A REGIONAL GENERAL EQUILIBRIUM MODEL OF THE UNITED STATES: TAX EFFECTS ON FACTOR MOVEMENTS AND REGIONAL PRODUCTION

William Morgan, John Mutti, and Mark Partridge*

Abstract—A six region general equilibrium model of the United States is used to assess the potential long-run effects of state-local and federal tax policies on output and the allocation of factors across regions and sectors. The nonuniform structure of state-local taxes and their interaction with federal taxes means that regional output is affected quite differently than would be projected solely on the basis of changing average regional tax burdens. The study provides a useful indication of conceptual and empirical issues that must be considered in further regional modelling efforts, issues which do not arise in closed-economy national models.

I. Introduction

THIS study develops a regional general equilibrium model of the U.S. economy and demonstrates its use by assessing the potential long-run effects of state-local and federal government tax policies on the allocation of factors and production across regions and sectors. Although a considerable applied general equilibrium literature exists, analyses of the effects of government tax and expenditure policies on regions within countries are limited. Reasons for the lack of such studies are that the necessary regional data are not available in suitable form, and a number of unresolved behavioral issues remain, including the extent of interregional factor mobility and the uniqueness of regional goods. In those studies that are available the regional representations, economic assumptions and policy issues considered are substantially different than in the present study. See Kimbell and Harrison (1984), Whalley and Trela (1986), and Jones and Whalley (1988) and (1989).

The public finance issue considered here has become increasingly important in state-local policy formulation, given the rapidly changing structure of the U.S. economy and the wide variation in regional growth patterns. Most factors that influence business location cannot be changed by

government policy (e.g., proximity to markets, climate, energy costs). Increasing the skills of the labor force can be accomplished only over a long-run horizon, and labor may not stay in the region once it is trained. A key instrument available to governments attempting to accelerate regional growth is tax policy, and tax differences among broad regions of the United States are considerable. Additionally, tax rates among economic sectors vary considerably at both the state-local and federal levels, and there are important differences among regions regarding the relative importance of business and household type taxes.

Recent econometric studies have considered several aspects of this situation (Newman and Sullivan, 1988). Although the results of those studies are mixed, they generally indicate that state and local tax policies do influence the geographic pattern of economic activity. The general equilibrium approach adopted in the present study represents a complementary perspective because it explicitly specifies the types of structural factors that lie behind the reduced form econometric relationships. Additionally, detailed consideration of the appropriate representation of and behavioral response to different tax policies is possible. In contrast, econometric studies face limitations over available degrees of freedom, potential multicollinearity if a variety of tax measures are considered, and an inability to incorporate complex constraints across different coefficient estimates that are suggested by economic theory. Also, econometric studies are unable to evaluate how regional changes in income or employment relate to broader measures, such as economic welfare, which are addressed here.

The present study shows that the effects of regional tax policies are quite different than might be projected solely on the basis of regional differences in tax burdens. Focusing on overall tax burdens alone ignores important differences in tax structures and economic composition across regions, the interaction of federal and regional taxes, and the nonneutrality of the federal tax-transfer system.

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* University of Wyoming, Grinnell College, and University of Illinois, respectively.

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TABLE 1.—BASIC FEATURES OF U.S. REGIONAL MODEL

Regions	Northeast (New England, Mideast); Great Lakes; Plains-Rockies (including Alaska); Southeast; Southwest (including Louisiana); Far West (including Hawaii).
Goods Produced	Traded goods—agriculture (including forestry and fisheries), mining, manufacturing; Nontraded goods—real estate, services, state-local public goods, federal public goods. Value added in each sector requires land, labor and capital inputs
Consumption	Consumers make expenditure allocations at four different levels based on a nested constant elasticity of substitution utility function. These levels are: —net payment for federal public good v. all other goods —state-local public goods v. all private goods —choice among five private goods —choice among region-specific products for each of the three traded goods
Factor Mobility	Capital is interregionally and intersectorally mobile. Land is interregionally immobile but (excluding mining) intersectorally mobile. Labor is intersectorally mobile; interregionally three alternatives are considered—perfect mobility, partial mobility, and complete immobility.
Factor Ownership	Corporate land and capital used in a region are owned by both residents and nonresidents. Noncorporate land and capital are owned by residents.
Fiscal Effects	Taxes and transfers are identified and budget constraints for regional and federal governments are incorporated. The varying extent of deductibility of different state-local taxes against federal taxes is recognized, a factor of special importance in considering alternative tax scenarios.

II. A Framework for Analyzing Regional Economic Activity

Basic characteristics of the model applied in this study are summarized in table 1. Some points raised there merit further elaboration. With respect to demand, the quantity of federal public goods provided and the distribution of their production across regions is assumed to be independently determined. Aggregate regional income, net of federal taxes and transfers, then is allocated in accord with the three remaining tiers of the nested CES utility function. At the most disaggregated level, the regionally differentiated traded goods are treated as highly substitutable but unique products (Armington, 1969). Tastes across regions are similar, transportation costs are ignored, and a national market for traded goods is assumed. Therefore, in the absence of taxes or other distortions, each region's consumption share for a particular traded good is given by its share of disposable income nationally.¹

¹ For example, if a region accounts for one-fourth of all income spent on traded goods, then it is assumed to buy one-fourth of the traded goods produced in each region. More important, the production and assumed consumption patterns imply a net trade position for each region. Regional trade data reported in the 1977 Census of Transportation are not entirely

With regard to production, all markets are assumed perfectly competitive, and constant returns to scale hold. As developed by Jones (1965) the production possibility frontier for each region can be determined, given the available supplies of labor, capital and land.

Demand for each input is a function of regional output, factor intensities in production, the extent of substitution among inputs, and relative factor prices. Relative factor prices depend upon the factor mobility assumptions made. Capital is assumed to be perfectly mobile across regions and sectors, and it is reallocated until a common after-tax rate of return emerges. If household taxes within a region are uniform, only business level

consistent with these equilibrium conditions. The Census data show a higher value of shipments to destinations within the region and consequently a smaller role for interregional trade. (A chi-square test rejects the national market assumption of purchases proportional to income if local sales are included in the calculation, but not if local sales are excluded.) The relatively large value of intraregional trade may be misleading, however, because it is based on gross transactions and not value added, the measure used in the present model. Nevertheless, with a less open trading system, the implication for a region's tax reduction policy is not clear a priori: a bigger nontraded goods sector results in a bigger cost of living decline and a larger inflow of labor, but the lower elasticity of demand for regional output may limit growth.

taxes affect this comparison; any differences in household taxes across regions are not relevant, because capitalists are assumed unable to change their region of residence or to consume outside their home region as their household level tax burden changes.²

The availability of labor in a region is assumed to be a function of real wages offered in that region relative to real wages available elsewhere. The greater the responsiveness of individuals on the margin to any real wage gap, the more likely that real wages are equalized across regions. For the United States, recent studies suggest real wages are equalized across regions once individual differences in human capital are recognized (Gerking and Weirick, 1983; Bellante, 1979). If this indirect evidence of mobility is regarded as inconclusive, a smaller degree of wage responsiveness can be assumed.³ The empirical simulations include the extreme of no labor mobility, as well as intermediate values.

Regional income is determined by the value of regional output, less net payments to owners of capital improvements and land who are residents of other regions. This net capital position is based on payments made to out-of-state stockholders and payments received by residents from shares in out-of-state corporations. Any change in the balance of federal taxes paid and transfers received in a region enters the income equation, too.

State-local tax policy changes are considered for scenarios where all regions eliminate current taxes or where just one region unilaterally eliminates its current taxes; existing distortive taxes are replaced by lump-sum taxes.⁴ These scenarios are

not intended to imply that all jurisdictions within a region actually change their tax policy in such a coordinated way. Rather, the approach addresses the question how much difference could taxes make to regional production patterns. Also, it allows behavioral responses to distorting taxes to be clearly identified and it demonstrates significant state-local-federal tax interactions if nondeductible taxes are substituted for deductible taxes.

This upper-bound interpretation is consistent with the assumption that existing taxes are not offset by a higher level of public goods provision. For the six regions represented here state-local public goods as a share of regional income are remarkably similar. Because relative differences in public good provision are small while significant differences in tax burdens do exist, tax differentials appear likely to create incentives to relocate factors of production. Further work might usefully distinguish the role of local property taxes versus state income taxes in funding different types of public goods. More concrete analysis requires an empirical basis for judging the value individuals and business place on these different services.

III. Empirical Development of the Applied General Equilibrium Model

The theoretical system was implemented by determining appropriate values for a tax distorted initial equilibrium of the U.S. economy. A key task was to estimate regional earnings (value added) by economic sector and then to allocate earnings to residence of factor ownership in order to estimate regional expenditures.

Labor income and total value added for each of the six regions are reported in table 2.⁵ Total value added in each private sector was estimated from national relationships (table 2, footnote b) and then adjusted to include estimated state and local property and severance taxes paid by each sector in each region. This step is taken because the

² The latter treatment is not significant in this study where all taxes are altered, but if the relative burden on labor and capital were changed, it might incorrectly imply that a region could tax capitalists at the household level without causing any erosion of the tax base.

³ Whalley and Trela assume less labor mobility, which gives results similar to the no mobility case, with bigger windfall gains and losses to individuals and smaller changes in regional output. Their mobility formulation is based on comparisons of nominal wages, a conceptually incomplete approach. Jones (1988) modified this framework to recognize the role of real wages, but his iterative solution algorithm did not converge unless a small degree of wage responsiveness was assumed or constraints were imposed on the pattern of interprovincial flows. Such ambiguities do not arise in the current simultaneous solution of a linear differential system. No one approach has been uniformly general or successful.

⁴ The lump-sum tax could be imposed on the immobile factor, land. Such a tax, however, can affect nonresident own-

ers, and thereby influence patterns of consumption across regions.

⁵ The estimates of gross state product developed by the U.S. Bureau of Economic Analysis were not used in the present study because of certain conceptual issues. Since relative income by sector and by region are quite similar, the choice of data sets should not alter the basic results. A more detailed discussion of this subject is available from the authors.

TABLE 2.—VALUE ADDED AND REGIONAL BUSINESS TAX RATES

Region	Labor Value Added, \$ Million (1979–81 Ave.) ^a	Total Value Added \$ Million (1979–81 Ave.) ^b	Average, Effective Regional Business Tax Rates ^c
Great Lakes			
Agriculture	6,280	11,996	31.5
Mining	2,487	3,339	24.3
Manufacturing	110,773	144,435	7.2
Real Estate	2,378	38,376	24.4
Services	145,767	177,460	11.6
State-Local Government	30,827	58,669	
Federal Government	8,022	12,796	
Total	306,534	447,071	
New England-Mideast			
Agriculture	3,955	7,146	22.7
Mining	1,903	2,516	19.7
Manufacturing	110,702	144,824	9.0
Real Estate	4,456	61,257	27.9
Services	220,615	270,078	14.1
State-Local Government	44,996	85,636	
Federal Government	22,008	35,105	
Total	408,635	606,562	
Plains-Rocky Mountains			
Agriculture	8,903	16,530	27.1
Mining	4,743	6,975	53.0
Manufacturing	35,194	45,774	6.2
Real Estate	1,422	23,077	19.4
Services	90,613	110,571	11.5
State-Local Government	19,065	36,284	
Federal Government	8,818	14,066	
Total	168,758	253,277	
Southeast			
Agriculture	8,806	15,360	16.2
Mining	5,576	7,531	25.4
Manufacturing	70,090	91,029	4.9
Real Estate	2,243	41,528	14.4
Services	146,022	177,048	8.2
State-Local Government	32,349	61,566	
Federal Government	22,200	35,411	
Total	287,286	429,473	
Southwest			
Agriculture	4,689	8,173	15.9
Mining	13,021	20,505	54.1
Manufacturing	33,883	44,143	4.0
Real Estate	1,452	23,081	13.3
Services	98,526	119,312	6.6
State-Local Government	18,606	35,411	
Federal Government	9,774	15,603	
Total	179,951	266,228	
Far West			
Agriculture	8,771	14,743	8.5
Mining	1,541	2,159	36.2
Manufacturing	55,352	72,131	8.6
Real Estate	2,481	51,757	12.3
Services	142,290	172,697	12.3
State-Local Government	30,172	57,423	
Federal Government	15,129	24,132	
Total	255,736	395,042	
United States			
Agriculture	41,404	73,948	
Mining	29,271	43,025	
Manufacturing	451,994	542,336	
Real Estate	14,432	239,076	
Services	843,833	1,027,166	
State-Local Government	176,015	334,990	
Federal Government	85,951	137,101	
Total	1,606,900	2,397,642	

^a Derived from, U.S. Department of Commerce, *Local Area Personal Income*, 1976–81.^b Labor income, sector *j*, region *i* (column 1) divided by the ratio of labor income, sector *j*, U.S. to value added, sector *j*, U.S. Returns to capital for the government sectors were estimated separately and added to labor value added to estimate total value added. Private value added was adjusted to include estimated state and local property taxes and severance taxes paid by each sector in each region. U.S. value added is from the U.S. Department of Commerce, *Survey of Current Business*.^c Estimated state corporate income taxes plus property and severance taxes paid, sector *j*, region *i* divided by gross returns to capital. Tax collections are from Tax Foundation, *Facts and Figures on Government Finance*, 1981 and 1983 editions.

TABLE 3.—ESTIMATED VALUES FOR KEY PARAMETERS

Sector	National Average Factor Shares				Rates of Substitution Among Factors			Average Effective Federal Business Tax Rates ^a
	Labor	Land	Mining Land	Capital	Capital and Land	Capital and Labor	Land and Labor	
Agriculture	0.56	0.33		0.11	0.4	1.0	0.2	0.017
Mining	0.68		0.21	0.11	0.2	0.4	0.05	0.297
Manufacturing	0.77	0.02		0.21	0.1	0.8	—0—	0.476
Real Estate	0.06	0.37		0.57	0.4	0.1	—0—	0.005
Services	0.82	0.02		0.16	0.1	1.0	0.05	0.214
State-Local Government	0.53	0.18		0.29	—0—	—0—	—0—	
Federal Government	0.63	0.10		0.27	—0—	—0—	—0—	
Average, All Sectors ^b	0.67	0.09	0.004	0.24				

Demand Elasticities of Substitution			Interregional Migration Response to Real Wage Gap, Elasticity Values	
Between state-local public goods and all private goods	—0—		Perfectly Mobile Labor	100.0
Between each of the five private goods	0.75		Partially Mobile Labor	0.1
Between traded goods produced in different regions	3.0		Immobile Labor	0.0

Region	Ownership Share of Nationally Held Business ^c	Average Effective Household Tax Rates	
		State-Local ^d	Federal ^e
Great Lakes	0.183	0.044	0.216
New England-Mideast	0.262	0.053	0.215
Plains-Rocky Mountain	0.112	0.044	0.203
Southeast	0.170	0.043	0.205
Southwest	0.108	0.034	0.216
Far West	0.165	0.056	0.198

^a The ratio of federal corporate income tax collections to gross returns to capital.

^b Details do not add to totals because of rounding.

^c Based on each region's share of dividends, interest and rent as reported in U.S. Department of Commerce, *Local Area Personal Income*, 1976-1981.

^d The sum of state-local tax collections from individual income and sales taxes divided by earnings at residence.

^e The sum of federal tax collections from individual income and social taxes divided by earnings at residence.

burden of these taxes is assumed to fall on capital owners in the short run, but they are treated as indirect business taxes in the national income accounts. A different procedure was used to estimate government returns to capital because they are not recognized in the national income accounts.⁶

The allocation of capital returns between land (or mineral land) and capital improvements is based on central values from other studies and then adjusted for each sector in each region to account for property and severance taxes paid. The national average factor shares are reported by sector in table 3, as well as the elasticities of factor

substitution and comparable information relevant to the demand side of the model. Additionally, the three alternative interregional migration elasticity values assumed in the analysis are shown.

Capital earnings were divided between incorporated and unincorporated ownership by sector at the national level by estimating the share of capital controlled in each sector by corporations, partnerships and proprietorships, where corporate capital is assumed to be nationally owned and noncorporate capital is regionally owned. Estimated nationally owned returns to capital were allocated according to the regional ownership shares reported in table 3.

Average effective tax rates were calculated for 1980 at the state-local and federal levels, by region, separating the taxes into two groups depending on whether a particular tax is levied on business or household sources of income. Corporate income, property and severance taxes are assumed to fall on capital earnings in the short run. Individual income, sales and social insurance taxes such as social security taxes are assumed to fall on

⁶ Returns to capital of state-local governments were estimated from the ratio of the estimated stock of capital improvements of state-local governments to the stock of private capital improvements, times the returns to private sector capital improvements. These returns were separated into those attributable to equipment and to structures. Value added from structures was used to estimate returns to public land, based on the same ratio of land to structures in private real estate. State-local returns to capital improvements and land were then allocated among the regions based on shares of state-local government labor value added. Returns to capital of the federal government were estimated similarly.

household earnings, which consist of labor income and distributed capital earnings.

State-local and federal business tax rates by region and sector are shown in tables 2 and 3, respectively. Federal rates vary among sectors because of differential levels of incorporation and differential tax treatment at the federal level. The corresponding household tax rates are shown in table 3. Federal rates differ among regions because individual income subject to federal taxation varies.

The net fiscal contribution to the financing of federal government services was estimated as the difference between federal taxes paid by each region minus federal transfers to state and local governments. Each region's estimated relative share of net fiscal contribution times federal value added was subtracted from earnings by residence of factor ownership to calculate region expenditures on all goods excluding federal public goods.

IV. Empirical Results

The multilateral or simultaneous removal of all regional taxes was considered first. Then regional taxes were removed unilaterally. The final change was the multilateral removal of all regional and federal taxes. Discussion of the multilateral and unilateral perspectives is included in Mutti and Morgan (1983), and Morgan and Mutti (1985). It is assumed that the nondistorting lump-sum taxes imposed at the regional level are not deductible against federal business and household tax liabilities. This assumption was imposed to assess the locational effects of existing tax policies relative to an alternative tax system that was as locationally neutral as possible. With the larger federal tax base, new lower federal tax rates can be levied which yield the same amount of tax revenue as when deductible regional taxes are imposed. The discussion here addresses the case of perfect labor mobility, but the results from alternative specifications are reported.

When regional taxes were removed multilaterally, economic growth and net factor inflows occurred primarily in the New England-Mideast and Far West regions, and there was no growth for the United States, all regions combined. The existing tax policies of the Southeast and Southwest regions appear to have resulted in the move-

ment of capital and labor to these regions and to have accelerated economic growth there. Regional growth rates and factor movements expressed in real terms are shown in table 4.

In contrast to the other scenarios reported, average regional tax burdens are relatively more important in explaining the growth observed in the New England-Mideast and Far West regions. When high capital or household taxes are levied on a particular sector or region the amount of capital or labor utilized there is reduced. Removing the taxes creates an incentive for capital and labor to move to the sector or region which previously had relatively high taxes. The New England-Mideast has on balance the highest regional business taxes and high household taxes, second only to the Far West.

There is an incentive for labor to move to the two expanding regions which had high household taxes previously, because the cost of living declines the most there. Beyond regional tax differentials, differences in sectoral factor intensities and elasticities of substitution are key factors in explaining the pattern of growth. Labor is most readily absorbed into labor intensive sectors such as manufacturing and services with relatively high elasticities of factor substitution between labor and capital. Labor is substituted for capital because nominal before-tax wages in these two regions decline and returns to capital increase. The marginal productivity of capital and land rise as labor is absorbed, thereby bidding up their returns.

The second policy change, removing state-local taxes one region at a time while holding constant the existing tax policies for the other five regions, provides an upper bound estimate of regional growth when tax policies are altered in a particular region. As shown in table 4, the region which removes its current distorting taxes always does better both in terms of regional growth and net inflows of factors relative to the situation where all regions alter their tax policies multilaterally. Although this result is conventional from the perspective of tax competition analysis, it is contrary to the expectation often expressed in considering the potential gains to regions that have been able to raise (not lower) mineral severance taxes. Also, unilateral tax reductions can lead to significant terms of trade losses if interregional demand elasticities are assumed to be relatively small.

TABLE 4.—REGIONAL GROWTH AND FACTOR MOVEMENTS RESULTING FROM TAX POLICY CHANGES
(PERCENT)

	Region						U.S. Total
	Great Lakes	New England– Midwest	Plains– Rocky Mountains	Southeast	Southwest	Far West	
Multilateral Removal of Regional Taxes							
a. Perfectly Mobile Labor							
Value Added	–0.6	1.9	0.3	–1.6	–2.4	0.9	0.0
Capital	0.0	3.0	1.1	–2.4	–3.1	–0.3	0.0
Labor	–0.8	1.9	0.0	–1.4	–2.5	1.6	0.0
b. Partially Mobile Labor							
Value added	–0.1	0.7	0.3	–0.7	–1.0	0.2	0.0
Capital	0.4	2.3	1.1	–1.8	–2.1	–0.9	0.0
Labor	–0.2	0.3	0.0	–0.3	–0.6	0.4	0.0
c. Immobile Labor							
Value Added	0.0	0.4	0.2	–0.5	–0.4	–0.3	0.0
Capital	0.5	2.1	1.1	–1.7	–1.8	–1.0	0.0
Unilateral Removal of Regional Taxes							
a. Perfectly Mobile Labor							
Value Added	7.5	8.8	8.9	6.5	6.5	9.7	0.0
Capital	10.1	11.2	11.5	7.5	7.9	9.8	0.0
Labor	7.6	9.0	9.2	7.0	6.8	10.9	0.0
b. Partially Mobile Labor							
Value Added	2.6	2.8	3.9	2.0	2.8	3.1	0.0
Capital	6.9	7.4	8.2	4.7	5.4	5.9	0.0
Labor	1.6	1.6	2.3	1.5	1.6	2.3	0.0
c. Immobile Labor							
Value Added	1.8	1.6	1.7	1.0	1.1	1.3	0.0
Capital	6.0	6.6	7.1	4.0	4.6	4.8	0.0
Multilateral Removal of Federal and Regional Taxes							
a. Perfectly Mobile Labor							
Value Added	3.3	4.0	–0.6	–3.7	–1.4	–0.5	0.6
Capital	6.4	5.0	0.0	–7.5	–3.4	–2.9	0.0
Labor	2.2	3.4	–1.5	–3.9	–1.6	–0.7	0.0

Note: All figures show percentage changes in regional value added or in physical stocks of labor and capital in a region, which result from substitution of existing taxes with lump-sum nondistorting taxes of equal real yield.

Labor mobility is an important determinant of regional growth, because less capital is attracted if the labor force cannot expand. The sensitivity results reported in table 4 suggest that when labor is immobile, then capital increases by only 60% relative to the perfect mobility case, and regional output grows by less than 25% of the perfect mobility figure. The Far West is disproportionately affected under this alternative because its large household tax cuts lose their effectiveness in spurring growth.

Overall U.S. economic growth is virtually zero with unilateral policy changes. Additionally, total output in the other five regions always contracted when unilateral tax changes were imposed. Therefore when tax policies are altered unilaterally economic growth in a particular region occurs almost

totally at the expense of economic activity in the other five regions.

Effective federal tax rates increase in the region unilaterally adjusting its tax policies because of the assumed nondeductibility of its lump-sum taxes against federal tax liabilities. With unilateral tax changes, regions with high regional capital and household taxes will fare relatively worse in terms of regional growth compared to the multilateral change, because their effective federal tax rates increase more without deductibility of regional taxes. Conversely, low-tax regions fare relatively better.

Both federal and regional taxes were removed multilaterally in the final policy change, to demonstrate the nonneutrality of federal tax policies. A significant cause of this nonneutrality is the dif-

ference in effective federal business tax rates across sectors. Total U.S. growth is positive, 0.6 of 1%. New England-Mideast and the Great Lakes are the regions where growth in output and net factor inflows occur, shown in table 4. They are the dominant manufacturing areas, and effective federal tax rates on manufacturing are the highest of all sectors. Because these two regions also have the highest federal household tax rates, they benefit the most from the removal of existing federal taxes that otherwise tend to depress real after-tax wages in these regions.

The largest declines in output and net factor outflows occurred in the Southeast and Southwest, which have relatively low business and household taxes. Also, the existing pattern of federal transfers to regional governments redistributes income from the Great Lakes to the Southeast. This distributional advantage to the Southeast is removed in policy change three when a system of federal transfers proportional to regional income is adopted.

To understand why national economic growth was positive when both federal and regional taxes were removed but was virtually zero when only regional taxes were altered, recognize that in policy change one resources move out of manufacturing, a low-tax sector at the regional level, to previously high tax sectors such as agriculture and real estate. In policy change three the situation is reversed; resources move to manufacturing as high federal taxes on manufacturing are removed, and out of real estate which loses its preferential tax treatment at the federal level.

The removal of regional taxes only represents a second best situation because existing federal taxes remain. Any efficiency gain from the transfer of resources into agriculture and real estate is offset by the loss that results from taking resources away from sectors such as manufacturing where their social product exceeds their private after-tax return. When policy change three was modified by removing federal taxes only, national growth was virtually the same as when both regional and federal taxes were removed. Federal business tax rates are highest in labor intensive sectors with high elasticities of substitution between capital and labor, while regional taxes tend to be higher in land or capital intensive sectors with lower factor elasticities. Another important distinction is that when regional taxes only were removed, re-

sources were drawn out of manufacturing, which faced the highest federal business tax rate, 48%.⁷ In contrast, when federal taxes only were removed, resources were drawn out of real estate, which faced an average regional tax rate of about 19%. Thus, second best losses are more significant in the first situation than the second.

Because of the apparent importance of the values of the elasticity of factor substitution between capital and labor in manufacturing and services, these elasticities were reduced by 50% to assess the sensitivity of output projections. Although national growth in policy change three was reduced by about one-fourth, manufacturing continued to be the leading growth sector, and the highest regional growth rates occurred in the same regions.

Economists have developed estimates of welfare costs resulting from the sectoral misallocation of capital in the United States caused by capital taxes (Harberger (1966) and Shoven (1976)). Their welfare loss estimates are comparable to the loss of 0.6 of 1% estimated in the current study. Moreover, when demand and supply elasticities are reduced the relative reductions in welfare losses obtained here parallel the pattern and magnitude reported by Harberger and Shoven: welfare losses are more sensitive to altering factor elasticities of substitution than to altering demand elasticities.

V. Conclusions

A regional general equilibrium model is developed and used to evaluate the way alternative tax policy changes might alter the location and sectoral pattern of production. Particular attention is paid to the nature of factor mobility and ownership, and to the interaction of state-local business taxes with state-local household taxes and federal taxes.

The study indicates issues that must be confronted in further regional modelling efforts; such issues do not arise in closed-economy national models. Two broad concerns identified below are recognized in the present paper, but future research must assess how alternative approaches

⁷ This 1980 figure predates the tax reductions enacted in 1981. Because the 1986 tax reform resulted in a shift of the tax burden back on to corporations, this general characterization still appears appropriate.

might affect the results obtained in different policy applications.

A particularly critical area appears to be the potential mobility of factor services and factor owners. The former type of mobility applies to the ability to relocate capital assets from one region to another or the willingness of labor to accept employment in another region. The latter type of mobility applies to the ability of households to consume in other regions, perhaps without changing their region of residence. The present treatment leaves open potentially complex interactions. For example, when workers do change their residence in response to changing real wages (as when commuting across regions is not possible), to what extent does this cause a simultaneous change in the location of capital owners, further affecting the household tax base in a region? If household location decisions are a weighted average function of returns to labor and capital, what weights apply on the margin?

In a metropolitan context, mobility of factor owners has traditionally meant that more attention must be paid to the benefits from government services provided. At the regional level used here, total expenditures on services do not appear very different, but the mix of these expenditures has not been addressed. However, the role of the federal government in financing these expenditures, either through direct grants or through the deductibility of state-local taxes, does appear critical here, and broader consideration of both these tax and expenditure issues is warranted in further research.

APPENDIX

The model is solved in linear differential form. Major elements are shown below.

Regional Demand for Goods Produced

$$D_{inj} - \sum_{m=1}^6 \sum_{h=1}^3 E_{injmh} \cdot p_{mh} - \sum_{h=4}^6 E_{injmh} p_{ih} - \beta_i (Y_i - NFT_i) = 0 \quad (1)$$

where D_{inj} is the percentage change in quantity of region i purchases of good j produced in region n , E_{injmh} is the elasticity of demand for that good given a price change for good h produced in region m , p_{ih} is the percentage change in the price of good h produced in region i , Y_i is the percentage change in regional income, and NFT_i is the percentage change in the region's net contribution for the federal public good, multiplied by the initial ratio of this contribution to regional

income. Values of h from 1 to 3 are traded goods, from 4 to 6 are nontraded goods.

Full Employment of Factors of Production

$$\begin{aligned} \sum_{j=1}^7 \lambda_{ifj} X_{ij} + \sum_{j=1}^7 \sum_{f=1}^3 \lambda_{ifj} \Theta_{ikj} \sigma_{kf} (r_{ki} - r_{fi}) - F_{ki} \\ = - \sum_{j=1}^7 \sum_{k=1}^3 \lambda_{ifj} \Theta_{ikj} \sigma_{kj} (T_{ikj} - T_{ifj}) \end{aligned} \quad (2)$$

where ifj is the share of factor f in region i used in sector j ; X_{ij} is the percentage change in production of sector j in region i ; Θ_{ikj} is the share of factor k in the production of good j in region i ; σ_{kf} is the partial elasticity of substitution between factor k and factor f ; r_{ki} is the percentage change in the after-tax return to factor k in region i ; F_{ki} is the percentage change in the available supply of factor k in region i , and T_{ikj} is the change in region i 's tax on factor k used in j production expressed relative to the initial after-tax return to that factor. For an interregionally mobile factor, the weighted sum of percentage changes in regional factor supplies, F_{ki} , must be zero.

Labor Mobility

$$F_{ki} - \sum_{j=1}^5 (S_j/S_i) \sigma_{ij} (rw_{ki} - rw_{kj}) = 0 \quad (3)$$

where S_i is the initial labor stock in region i , rw_{ki} is the percentage change in the real wage paid to labor in region i , and σ_{ij} is the labor migration elasticity varied proportionally in the simulations reported in table 4. Cross-equation constraints on this value are imposed to ensure that the labor attracted out of region i into region j is (consistently) included in the calculation of both F_i and F_j .

Zero Profit Constraint in Production

$$\sum_{k=1}^3 \Theta_{ikj} r_{kj} - P_{ij} = - \sum_{k=1}^3 \Theta_{ikj} T_{ikj} \quad (4)$$

If factors are to receive the same after-tax return, an increased tax on factor inputs requires that producers charge higher prices.

Regional Income

$$\begin{aligned} \sum_{j=1}^7 \phi_{ij} X_{ij} + \sum_{j=1}^7 \phi_{ij} P_{ij} + \Omega_i z - \alpha_i K_i + \\ \sum_{k=1}^2 \sum_{j=1}^6, r_{kj} \delta_{ikj} - \sum_{k=1}^2 \sum_{j=1}^6, r_{ki} \delta_{jki} - Y_i = 0 \end{aligned} \quad (5)$$

where ϕ_{ij} is the initial value share of good j output in total income of region i ; Ω_i is the return to region i residents from their net ownership of capital utilized in other regions, expressed as a share of region i 's income; α_i is capital's share of income in region i ; K_i is the percentage change in the stock of capital used in region i ; z is the percentage change in returns to capital; and δ_{ikj} is the return to region i stockholders who own immobile factors k located in region j , expressed as a share of region i 's income.

Other Elements

Additional relationships included in the model are regional and federal government budget constraints, and market equilibrium conditions (that quantity supplied equals quantity demanded in all markets).

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