quad \text{for all } t \geq \tilde{t},$$

$$(24) \quad \hat{P}_B = r = \text{constant} > 0 \quad \text{for all } t \geq \tilde{t},$$

$$(25) \quad \hat{H} = \hat{a} - \eta\beta \hat{P}_B = \text{constant} > 0 \quad \text{for all } t \geq \tilde{t},$$

$$(26) \quad \hat{B} = \hat{F} = \hat{a} - (\eta\beta + \alpha) \hat{P}_B = \text{constant} < 0 \quad \text{for all } t > \tilde{t}$$

Equation (26) states that

- the stock of vacant land will shrink continuously but will never be completely exhausted in finite time;
- the supply of vacant land will decrease steadily over time, but will be greater than zero at each finite point of time.

⁵ See Appendix 2

⁶ See Appendixes 2 and 3

Equations (22) to (25) state that

- the house price, the rental price, the land price, the marginal capital intensity and the stock of housing units will increase at a constant rate over time;
- the price of a unit vacant land grows faster than the price of a housing unit.

Figure 1

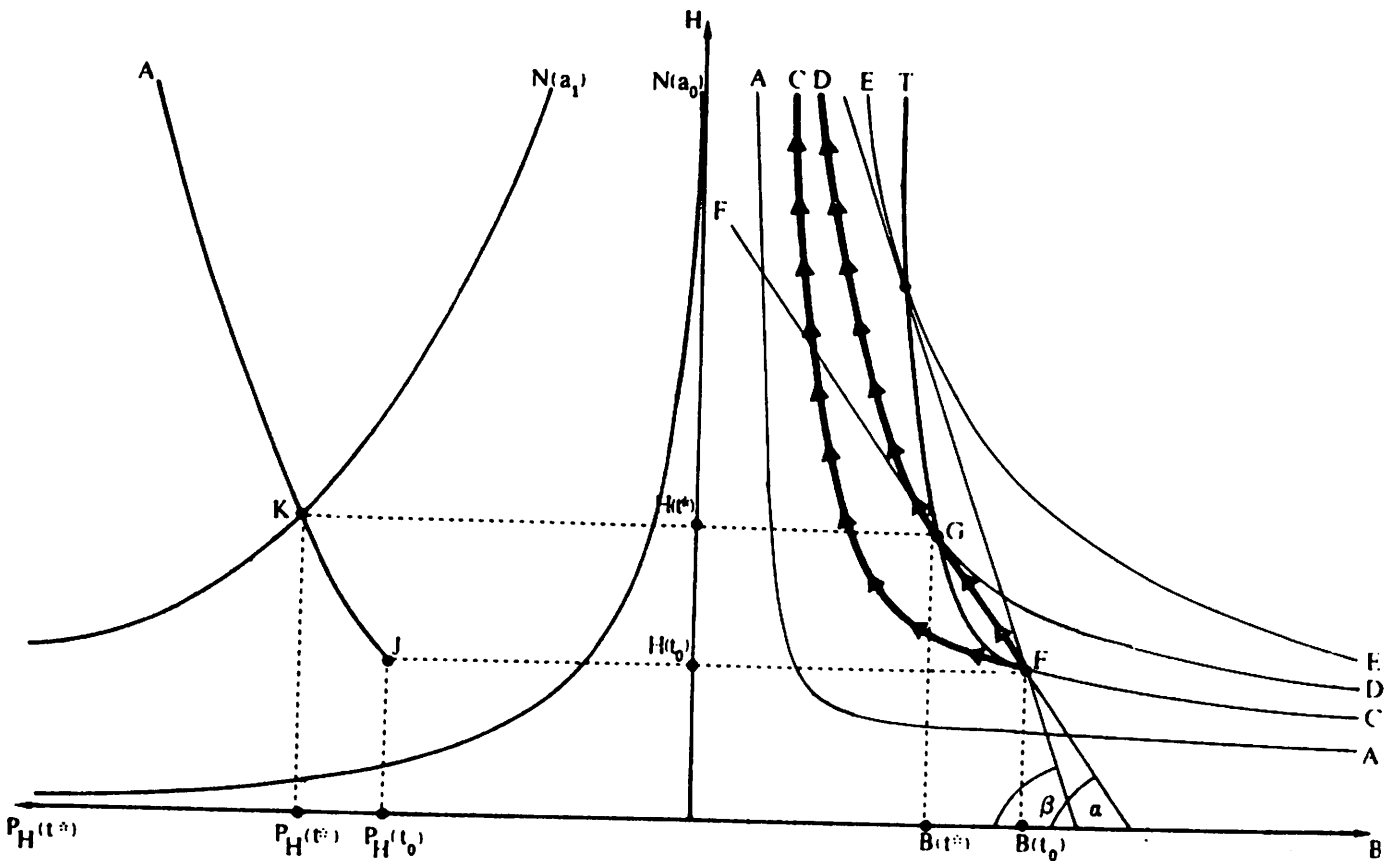


Figure 1 is the graphical representation of the model's dynamics. The combined time paths of H and B in real time can be described by a family of rectangular hyperbolas, derived from (25) and (26) in the following way:

$$(27) \quad \frac{\dot{H}}{\dot{B}} = \frac{H}{B} = \frac{H[a - \eta\beta P_B]}{B[a - (\eta\beta + \alpha)P_B]} < 0, \quad \frac{d(\frac{H}{B})}{dP_B} > 0.$$

Using (6), (9) and (11), the slope of these hyperbolas can also be described as a function of the marginal structural density

$$(28) \quad \frac{\dot{H}}{\dot{B}} = \frac{H}{B} = -\varphi(\epsilon^*).$$

In Figure 1, AA, CC, DD and EE are four representatives of this family. It depends on the initial state $[H_0, B_0]$ of the economy which hyperbola is the relevant (in our example this is CC).

The left quadrant of Figure 1 shows the situation in the rental market in the planning period $t_0 (\equiv t^*$ in real time). The curve N is derived from optimality condition (17), using (12), (22), (23) and (24):

$$(29) \quad P_H = \frac{a}{m_H(1-\beta)r}.$$

(29) describes the marginal willingness of a potential house purchaser to pay for a unit of housing stock at different levels of this stock. And because P_H is directly related to the households' marginal willingness to pay, the curve N also provides information about the consumption behavior of households. In what follows N is referred to as 'the demand curve'. Holding parameter a constant and considering $m_H < 0$, it is easy to show that the slope of this curve has to be negative. The curve A is akin to a 'supply curve' which

relates alternative stocks of housing units to the price per housing unit. The algebraical expression for this curve can be derived by considering the possibility of jumps in the state variables H and B at the beginning of the planning horizon. During such jumps, neither P_H nor P_B change; this is required by condition (16). Condition (15) shows that, because P_B is constant, ϵ and therefore the marginal structural density $\varphi(\epsilon)$ also remains constant during such jumps. Therefore, using (28), the combined adjustment path of H and B during the meta time (t_0, t^*) can be described by a negatively sloped straight line, for example FF in Figure 1; t^* (the end of meta-time) is reached when the straight line is tangent to another hyperbola, in our example DD . This results because of the fact that the dynamic behavior of H and B in real time is described by a certain hyperbola and because of the requirement that the costate variables be continuous functions of time. After the end of the meta-time period, the evolution path of the economy is identical with the part GD of the hyperbola DD . Performing the same operation for different initial values of $P_B(t_0)$ or $\epsilon(t_0)$ a family of such tangential points can be depicted by the curve FT in Figure 1. FT is the locus of all admissible adjustment reactions taking place in period t_0 . Quite obviously, a movement up this curve is related to an increase in the marginal structural density as well as to an increase in the stock of housing units. This relation implies

$$(30) \quad H(t^*) = \phi[\varphi(\epsilon(t^*))], \quad \phi' > 0.$$

Applying the inverse function of condition (14) results in

$$(30) \quad H(t^*) = \phi\left\{\varphi\left[\varphi'^{-1} \frac{1}{P_H(t^*)}\right]\right\},$$

with $dH(t^*)/dP_H(t^*) > 0$. (30) is the algebraic expression of the 'supply curve' in the left quadrant of Figure 1. The curve A describes the

representative landlord's willingness to invest in housing stock at different rental values of this stock. And because of the assumption concerning the homogeneity of H the curve A also describes the supply side of the market for housing services.

Knowing the position of the 'demand curve' and the 'supply curve' we also know the situation on the rental market in the initial period t_0 . There are three possible cases:

1. The 'demand curve' and the 'supply curve' do not intersect. In this case there is no incentive for the landlord to invest in housing, i.e. to increase the existing excess supply of housing services;

we have the corner solution described by (15): $\frac{\beta}{\alpha} < P \Rightarrow F = 0$.

With regard to the (H, B) - plane in Figure 1, the economy rests in point F. But given assumption (21), this situation cannot persist.⁷ Since parameter α continually increases, the 'demand curve' gradually drifts to the left, while the 'supply-curve' maintains its position (production is by assumption irreversible and there is no depreciation). Therefore, the 'demand curve' must intersect the 'supply curve' at a finite point of time $\tilde{t} > t^*$, satisfying (15) with equality. After \tilde{t} , the economy evolves along CC, the dynamics of the endogenous variables described by (22) - (26).

2. The 'demand curve' intersects the 'supply curve', for example in point K. In this case we face an excess demand for housing services, which makes it profitable for the landlord to adjust his given stock

⁷ See Appendix 3.

of housing units, $H(t_0)$, to the higher level $H(t^*)$. In real time there is an initial jump from F to G, and then a steady movement along GD.

3. The 'demand curve' and the 'supply curve' touch at the lower end of the supply curve. In this case, (14) holds with equality right a way. There is neither an initial jump in the state variables nor an initial halt in housing construction. The equilibrium point F will move along FC as real time progresses.

4. LAND TAXATION AND MARKET BEHAVIOR⁸

4.1 A TAX ON THE VALUE OF LAND

4.1.1 TAXING THE LAND-OWNER

The tax the landowner has to pay depends on the current market value P_B of his stock of vacant land. With τ_L as the tax rate his decision problem now is

$$(31) \quad \text{Max}_{\{F^S\}} M_B \equiv \int_{t_0}^{\infty} [P_B(t)F_B^S(t) - z \cdot \tau_L P_B(t)B(t)] e^{zr(t-\min(t,t^*))} dt$$

under the constraints (2) and (9).

Differentiating the Hamiltonian for (31) with respect to F^S and B we obtain

⁸In what follows the government is assumed to use the tax revenues for financing a transfer program which is sufficient to avoid any tax induced income effect in the consumption decision of households.

$$(32a) \quad \hat{P}_B = 0 \quad \text{for } t_0 \leq t < t^*$$

$$(32b) \quad \hat{P}_B = r + \tau_L \quad \text{for } t \geq t^*$$

As in the tax-free situation the land price remains constant during the meta time period (t_0, t^*) . But (32b) signals that the land price grows at a higher rate after t^* in response to the introduction of the tax; obviously, the landowner changes his plans to the effect that he advances the sale of vacant land in order to avoid a part of the tax, buying tax free assets with the additional revenues. As a consequence of the altered sale plan the land price falls in the initial period.

The advance of sales leads to a shortage in the supply of vacant land in future periods, which, given the time path of land demand, causes an increase in the growth rate of P_B . Therefore, despite the initial drop in land prices, P_B will exceed its laissez-faire level after some finite point of time $t > t^*$.

Whether the landlords is willing to cover this tax-induced increase in the opportunity cost of holding vacant land depends upon the demand for housing services. As can be shown,⁹ the parameter a must now grow at the, compared with the laissez-faire situation, higher rate

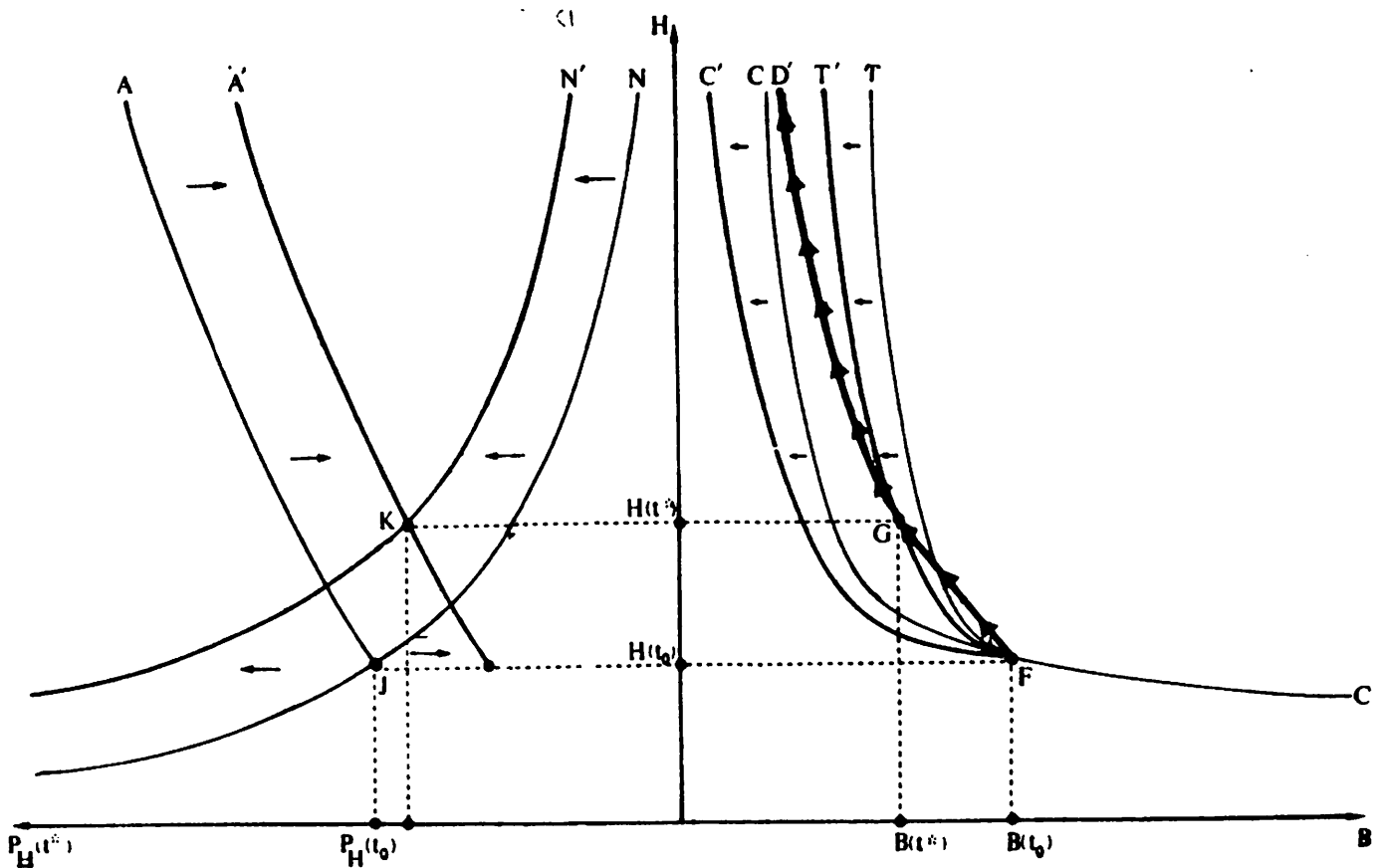
$$(33) \quad a > \eta\beta(r + \tau_L) > \eta\beta r$$

⁹In Appendix 2 it is shown that in a situation without construction activities the marginal willingness to pay for land has to grow at a higher rate than the landprice in order to make land speculation profitable. Using (32b) and employing the same procedure as in Appendix 2 it can be shown that (33) is sufficient to guarantee permanent housing investment.

in order to make permanent housing investment profitable. With $\hat{a} \leq \eta\beta(r + \tau_L)$ all vacant land will be sold and built on in the planning period t_0 .

But it is more interesting to consider the case where (33) is fulfilled. If (33) holds then Figure 2 illustrates the dynamic effects of the introduction of a tax on the value of vacant land.

Figure 2



Since (27) implies $d(\frac{dH}{dB})/dP_B > 0$, the slope of each isoelastic curve becomes flatter at each point of the (H, B) -plane; because of this change the tangency curve FT pivots to the left in its new position FT' . The increase in the slopes of the rectangular hyperbolas also causes a shift of the 'supply curve' to the right. This follows from substituting the inverse function of (28) into the optimality condition (14); after rearranging terms, this

operation yields

$$(34) \quad P_H = 1/\varphi' [\varphi^{-1}(dH/dB)],$$

with $dP_H/d(dH/dB) < 0$ confirming the shift.

Substituting (22) in (17), using (23) and (32b), we achieve the equation for the after tax demand curve N' :

$$(35) \quad P_H = \frac{m_H^a}{(1 - \beta)r - \beta\tau_L} > 0. \quad 10$$

Obviously, N' is located above the laissez-faire 'demand curve' N .

Point K in Figure 2 represents the after-tax equilibrium in the rental market at $t_0 (\equiv t^*)$: After the imposition of the tax we can observe a short-run construction boom - the economy jumps from F to G - after which the further development of the economy is described by the path FD' .

The economic intuition for this construction boom is straight-forward:
 - because of the initial drop in land prices the use of land in the production of housing units and therefore the overall production costs decrease; this results in a decline in the optimal capital intensity and in an increase in housing investment, both represented by the shift of the supply-curve;

¹⁰ $(1 - \beta)r > \beta\tau_L$ follows from the after tax transversality condition

$$\lim_{t \rightarrow \infty} [P_H(t)H(t)e^{-r(t - t^*)}] = 0, \text{ using (36), (37) and (38).}$$

- second, because the stock of housing units is not yet subject to land-taxation, the user-cost of wealth tied in the housing sector decrease, the housing stock has become the more desirable asset. This is illustrated by the shift of the 'demand curve'.

Moving along FD' , the long-run behavior of the endogeneous variables is described by the following equations.

$$(36) \quad \hat{P}_H = \beta \hat{\epsilon} = - \frac{m}{P_H} + r = \text{constant} > 0 \text{ for } t > t^*$$

$$(37) \quad \hat{\epsilon} = \hat{P}_B = \text{constant} > 0 \text{ for } t > t^*$$

$$(38) \quad \hat{P}_B = r + \tau_L = \text{constant} > 0 \text{ for } t > t^*$$

$$(39) \quad \hat{H} = a - \eta \beta \hat{P}_B = \text{constant} > 0 \text{ for } t > t^*$$

$$(40) \quad \hat{B} = \hat{F} = a - (\eta \beta + \alpha) \hat{P}_B = \text{constant} < 0 \text{ for } t > t^*$$

The landowner is able to shift a part of his tax burden to the landlord by reducing his future land sales; this follows from (40) with regard to (38). Also, the landlord is able to shift a part of his tax burden to his tenants: according to (39) the stock of housing units grows at a lower rate and given the time path of demand for housing services, this causes a faster growth in housing rentals and houseprices.

4.1.2 TAXING THE LAND-LORD

Concerning the taxation of land possessed by the landlord, there are two possible tax bases:

- a. the value of the whole property $P_H H$.¹¹
 b. the value of land's share in the overall housing stock.

These two cases will be dealt with separately below.

Case (a): Taxation of Land and Improvements

In this case the tax base is the value of the housing stock, $P_H H$; let τ_L denote the tax rate. The decision problem of the landlord is

$$(41) \text{Max}_{\{F^d, \epsilon\}} M \int_0^{\infty} \{z m(t) H(t) - P_B(t) F^d(t) - F^d(t) \epsilon(t) - z \tau_L P_L H(t)\} e^{-zr(t - \min(t, t^*))} dt$$

subject to the constraints (2) and (6). Differentiating the Hamiltonian related to (41) with respect to F^d , ϵ and H , we obtain the optimality conditions

$$(42) \quad P_H \phi'(\epsilon) = 1 \quad \text{for } t \geq t^*,$$

$$(43) \quad \frac{\beta}{\alpha} - \epsilon \leq P_B \Rightarrow F^d \geq 0 \quad \text{for } t \geq t^*,$$

$$(44a) \quad \hat{P}_H = 0 \quad \text{for } t < t^*,$$

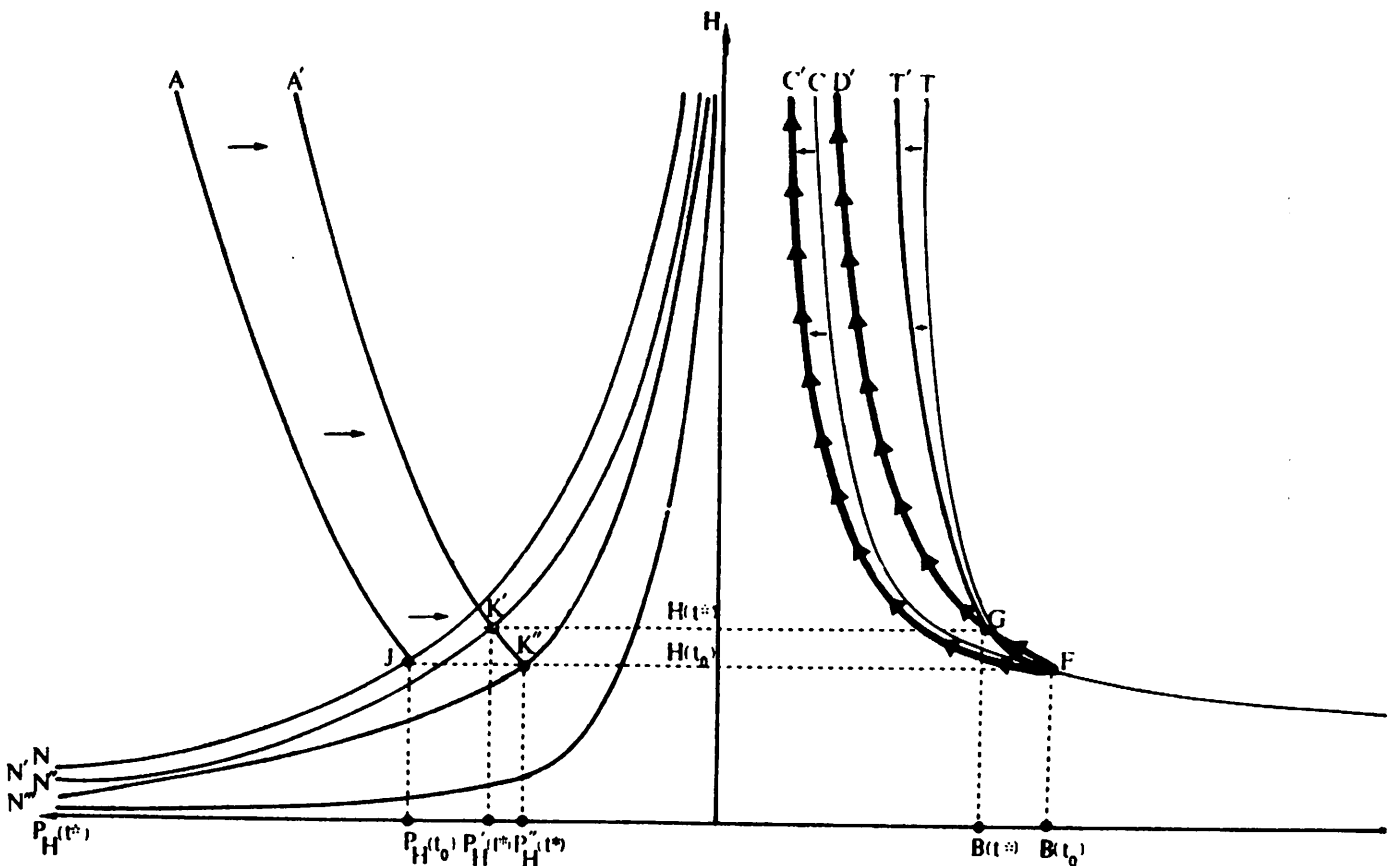
$$(44b) \quad \hat{P}_H = -\frac{m}{P_H} + r + \tau_L \quad \text{for } t \geq t^*.$$

¹¹This, for example, represents the German situation: in addition to a more or less general property tax there is a special land tax levied on the value of the whole structure.

As is shown by (42) and (43), the tax on the value of the structure has no impact on the choice of the capital/land ratio of housing investment. But there is an impact on the opportunity cost of housing, indicated by (44b): in the after-tax equilibrium the effective rate of return from the housing stock has to cover the foregone interest as well as the collectible tax. This increase in the opportunity cost can be illustrated by a downward shift of the 'demand curve', which exceeds the upward shift in the demand curve shown in Figure 2. Taking into account the reaction of the landowner to the imposition of the tax, the algebraic expression for the 'demand curve' in Figure 3 is

$$(45) \quad P_H = \frac{m(-)^a}{(1-\beta)r + (1-\beta)\tau_L}$$

FIGURE 3



Comparing (45) with its laissez-faire counter-part (29), it is easy to see that the after tax 'demand curve' described in (45) must lie below its laissez-faire level.

Therefore, in the short run the economic effects of a tax on both vacant land and structures are not clearcut: a short run boom in construction activities (the shift of the 'supply curve' dominates the shift of the 'demand curve'; point K' in Figure 3 describes this situation) is as possible as a temporary halt in housing investment (the shift of the 'supply curve' is dominated by the shift of the 'demand curve').

However, the behavior of the economy in the long run is unambiguous, because the tax on the housing stock does not alter the after-tax growth rates described in (36) - (40):

- the stock of housing units grows at a larger rate than in the tax-free situation;
- the stock of vacant land and the consumption of vacant land both shrink at a higher constant rate;
- the rental rate, the per-unit price of housing stock, the price of vacant land and the marginal capital intensity of housing investment grow at a higher rate than in the laissez-faire economy.

The results states above provide some remarkable implications for policy issues. Usually the taxation of land, particularly the taxation of vacant land, is justified by the argument that it puts a pressure on the landowner to advance the sale of vacant land, thus leading to lower land prices, intensified construction and a better and cheaper provision of housing services.

As pointed out above, this argument may be valid in the short run. But

if an increase in the provision of housing services is the declared goal of government policy, the use of land taxes based on the value of the property is unambiguously counterproductive in the long run. Even in the case where the tax on land and development induces a short run construction boom, the stock of housing units will fall short of its laissez-faire level in finite time. This results because the stock of housing units grows at a lower rate in the equilibrium with taxes than in the tax free situation.

In addition, because the tax induced change in the landowner's sale plan causes an increase in the growth rate of the rental rate, m , the house price, P_H , and the price of vacant land, P_B , the values of these variables will exceed their laissez-faire level in finite time.

Case b: Taxation of Site Value

In recent years there has been some interest in adopting site value as the tax base, i.e. tax liability is assessed purely on the value of land. But there are different ideas about the way in which such a site value tax should be implemented. The disagreement essentially concentrates on the determination of the value of land.

One suggestion is that the share of land ought to be valued by the price P_B of vacant land. At least in the context of the model presented here, the impact of this proposition would be dramatic. Suppose that $B^*(t)$ stands for the share of land at a given point t of time, with $B^*(t) = F^d(t)$. Hence $T_L(t) = \tau_L P_B(t) B^*(t)$ would describe the tax liabilities of the landlord in this period. In addition, B^* would enter the landlords decision problem as a state variable, requiring the transversality condition

$$(46) \quad \lim_{t \rightarrow \infty} [P_B(t) B^*(t) e^{-r(t-t^*)}] = 0$$

to hold. Without (46) being fulfilled, the present value of the landlord's tax liabilities would be infinite and housing investment would not be profitable any longer. (46) holds only when

$$(47) \quad \hat{P}_B + \hat{B} - r = X < 0$$

also holds. Substituting (32b) into (47) and taking into account that $\hat{B} > 0$ for all t , $t_0 \leq t < \infty$, it can easily be shown that X is positive at each point of time, thus violating (47) and (46), respectively.

A second proposal is based on a revival of Ricardo's theorem on the neutrality of a tax on the rental value of land, excluding the value of capital invested in this land. In the context of our model, the revenue of a Ricardian land tax can be described by

$$(48) \quad T_L = \tau (P_H - K),$$

with K as the stock of housing capital and τ as the relevant tax rate. K follows the motion-equation

$$(49) \quad \dot{K} = I = F^d \epsilon.$$

Using λ_K as the shadow value of the capital stock, the Hamiltonian for the landowner's decision problem then is

$$(50) \quad \mathcal{H} = z m_H - P_B F^d - F^d \epsilon - z \tau (P_H - K) + P_H F^d \varphi(\epsilon) + \lambda_K F^d \epsilon.$$

Differentiating (50) with respect to the control variables ϵ and F^d and to the state variables H and K , we obtain the necessary conditions

$$(51) \quad P_H \varphi'(\epsilon) = 1 - \lambda_K \quad \text{for } t \geq t^*,$$

$$(52) \quad \frac{\beta}{\alpha} \epsilon (1 - \lambda_K) < \frac{P_B}{B} \Rightarrow F^d = 0 \quad \text{for } t > t^*,$$

$$(53) \quad \hat{P}_H = 0 \quad \text{for } t_0 \leq t < t^*,$$

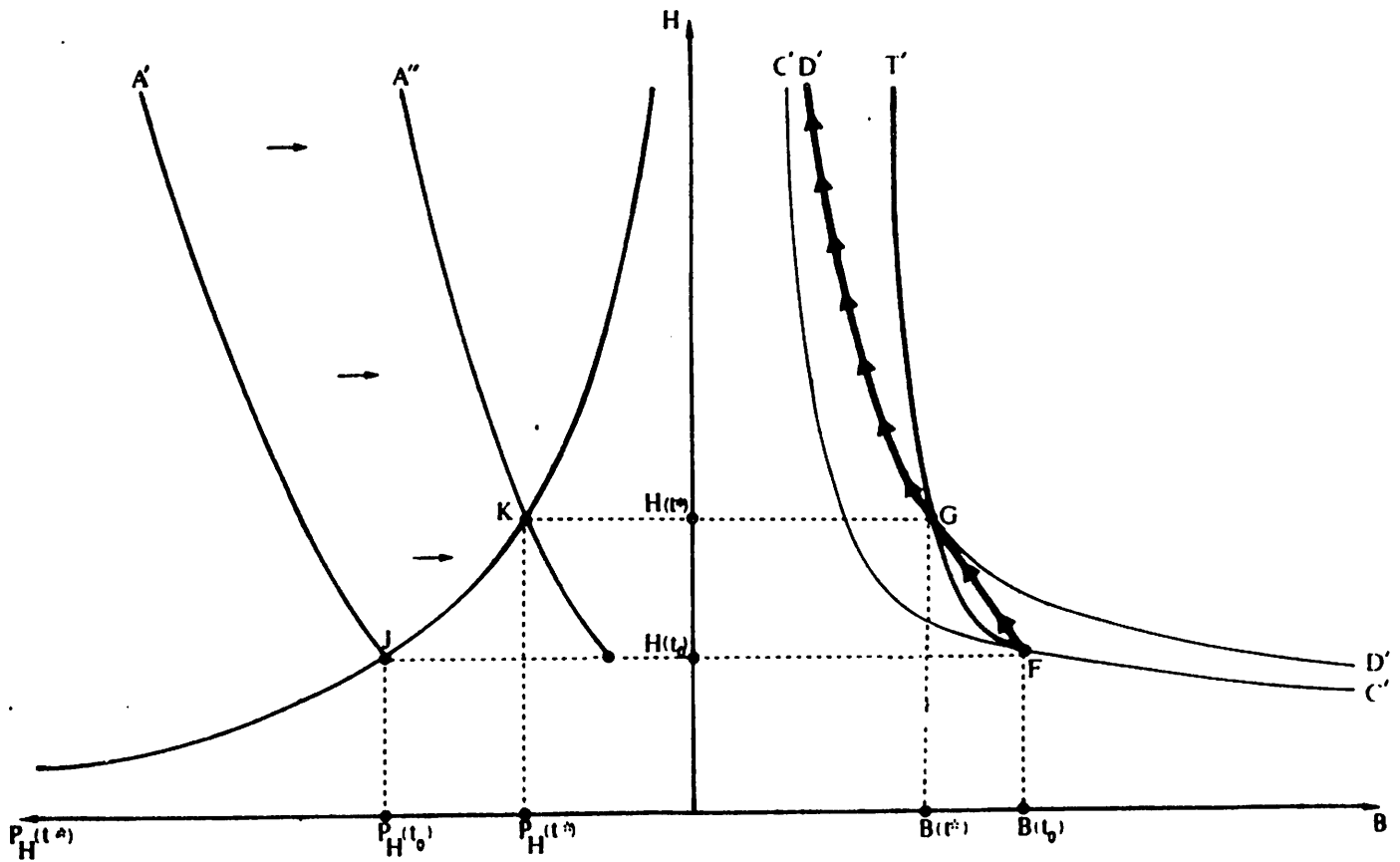
$$(54) \quad \hat{P}_H = -\frac{m}{P_H} + r + \tau_L \quad \text{for } t \geq t^*,$$

$$(55) \quad \lambda_K = \frac{\tau_L}{r} \quad \text{for } t \geq t^*.$$

Under the regime of a Ricardian land tax, the landowner is taxed in the same way as described in section 4.1.1. Hence his reactions on the imposition of the tax are specified by the conditions (32a) and (32b). Therefore, the differential incidence between a 'land tax' on the value of the structure and a site value tax can be derived by comparing (51) - (55) with the necessary conditions (42) - (44b). Obviously, the differential incidence is due to the shadow value λ_K ; (55) tells us that λ_K is the present value of land taxes that can be saved by a marginal increase in the stock of housing capital, all other things equal. In fact it turns out that the switch from a land tax imposed on the value of the structure to a pure land tax results in a governmental subsidy on the use of capital goods in the production of housing units. This subsidy leads to an increase in the optimal capital intensity of new housing investment and, since it also reduces the overall production costs of housing units, to a short-term boom in construction activities. Figure 4 illustrates this differential incidence graphically when J represents the housing market equilibrium occurring under the regime of a tax on the value of the structure. Switching from this tax to a site value tax causes a shift of the 'supply curve' to the right. This can be proved algebraically by substituting the inverse function of condition (51) into (30). Therefore, the time path of the housing and vacant land markets is shown by the line FGD':

we can observe a jump from F to G in the planning period, after which H and B move along the curve GD'.

FIGURE 4



Since the taxation of the landlord has no impact on the dynamic behavior of the economy, the intertemporal incidence of a Ricardian land tax can be described by the growth-equations (36) - (40): the Ricardian land tax as well as the tax on the structure causes - compared with the tax-free situation -

- a reduction in the supply of housing services at least beyond some finite point of time and
- an acceleration in the growth of all endogenous prices.

The economic intuition of this dynamic incidence is the same given in section 4.1.1.

4.2 A NEUTRAL LAND TAX

Obviously, the Ricardian land tax is neutral neither in the short run nor in the long run. And while the long-run incidence of this tax is unambiguous, it is impossible to make a similar clear cut statement about its short-run incidence. Given these results we have to ask whether there is any chance for a neutral taxation of land; quite obviously, the landowner always has the possibility of avoiding the burden of the tax by selling the taxed item. In this context it is interesting to examine the incidence of a tax, that according to the recent tax literature is also said to be neutral - the per-unit taxation of land. This tax is not imposed on the current value but on the area of land owned by landlords and landowners. Therefore, the tax paid by the landowner is

$$(56) \quad T_L^{L0} = \tau_L B,$$

with τ_L as the tax rate, whereas the landlord's tax liability is given by equation

$$(57) \quad T_L^{LL} = \tau_L B^*,$$

where B^* is the share of land included in the housing stock H . B^* is a new state variable in the landlord's decision problem; the motion equation for B^* is

$$(58) \quad \dot{B}^* = F^d.$$

Substituting (56), (57) and (58) in the laissez-faire decision problems (5) and (8), formulating the corresponding Hamiltonians and differentiating them with respect to the state and control variables yields the optimality conditions

$$(59) \quad P_H \varphi'(\epsilon) = 1 \quad \text{for } t \geq t^*,$$

$$(60) \quad \frac{\beta}{\alpha} \in \begin{matrix} < \\ = \\ \geq \end{matrix} \bar{P}_B \Rightarrow F \begin{matrix} = \\ \geq \end{matrix} 0, \quad \bar{P}_B = P_B - \frac{\tau L}{r} \quad \text{for } t \geq t^*,$$

$$(61) \quad \hat{P}_H = \hat{P}_B = 0 \quad \text{for } t_0 \leq t \leq t^*,$$

$$(62) \quad \hat{P}_H = \frac{m}{P_H} + r \quad \text{for } t \geq t^*,$$

$$(63) \quad \hat{P}_B = r \quad \text{for } t \geq t^*,$$

$$(64) \quad \lim_{t \rightarrow \infty} [P_x(t) X(t) e^{-r(t-t^*)}] = 0, \quad x = H, B.$$

Comparing conditions (59) - (64) with their laissez-faire counterparts, we see that the optimality conditions which appear under the regime of a per-unit land tax are the same as those achieved for the tax free economy. Only the time path of the market price for vacant land has changed its level: as pointed out in conditions (60), the new land price \bar{P}_B is equal to the difference between the laissez-faire price P_B and the present value of land-taxes the landlord has to pay; or, to put it in another way, the landlord shifts his tax burden completely back to the landowner. And although the landowner in principle has the possibility to advance the sale of vacant land, there is no rational motive for him to do so; the only outcome of such a reaction would be a decrease in the present value of 'before-tax-revenues' while the present value of his tax burden would remain unchanged.

Table 1 summarizes the tax induced changes in the model variables, distinguished with respect to the alternative methods of land taxation examined in chapter 4 and in each case compared to the laissez-faire situation; the sign "+" signals a tax induced rise, the sign "-" a tax induced fall in the variable's value, the letter "0" indicates that there is no

tax induced change, and "?" describes the situation where there is a tax induced change, but where the sign of the change is undetermined,

TABLE 1		tax on the value of land and development	site value tax	per unit land tax
price of vacant land, P_B .	short run	-	-	-
	long run	+	+	-
rental rate, m	short run	?	?	0
	long run	+	+	0
house price, P_H	short run	-	-	0
	long run	+	+	0
marginal capital intensity, ϵ	short run	?	?	0
	long run	+	+	0
housing stock, H .	short run	?	?	0
	long run	-	-	0
stock of vacant land, B .	short run	?	?	0
	long run	-	-	0

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APPENDIX 1: DERIVATION OF THE OPTIMALITY CONDITIONS

The Hamiltonian for the landlord's decision problem is

$$(A1) \quad \mathcal{H} = z\alpha H - P_B F^d - F^d \epsilon + P_H F^d \varphi(\epsilon)$$

F^d and ϵ are the control variables, H is the state variable. There must be an interior solution $\epsilon = \epsilon^*$ because of the assumptions about the production function:

$$(A2) \quad \frac{\partial \mathcal{H}}{\partial \epsilon} = 0 = -F^d + P_H F^d \varphi'(\epsilon^*) \rightarrow P_H \varphi'(\epsilon^*) = 1$$

Because of the linearity of H in F^d , there can be either a corner solution or an interior solution for the optimal equality of land consumption:

$$(A3) \quad \frac{\partial \mathcal{H}}{\partial F^d} = -P_B - \epsilon^* + P_H \varphi(\epsilon^*) \begin{matrix} < 0 \\ = \\ \geq \end{matrix} \Rightarrow F^d = \begin{matrix} 0 \\ \\ 0 \end{matrix}$$

$P_H \varphi(\epsilon^*) - \epsilon$ is the marginal value product of land in the production of housing units:

$$\partial [P_H F^d \varphi(\epsilon^*)] / \partial F^d = P_H \varphi(\epsilon) - P_H \varphi'(\epsilon) \epsilon = P_H \varphi(\epsilon) - \epsilon.$$

Because of $\alpha = \varphi' \cdot \epsilon / \varphi$ and $\alpha + \beta = 1$ (A3) can be simplified to

$$(A3)' \quad \frac{\beta}{\alpha} \epsilon \begin{matrix} < \\ = \\ \geq \end{matrix} P_B \Rightarrow F^d = \begin{matrix} 0 \\ \\ 0 \end{matrix}.$$

The necessary condition for the optimal stock of housing units is

$$(A4) \quad - \frac{\partial \mathcal{H}}{\partial H} = P_H - z r P_H = -z m.$$

Rearranging terms, one obtains

$$(A5a) \quad \hat{P}_H = 0 \quad \text{for } t_0 \leq t < t^* \quad (z = 0),$$

$$(A5b) \quad \hat{P}_H = - \frac{m}{P_H} + r \quad \text{for } t \geq t^* \quad (z = 1).$$

The Hamiltonian for the landowner's decision problem is

$$(A6) \quad \mathcal{H} = P_B F^S - \lambda_B F^S$$

F^S is the control variable, B is the state variable. The necessary conditions for an interior solution are

$$(A7) \quad \frac{\partial \mathcal{H}}{\partial F^S} = 0 = P_B - \lambda_B \Rightarrow P_B = \lambda_B, \quad \dot{P}_B = \dot{\lambda}_B$$

$$(A8) \quad -\frac{\partial \mathcal{H}}{\partial B} = \dot{\lambda}_B - zr\lambda_B = 0$$

Substituting (A7) into (A8) yields

$$(A9a) \quad \hat{P}_B = 0 \quad \text{for } t_0 \leq t < t^* \quad (z = 0),$$

$$(A9b) \quad \hat{P}_B = r \quad \text{for } t \geq t^*.$$

APPENDIX 2: DERIVATION OF THE REQUIRED MINIMUM GROWTH RATE OF THE DEMAND FOR HOUSING SERVICES

The shadow value of the housing stock, P_H , is defined as

$P_H \equiv \partial \mathcal{M} / \partial H$. Differentiating equation (4) with respect to H yields

$$(A10) \quad P_H = \frac{m_H^a}{r}$$

Differentiating (A10) with respect to time and dividing this differential by

P_H , we get

$$(A11) \quad \hat{P}_H = \frac{\hat{a} - \hat{H}}{\eta}$$

with

$$(A12) \quad \eta = \left| \frac{m \cdot a}{m' \cdot H} \right|$$

as the (constant) absolute price elasticity of demand. (A11) implies that P_H

and hence $m\left(\frac{a}{H}\right)$, grows at a maximum rate when $H = 0$:

$$(A13) \quad \hat{P}_H^{\max} = \frac{\hat{a}}{\eta}$$

Because of $\beta = -\varphi'' \cdot \epsilon / \varphi'$, we can derive from condition (14) the relation

$$(A14) \quad \hat{P}_H = \beta \hat{\epsilon}^*$$

Substituting (A13) into (A14), we achieve

$$(A15) \quad \hat{\epsilon}^{\max} = \frac{\hat{a}}{\eta \cdot \beta}$$

(A15) describes the relation between the relative change in the marginal willingness to pay for land and the relative change in the demand for housing services in the case where there are no construction activities.

From conditions (15) and (18) it follows that in equilibrium an interior solution requires

$$(A16) \quad \hat{P}_B = \hat{\epsilon}^* = r.$$

Now, suppose the case, that

$$(A17) \quad \hat{a} \leq \eta \beta \hat{P}_B$$

According to (A15), (A17) implies $\hat{\epsilon}^{\max} \leq \hat{P}_B$. Suppose also that there

is a stock of vacant land after a finite point of time t_1 , $t^* < t_1 < \infty$.

Because the transversality condition (19) requires $\lim_{t \rightarrow \infty} B(t) = 0$,

this land has to be built upon within the time period (t_1, ∞) , implying

$F, \dot{H} > 0$ within this period. From (15) it follows that $F > 0$ only

holds if $\frac{\beta}{\alpha} \epsilon = P_B$. From the above discussion it is clear that $\dot{H} > 0$ implies

$\epsilon^* < \epsilon^{\max} \leq P_B$. From this it follows that $\frac{\beta}{\alpha} \epsilon^* > P_B$ for some $t < t_1$,

i.e. that there is a period where the marginal willingness to pay for land exceeds the demanded price for land. Such a situation violates the existence conditions for the maximum of the Hamiltonian in (7). Therefore,

$a \leq \eta\beta P_B$ implies that all vacant land will be sold and build upon in the meta time period (t_0, t^*) .

For $a > \eta\beta P_B$ there will be vacant land at every finite point of time. To prove this, assume that all vacant land will be used up at some finite

point of time $t_1, t^* < t_1 < \infty$, with $\frac{\beta}{\alpha} \epsilon = P_B$ in t_1 . Beyond t_1 , we have

$\dot{H} = 0$; what in turn implies $\epsilon^* = \epsilon^{\max} > P_B$, so that $\frac{\beta}{\alpha} \epsilon > P_B$ for all

$t > t_1$. This again violates the existence conditions for an optimal solution in the landlord's decision problem and hence confirms the statement made above.

APPENDIX 3: DERIVATIONS OF THE STOCK-GROWTH EQUATIONS

Given $a > \eta\beta P_B$, there initially are two possible situations in the

market for vacant land: a) $\frac{\beta}{\alpha} \epsilon < P_B$; if the willingness to pay for

land is lower than the demanded price, then $F = \dot{H} = 0$; from $\dot{H} = 0$ it follows

that $\hat{\epsilon} = \hat{\epsilon}^{\max} > \hat{P}_B$. Hence there must be a finite point of time

$\tilde{t} > t^*$, where condition (15) holds with equality, i.e. where the landlord is willing to pay the demanded price.

b) Condition (15) holds with equality right a way, implying $\tilde{t} = t^*$.

After \tilde{t} , H has to grow at a speed which is just high enough to ensure

$\epsilon = P_B$ at

$\hat{\epsilon} = \hat{P}_B$ at each point of time t , $t \geq \tilde{t}$. If H grows too slow, we have

$\epsilon > P_B$ or

$\hat{\epsilon} > \hat{P}_B$ or $\frac{\beta}{\alpha} \epsilon > P$, respectively, violating condition (15). If H grows

too fast then $\hat{\epsilon} < \hat{P}_B$ and $\frac{\beta}{\alpha} \epsilon < P$. This implies $F = \dot{H} = 0$, an obvious contradiction.

The growth rate of the housing stock H can be derived from the equations (A11), (A14) and (A16). Substituting (A16) into (A14) and (A14) into (A11), we get

$$(A18) \quad \dot{H} = a - \eta \beta P_B = \text{constant} > 0.$$

The constance of H implies $\dot{H} = H$. Hence it follows from (6) that

$$(A19) \quad H = \dot{H} = F + \varphi(\hat{\epsilon}) = F + \alpha \hat{\epsilon}.$$

Combining (A19) and (A18) yields with regard to (A16)

$$(A20) \quad F = a - P_B(\eta\beta + \alpha) = \text{constant}.$$

The sign of F can be determined by using the transversality condition for H:

(19) implies

$$(A21) \quad H + P_H - r < 0 \quad \text{for all } t, t \geq \tilde{t}.$$

Substituting (A14), (A16) and (A19) in (A21) yields

$$(A22) \quad \hat{F} + \alpha \hat{E} + \beta \hat{E} - \hat{E} = \hat{F} + (\alpha + \beta) \hat{E} - \hat{E} = \hat{F} < 0.$$

Because of $\frac{dF}{dB} = \frac{\dot{F}}{F}$ it follows from (9) that B is a linear function of F:

$$(A23) \quad \frac{dB}{dF} = \frac{F}{-F} = -1 = \text{constant} > 0.$$

It is easy to show that in the general equation $F = b_1 + b_2 B$ the parameter b_1 has to equal zero; otherwise the transversality condition (19), requiring $\lim_{t \rightarrow \infty} B(t) = 0$, would be violated: with $b_1 > 0$ vacant land would be

used up completely at a finite point of time, with $b_1 < 0$ and area of vacant land would never be built upon; $b_1 = 0$ implies $B = \hat{F}$ or

$$(A24) \quad B = a - P_B(\eta\beta + \alpha) = \text{constant} < 0.$$

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