To the Graduate Council:

I am submitting herewith a dissertation written by Kelly Dane Edmiston entitled "Romancing the Smokestack: Formula-Apportioned Corporate Income Taxes and Regional Economic Development." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Economics.

William F. Fox, Major Professor

We have read this dissertation
and recommend its acceptance:

Accepted for the Council:

Associate Vice Chancellor and
Dean of The Graduate School

ROMANCING THE SMOKESTACK

FORMULA-APPORTIONED CORPORATE INCOME TAXES AND REGIONAL ECONOMIC DEVELOPMENT

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Kelly Dane Edmiston
August, 1998

DEDICATION

This dissertation is dedicated to my parents

Mr. Willard D. Edmiston

and

Mrs. Patsy K. Edmiston

Anything one may find attractive or admirable in my character is a result
not of my own accord, but of the gracious and loving upbringing
I received from my parents.

ACKNOWLEDGMENTS

The work contained in this volume says as much about my teachers, colleagues, family, friends, and other benefactors as it does about my own abilities as an economist, and there are a great many people who deserve my special thanks for making my four years at the University of Tennessee such a rewarding, enriching, and enjoyable experience.

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I've often told other graduate students that I've learned more economics by talking with Matt Murray in the halls of CBER than in any class I've taken as a student. There is a big difference in learning economics and learning how to be an economist. My course work has taught me much about the theory and methods of economics, but it is Dr. Murray who taught me how to think, write and speak like an economist. I am especially grateful to him for being such a good friend to me these past four years.

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ABSTRACT

States have always competed for new investment and business expansion, but the competitiveness of economic development at the state level has greatly intensified over the last several years. This increased use of economic development incentives and intensified levels of state and local tax competition has generated some controversy over the efficacy and efficiency of these policies. This paper is a detailed investigation of one such policy: altering the factor weights in state corporate income tax apportionment formulas.

Formula apportionment, which is used by all U.S. states to allocate the taxable income of multistate corporations, measures the proportion of a multistate firm's income earned in a given state as a weighted average of the state's shares of total firm sales, property, and payroll. Traditionally, states have employed an equally weighted formula, but recently many states have moved towards a greater weight on the sales factor (uniformly lowering the weights on property and payroll factors) in an effort to export more of the corporate income tax burden and to encourage economic development.

A two-region, eight-sector computable general equilibrium (CGE) model is developed to evaluate the likely impact of disproportionate sales factor weights on economic development, state government finances, and state and national welfare. The choice of specific policy changes examined is designed to highlight the competitive nature of recent moves towards disproportionate sales factor weighting. Not only is a single state's move to disproportionate weighting considered, but also the impact of potential responses by other states.

The results from the CGE analysis indicate that the efforts of states to stimulate economic development by placing a disproportionate weight on the sales factor are effective in terms of the direction of the effects, but that the magnitude of the effects is very small. Regional characteristics such as size and industrial make-up and situsing rules can significantly influence the efficacy of the policy. Revenue effects, while also small, are significantly larger in magnitude than are the economic development effects. The analysis shows that states may have been overestimating the impact that disproportionate sales factor weighting has on economic development, while at the same time, states may have been paying too little attention to the revenue consequences.

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CHAPTER 1
INTRODUCTION

States have always competed for new investment and business expansion, but the competitiveness of economic development at the state level has greatly intensified over the last several years. A case in point is the bidding war for automobile manufacturing plants that occurred in the 1980s and early 1990s. In 1980, the State of Tennessee lured Nissan at a cost of $19, 510 per job created (in 1994 dollars). Only thirteen years later, the State of Alabama incurred a cost of $172,850 per job created (in 1994 dollars) to lure Mercedes-Benz, fully 8.9 times greater in real terms than the incentive packaged offered to Nissan by the State of Tennessee (Fox and Mayes, 1995). Most economic development incentives offered by states are less newsworthy, but are substantial nonetheless. A recent survey by Bartik (1994) suggests that state and local direct expenditure on economic development was in the neighborhood of $8 per capita annually in the 1990s. In addition, state and local governments incurred costs from tax incentives of $16 - $60 per capita annually.

The increased use of economic development incentives and intensified levels of state and local tax competition in recent years has generated some controversy over the efficacy and efficiency of these policies.[1] This dissertation is an investigation of one such policy: altering the factor weights in state corporate income tax apportionment formulas.

The remainder of this chapter begins with a brief analysis of the role of corporate

[1] For example, some investigations suggest that taxes are a very important factor in state and local economic development (Papke, 1987; Bartik, 1991, 1992), while others downplay the role of taxes (Wasylenko, 1981; Wheaton, 1984; Wolkoff, 1985). Fox and Murray (1998) even suggest that some efforts to encourage large plant locations may have negative consequences for economic growth. See Ladd (1998) for an unbiased review.

income taxes in state budgets, followed by a detailed examination of formula apportionment and some issues surrounding its use by U.S. states. Next will be a discussion of the manipulation of factor weights in apportionment formulas, including an inquiry into the economic development intentions of the policy and an examination of current trends. The chapter then closes with an explanation of the methodology that will be used in the analysis and a brief outline of the dissertation's structure.

The Role of Corporate Income Taxes in State Budgets

As demonstrated in Figure 1.1, inflation-adjusted state corporate income tax collections (——) have been volatile over the last couple of decades, but as the linear time trend line (-----) indicates, collections have trended upward over time.

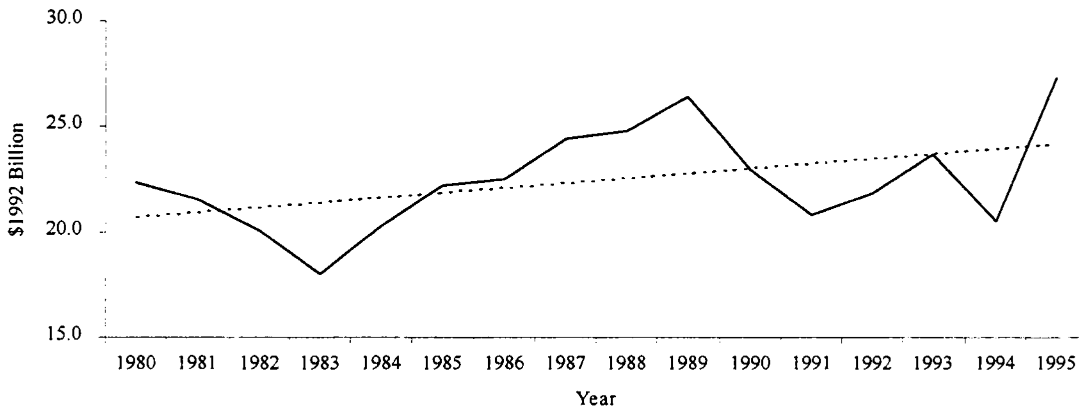

Figure 1.1
State Corporate Income Tax Collections, U.S. Total, Adjusted for Inflation 1980-1995

In 1980, corporate income taxes provided $22.3 billion (1992 dollars) in revenue to the states, compared with $27.2 billion (1992 dollars) in 1995. However, there was a large spike in inflation-adjusted state corporate tax collections in the final year of the series, up from $20.5 billion (1992 dollars) in 1994.

Although inflation-adjusted state corporate income tax collections have trended upward over time, they have not kept pace with the growth in total state revenues, as shown in Figure 1.2.

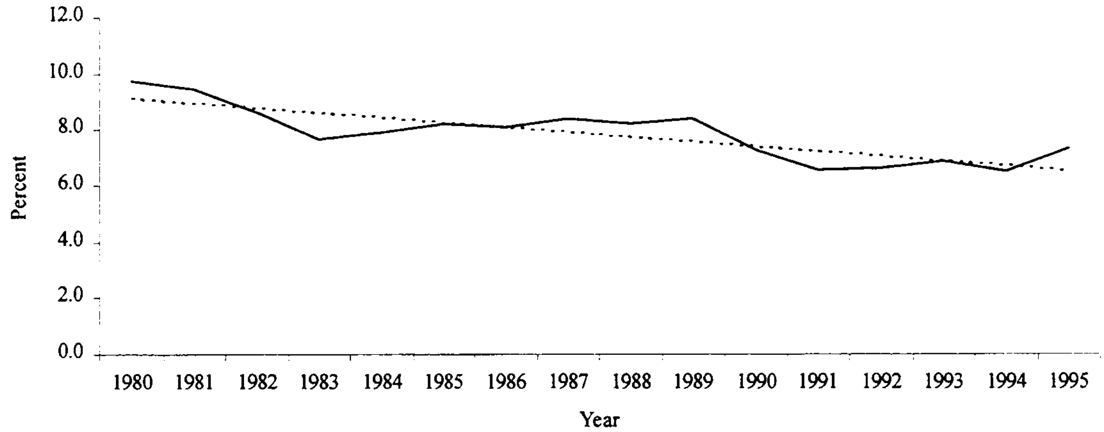

Figure 1.2
State Corporate Income Tax Collections as a Percent of Total State Tax Collections 1980-1995

In 1980 corporate income taxes provided 9.7 percent of total state tax collections. By 1994, the corporate tax share had fallen to 6.5 percent, but then spiked upwards to 7.3 percent in 1995. Because corporate tax revenues increased in real terms over the same period, the declining corporate tax share was a result of faster growth in other tax collections. Most likely, states have been emphasizing other tax instruments when faced with increased expenditure needs.

Formula Apportionment

Before discussing the issues surrounding the manipulation of factor weights in apportionment formulas, it is important first to delve deeper into formula apportionment to explain precisely how it is applied and used, and to mention some side issues that help to put the formula apportionment issue in perspective. Among these issues are the choice of formula apportionment as an allocation rule rather than the separate accounting approach, the establishment of nexus, the unitary business concept, and the make-up and situsing of apportionment factors.

Formulary Apportionment vs. Separate Accounting

Governments have two main options for deciding how much of a multijurisdictional firm's profits to tax: separate accounting and formula apportionment. The separate accounting approach, which is used by the U.S. federal government to tax the profits of multinational corporations (U.S. Internal Revenue Service Code, section 482) and by the State of Alaska to tax the petroleum industry, treats the firm's activities in each jurisdiction as a separate business. Formula apportionment, as employed by all state and provincial governments in the United States and Canada, assumes that the proportion of a multijurisdictional corporation's income earned in a given region is a weighted average of the proportion of the firm's total gross receipts, payments to property, and payroll in that region.

The separate accounting approach is probably better at getting at the precise portion of profits that is attributable to activities in any one jurisdiction, but only in the absence of problems such as joint costs and transfer pricing. The problem of joint costs arises because some of the firm's operations are indivisible. Transfer pricing involves the shifting of profits from high-tax jurisdictions to low-tax jurisdictions. An example of how profits can be shifted in this way is vertical integration. When transfer pricing is not limited, a (parent) firm in a high-tax jurisdiction has the option of purchasing an input z on the world market and paying a price p_z or buying the input from a subsidiary firm in a low tax jurisdiction at an artificially inflated price of $p_z^* > p_z$. By purchasing the input from the subsidiary, the parent firm reduces its tax burden while the subsidiary firm's tax burden increases. This process results in a shift of corporate income from high-tax jurisdictions to low-tax jurisdictions, which reduces the overall tax burden of the conglomerate firm.

Gordon and MacKie-Mason (1994) demonstrate that in the absence of penalties, all taxable profits will be shifted to the low-tax subsidiary. Recent empirical examinations support the Gordon-MacKie-Mason proposition. In a cross-country study of U.S. multinationals, Grubert and Mutti (1991) find a significant large negative relationship between foreign taxes and foreign subsidiary profits. Harris et al. (1993) provide evidence that U.S. manufacturing companies are able to shift income out of high-tax countries into the U.S. and from the U.S. to low-tax countries. This potential for income shifting with separate accounting was clearly recognized by the U.S. Supreme Court in its opinion for *Mobil Oil Corp v. Commissioner of Taxes of Vermont* [445 U.S. 425, 100 S. Ct. 1223 (1980)]:[2]

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[2] As cited in McClure (1986), p. 74.

> [S]eparate accounting, while it purports to isolate portions of income received in various states, may fail to account for contributions to income resulting from functional integration, centralization of management, and economies of scale. Because these factors of profitability arise from the operation of the business as a whole, it becomes misleading to characterize the income of the business as having a single identifiable "source."

The use of transfer pricing and other tax avoidance schemes is so pervasive that serious consideration has been given to using the method of formula apportionment to determine the U.S. tax liability of multinational firms rather than separate accounting (Grierson, 1996).[3] Bucks and Mazerov (1991) clearly state their opinion on this issue:

> Thirty years ago, the U.S. government led its trading partners down the arm's length pricing path. We now know that the path has reached a dead end, and it is now time for the U.S. government, through Treasury, to lead its trading partners down a new path of dividing profits through formula apportionment.

Formula apportionment not only reduces the transfer pricing and joint costs problems by treating all of a firm's activities as a unitary business, but also benefits from being administratively much less costly than separate accounting. It is for these reasons that states choose to use a formulary apportionment system.

Nexus Issues[4]

Simply put, nexus, in the context of corporate income taxation, is a minimum presence of income-producing activity in a locale that gives that locale sufficient jurisdiction to tax the net income of the corporation. If a corporation derives its income in part from activity that is conducted in states other than its state of domicile, those states generally will claim a portion of the corporation's net income for tax purposes, but

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[3] A federal shift to formula apportionment had been suggested as early as 1972 (Musgrave, 1972).

[4] Much of this section comes from the 1997 Multistate Corporate Tax Guide, vol. I (Raabe and Boucher, 1997). Nexus is a legal issue, not an economic issue. An extended, comprehensive discussion of nexus is beyond the scope of this dissertation, but interested readers are encouraged to consult Raabe and Boucher's guide.

sufficient nexus must first be established with those states.

As a general rule, "sufficient nexus for income tax purposes is present when a corporation uses owned or leased property in the state or employs personnel in the state" (Raabe and Boucher, 1997, I-39). However, nexus rules vary widely from state to state, and have been heavily litigated in the courts. The U.S. Constitution frames the nexus debate (Due Process Clause and Commerce Clause), but it is the courts that interpret the law and set precedents by which nexus rules are established. While nexus rules are for the most part left up to individual states, federal law (P. L. No. 86-272) has established that a state may not tax the income of a corporation whose only business activity within the state consists of the "solicitation of orders for sales of tangible personal property that are sent outside the state for approval and are filled and shipped from outside the state" (Raabe and Boucher, 1997, I-39). Activities that are deemed "ancillary" to the solicitation of orders are also insufficient to create nexus.[5]

The Unitary Business Concept[6]

A contentious issue in the state taxation of multijurisdictional corporations is the question of what constitutes a unitary business. In other words, if two firms X and Y are affiliated firms in some sense, then there is a question as to whether X and Y can file separate tax returns or should be required to file a joint return. If the activities of X and Y are deemed to constitute a unitary business, then they are required (or should be required)

[5] The Multistate Tax Commission, in their "Statement of Information Concerning Practices of Multistate Tax Commission and Signatory States Under Public Law 86-272," has delineated those activities that are not considered the solicitation of orders or ancillary thereto and thus likely to cause a corporation to lose its protection under P.L. 86-272.

[6] This section draws heavily from McClure (1984).

to file a joint return.[7]

The classification of groups of firms as unitary or nonunitary businesses has great implications for their tax liabilities. For example, highly integrated firms treated as separate businesses for tax purposes have a great potential for reducing their joint tax burden via prodigious use of transfer prices. This potential for income shifting and the possibility of arbitrariness in the separation of firm profits was recognized by Musgrave (1984), who provides some idea of an appropriate rationale for defining what constitutes a unitary business:[8]

> The need for combining firms into the so-called unitary business . . . arises under . . . two sets of circumstances. The first occurs where firms are in a position to manipulate their accounts so as to shift accounting profits . . . the second situation arises where there is structural linkage among firms which renders the separation of their profits an arbitrary procedure.

Despite much debate, there remains no consensus opinion for the appropriate definition of a unitary business, and, as a result, attempts by states to jointly determine the profits of affiliated firms often have resulted in intense litigation.[9] Nevertheless, a three-stage test proposed by McClure (1984) provides a concise definition that appears to be a step in the right direction (See Figure 1.3).

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[7] Some states treat all corporations as separate businesses, regardless of how interdependent their activities may be.

[8] As cited in McClure (1984).

[9] See for example *ASARCO, Inc. v. Idaho State Tax Commission* [102 S. Ct. 3103 (1982)] and *F.W. Woolworth v. Taxation and Revenue Department of New Mexico* [102 S. Ct. 3128 (1982)]. Both of these cases involved the unitary combination of income from domestic parent companies and their foreign affiliates. So-called "world-wide unitary combination," as opposed to "water's edge unitary combination" (*i.e.* national boundary) is currently a hot debate among industry and state revenue departments and in the courts.

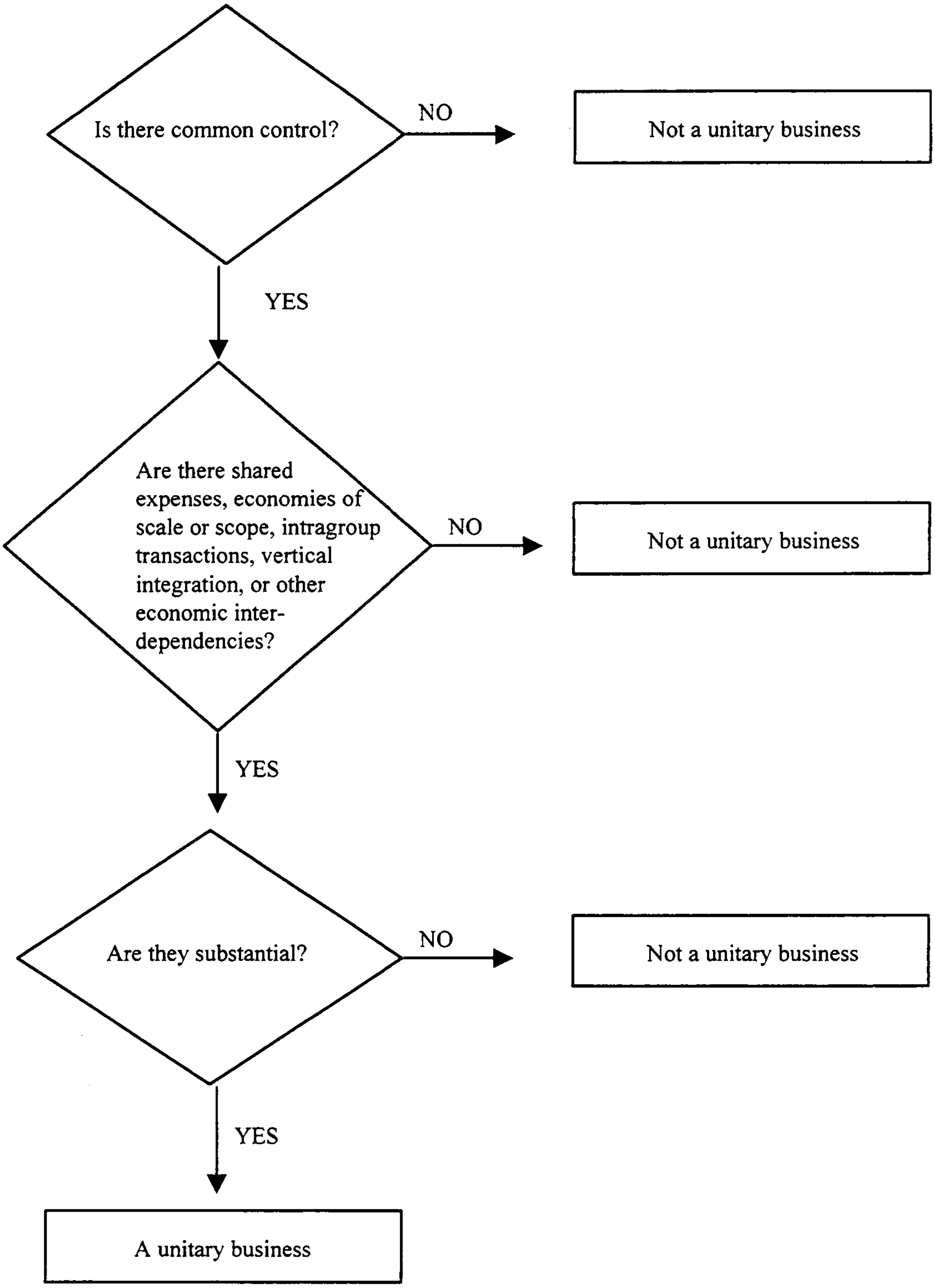

Figure 1.3
Three-Stage Test for a Unitary Business

Apportionment Factors[10]

Allocation Rules

As noted earlier in the chapter, the method of formula apportionment assumes that the proportion of a multijurisdictional firm's income earned in a given region is a weighted average of the proportion of the firm's total gross receipts, payments to property, and payroll in that region. Specifically, the formula for apportioning some firm j's profits to some jurisdiction i is given by

$$[1.1] \qquad \phi_j^{\,i} = \sigma^i \frac{S_j^{\,i}}{S_j} + \rho^i \frac{R_j^{\,i}}{R_j} + \lambda^i \frac{W_j^{\,i}}{W_j}$$

where ϕ_j^i	:=	the apportionment (in percentage terms) of firm j's profits to jurisdiction i
σ^i	:=	jurisdiction i's weight on gross receipts in its apportionment formula (sales factor weight)
ρ^i	:=	jurisdiction i's weight on payments to property in its apportionment formula (property factor weight)
λ^i	:=	jurisdiction i's weight on payroll in its apportionment formula (payroll factor weight)
S_j^i	:=	firm j's gross receipts in jurisdiction i
S_j	:=	firm j's gross receipts nationally
R_j^i	:=	value of firm j's property in jurisdiction i
R_j	:=	value of firm j's property nationally
W_j^i	:=	firm j's payroll in jurisdiction i
W_j	:=	firm j's payroll nationally

The basis of the gross receipts factor $(S_j^{\,i} / S_j)$ is total gross receipts net of returns, allowances, and discounts. It generally includes not only receipts from the sale of goods and services, but also receipts from the sales of assets, interest, dividends, rentals, and royalties. Excise taxes, including sales taxes, are included in the factor if they are

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[10] Much of this section comes from the 1997 Multistate Corporate Tax Guide, vol. I (Raabe and Boucher, 1997).

passed on to the buyer or included in the selling price.

The basis of the property factor (R_j^i / R_j) is "real and tangible personal property," which consists of "land, buildings, machinery, stocks of goods, equipment, and other real and tangible personal property [other than] coin or currency" [MTC Reg IV.10(a)]. Intangible property is included in some cases. In order to be included in the property factor, the property must be "used or capable of being used during the tax period for producing net 'business' income" (Raabe and Boucher, 1997, I-417). Owned property must be valued at original cost, while leased property is valued at eight times its net annual rental rate.

Finally, the basis of the payroll factor (W_j^i / W_j) is the total compensation paid to employees, including wages, salaries and any amounts paid to employees for board, housing, and any other benefits paid in exchange for services. These amounts are to be considered as compensation if they are so considered under the Internal Revenue code.[11] Only compensation that is related to the production of business income is to be included in the payroll factor.

Situsing Issues

The calculation of the gross receipts factor, discussed above, is complicated by situsing issues that generally do not arise in the context of payroll and property factors. As a general rule, gross receipts are sitused to the location of final sale (destination) rather than to the location of production (origin), as provided by the UDITPA's destination test:

---

[11] See Raabe and Boucher (1997), p. I-459.

> Sales of tangible property are in this state if the property is delivered or shipped to a purchaser other than the United States government within this state, regardless of the f.o.b. point or other conditions of sales [UDITPA §16(a)].

In some cases, however, the situsing of gross receipts on a destination basis becomes administratively difficult and gross receipts are sitused at origin. Specifically,[12]

> UDITPA provides that sales, other than the sales of tangible personal property, are considered in-state sales if either the income-producing activity is performed in the state; or the income producing activity is performed both inside and outside the state and a greater proportion of the income-producing activity is performed in the state than in any other state, based on costs of performance (UDITPA §17).

In the case of most services, for example, gross receipts are allocated to a state to the extent that the performance of those services occurs in the state. As will be demonstrated throughout the analysis that follows, the situsing of gross receipts has important implications for the effects of state corporate income tax policies, especially with regard to the manipulation of apportionment formula factor weights.

State Manipulation of Apportionment Formulas

The framers of the *Uniform Division of Income for Tax Purposes Act* (UDITPA, 1957), which set out the three-factor apportionment formula shown in equation [1.1], intended for states to employ an equally-weighted formula ($\sigma = \rho = \lambda = 1/3$) so as to provide for uniformity in state tax structures and avoid multiple taxation of corporate income across states. Recently, however, many states have moved towards a greater weight on the sales portion of the state corporate income tax (raising σ and lowering ρ and λ) in an effort to export more of the corporate income tax burden and to encourage

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[12] As cited in Raabe and Boucher (1997), p. I-475. Costs of performance are direct costs as determined by GAAP and accepted practices in the relevant business or trade.

economic development.[13] Other states have offered optional formulas with greater sales factor weights. By increasing the sales factor weight, production in the state becomes relatively less expensive because firms face lower (implicit) tax burdens on property and payroll than they would under equal factor weights.[14] A recent informal survey of states which have put greater weight on the sales factor revealed that many intended to "confer benefits so as to attract new business to the state" (Francis and McGavin, 1992, p.64). Table 1.1 shows the current apportionment formulas employed by states which have switched away from an equally weighted formula and the date at which states last altered their factor weights.

As Table 1.1 indicates, 29 of the 47 states (and District of Columbia) that currently impose a corporate income tax weight the sales factor more heavily than property and payroll factors, and most (17) made the switch in the 1990s. Much of this recent rush to alter apportionment formulas can be attributed to the increasingly competitive nature of economic development at the state level. While in the past disproportionate weighting was an "offensive" move intended to generate industrial development, now states are putting disproportionate weights on sales factors in a purely defensive posture -- they do so because they believe that the tax structures of other states put them at a disadvantage when it comes to economic development. A 1994 document

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[13] Many legal scholars have argued that disproportionate weight on sales factors violates the U.S. Constitution by discriminating against out-of-state firms in favor of in-state firms (Simafranca, 1995). Despite the pleas of some legal scholars, however, Iowa's single-factor sales formula was sanctioned by the Supreme Court in *Moorman Manufacturing Company v. Blair* (437 US 267 1978) -- an indication that the Court is not going to take any action in the near future to reverse the trend toward greater weights on sales factors. See also Peters (1998).

[14] The mechanics of this change in implicit excise tax rates is discussed in detail in Chapter 2.

TABLE 1.1
State Apportionment Weights 1997 (a)

STATE	S	R	W	YEAR	STATE	S	R	W	YEAR
Arizona	0.50	0.25	0.25	1991	Minnesota	0.70	0.15	0.15	1987
Arkansas	0.50	0.25	0.25	1994	Nebraska	1	0	0	1992
California	0.50	0.25	0.25	1993	New Hampshire	0.50	0.25	0.25	1992
Connecticut	0.50	0.25	0.25	1981	New Jersey	0.50	0.25	0.25	1996
Florida	0.50	0.25	0.25	1983	New York	0.50	0.25	0.25	1976
Georgia	0.50	0.25	0.25	1995	North Carolina	0.50	0.25	0.25	1989
Idaho	0.50	0.25	0.25	1994	Ohio	0.50	0.25	0.25	1983
Illinois	0.50	0.25	0.25	1987	Oregon	0.50	0.25	0.25	1991
Indiana	0.50	0.25	0.25	1991	Pennsylvania	0.50	0.25	0.25	1995
Iowa	1	0	0	1984	South Carolina	0.50	0.25	0.25	1995
Kentucky	0.50	0.25	0.25	1986	Tennessee (c)	0.50	0.25	0.25	1998
Maine	0.50	0.25	0.25	1991	Texas (d)	1	0	0	1995
Maryland	0.50	0.25	0.25	1992	West Virginia	0.50	0.25	0.25	1986
Massachusetts	0.50	0.25	0.25	1978	Wisconsin	0.50	0.25	0.25	1974
Michigan (b)	0.80	0.10	0.10	1991					

(a) All other states imposing corporate income taxes use an equally weighted three-factor formula; some states have optional alternative formulas; Nevada, South Dakota, Washington, and Wyoming do not impose broad-based corporate income taxes (b) Value-added tax (c) 150% weighted sales effective 12/15/97; double-weighted sales effective 12/15/98 (d) unitary business tax

SOURCES: Federal Tax Administration, 1997; Brown, 1992; Pennsylvania Economy League, 1994; Commerce Clearing House, Inc., various years.

designed to persuade the Pennsylvania legislature to adopt a double-weighted sales factor formula elucidates this competitive impetus:

> Actions taken by major industrialized *competitor* states to adopt double-weighting have created a *new standard for apportionment uniformity*. There is a new "level playing field," and Pennsylvania is not on it (Pennsylvania Economy League, 1994, p.i, emphasis added).

Given the large number of states moving to a disproportionate sales factor weight in the last few years, it is reasonable to project that most if not all other states will soon move in that direction. Most states have opted for a double-weighted sales factor formula, but those states desiring to stay ahead of the economic development game have now begun implementing single factor sales apportionment formulas. As seen in Table 1.1, Iowa, Nebraska, and Texas now have single factor sales formulas.[15]

The Method of Applied General Equilibrium Analysis

With interjurisdictional tax competition accelerating, aggressive policy measures aimed at encouraging state and local economic development, such as disproportionate sales factor weighting, are being put forth with little or no formal analysis. The danger is that large amounts of scarce government resources will be poured into development efforts that have little chance of succeeding or that may not be cost-effective. This dissertation seeks to fill part of the void by answering important questions surrounding the issue of disproportionate sales factor weighting. Specifically, the analysis asks if the policy is effective in encouraging economic development, and if so, how effective the policy is and what the factors are that determine its success. The revenue and welfare consequences of disproportionate sales factor weighting are also examined.

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[15] The State of Missouri has an optional single factor sales formula.

The remainder of this dissertation involves the development of a two-region, eight-sector computable general equilibrium (CGE) model and the use of that model to evaluate the likely impact of disproportionate sales factor weights on economic development, state government finances, and state and national welfare. The choice of policy experiments is designed to highlight the competitive nature of recent moves towards disproportionate sales factor weighting. Not only is a single state's policy considered, but also the impact of potential responses by other states.

The first step in an applied general equilibrium analysis, after a model is developed and equilibrium conditions are specified, is to collect data that is exogenous to the model. Sources for these data generally will include national income and product accounts (NIPA), household expenditure data, and tax data. Empirical estimates of model parameters often are also used. The "free" parameters of the model are then chosen through a calibration procedure in such a way that the specified model will reproduce the benchmark equilibrium data set as an equilibrium solution. This solution is the benchmark equilibrium. Once a policy change is specified, a new "counterfactual equilibrium is calculated using numerical optimization techniques, and an appraisal of the policy proceeds as a pair-wise comparison of the counterfactual equilibrium with the benchmark equilibrium. The flowchart presented in Figure 1.4 shows the steps involved in building and using an applied general equilibrium model.[16]

The decision to use an applied general equilibrium model for this dissertation was made for several important reasons. First, formula-apportioned corporate income taxes

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[16] Shoven and Whalley (1992).

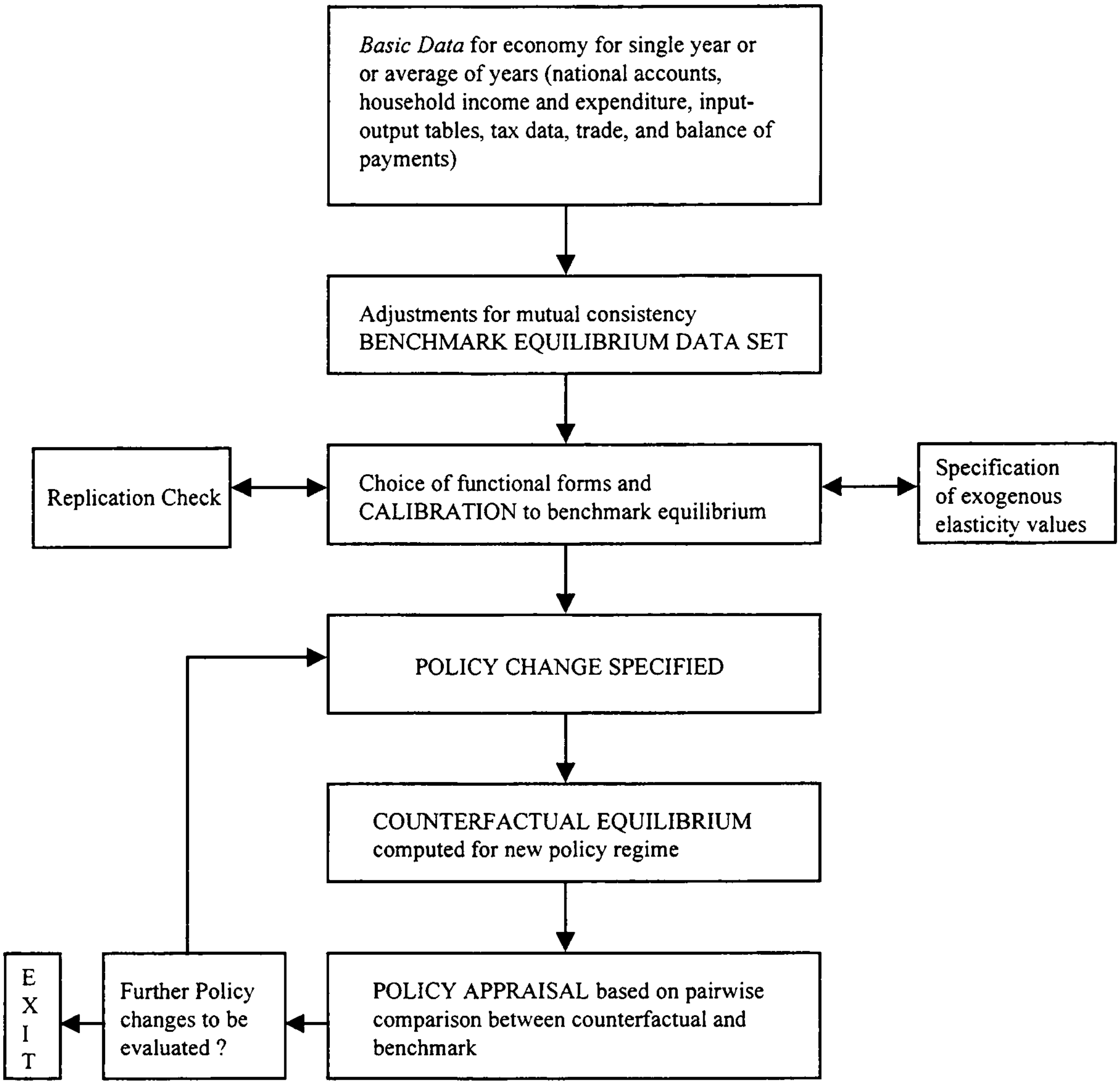

Figure 1.4
Steps Involved in Constructing and Using Applied General Equilibrium Models

have an extremely complicated structure that is difficult to implement in an analytical general equilibrium model. To do so would require such a simplification of the economy that only very general, if any, results would be attainable.[17] For example, most analytical general equilibrium tax models analyze tax incidence from an initial zero-tax equilibrium, have at most three sectors, and are limited to a highly simplified tax structure, usually a single *ad valorem* tax. Applied general equilibriums models, on the other hand, allow for a much more detailed presentation of the economy, which in turn allows the modeler to pick up interesting effects that might not be available in an analytical model. Secondly, applied general equilibrium models provide exact numerical estimates of policy impacts, and the magnitudes of these effects are every bit as important in policy evaluation as are the directions of the effects.

That being said, there are some limitations in applied general equilibrium models. Although they are much more complex and sophisticated in structure than are analytical approaches, they remain simplified versions of the real economy. Numerical results are sensitive to parameter specification, for example, so analysts must be careful about making very specific appraisals of policies based only on the results of their CGE analysis.

Structure of the Dissertation

The remainder of the dissertation is structured as follows. Chapter 2 is a theoretical discussion of formula apportionment, including a discussion of incidence and a partial equilibrium examination of the effects of factor weight changes on the incentives

[17] Even if a closed-form solution exists, it is often impossible to sign the comparative statics.

facing firms. These theoretical foundations serve to motivate the applied general equilibrium analysis that follows and provide a framework around which to develop the formal model. Chapter 3 develops the formal applied general equilibrium model, focusing on the specific structure of the economy in all of its mathematical detail and on the assumptions that underlie this detail. Chapter 4 then presents the data used to construct the benchmark equilibrium data set and the calibration procedure used to parameterize the model. The results of the policy experiments simulated with the model developed in Chapters 3 and 4 are presented and discussed in Chapter 5, and Chapter 6 utilizes the results to evaluate optimal formula apportionment policies in a game-theoretic framework. Finally, Chapter 7 provides concluding comments and proposes directions for future research.

CHAPTER 2
THEORETICAL FOUNDATIONS

Before proceeding with the development of the applied general equilibrium model and policy simulations, it is important first to understand how formula apportionment affects firm behavior, and how altering factor weights in apportionment formulas might change that behavior. This chapter provides these theoretical foundations. The discussion begins with a brief look at the incidence of formula apportionment, drawing heavily from the limited literature on state corporate income taxes. The analysis is then extended to examine the firm-level effects of a national system of formula-apportioned corporate income taxes with both uniform and nonuniform factor weights. Finally, first-order conditions for profit maximization are utilized to determine the likely responses of firms to disproportionate sales factor weighting.

The Economic Incidence of A Partial State Corporate Income Tax[18]

In what was probably the first inquiry into the incidence of formula-apportioned corporate income taxes, Charles McClure (1971) suggests that formula-apportioned corporate income taxes levied on multijurisdictional firms have roughly the same effects as discriminatory excise taxes on corporate gross receipts, payments to property, and payrolls.[19] Algebraically, this can be shown by rewriting the tax liability for a single firm in some state i as:

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[18] The term "partial state corporate income tax" is borrowed from Mieszkowski and Zodrow (1985) and refers to a corporate income tax imposed by a subset of states, possibly one.

[19] The taxes are discriminatory in that the implicit gross receipts and factor tax rates are firm specific. Although McClure was looking at multistate firms in the U.S., his analysis applies to any business income taxation of multijurisdictional firms under a formula allocation rule. The term *state*, as applied herein, could refer more generally to any region of reference.

$$[2.1] \quad T_i = \left(t_i^{\prime}\frac{\pi_T}{S}\right) S_i + \left(t_i^{\prime}\frac{\pi_T}{R}\right) R_i + \left(t_i^{\prime}\frac{\pi_T}{W}\right) W_i = t_{iS}{}^{*}S_i + t_{iR}{}^{*}R_i + t_{iW}{}^{*}W_i$$

where the parenthetical terms represent "pseudo" average tax rates on gross receipts, payments to property, and payrolls, respectively.

McClure (1980, 1981) sets out to provide justification for this assertion. Suppose a firm's total economic profits are given by S - R - W. Then, considering only the sales-related portion of its corporate income tax burden in state i, the firm's net profits can be written as $\pi_n = (S - R - W)(1 - a_i t_i^{\prime})$, where $a_i = S_i / S$ is the proportion of the firm's total sales that occur in state i.[20] Net (of tax) profits can then be differentiated with respect to Q_i, the quantity of sales in state i, and the result set equal to zero to give the divergence between marginal revenue and marginal cost at the (net) profit-maximizing level of sales:[21]

$$[2.2] \quad \frac{\partial S}{\partial Q_i} - \frac{\partial R}{\partial Q_i} - \frac{\partial W}{\partial Q_i} = \left(t_i^{\prime}\frac{S_i}{S}\right)\frac{\partial \pi}{\partial Q_i} + \left(1 - \frac{S_i}{S}\right)\left(t_i^{\prime}\frac{\pi}{S}\right) = \left[\frac{1 - a}{1 - t_i^{\prime}a}\right]\left(t_i^{\prime}\frac{\pi}{S}\right)\frac{\partial S_i}{\partial Q_i}$$

If state i were to levy a gross receipts tax (at rate t_s) rather than a formula-apportioned corporate income tax, the firm's net profits would be $\pi_n = S - R - W - t_s S_i$, and the divergence between marginal revenue and marginal cost at the (net) profit-maximizing level of sales in state i would be $\frac{\partial S}{\partial Q_i} - \frac{\partial R}{\partial Q_i} - \frac{\partial W}{\partial Q_i} = t_s \frac{\partial S_i}{\partial Q_i}$. Because the divergence in marginal revenue and marginal

[20] McClure explicitly considers only noncompetitive firms because the tax is levied on economic profits. Of course, in reality the tax is levied on accounting profits.

[21] Q_i is probably better viewed as production in state i that is targeted for sale in state i.

cost under the two tax regimes differ only by a scale factor, McClure concludes that for a state constituting a very small fraction of the national market for a firm's product (a_i is very close to zero), the sales-related portion of the formula-apportioned corporate income tax mimics the effects of a gross-receipts tax levied on the firm's sales in that state (see Figure 2.1). As a_i approaches one, however, the scale factor approaches zero and the sales portion of the formula-apportioned corporate income tax becomes more like a tax on profits, and thus distortions are reduced or eliminated.

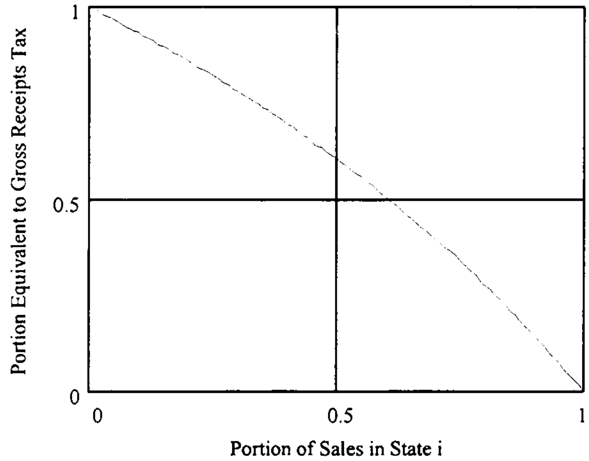

Figure 2.1
Profits Tax and Excise Tax Effects

The idea that the incidence of a formula-apportioned corporate income tax levied by some region depends on the proportion of total national firm activity attributable to that region was echoed in a more general setting by Mieszkowski and Morgan (1984), who looked at first-order conditions for profit maximization in an effort to better understand the incidence of the formula-apportioned corporate income tax.[22] First order conditions in the Mieszkowski-Morgan model yielded the following relations:[23]

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[22] Competitive firms produce a single homogenous good, x, with production given by $x_i = x(L_i, K_i)$, where L is labor, K is capital, and i = A, B are regions, where A is the taxing region. Normal profits are accounted for by disallowing a deduction for capital expenses in the calculation of taxable income. In an effort to maintain notational consistency throughout the paper, the notation presented here differs significantly from that used by Mieszkowski and Morgan.

[23] An error was discovered in Mieszkowski and Morgan's first-order conditions, an error that may have simply been a printing oversight. The first-order conditions presented here are in their corrected form.

$$MRPL_i \left[1 - t_A \Phi_A \right] = w \left[1 - t_A \Phi_A \right] + \begin{cases} t \left(\frac{L_B}{L^2} \right) \pi & \text{if } i = A \\ -t \left(\frac{L_A}{L^2} \right) \pi & \text{if } i = B \end{cases}$$

[2.3]

$$MRPK_i \left[1 - t_A \Phi_A \right] = r + \begin{cases} t \left(\frac{K_B}{K^2} \right) \pi & \text{if } i = A \\ -t \left(\frac{K_A}{K^2} \right) \pi & \text{if } i = B \end{cases}$$

which elucidate two separate effects of the formula-apportioned corporate income tax, the "tax-base effect" and the "apportionment effect." The tax base effect, which is represented by the bracketed terms, captures the impact on the firm's corporate income tax liability from increased profits that arise when the firm employs additional capital or labor. The apportionment effect, which is represented by the last term of each equation, reveals an implicit tax or subsidy that arises because the firm's overall activity in state i (relative to the other state), as measured by the apportionment formula, changes when the firm employs additional capital or labor in that state. There are no tax-base effects for labor because payroll costs are deducted from the tax base. Thus, in the absence of apportionment effects, the marginal revenue product of labor (MRPL) is equal to the wage rate. Capital costs are not deductible from taxable income, however, so the tax-base effect serves to increase the cost of capital relative to its net return by the amount of the tax. This tax base effect is a national effect in that the cost of capital in the nontaxing state (B) is also increased by the amount of the tax. Mieszkowski and Morgan (1984) use numerical examples to demonstrate that the relative magnitudes of the tax base effect and apportionment effect depend on the relative size of the taxing state, thereby reaffirming

McClure's (1980, 1981) conclusion. For the sales component, Mieszkowski and Morgan (1984) demonstrate that consumer prices in taxing states will be higher than consumer prices in non-taxing states and that the price difference reflects the sales component of the tax. They further demonstrate a symmetry in the apportionment effects in the two states. The implicit gross receipts tax in the taxing state is offset by an implicit gross receipts subsidy in the non-taxing state.

Mieszkowski and Zodrow (1985) develop a more complete general equilibrium model characterized by a single composite commodity and N identical states. All firms are multijurisdictional and produce and sell in every state in a perfectly competitive environment. Beginning from an initial zero-tax equilibrium, the authors consider a formula-apportioned corporate income tax imposed by $N_1 < N$ of the states, and determine the effects of the tax on taxing versus nontaxing states. The methodology employed is (general equilibrium) comparative statics analysis.

The primary result of Mieszkowski and Zodrow's analysis is that capital owners throughout the nation bear the full burden of a (partial) formula-apportioned corporate income tax. The authors demonstrate that the change in the net return to capital is given by $dr/dT = -(N_1/N)r^\circ < 0$ and that capital bears the full burden of the tax if $Kdr/dT = -\phi^\circ\pi^\circ$.[24] Since $\phi^\circ = N_1/N$ (because the N states are initially assumed to be identical in all respects) and $\pi^\circ = r^\circ K^\circ$, capital owners bear the entire burden

[24] The ϕ term has the same interpretation here as in the rest of this document.

of the tax.[25] Mieszkowski and Zodrow also show that the imposition of a formula-apportioned corporate income tax harms immobile factors in the taxing states through declines in factor prices and harms consumers in the taxing states through increases in commodity prices. But they find that these effects are exactly offset by higher factor prices and lower commodity prices in the non-taxing states. From a national perspective, then, on net consumers and owners of immobile factors do not appear to bear any burden of the formula-apportioned corporate income tax. Rather, outside of the burden of capital owners, there is merely a redistribution of income from residents in taxing states to residents in non-taxing states.

Although the reallocation of capital resulting from the imposition of a formula-apportioned corporate income tax may be detrimental from the economic development perspective of the taxing states, it is not clear whether or not agents in the taxing states are made better or worse off from the imposition of the tax. Mieszkowski and Zodrow note that although consumer prices rise and the return to immobile factors fall in the taxing states, a possibility exists for consumption to increase in the taxing state because the tax burden is primarily exported to nonresident capital owners.[26] The government

[25] It is not clear from Mieszkowski and Zodrow's (1985) analysis that $dr/dT = -\phi^\circ r^\circ$ when regions are not initially homogeneous, which must be the case to generalize the conclusion that capital owners bear the full burden of the tax. On the surface, it appears that the magnitudes of their results, including the magnitude of effects on immobile factor prices and commodity prices, depend highly on the assumption that regions are initially identical.

[26] Mieszkowski and Zodrow note that increased consumption in the taxing state is unlikely because such a result would require capital's share in gross production costs to be greater than one-half. Moreover, the assertion that the tax burden is primarily exported to nonresident capital owners is probably too strong a generalization. The relative size of the taxing region and its industrial make-up are likely to be key factors in determining the degree of tax exporting.

sector returns revenues lump-sum to its constituents, and thus the decrease in factor incomes and increase in consumer prices are at least partially offset. Mieszkowski and Zodrow show that total production is unchanged after the tax (an artifact of the incidence expressions being evaluated at a zero-tax equilibrium), and that the effects on the distribution of sales from imposing a formula-apportioned corporate income tax in a subset of states is ambiguous.

Gordon and Wilson (1986) examine the effects of formula apportionment on government revenues and political stability. Like McClure (1980, 1981), Gordon and Wilson assume a single-factor apportionment formula (in this case capital) to simplify their analysis. In all states taxable profits are defined to be equal to $\pi_i^T = \pi + \mu K_i$, where μ is some positive constant and $0 \leq \mu \leq 1$. A firm's tax payments to state i are then $T_i = t_i(K_i/K)(\pi + \mu K)$. Consequently, the firm's total tax payments are given by $T = \sum T_i$ and the "average" tax rate is given by $t = \sum t_i(K_i/K)$.

Gordon and Wilson demonstrate that the use of formula apportionment benefits low tax states ($t_i < t$) at the expense of high tax states ($t_i > t$) in terms of corporate income tax collections. To illustrate, they examine a universal shift by all states to a property tax system that maintains the existing marginal tax on each state's capital. The authors show that under formula apportionment the relationship between average tax revenue and marginal tax revenue in state i is given by

$$[2.4] \quad \frac{T_i}{K_i} = \frac{\partial T_i}{\partial K_i} - \mu\frac{t\,(t_i - t)}{(1-t)^2}.$$

Any (proportional) property tax rate (b_i) set to produce the same marginal tax on capital

($b_i = \partial T_i/\partial K_i = T_i/K_i$) , must raise the average tax rate by $\mu t(t_i - t) \ / \ (1 - t)^2$. The result is that each state's capital stock remains unchanged, but total tax revenue rises in high tax states and falls in low tax states.

Based on the above observation, Gordon and Wilson conclude that each state would wish to select t_i and b_i so as to minimize $\partial T_i/\partial K_i$ for any given T_i/K_i. This in turn implies that the only "political equilibrium" is where $t_i = 0 \ \forall$ i. Hence, the authors conclude that formula apportionment is politically unstable.

Formula Apportionment in Multiple Jurisdictions

Past research has gone far in identifying the incidence of formula-apportioned corporate income taxes, but it has not explicitly considered the effects of a national system of taxes. Articulating the impact of a national system of taxes can uncover some interesting and important interplay among states, interplay that brings about the kind of tax competition that is the focus of this paper.

We begin by writing the objective function for some multistate firm as

$$[2.5] \quad \max \ \pi_N = (S - W)\left(1 - \sum_{i=1}^{M} t_i' \phi_i \right) - R$$

where $t_i' = \frac{1}{3} t_i$. Similar to Mieszkowski and Zodrow (1985), the tax on normal profits is incorporated by disallowing a deduction for capital costs in the determination of taxable income. With a national system of formula-apportioned corporate income taxes, first-order conditions for profit maximization are given by differentiating [2.5] with respect to capital and labor utilization in each region:

$$[2.6] \quad \sum_{j=1}^{N} p_j \frac{\partial x_j}{\partial K_i} \left[1 - \sum_{h=1}^{N} t_h{}' \Phi_h - \frac{\pi_T}{S} \left(\sum_{j=1}^{N} (t_j{}' - \sum_{h=1}^{N} \frac{S_h}{S} t_h{}') \, p_j \frac{\partial x_j}{\partial K_i} \right) \right] = \left[1 + \frac{\pi_T}{R} \left(t_i{}' - \sum_{h=1}^{N} \frac{R_h}{R} t_h{}' \right) \right] r_i$$

$$[2.7] \quad \sum_{j=1}^{N} p_j \frac{\partial x_j}{\partial L_i} \left[1 - \sum_{h=1}^{N} t_h{}' \Phi_h - \frac{\pi_T}{S} \left(\sum_{j=1}^{N} (t_j{}' - \sum_{h=1}^{N} \frac{S_h}{S} t_h{}') \, p_j \frac{\partial x_j}{\partial K_i} \right) \right] = \left[1 - \sum_{h=1}^{N} t_h{}' \Phi_h + \frac{\pi_T}{W} \left(t_i{}' - \sum_{h=1}^{N} \frac{W_h}{W} t_h{}' \right) \right] w_i$$

for i = 1, . . . N.

To simplify the exposition, now assume that the output arising from a marginal addition of capital or labor in state i is sold solely to consumers in state i.[27] First-order conditions can then be written as

$$[2.8] \quad MRPK_i = \left[\frac{1 + \frac{\pi_T}{R} \left(t_i{}' - \sum_{j=1}^{N} \frac{R_j}{R} t_j{}' \right)}{1 - \sum_{j=1}^{N} t_j{}' \Phi_j - \frac{\pi_T}{S} \left(t_i{}' - \sum_{j=1}^{N} \frac{S_j}{S} t_j{}' \right)} \right] r_i$$

and

$$[2.9] \quad MRPL_i = \left[\frac{1 - \sum_{j=1}^{N} t_j{}' \Phi_j + \frac{\pi_T}{W} \left(t_i{}' - \sum_{j=1}^{N} \frac{W_j}{W} t_j{}' \right)}{1 - \sum_{j=1}^{N} t_j{}' \Phi_j - \frac{\pi_T}{S} \left(t_i{}' - \sum_{j=1}^{N} \frac{S_j}{S} t_j{}' \right)} \right] w_i$$

where $MRPN_i = \sum_{j=1}^{N} p_j \partial x_j \,/\, \partial N_i$ for $N_i = K_i, L_i$.

The parenthetical terms in each equation ([2.8] and [2.9]) represent the apportionment effects of a national system of corporate income taxes. They can be

[27] This is a very reasonable assumption for [2.9] but completely realistic for [2.8] only in the case where capital is owned regionally. Nevertheless, the assumption is not made because it is realistic, but because it aids in the interpretation of the first-order conditions.

interpreted as tax differentials weighted by taxable profit margins. For example, the apportionment effect on the cost of capital in state i, which is given by $\frac{\pi_T}{R} (t_i' - \sum \frac{R_j}{R} t_j')$, is the firm's taxable profit margin on capital (π_T / R) multiplied by the differential between state i's corporate tax rate and the national weighted-average tax rate, where the weights are each state's share of total firm property payments. Similar interpretations hold for the gross receipts and payroll factors.

Apportionment effects arise only when tax rates are not uniform across regions. In the case where statutory tax rates are uniform, the first-order conditions for profit maximization reduce to

$$[2.10] \quad MRPK_i = \frac{r_i}{1-t} ; \qquad MRPL_i = w_i \quad \forall i$$

where $t = t_i \; \forall \; i$. Hence, with uniform tax rates across regions, a national system of formula-apportioned corporate income taxes would affect firms in the same way as a tax levied at the national level (at rate t), only the resulting revenues would be distributed to individual states according to their ϕ_i's.

Now consider the case of nonuniform tax rates. For purposes of illustration, assume that state i's corporate tax rate is higher than the national weighted-average tax rate when the weights are state shares of total firm property payments. If a firm increases its capital utilization in state i, it faces both a "profits tax" penalty and an "excise tax" penalty. The profits tax penalty arises because the increase in capital raises total firm profits, which are taxed by all states (the tax base effect). This penalty arises whether or not tax rates are uniform across states. The excise tax penalty, which arises only when the tax differential is positive,[28] is a result of the reallocation of the firm's profits. By increasing capital in state i, the firm raises the proportion of its total activity attributable to the higher tax state relative to lower tax states.[29]

It should be noted that from the regional perspective of the firm, apportionment effects arise even when tax rates are uniform, and it is from *the national perspective of the firm* that apportionment effects cancel out. For example, suppose that tax rates are uniform at rate t and that a firm increases its use of capital in state i. The resulting apportionment effect on the cost of capital in state i from state i's tax is given by $t\,\frac{\pi_T}{R}\left(1-\frac{R_i}{R}\right)r_i$, while the apportionment effect on the cost of capital in state i from some other state j's tax is given by $t\,\frac{\pi_T}{R}\left(-\frac{R_j}{R}\right)r_i$. Summing these effects across regions gives

$$[2.11] \quad t\cdot\frac{\pi_T}{R}\cdot r_i - \sum_{j=1}^{N}\frac{R_j}{R}\cdot t\cdot\frac{\pi_T}{R}\cdot r_i = t\cdot\frac{\pi_T}{R}\cdot r_i\left[1-\sum_{j=1}^{N}\frac{R_j}{R}\right] = 0$$

Thus, because the tax rate is the same in every state, these apportionment effects cancel out. The intuition behind this result is that when the share of some firm's total activity increases in one state, it necessarily decreases in all other states by the same amount (in sum). When tax rates are uniform, the firm's tax liability does not change when it increases its use of capital except for the resulting change in its taxable income. With

[28] If the tax differential is negative, the firm receives an excise subsidy to its cost of capital.

[29] A similar argument was made by Mieszkowski (1972) in discussing the excise tax and profits tax effects of the property tax. See also McClure (1977).

nonuniform tax rates; however, the firm's marginal tax liability will be higher (lower) than the uniform tax rate case if the additional use of capital occurs in a relatively high-tax (low-tax) state.

Formula Apportionment with Nonuniform Factor Weights

Now consider the case where the factor weights on gross receipts, payroll, and payments to property are not uniform across states. Recall that in this case, the apportionment of a firm's profits to a state i is given by

$$[2.12] \qquad \phi_i = \sigma_i \frac{S_i}{S} + \rho_i \frac{R_i}{R} + \lambda_i \frac{W_i}{W}$$

Substituting [2.12] into [2.5] and again differentiating with respect to capital and labor in each region yields the following first-order conditions:

$$[2.13] \quad \sum_{j=1}^{N} p_j \frac{\partial x_j}{\partial K_i} \left[1 - \sum_{h=1}^{N} t_h \phi_h - \frac{\pi_T}{S} \left(\sum_{j=1}^{N} (t_j \sigma_j - \sum_{h=1}^{N} \frac{S_h}{S} t_h \sigma_h) p_j \frac{\partial x_j}{\partial K_i} \right) \right] = \left[1 + \frac{\pi_T}{R} \left(t_i \rho_i - \sum_{h=1}^{N} \frac{R_h}{R} t_h \rho_h \right) \right] r_i$$

$$[2.14] \quad \sum_{j=1}^{N} p_j \frac{\partial x_j}{\partial L_i} \left[1 - \sum_{h=1}^{N} t_h \phi_h - \frac{\pi_T}{S} \left(\sum_{j=1}^{N} (t_j \sigma_j - \sum_{h=1}^{N} \frac{S_h}{S} t_h \sigma_h) p_j \frac{\partial x_j}{\partial K_i} \right) \right] = \left[1 - \sum_{h=1}^{N} t_h \phi_h + \frac{\pi_T}{W} \left(t_i \lambda_i - \sum_{h=1}^{N} \frac{W_h}{W} t_h \lambda_h \right) \right] w_i$$

for i = 1, . . . N.

Again to simplify the exposition, assume that the output resulting from a marginal addition to capital or labor utilization in state i is sold in state i. Then the first-order conditions can be rewritten as:

$$[2.15] \quad MRPK_i = \left[\frac{1 + \frac{\pi_T}{R}\left(\rho_i t_i - \sum_{j=1}^{N} \frac{R_j}{R}\rho_j t_j \right)}{1 - \sum_{j=1}^{N} t_j'\phi_j - \frac{\pi_T}{S}\left(\sigma_i t_i - \sum_{j=1}^{N} \frac{S_j}{S}\sigma_j t_j \right)} \right] r_i$$

and

$$[2.16] \quad MRPL_i = \left[\frac{1 - \sum_{j=1}^{N} t_j\phi_j + \frac{\pi_T}{W}\left(\lambda_i t_i - \sum_{j=1}^{N} \frac{W_j}{W}\lambda_j t_j \right)}{1 - \sum_{j=1}^{N} t_j\phi_j - \frac{\pi_T}{S}\left(\sigma_i t_i - \sum_{j=1}^{N} \frac{S_j}{S}\sigma_j t_j \right)} \right] w_i$$

Comparing equations [2.8] and [2.9] to [2.15] and [2.16], it is easy to see that with nonuniform factor weights, apportionment effects are likely to arise even in the case where statutory corporate income tax rates are uniform across states. The analysis of the effects of tax differentials discussed above in the context of factor weight uniformity also applies in the case of nonuniform factor weights, only the differentials depend not only on statutory tax rates and shares of firm activity, but also on factor weights. Suppose for example that there are two regions and region 1's statutory corporate income tax rate is $t_1 = 5\%$. Further assume that region 2's statutory corporate income tax rate is $t_2 = 4\%$ and that a firm's property payments are distributed equally between the two regions. If both regions were to have equally weighted apportionment formulas, the implicit excise tax differential on property in region 1 is

$$[2.17] \quad \rho_1 t_1 - \frac{R_1}{R}\rho_1 t_1 - \frac{R_2}{R}\rho_2 t_2 = \left(\frac{1}{3}\right)(0.05) - \left(\frac{1}{2}\right)\left(\frac{1}{3}\right)(0.05) - \left(\frac{1}{2}\right)\left(\frac{1}{3}\right)(0.04) = +0.0067$$

If region 1 were to place a weight of 1/4 on the property factor, on the other hand, the tax differential in region 1 would be [30]

$$[2.18] \quad \rho_1 t_1 - \frac{R_1}{R}\rho_1 t_1 - \frac{R_2}{R}\rho_2 t_2 = \left(\frac{1}{4}\right)(0.05) - \left(\frac{1}{2}\right)\left(\frac{1}{4}\right)(0.05) - \left(\frac{1}{2}\right)\left(\frac{1}{3}\right)(0.04) = -0.00045$$

Thus, in this example, factor weights can determine whether the tax differential in region 1 is positive or negative. It is this dependency of implicit excise tax differentials on factor weights that has encouraged U.S. states to manipulate their factor weights in hopes of encouraging economic development. Altering factor weights allows states to maintain the same tax rate on domestic corporations, while lowering taxes for interstate businesses. Constitutional restrictions preclude states from taxing interstate businesses at a different rate, but altering factor weights achieves the same result.

Economic Effects of Altering Apportionment Formula Factor Weights

The primary purpose of this dissertation is to examine the economic effects of altering factor weights in corporate income apportionment formulas, specifically, increasing the sales factor weight and decreasing the payroll and property factor weights. One way to gain insight into these effects is by examining the change in the tax burden terms of the first-order conditions given in equations [2.15] and [2.16] when factor weights change.

We begin by noting that the factor weights in apportionment formulas must sum

[30] Of course, the distribution of capital between the two regions is not likely to be the same in this case.

to one:[31]

$$[2.19] \quad \sigma + \rho + \lambda = 1$$

This restriction prevents states from taxing the tax bases of other states, which would violate the interstate commerce clause of the U.S. Constitution. When states have altered their apportionment formulas in the past, they have raised the gross receipts factor weight and lowered the payroll and property weights uniformly to satisfy [2.19]. We now let $\rho = \lambda = \alpha$ in which case [2.19] can be solved for α:

$$[2.20] \quad \alpha = \frac{1 - \sigma}{2}$$

and it can be seen that the property and payroll factor weights each decline by half of any increase in the gross receipts factor weight:

$$[2.21] \quad d\alpha = -\frac{1}{2}\, d\sigma$$

Now suppose that some state i decides to increase the weight on its gross receipts factor, and hence, uniformly lower the weights on its payroll and property factors. The effect of this policy on the "profits tax" burden is given by

$$[2.22] \quad \frac{\partial(t_i \phi_i)}{\partial \sigma_i} = t_i \left[\frac{S_i}{S} - \left(\frac{1}{2}\right)\frac{R_i}{R} - \left(\frac{1}{2}\right)\frac{W_i}{W} \right]$$

Whether or not the firm's profits tax burden increases, decreases, or stays the same depends on the relative magnitudes of state i's share of the firm's total gross receipts,

[31] Subscripts are dropped when they are not necessary for the analysis.

payroll, and payments to property. If these shares are equal, then there will be no change in the firm's profits tax burden. However, if state i's share of the firm's total gross receipts is relatively larger (smaller) than its share of the firm's total payroll and payments to property, then the firm's profits tax burden will increase (decrease) in state i.

An important effect evident in [2.22] is that state i's policy change may result in more of a firm's profits being apportioned to state i. This is a problem because there is no change in ϕ_j for $j \neq i$. If initially $\sum_{j=1}^{N} \phi_j = 1$ and state i's share of the firm's total gross receipts is relatively larger than its share of the firm's total payroll and property (as defined in [2.22]), then after the policy change it would then be the case that $\sum_{j=1}^{N} \phi_j > 1$. Thus, the potential exists for greater than 100 percent of a firm's income to be taxed by the states nationally as a result of state i's policy change.[32] Likewise, if state i's share of the firm's total gross receipts is relatively smaller than its share of the firm's total payroll and property, then less than 100 percent of the firm's income would be taxed by the states nationally after state i's policy change.

The effects of an increase in the gross receipts factor weight on a firm's "excise tax" burdens are determined by differentiating the implicit excise tax rates arising from formula apportionment with respect to the gross receipts factor weight, giving:

$$[2.23] \qquad \frac{\partial\left[\frac{\pi_T}{S}\left(\sigma_i t_i - \sum_{j=1}^{N} \frac{S_j}{S}\sigma_j t_j\right)\right]}{\partial \sigma_i} = \frac{\pi_T}{S}\left(1 - \frac{S_i}{S}\right) t_i > 0$$

[32] For a detailed analysis of this issue, see Lopez (1996) or Lopez and Martinez-Vazquez (1998).

$$[2.24] \quad \frac{\partial\left[\frac{\pi_T}{R}\left(\rho_i t_i - \sum_{j=1}^{N}\frac{R_j}{R}\rho_j t_j\right)\right]}{\partial\sigma_i} = -\frac{1}{2}\left[\frac{\pi_T}{R}\left(1 - \frac{R_i}{R}\right)t_i\right] < 0$$

$$[2.25] \quad \frac{\partial\left[\frac{\pi_T}{W}\left(\lambda_i t_i - \sum_{j=1}^{N}\frac{W_j}{W}\lambda_j t_j\right)\right]}{\partial\sigma_i} = -\frac{1}{2}\left[\frac{\pi_T}{W}\left(1 - \frac{W_i}{W}\right)t_i\right] < 0$$

These effects elucidate states' incentives to double-weight their sales factors. By doing so, the states reduce the excise burdens associated with productive activity in their states and hence encourage economic development. However, these economic development incentives come at a cost of discouraging sales in the state and raising tax-inclusive consumer prices. There may also be some negative revenue consequences associated with double-weighting the gross receipts factor, depending on how the multitude of effects play out in the end. If the change in factor weights does depress corporate tax revenues, states are likely to increase other tax rates in order to make up the deficiency. How a state chooses to recoup lost revenue must be considered in the analysis because the choice may have effects that offset the economic development incentives arising from double-weighted sales. These broader issues will be considered in the applied general equilibrium analysis by examining various tax adjustment mechanisms under a government-budget-constant assumption.

Altering Factor Weights When Gross Receipts Are Sitused at Origin

The preceding analysis assumed that gross receipts factors are sitused at destination rather than at origin. When gross receipts are sitused at destination, the implicit property and payroll excise taxes are independent of the implicit gross receipts excise tax because the situsing of gross receipts is independent of the location of production. When gross receipts are sitused at origin, however, the independence no longer holds, and the implicit gross receipts excise tax becomes a cost of production. When gross receipts are sitused at origin, the implicit excise tax cost associated with a marginal increase in the use of capital in some state i is the implicit excise tax on one unit of capital [2.24] plus the implicit sales tax on the marginal revenue product arising from the use of that capital [2.23]:

$$[2.26] \quad \frac{\pi_T}{R}\left[\rho_i t_i - \sum_{j=1}^{N} \frac{R_j}{R}\rho_j t_j\right] r_i + \frac{\pi_T}{S}\left[\sigma_i t_i - \sum_{j=1}^{N} \frac{S_j}{S}\sigma_j t_j\right] \bar{p}\,\frac{\partial q_i}{\partial K_i}$$

and an increase in the gross receipts factor weight (and uniform reduction in property and payroll factor weights) encourages the use of capital in state i only if

$$[2.27] \quad \frac{1}{2}\left[\frac{\pi_T}{R}\left(1 - \frac{R_i}{R}\right)\right] r_i > \frac{\pi_T}{S}\left(1 - \frac{S_i}{S}\right)\bar{p}\,\frac{\partial q_i}{\partial K_i}$$

Assuming constant returns to scale and recognizing that $S_i / S = \bar{p}q_i / \bar{p}q = q_i / q$, [2.27] can be rewritten as

$$[2.28] \quad \frac{1}{2}\left[\frac{\pi_T}{R}\left(1 - \frac{R_i}{R}\right)\right] > \frac{\pi_T}{S}\left(1 - \frac{q_i}{q}\right)$$

Because the ratio R_i / R is likely to be very close to the ratio $q_i \backslash q$, it is unlikely that [2.28] would be satisfied. That is, if R_i / R were significantly different from q_i / q, it would have to be the case that firms use very different technology from one region to another or that firms produce very heterogenous products from region to region. In the applied general equilibrium analysis that follows, the origin *vs.* destination issue will be examined by situsing the gross receipts of the services industry on an origin basis, while situsing the gross receipts of all other industries on a destination basis.

Alternatives

The preceding analysis begs the question: Are there better, alternative policies states could employ to encourage economic development? There are of course a multitude of alternative policies, but one is particularly pertinent to the analysis at hand: lowering the statutory corporate income tax rate. If a state were to change its corporate tax rate, the effect on the profits tax burden would be equal to $\phi_i dt_i$, which is unambiguously negative in the case of lowering the tax rate. The excise tax effects, which would be identical in sign for all factors, can be shown by looking at the property factor only:

$$[2.29] \qquad \frac{\partial\left[\frac{\pi_T}{R}\left(\rho_i t_i - \sum_{j=1}^{N}\frac{R_j}{R}\right)\right]}{\partial t_i} = \frac{\pi_T}{R}\left(1 - \frac{R_i}{R}\right)\rho_i > 0$$

Thus the implicit excise tax rates on gross receipts, payroll, and payments to property also fall unambiguously when the statutory tax rate declines. Comparing [2.29] with [2.24], it becomes clear that by lowering its statutory corporate income tax rate by 25 percent, a state could produce an excise effect on payroll and property that would be identical to the effects of double-weighting the sales factor (and hence uniformly reducing the payroll and property portion by 25 percent). In general, the excise effects of any change in the sales factor weight, given by $d\sigma$, are identical to the effects of lowering the statutory corporate income tax rate t such that

$$[2.30] \quad \frac{dt}{t} = -\frac{d\sigma}{\sigma}$$

The difference, however, is that the implicit gross receipts excise tax is also reduced in the case of lowering the tax rate, while it is increased in the case of double-weighted sales. Also, tax collections are certain to fall in the former case, while the effect on tax collections is ambiguous in the latter. Thus, the means by which states would make up the lost revenue would have nontrivial implications for the analysis.

CHAPTER 3
MODEL SPECIFICATION [33]

This chapter presents the structure of the applied general equilibrium model in all of its mathematical detail. The model consists of $j = 1, \ldots, M$ regions which operate in an otherwise closed economy. Each region consists of a homogeneous cohort of citizens governed by a single, autonomous government. There are $i = 1, \ldots, N$ industries that produce output. Each industry is represented by a single corporation that operates nationally and produces and sells in every region (for a total of N corporations nationally), and M unincorporated firms that operate autonomously within each region (for a total of NxM unincorporated firms nationally). Only corporations are allowed to engage in interstate activity.

In an effort to maintain clarity, consistency, and flow, the chapter is broken down by public sector, consumption sector, and production sector. A theme that will be pervasive throughout the discussion of model specification is the balance between choosing a model complex enough to capture all relevant implications of the policy issues being examined and keeping the model tractible and analytically useful.

The Public Sector

The preferred methodology for isolating tax incidence from expenditure incidence in a model such as this one is to employ a government-budget-constant assumption (Tresch, 1981), which means that the government sector provides a fixed vector of goods

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[33] The structure of the model presented in this chapter, while unique and innovative in many of its aspects, draws heavily on the previous work of Ballard *et al.* (1985) and Piggott and Whalley (1985). Shoven and Whalley (1992), Varian (1993), Silberberg (1990), and Follain and Miyake (1986) were also indispensable guides in the modeling effort.

and services and raises whatever revenue is necessary to provide that fixed bundle. In this specific case, the government purchases a fixed bundle of goods and services at market prices, and following a change in tax policy, obtains sufficient revenues from an alternative source to enable the purchase of this same bundle at the new equilibrium prices.

Similar to Ballard *et al.* (1985), this model assumes that government expenditures are a component of final demands but do not enter consumers' utility functions directly. In other words, the consumers' utility is given by

$$[3.1] \quad U = U_1(\bar{\boldsymbol{G}}) + U_2(\boldsymbol{X})$$

where $\bar{\boldsymbol{G}}$ is the government's fixed bundle and **X** is the consumer bundle. The producer goods purchased by the government are packaged into a uniform public good which does not affect the enjoyment of the private consumer goods, positively or negatively. That is

$$[3.2] \quad \frac{\partial}{\partial X_i}\left[\frac{\partial U}{\partial \bar{G}}\right] = \frac{\partial}{\partial \bar{G}}\left[\frac{\partial U}{\partial X_i}\right] = 0 \quad \forall i$$

Because U_1 never changes and does not affect U_2, it is ignored in the model. Thus, because the utility arising from government spending will be constant, the welfare change from some policy can be evaluated by looking exclusively at changes in consumer utility levels. As noted in Tresch (1981), with the government-budget-constant assumption, "government *expenditures* may change, but as long as the government does not vary [its fixed bundle of goods], there will be no change in consumer welfare arising from the expenditure side of the budget" (p. 381).

Because one goal in developing this model is to evaluate the distributional and welfare effects (differential incidence) of various corporate income tax policies, there must be a budget-balancing alternative revenue source that is non-distorting. Thus, the government imposes an endogenously adjusting lump-sum tax instrument in addition to a formula-apportioned corporate income tax. Although such a tax instrument provides benefits in that it permits the complete isolation of the incidence of the specific policy at hand, it suffers in its realism. Abstracting from equity considerations, if lump-sum taxes were politically feasible, government's optimal policy would be to reduce corporate income tax rates to zero and collect all revenues *via* lump-sum taxes. Any alternative tax instruments would themselves be distorting, however, which would severely complicate the incidence analysis. Nevertheless, another goal of this model is to provide a means for predicting the effects of various corporate income tax policies in the real world, in which case more realistic government responses to falling (or rising) tax revenues must be incorporated. These issues will be considered separately from the differential incidence analysis, *per se*, by including a personal income tax for which the rate will be allowed to vary endogenously to balance the budget.

With a formula-apportioned corporate income tax, a personal income tax, and a lump-sum tax as revenue instruments and a fixed bundle of goods and services, the government budget constraint for each region j is written as[34]

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[34] Throughout the chapter subscripts are dropped when they are not necessary for clarity.

$$[3.3] \quad \sum_{i=1}^{N} p_i \bar{G}_i = t_c \sum_{i=1}^{N} \phi_i \pi_{i,c} + t_y \left[Y + \sum_{i=1}^{N} \pi_{i,nc} \right] + H$$

where t_c and t_y are statutory corporate and personal income tax rates in region j, ϕ_i is the apportionment of corporate industry i's taxable income to region j, $\pi_{i,c}$ is the nation-wide normal (taxable) profits of corporate industry i, $\pi_{i,nc}$ is normal profits of noncorporate industry i in region j, Y is personal income in region j, H is lump-sum tax collections in region j, p_i is the market price for industry i output in region j, and $\bar{G}_i$ is the fixed government demand for industry i output in region j. The normal profits of noncorporate firms are taxed as personal income, which is consistent with the way in which proprietorships and partnerships are actually taxed.

Production

Production technology for each industry is characterized by a linearly homogeneous constant elasticity of substitution (CES) production function given by

$$[3.4] \quad q = \alpha \left[\gamma L^{\rho} + (1 - \gamma) K^{\rho} \right]^{\frac{1}{\rho}}$$

where the elasticity of substitution is $\sigma = \frac{1}{1 - \rho}$, γ is labor's share in production, and α is a parameter defining units of measurement. In the case where $\sigma = 1$, [3.4] collapses to the familiar Cobb-Douglas production function:[35]

$$[3.5] \quad q = \alpha L^{\gamma} K^{1-\gamma}$$

[35] Following Ballard, *et. al* (1985), industries in which no empirical measures of the elasticity of substitution existed were assumed to operate with Cobb-Douglas technology.

Because industries are assumed to operate with linearly homogeneous technology, industry behavior is identical to firm behavior. Therefore, industries are treated as optimizing firms in the model. Labor and capital are assumed to be homogeneous across industries and regions, labor is fixed in regional supply, and capital supply is fixed nationally. Capital is assumed to be completely mobile across industries and across regions, while labor is mobile across industries but geographically immobile.[36]

The objective of each corporate industry is to maximize after-tax economic profits (ζ), which are given by

$$[3.6] \quad \zeta = \left[\sum_{j=1}^{M} p_j x_j - \sum_{i=1}^{M} w_i L_i\right]\left[1 - \sum_{m=1}^{M} t_{cm}\phi_m\right] - \sum_{i=1}^{M} r_i K_i$$

where w_i is the wage rate in region i, r_i is the rental price of capital in region i, L_i is labor used in region i production, and K_i is capital used in region i production. Because all industries operate in a competitive environment $\zeta = 0$ for all industries in equilibrium.

Optimization of [3.6] requires satisfying the following first-order conditions:

$$[3.7] \quad \frac{1-\gamma}{\gamma}\left[\frac{K_i}{L_i}\right]^{\rho - 1} = \frac{T(K,\, i,\, j)}{T(L,\, i,\, j)} \cdot \frac{r_i}{w_i} \qquad i = \{\, 1, \ldots, M \,\}\ ;\ j = \{1, \ldots, M\}$$

where

[36] Labor must be immobile geographically for the lump sum taxes used in the model to be non-distorting.

$$[3.7a] \quad T(K,i,j) = \left[\frac{1 + \frac{\pi^0}{R^0}\left[t_{ci}\, f_{Ri} - \sum_{h=1}^{M} \frac{R_h^{\,0}}{R^0} t_{ch}\, f_{Rh} \right]}{1 - \sum_{h=1}^{M} t_{ch}\Phi_h^{\,0} - \frac{\pi^0}{S^0}\left[t_{cj}\, f_{Sj} - \sum_{h=1}^{M} \frac{S_h^{\,0}}{S^0} t_{ch}\, f_{Sh} \right]} \right]$$

$$[3.7b] \quad T(L,i,j) = \left[\frac{1 - \sum_{h=1}^{M} t_{ch}\, \Phi_h^{\,0} + \frac{\pi^0}{W^0}\left[t_{ci}\, f_i - \sum_{h=1}^{M} \frac{W_h^{\,0}}{W^0} t_{ch}\, f_{Wh} \right]}{1 - \sum_{h=1}^{M} t_{ch}\Phi_h^{\,0} - \frac{\pi^0}{S^0}\left[t_{cj}\, f_{Sj} - \sum_{h=1}^{M} \frac{S_h^{\,0}}{S^0} t_{ch}\, f_{Sh} \right]} \right]$$

and

$$[3.7c] \quad \Phi_i = f_{Si} \frac{p_i\, x_i}{\sum_{j=1}^{M} p_j\, x_j} + f_{Ri} \frac{r_i\, K_i}{\sum_{j=1}^{M} r_j\, K_j} + f_{Wi} \frac{w_i\, L_i}{\sum_{j=1}^{M} w_j\, L_j}$$

A modeling inconvenience of linearly homogeneous production functions is that an infinite spectrum of output levels will satisfy the zero profit condition. In the computer model, factor demand functions are written as functions of output (q), but K and L are determined simultaneously with q. The explicit mathematical form of these factor demand functions in the computer model are, for the CES case[37]

$$[3.8a] \quad K = \left[\frac{p\,(1-\gamma)}{r^*} \right]^{\frac{1}{1-\rho}} \cdot \alpha^{\frac{\rho}{1-\rho}} \cdot q$$

[37] For the derivation of these demand functions, see Appendix I.

$$[3.8b] \quad L = \left[\frac{p\,\gamma}{w^*}\right]^{\frac{1}{1-\rho}} \cdot \alpha^{\frac{\rho}{1-\rho}} \cdot q$$

and for the Cobb-Douglas case

$$[3.9] \quad \begin{aligned} K &= \frac{p\,(1-\gamma)}{r^*} \cdot q \\ L &= \frac{p\,\gamma}{w^*} \cdot q \end{aligned}$$

where w* and r* are factor prices cum tax distortions.

Corporate firms optimize not only with respect to the use of capital and labor, but also with respect to the location of production. There are a host of factors that enter into a firm's production location decision, including transportation costs, proximity to resources, the "friendliness" of civic leaders to business, the quality of workers, and a host of other issues. For the purposes of this model, these factors are incorporated into a Cobb-Douglas aggregation function, given by

$$[3.10] \quad q = \eta \prod_{i=1}^{M} q_i^{\mu_i}$$

which identifies the firm's production location preferences.

One might argue that the unitary value of the elasticity of substitution (δ) implicit in [3.10] would have important implications for the magnitude of the effects of the various policies that will be examined in this analysis. For example, one might expect larger regional shifts of production in response to policy changes if [3.10] were linear in the q_i (*i.e.* $\delta \rightarrow \infty$). However, as a general rule, an elasticity of unity is probably the most appropriate choice when the true value of δ is not known,[38] and the benchmark equilibrium data set indicates that the value of δ is finite.[39] Furthermore, calibrating the parameters in [3.10] to real-world data recognizes that there are many factors other than tax rates that cause firms to produce or sell in one region *versus* another. Nevertheless, the issue of δ's value (and the value of the μ_i) is an important one, and a sensitivity analysis is used to test the sensitivity of the results to the values of these parameters. In the sensitivity analysis, [3.10] takes the form of

$$[3.11] \quad q = \eta \left[\sum_{i=1}^{M} \mu_i q_i^{\frac{\delta-1}{\delta}} \right]^{\frac{\delta}{\delta-1}}$$

The first step in deriving the location functions is to determine the cost-minimizing input requirements per unit of output, and then, in turn, determining the minimum output cost in each region. For corporate industries, this task is accomplished by optimizing the following Lagrangian function:

$$[3.12] \quad \min \quad w_i^* L_i + r_i^* K_i - \lambda \left[q_i - 1 \right]$$

where w_i* and r_i* are factor prices cum tax distortions. The resulting first-order conditions are

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[38] Modelers generally choose a unitary elasticity of substitution when the value is not known in the context of production functions, as will be the case in this analysis as well.

[39] If [3.10] were linear, the unit costs of production would have to be identical across regions. Given the tax-induced factor price distortions and the complete mobility of capital, this restriction would require altering the factor shares and regional distribution of production implied by the data.

$$[3.13a] \quad \frac{\partial \mathcal{L}}{\partial L_i} = w_i^* - \lambda \frac{\partial q_i}{\partial L_i}$$

$$[3.13b] \quad \frac{\partial \mathcal{L}}{\partial K_i} = r_i^* - \lambda \frac{\partial q_i}{\partial K_i}$$

$$[3.13c] \quad \frac{\partial \mathcal{L}}{\partial L_i} = q_i - 1$$

Solving [3.13a] - [3.13c] gives the cost-minimizing input requirements per unit of output. For the CES case these functions are given by

$$[3.14a] \quad L_i^* = \frac{1}{\alpha}\left[(1-\gamma)\left(\frac{\gamma r_i^*}{(1-\gamma)w_i^*}\right)^{1-\sigma} + \gamma\right]^{\frac{\sigma}{1-\sigma}}$$

$$[3.14b] \quad K_i^* = \frac{1}{\alpha}\left[\gamma\left(\frac{(1-\gamma)w_i^*}{\gamma r_i^*}\right)^{1-\sigma} + (1-\gamma)\right]^{\frac{\sigma}{1-\sigma}}$$

and for the Cobb-Douglas case,

$$[3.15a] \quad L_i^* = \frac{1}{\alpha}\left[\frac{\gamma\, r_i^*}{(1-\gamma)w_i^*}\right]^{(1-\gamma)}$$

$$[3.15b] \quad K_i^* = \frac{1}{\alpha}\left[\frac{(1-\gamma)\, w_i^*}{\gamma r_i^*}\right]^{\gamma}$$

Given the cost-minimizing factor input requirements per unit of output for each region,

K_i* and L_i*, firm's locate production activity such that the following condition holds:

$$[3.16] \qquad \frac{C_h^*}{C_j^*} = \left[\frac{\mu_h}{\mu_j}\right]\frac{q_j}{q_h} \qquad \forall h,j$$

where $C_i^* = r^* \cdot K_i^* + w^* \cdot L_i^*$, is minimum output cost in region i. In the computer model, [3.16] is incorporated through [3.17], which for clarity is presented below for the two-region (1,2) case.[40]

$$[3.17] \qquad \begin{aligned} q_2^* &= \frac{1}{\eta}\left[\frac{(1-\mu)\,C_1^*}{\mu\,C_2^*}\right]^{\mu} \\ q_1^* &= \frac{1}{\eta}\left[\frac{\mu\,C_2^*}{(1-\mu)\,C_1^*}\right]^{1-\mu} \end{aligned}$$

The functions in [3.17] determine the optimal portion of total firm output to be allocated to each region. It is always the case that $\sum_{i=1}^{M} q_i^* = 1$, and output in each region i is given by $q_i = q_i^* \cdot q$.

For noncorporate firms, the personal income tax rate plays out as an added cost of capital, similar to the methodology used by Harberger (1962) and others to model the federal corporate income tax in the U.S. The input cost-minimizing input requirements for noncorporate firms are identical to those given above for the corporate case, only the tax distortions are given by

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[40] In this case the aggregation function is given by $q = \zeta q_1^{\mu} q_2^{1-\mu}$.

$$[3.18] \qquad r_i^* = \left[1 + \frac{t_{yi}}{(1 - t_{yi})} \right] r_i$$

$$w_i^* = w_i$$

As mentioned above, each noncorporate firm operates autonomously in each region; therefore, there is no location decision to be made for these firms, and the production location functions discussed in the context of corporations are not relevant.

Household Income and Consumption

Consumers are assumed to be homogeneous in preferences and income within a given region. These preferences are represented by a linearly homogeneous Cobb-Douglas utility function given by

$$[3.19] \qquad \prod_{i=1}^{N} X_i^{\beta_i} \qquad where \quad \sum_{i=1}^{N} \beta_i = 1$$

Furthermore, consumers have preferences for corporate versus noncorporate goods in each consumption category, which are represented by the Cobb-Douglas aggregation function

$$[3.20] \qquad X_i = X_{c,i}^{\psi} X_{nc,i}^{1-\psi}$$

The nested utility function is then given by

$$[3.21] \qquad \prod_{i=1}^{N} \left[X_{c,i}^{\psi} X_{nc,i}^{1-\psi} \right]^{\beta_i}$$

The consumers in each region maximize [3.21] subject to a budget constraint given by $\sum p_i X_i = Y$ where Y is personal income net of state taxes. Sources of personal income include wages and capital income. The consumers in each region m are initially endowed with a fixed amount of labor given by $\bar{L}_m$ and a fixed share of the national capital stock: $\bar{K}_m = \theta^m \bar{K}$. The population is defined such that one unit of labor corresponds to one individual. That is, $POP_m = \bar{L}_m$. Personal consumption income for an individual in region m is thus given by

$$[3.22] \quad Y^m = \left[w_m + \theta^m \frac{\sum_{i=1}^{N} \sum_{m=1}^{M} r_m K_{im}}{\bar{L}_m} \right] \left[1 - t_{ym} \right] - \frac{H^m}{\bar{L}_m}$$

Optimization of [3.21] subject to [3.22] yields the following demand functions:

$$[3.23a] \quad X^*_{c,i} = \frac{\psi_i \beta_i Y}{P_{c,i}}$$

$$[3.23b] \quad X^*_{nc,i} = \frac{(1-\psi_i)\beta_i Y}{P_{nc,i}}$$

Measurement of Welfare and the Cost of Living

Before proceeding to the model's benchmark data and calibration and the analysis of results, it is important first to discuss two other concepts that will be employed in the analysis: the measurement of welfare and cost-of-living.

Welfare Measurement

Prior to the birth of applied general equilibrium models, the welfare impacts of public policies could be appraised only as an approximation, generally by evaluating consumer surplus.[41] The appropriateness of consumer surplus as an approximate measure of changes in welfare continues to be a contentious issue.[42] Fortunately, with applied general equilibrium models there is no need to rely on approximations because changes in welfare can be computed exactly using the utility functions specified in the model.

The assumptions that underlie the model presented above provide for a very simple and reasonable measure of social welfare. First, because consumers are identical in preferences and income, a simple additive utility function can be used. Moreover, with geographically immobile labor, welfare in the counterfactual equilibria can be properly compared to welfare in the benchmark equilibrium.

In the analysis that follows, regional welfare (W_R) in each region R is given by the sum of the indirect utility functions of the population, which, with identical consumers, becomes

$$[3.24] \quad W_R\left(\bar{L}_R\,,\,\boldsymbol{p}\,,\,Y_R\right) = \bar{L}_R \prod_{i=1}^{N}\left[\left(\frac{\psi_i\beta_i\,Y}{p_{c,\,i}}\right)^{\psi_i}\left(\frac{(1-\psi_i)\,\beta_i\,Y}{p_{nc,\,i}}\right)^{1-\psi_i}\right]^{\beta_i}$$

and national welfare is given by $W_N = \sum W_R$. The measurement of changes in

[41] The term *consumer surplus*, as used here, refers specifically to the area under the Marshallian demand curve above the price line, not to a general concept of consumer welfare.

[42] See, for example, Willig (1976).

regional welfare are given by percentage changes in the welfare function post policy change:

$$[3.25] \quad \frac{W_R(\bar{L}_R, \boldsymbol{p}', Y_R') - W_R(\bar{L}_R, \boldsymbol{p}^0, Y_R^0)}{W_R(\bar{L}_R, \boldsymbol{p}^0, Y_R^0)}$$

Changes in national welfare are then given by

$$[3.26] \quad \frac{W_N' - W_N^0}{W_N^0}$$

Because consumer preferences are linearly homogeneous, equivalent variation, shown below,

$$[3.27] \quad EV = E(u', \boldsymbol{p}^0) - E(u^0, \boldsymbol{p}^0)$$

can be written as [43]

$$[3.28] \quad EV = \frac{u' - u^0}{u^0} \cdot Y^0$$

Thus, the measures of welfare gain/loss given in [3.25] and [3.26] are measures of equivalent variation (EV) expressed in terms of benchmark income (Y):

$$[3.29] \quad \%\Delta W = \frac{EV}{Y}$$

[43] Shoven and Whalley (1992), p.125. E(·) is the expenditure function.

Cost of Living

For Cobb-Douglas preferences, a true cost-of-living index is given by Konüs (1939) price index:[44]

$$[3.30] \quad \kappa(p^0, p^l, u) = \prod_{i=1}^{N} \left[\left(\frac{p_{i,c}^{l}}{p_{i,c}^{0}} \right)^{\psi} \left(\frac{p_{i,nc}^{l}}{p_{i,nc}^{0}} \right)^{1-\psi} \right]^{\beta_i}$$

In the analysis that follows, this index will be used as an aggregate measure of consumer price changes.

[44] Note that the Konüs index is independent of u. The true cost-of-living index is always independent of utility levels when preferences are homothetic. For a proof, see Cornwall (1984), pp. 635-37.

CHAPTER 4
DATA, CALIBRATION, AND COMPUTATIONAL TECHNIQUES

Benchmark Equilibrium Data Set [45]

Aggregation

The level of aggregation chosen in applied general equilibrium models generally is heavily influenced by the orientation of the model. General purpose models, which are designed for use in analyzing multiple policy issues, tend to be much more complex and detailed than single-issue models, such as that considered here.[46] Shoven and Whalley (1992) elucidate the difficult issues involved in choice of aggregation:

> Choice of the level of aggregation for an applied model is one of the more difficult issues that any prospective modeler must confront. On the one hand, there is the natural desire to make the model as detailed as possible in the belief that this will increase its realism. On the other hand, more detail is not always beneficial; much of it may prove superfluous to the issues at hand . . . In practice, three considerations enter the choice of aggregation level in applied models: the need to accurately capture the main discriminatory features involved in the policy issues under discussion; the limits of data availability; and the need to constrain computer costs by using a model structure that can be manipulated with relative ease (p. 100).

Much attention was paid to the trade-off between tractability and realism in choosing the levels of aggregation for this analysis. Some of the choices for this model, such as the number of regions and the homogeneity of the population, are heavily aggregated because a more disaggregate presentation offers little to the analysis but much to the complexity of the model. Other choices, such as the number of industries, have important implications for the ensuing policy analyses and hence are more disaggregated.

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[45] For general information on the construction of micro-consistent data from government income and product accounts, see St-Hillaire and Whalley (1983) or Shoven and Whalley (1992).

[46] Examples of large-scale general purpose applied general equilibrium models include Dixon *et al.* (1982), Piggott and Whalley (1985), and Ballard *et al.* (1985). Examples of small single issue applied general equilibrium models include Hamilton and Whalley (1985), Shoven and Whalley (1972), and Lenjosek and Whalley (1986). See Shoven and Whalley (1984) for an extensive review.

Regional Aggregation

Data for the model presented in this chapter was collected for each of the eight regions defined by the Bureau of Economic Analysis (see figure 4.1). To make the model tractable, these eight regions were then further aggregated into two regions. The choice of two regions allows the model to pick up the competitive interplay between state governments in the model while also providing a simple way to allocate the sales of national corporate firms across regions.[47]

One data set (BASE model, Figure 4.2) includes data aggregated to two regions of approximately the same size, while other regional specifications consist of a small region and a large region. The regions comprising the BASE model are North, which consists of

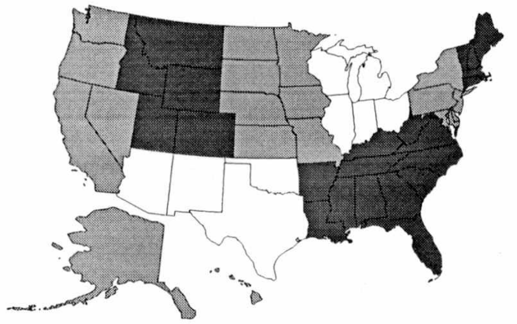

Figure 4.1
BEA Regions

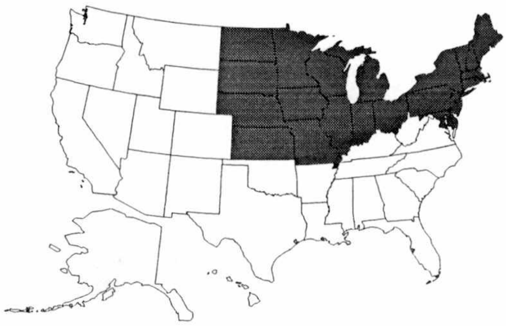

Figure 4.2
North and South Regions

the North Central and Northeast Census Bureau regions, and South, which consists of the South and West Census Bureau regions. In other regional specifications, the small region

[47] As detailed later in the chapter, the allocation of corporate sales between regions was accomplished using linear programming techniques. Because an Armington (1969) assumption of heterogeneous commodities across regions is inappropriate in this case (single firms produce output in both regions for sale in both regions), assumptions had to be made regarding the allocation of output across regions. With more than two regions, the allocation became somewhat of a guessing game. Moreover, the output of the simulation model (results) increases geometrically with the number of regions, yet adding regions offers little to the analysis.

consists of a single BEA region, and the large region comprises the rest of the United States. Most of the analysis will utilize the BASE model, while other regional specifications are used to highlight the effects of geographic size on the results. For this reason, the data presented in this Chapter will be for the BASE model aggregates.[48]

Aggregation of Households, Producer Goods, and Consumer Goods

Because the analyzes in this dissertation are focused on the impacts of state corporate income tax policies on economic development and regional welfare, and not on the distribution of gains and losses across classes of individuals, no distinction is made between households on the basis of economic resources. Hence, the household consumption choices in each region are described by the preferences of a single representative consumer. The structure of these preferences are detailed in Chapter 3.

There are eight broadly defined industries (SIC 1-digit) which produce output directly for the government and consumer sectors.[49] These industries are agriculture, mining, construction, manufacturing, TPU (transportation and public utilities), trade, FIRE (finance, insurance, and real estate), and services. The level of disaggregation employed is an effort to account for differences in the corporate tax treatment across industries (*i.e.* the situsing of sales at origin *vs.* destination) and to monitor the effects of

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[48] The specific make-up of alternative regional specifications is discussed in Chapter 5.

[49] The federal government and investment sectors are excluded from explicit consideration in the model. The explicit consideration of an investment sector is not necessary in a static model such as this one, while the inclusion of federal government would complicate the model while adding little to the analysis. Federal deductibility of state taxes would lower a firm's tax burden in both the benchmark and counterfactual equilibriums. Because the policy analysis is conducted in relative terms, the effect of federal deductibility on the policy results is likely to be negligible . As noted above, in a single issue model such as this one, the objective is to make the model as complex as necessary to assure valid results, but simple enough to maintain the model's analytic strength .

state tax policies that may vary across regions according to the industries concentrated there.

Production Sector

Gross Receipts, Payroll, and Taxable Profits for Corporate and Noncorporate Industries

Data on Gross State Product by State for 1992 were obtained from Friedenberg and Beemiller (1997). These data were aggregated to eight production sectors (SIC 1-digit classification, SIC I) and two regions (North and South), and are reported as gross regional product (GRP) in columns 3 and 5 of Table 4.1. Columns 4 and 6 report the percentage distribution of GRP across industries.

The next step was to allocate GRP to the corporate and noncorporate sectors.

TABLE 4.1
Gross Regional Product by SIC 1-Digit Classification
Benchmark, 1992

Industry (1)	Percent Corporate (2)	Region: North $Millions (3)	North % (4)	South $Millions (5)	South % (6)
Agriculture	75.4	52,518	1.8	81,151	2.6
Mining	81.6	11,342	0.4	95,080	3.0
Construction	79.8	120,621	4.1	160,225	5.0
Manufacturing	96.9	627,779	21.3	592,512	18.6
TPU	91.2	277,814	9.4	322,404	10.1
Trade	91.1	506,675	17.2	577,154	18.1
FIRE	91.5	675,439	22.9	646,609	20.3
Services	66.8	677,913	23.0	704,789	22.2

U.S. Internal Revenue Service (1995a) reports gross receipts by organizational form for each of the eight SIC I industries. These figures were used to calculate the shares of gross receipts in each industry that were attributable to corporations and noncorporate firms in 1992. The corresponding percentages are reported in column 2 of Table 4.1.

Labor employment and capital utilization by each industry and sector in each region were calculated using capital/labor ratios and gross receipts as their basis. Internal Revenue Service (1994, 1995b) provides comprehensive reports of items from business tax returns. Information from these reports was used to estimate capital/labor ratios for each industry (Table 4.2).[50] Labor payments were taken from the item *payroll*, while capital payments were taken as the sum of items *depreciation deduction* and *rent paid.*

TABLE 4.2
Capital/Labor Ratios by Industry
Estimated, 1992 Benchmark

Noncorporate Industry	Estimated Capital / Labor Ratio	Corporate Industry	Estimated Capital / Labor Ratio
Agriculture	0.5480	Agriculture	0.6095
Mining	3.6946	Mining	3.7468
Construction	0.2949	Construction	0.2945
Manufacturing	0.6656	Manufacturing	0.7051
TPU	1.7131	TPU	1.7344
Trade	0.6389	Trade	0.6438
FIRE	0.5541	FIRE	0.5576
Services	0.5469	Services	0.5503

[50] The capital/labor ratios presented in Table 4.2 were adjusted during the calibration procedure, but in no case was there more than a third order difference from the original values.

Labor payments by industry, sector, and region were calculated by multiplying labor's share of gross receipts, as determined by the capital/labor ratio, by gross product. Labor employment, which is shown in Table 4.3, was then determined by dividing labor payments by the appropriate wage rate. The calibrated wage rate in both regions was 0.9884, and the price of capital was normalized to 1.0000.

TABLE 4.3
Labor Employment by Industry, Sector, and Region
Benchmark, 1992

Industry	North		South	
	Corporate (1)	Non-corporate (2)	Corporate (3)	Non-corporate (4)
Agriculture	24,498	8,287	37,897	12,820
Mining	1,924	435	16,255	3,661
Construction	74,165	18,778	98,310	24,988
Manufacturing	354,895	11,606	335,504	10,973
TPU	91,711	8,902	107,190	10,349
Trade	279,350	27,445	318,933	31,314
FIRE	395,129	36,840	378,296	35,320
Services	290,804	144,564	302,705	150,537

Taxable profits, as defined in chapter 3, were then calculated by subtracting payroll costs from gross receipts (SAL). Gross receipts are simply the value of output, as given by GRP in Table 4.1. For corporations, gross receipts are given by the value of national output, while for unincorporated firms, gross receipts are given by the value of regional output.

$$[4.1a] \quad \pi_{i,c} = \sum_{m=N,S} SAL_{i,c,m} - PAY_{i,c,m}$$

$$[4.1b] \quad \pi_{i,nc,N} = SAL_{i,nc,N} - PAY_{i,nc,N}$$

$$[4.1c] \quad \pi_{i,nc,S} = SAL_{i,nc,S} - PAY_{i,nc,S}$$

The remainder of the value-added for each industry (after accounting for payroll costs) is then the sum of capital payments and tax payments. Allocating this remainder required the simultaneous solution of a system of equations because of the relatively large number of industries, dual regions and sectors, and the complicated structure of the formula-apportioned corporate income tax.[51]

Corporate Property Payments, Corporate Tax Rates, and Apportionment Factors

Let R_{iN} be corporate property payments in the North region, let R_i be total corporate property payments, let the ϕ_{iN} be the North region's share of national corporate economic activity for each industry, and let t_{cN} and t_{cS} be the statutory corporate tax rates for the North and South regions, respectively. Then, given the data on corporate gross receipts (Table 4.1) and corporate payroll (Table 4.3, columns 1 and 3), the following system of 26 equations (4.2a - 4.2e; CORPTAX), solved simultaneously, are sufficient to calculate unique values for corporate property payments, corporate tax payments, the distribution of corporate economic activity between regions (as measured by the uniform three-factor apportionment formulas), and statutory corporate income tax rates:

[51] The GAMS computer code for solving these and other nonlinear and linear programming models used in this dissertation can be found in Appendix II.

$$[4.2a] \quad \frac{R_{iN}}{R_i} = 1 - \frac{R_i - R_{iN}}{R_i} \qquad i = 1,\ldots,8$$

$$[4.2b] \quad \phi_{iN} = \frac{S_{iN}}{3 \cdot S_i} + \frac{W_{iN}}{3 \cdot W_i} + \frac{R_{iN}}{3 \cdot R_i} \qquad i = 1,\ldots,8$$

$$[4.2c] \quad R_i = \pi_i^T \left[1 - t_{cN}\, \phi_{iN} - t_{cS} (1 - \phi_{iN}) \right] \qquad i = 1,\ldots,8$$

$$[4.2d] \quad t_{cN} = \frac{REV_{cN}}{\sum_{i=1}^{8} \phi_{iN}\, \pi_i^T}$$

$$[4.2e] \quad t_{cS} = \frac{REV_{cS}}{\sum_{i=1}^{8} (1 - \phi_{iN})\, \pi_i^T}$$

The set of equations given by 4.2a states that the shares of corporate property in the two regions must sum to unity for each region. Set 4.2b assures that the values of R_{iN} and R_i selected in the model determine the apportionment of corporate activity across the two regions (given regional shares of gross receipts and payroll). Set 4.2c assures that each industry earns zero economic profits. Finally, equations 4.2d and 4.2e state that statutory corporate income tax rates are determined by dividing corporate tax revenues in each region by the corporate income tax base in that region. The solution values for the endogenous variables in the system are given in Table 4.4.[52] The statutory corporate tax

[52] Property payments in the South region are given by $R_{iS} = R_i - R_{iN}$ for each industry, and the South region's share of national corporate economic activity is given by $\phi_{iS} = 1 - \phi_{iN}$ for each industry.

TABLE 4.4
Solution Values for Program CORPTAX

	R_{iN}	R_{iS}	ϕ_{iN}	ϕ_{iS}
Agriculture	14,931	23,117	0.4307	0.5693
Mining	7,207	60,490	0.2599	0.7401
Construction	21,841	29,315	0.4586	0.5414
Manufacturing	250,247	236,573	0.5027	0.4973
Transportation	159,064	184,581	0.4702	0.5298
Trade	179,840	205,239	0.4715	0.5285
FIRE	220,305	211,672	0.4990	0.5010
Services	160,040	167109	0.4898	0.5102

rates for the North and South were 0.0122 and 0.0083, respectively.

Noncorporate Property Payments, Total National Property Returns, Regional Shares of Property Returns, and Personal Income Tax Rates

Let $R_{i,\,nc,\,m}$ be noncorporate property payments for each industry in each region and let t_{yN} and t_{yS} be personal income tax rates for the North and South regions, respectively. Further, let θ be the North region's share of total national property payments and let P be total national property returns such that

$$[4.3] \quad P = \sum_{i=1}^{N} \sum_{m=N,S} \left[R_{i,\,c,\,m} + R_{i,\,nc,\,m} \right]$$

Then, given noncorporate taxable profits ($\pi_{nc,i}$), corporate and noncorporate payroll (EMP), personal consumption expenditures (PCE), personal income tax collections (REV_{yN} and REV_{yS}), and head tax collections (H_N and H_S), the following system of 20 equations (4.4a - 4.4e; PITAX) is sufficient to calculate unique values for property payments of noncorporate firms, personal income tax rates, national property returns, and regional shares of national property returns:

$$[4.4a] \quad PCE_N = \left[EMP_N + \theta P \right]\left[1 - t_{yN} \right] - H_N$$

$$[4.4b] \quad PCE_S = \left[EMP_S + (1-\theta)P \right]\left[1 - t_{yS} \right] - H_S$$

$$[4.4c] \quad t_{yN} = \frac{REV_{yN}}{\sum_{i=1}^{8} \pi_{nc,\,i} + EMP_N + \theta P}$$

$$[4.4d] \quad t_{yS} = \frac{REV_{yS}}{\sum_{i=1}^{8} \pi_{nc,\,i} + EMP_S + (1-\theta)P}$$

$$[4.4e] \quad R_{nc,\,i,\,m} = \pi_{nc,\,i}\left(1 - t_{ym} \right) \qquad i = 1,\ldots,8; \quad m = N, S$$

where

$$[4.4f] \quad EMP_m = \sum_{i=1}^{N} \left[PAY_{i,\,c,\,m} + PAY_{i,\,nc,\,m} \right]$$

Equations 4.4a and 4.4b state that personal consumption expenditures in each region are equal to personal income in the region less taxes; equations 4.4c and 4.4d state that personal income tax rates are calculated by dividing personal income tax revenues in each region by the personal income tax base in that region; and equation set 4.4e assures that each industry in each region earns zero economic profits. Solution values for the endogenous variables in the system are presented in Table 4.5 below.[53]

Location of Corporate Output by Region of Production and Region of Sale

In order to calibrate the parameters μ and η of the production aggregation function (Chapter 3, equation 3.8), it was necessary first to allocate the regional sales of each corporate firm to regional production facilities. Let $PC_{i,c,m}$ be the benchmark price of corporate output of industry i sold in region m, $Q_{i,c,m,m'}$ be the quantity of corporate industry i output produced in region m for sale in region m', $SAL_{i,c,m'}$ be the total sales of corporate industry i in region m', and $VLP_{i,m}$ be the value of industry i production in region m. Then, assuming that cross-hauling of output is not allowed and that firms minimize transportation costs, *ceteris paribus*, the optimal allocation of sales to production facilities is given by the solution of the following linear programming

TABLE 4.5
Solution Values for Program PITAX

Industry	$R_{nc,i,N}$	$R_{nc,i,S}$		
Agriculture	4,541	7,054	P	2,458,664
Mining	1,609	13,578		
Construction	5,537	7,367	θ	0.4739
Manufacturing	7,725	7,326		
Transportation	15,250	17,807	t_{yN}	0.0199
Trade	17,535	20,071		
FIRE	20,413	19,634	t_{yS}	0.0130
Services	79,069	82,577		

[53] The South region's share of total national property returns is given by $1 - \theta$.

problem (UNITS2):

$$[4.5a] \quad \max \sum_{i=1}^{m} Q_{i,c,m,m} \quad s.t.$$

$$[4.5b] \quad PC_{i,c,N}\left[Q_{i,c,N,N} + Q_{i,c,S,N} \right] = SAL_{i,c,N}$$

$$[4.5c] \quad PC_{i,c,S}\left[Q_{i,c,N,S} + Q_{i,c,S,S} \right] = SAL_{i,c,S}$$

$$[4.5d] \quad PC_{i,c,N} Q_{i,c,N,N} + PC_{i,c,S} Q_{i,c,N,S} = VLP_{i,N}$$

$$[4.5e] \quad PC_{i,c,N} Q_{i,c,S,N} + PC_{i,c,S} Q_{i,c,S,S} = VLP_{i,S}$$

The solution values for the $Q_{i,c,m,m'}$ are presented in Table 4.6 below.

TABLE 4.6
Solution Values for Program UNITS2

Industry	$Q_{i,c,N,N}$	$Q_{i,c,N,S}$	$Q_{i,c,S,N}$	$Q_{i,c,S,S}$
Agriculture	39,603	0	11,509	49,687
Mining	9,255	0	40,015	37,571
Construction	96,242	0	20,011	107,830
Manufacturing	567,705	40,586	0	574,119
Transportation	253,286	0	13,029	280,910
Trade	461,343	0	12,693	512,824
FIRE	575,744	42,055	0	591,430
Services	438,171	14,615	0	470,738

Consumption Sector

The National Income and Product Accounts include four major components of final demand (Y): consumption (C), investment (I), net exports (X_n), and government purchases (G), yielding the familiar textbook income/output identity:

$$[4.6] \quad Y = C + I + G + X_n$$

For the model presented in chapter 3, the only relevant components of final demand are consumption and state government purchases; therefore, investment expenditures, net exports, and federal and local government expenditures must be otherwise accounted for. For the purposes of this static model, these components were relegated to the consumption sector so that the national income/output identity becomes

$$[4.7] \quad Y = PCE + G_S$$

where $PCE = C + I + G_{federal} + G_{local}$ is personal consumption expenditures and G_S is state government purchases.

Government Revenues and Expenditures

Data on state government revenues were obtained from Bureau of the Census, *State Government Finances 1992*. Consistent with the government budget constraint shown in equation [3.1], all tax collections other than individual income taxes (IITC) and corporate income taxes (CITC) were allocated to the broad category *head taxes*. Only direct expenditure by state governments (EXP_D) was considered, so that head taxes(H) became

$$[4.8] \quad H = EXP_D - CITC - IITC$$

Benchmark tax collections for each region are shown in Table 4.7.

TABLE 4.7
State Government Tax Collections, 1992 Benchmark

Tax Item	North	South
Corporate Income Tax	12,616	9,258
Individual Income Tax	61,080	43,187
Head Tax	179,301	189,799
Total Tax Collections	252,997	242,243

SOURCE: Bureau of the Census, *State Government Finances 1992*

The allocation of state government revenues to producer good categories was accomplished by appealing to the U.S. benchmark input-output accounts for 1987 (*Survey of Current Business*, April, 1994).[54] The I-O accounts show the use of output of all industries in the production of state and local governments as well as value-added. Value-added (39.9 percent of total value of output) was ignored because there is no government production in the model. The other inputs were aggregated to the SICII level, and then percentage distributions were used as the basis for the allocation of revenues to expenditures on producer goods. For example, TPU comprised 22.1 percent of state and local government purchases in 1987, so the value of TPU purchases in the benchmark was calculated by multiplying government revenues by 0.221. Table 4.8

[54] The latest year for which input-output tables are available for the U.S. economy is 1987.

TABLE 4.8
State Government Purchases, 1992 Benchmark

Industry	Percent Distribution	North	South
Agriculture	0.3	771	738
Mining	2.6	6,648	6,365
Construction	38.6	98,426	94,238
Manufacturing	19.4	49,503	47,397
TPU	22.1	56,415	54,014
Trade	3.8	9,718	9,305
FIRE	3.8	9,670	9,258
Services	9.3	23,657	22,650

shows the pattern of state government expenditures in the benchmark equilibrium.

Units Conversion and Sectoral Division for Consumer and Government Expenditures

Given the allocation of personal consumption expenditures and state government expenditures across industries and regions, the next step was to allocate expenditures across corporate and noncorporate sectors and to convert expenditures to physical quantities of output.

Because no information was available regarding the distribution of purchases across corporate and noncorporate sectors, an assumption had to be made. Since corporations are likely to find procuring government contracts much easier than procurement by noncorporate firms, it was assumed that state governments would purchase output from corporations only. The conversion from expenditures to physical commodities was made simple by the use of the following nonlinear programming model

(CONSUMP):

$$[4.9] \qquad \max \sum_{m=1}^{2} \sum_{i=1}^{8} \left[\bar{G}_{i,C}^{\,m} \right]^2$$

subject to

$$[4.9a] \quad PC_{i,nc,m}\,\bar{G}_{i,nc,m} + PC_{i,c,m}\,\bar{G}_{i,c,m} = GEPG_{i,m}$$

$$[4.9b] \quad PC_{i,nc,m}X_{i,nc,m} + PC_{i,c,m}X_{i,c,m} = CEPG_{i,m}$$

$$[4.9c] \quad PC_{i,nc,m}\left[\bar{G}_{i,nc,m} + X_{i,nc,m} \right] = SAL_{i,nc,m}$$

$$[4.9d] \quad PC_{i,c,m}\left[\bar{G}_{i,c,m} + X_{i,c,m} \right] = SAL_{i,c,m}$$

$PC_{i,s,m}$ is the market price of commodity i from sector s in region m. Prices were calculated by (1) assuming net prices were 1.0 in the benchmark and then (2) adjusting for tax distortions. In other words, market prices were set to just cover costs, including tax liabilities. $G_{i,s,m}$ is units of industry i, sector s output purchased by the region m government, and $X_{i,s,m}$ is industry i, sector s output purchased by consumers in region m.

The objective function ([4.9]), simply states the assumption that governments purchase from corporations when possible. Constraints [4.9a] and [4.9b] state that the sum of corporate and noncorporate expenditures in each region and industry must equal the total expenditure on that commodity. Constraints [4.9c] and [4.9d] state that the sum of government and consumer purchases on each commodity in each region must equal the total sales of that commodity in that region. Solution values for the endogenous variables are presented in Tables 4.9 and 4.10.

Model Calibration

The solution of the computable general equilibrium model presented in Chapter 3 requires specific values to be chosen for the parameters of the model. The procedure used to select parameter values for this model is "calibration," which involves solving the model from the benchmark equilibrium data for the parameter values.[55] The goal of calibration is to choose parameter values so that the completely specified model is capable of reproducing the benchmark data set as an equilibrium solution.

Production Parameters

The first step in calibrating the production functions used in the model was to calculate the tax distortions implicit in the benchmark equilibrium data set.

Tax Distortions: Corporate

Recalling equations [3.5a] - [3.5c], which show the distortions arising from the formula-apportioned corporate income tax, and using data from the benchmark equilibrium data set, we can solve for the implicit tax-distorted price of capital (r^*), labor (w^*) and output (p^*). For industries where sales are apportioned at destination (all but services), these tax-inclusive prices are given by

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[55] Mansur and Whalley (1984) is a comprehensive source for information about the specification of key parameters in applied general equilibrium models. This source, along with Shoven and Whalley (1992) and Ballard *et al.* (1985) were the primary resources used to calibrate the model in this study.

TABLE 4.9
Solution Values for Program CONSUMP
Benchmark Consumer Demands

Industry	$X_{i,nc,N}$	$X_{i,nc,S}$	$X_{i,c,N}$	$X_{i,c,S}$
Agriculture	12,920	19,967	49,906	48,557
Mining	2,077	17,418	17,680	13,486
Construction	24,427	32,452	17,680	13,486
Manufacturing	19,487	18,395	512,815	561,807
Transportation	24,461	28,391	207,109	224,103
Trade	45,335	51,648	459,513	498,646
FIRE	57,666	55,212	560,387	618,346
Services	225,235	234,197	410,487	458,274

TABLE 4.10
Solution Values for Program CONSUMP
Government Fixed Demands

Industry	$G_{i,c,N}$	$G_{i,c,S}$	Industry	$G_{i,c,N}$	$G_{i,c,S}$
Agriculture	762	731	TPU	55,819	53,490
Mining	6,583	6,309	Trade	9,617	9,213
Construction	97,420	93,304	FIRE	9,568	9,165
Manufacturing	48,982	46,924	Services	23,410	22,425

$$[4.10a] \quad r_i^* = \left[1 + \frac{\pi^0}{R^0} \left[t_{ci} f_{Ri} - \sum_{h=1}^{2} \frac{R_h^0}{R^0} t_{ch} f_{Rh} \right] \right] r_i$$

$$[4.10b] \quad w_i^* = \left[1 - \sum_{h=1}^{2} t_{ch} \Phi_h^0 + \frac{\pi^0}{W^0} \left[t_{ci} f_{Wi} - \sum_{h=1}^{2} \frac{W_h^0}{W^0} t_{ch} f_{Wh} \right] \right] w_i$$

$$[4.10c] \quad p_j^* = \left[1 - \sum_{h=1}^{2} t_{ch} \Phi_h^0 - \frac{\pi^0}{S^0} \left[t_{cj} f_{Sj} - \sum_{h=1}^{2} \frac{S_h^0}{S^0} t_{ch} f_{Sh} \right] \right] p_j$$

while for industries for which sales are taxed at origin (services), tax-inclusive prices are given by

$$[4.11a] \quad r_i^* = \left[\frac{1 + \frac{\pi^0}{R^0} \left[t_{ci} f_{Ri} - \sum_{h=1}^{2} \frac{R_h^0}{R^0} t_{ch} f_{Rh} \right]}{1 - \sum_{h=1}^{2} t_{ch} \Phi_h^0 - \frac{\pi^0}{S^0} \left[t_{ci} f_{Si} - \sum_{h=1}^{2} \frac{S_h^0}{S^0} t_{ch} f_{Sh} \right]} \right] r_i$$

$$[4.11b] \quad w_i^* = \left[\frac{1 - \sum_{h=1}^{2} t_{ch} \Phi_h^0 + \frac{\pi^0}{W^0} \left[t_{ci} f_i - \sum_{h=1}^{2} \frac{W_h^0}{W^0} t_{ch} f_{Wh} \right]}{1 - \sum_{h=1}^{2} t_{ch} \Phi_h^0 - \frac{\pi^0}{S^0} \left[t_{ci} f_{Si} - \sum_{h=1}^{2} \frac{S_h^0}{S^0} t_{ch} f_{Sh} \right]} \right] w_i$$

and

$$[4.11c] \quad p_j^* = p_j$$

Tax Distortions: Noncorporate

As outlined in Chapter 3, unincorporated firms are taxed at the individual income tax rate. Subsequently, there are no distortions to the price of labor or to output prices, and the tax-inclusive price of capital is given by

$$[4.12] \quad r_i^* = \left[\frac{t_Y}{1 - t_Y} \right] r_i$$

Specification of Parameters

In calibrating production functions, it is assumed that firms minimize costs and earn zero economic profits net of taxes. When using CES production functions, the assumption of cost minimization is not sufficient to calculate all parameters, and thus it is necessary to utilize empirical estimates of the elasticity of substitution from the literature (Piggott and Whalley, 1985). These empirical estimates are shown in Table 4.11 below.

TABLE 4.11
Elasticity of Substitution Between Capital and Labor

Industry	σ	Industry	σ
Agriculture	0.8312	TPU	1.0000
Mining	1.0000	Trade	1.0000
Construction	1.0000	FIRE	1.0000
Manufacturing	0.8719	Services	1.0000

In many cases no information was available on the relevant elasticities of substitution, and following Ballard *et al.* (1985) and Piggott and Whalley (1985), the elasticity of substitution was assumed to be unity in those cases.

CES Functions. Once the elasticities of substitution are specified, share parameters in the CES production function reproduced below

$$[4.13] \quad q = \alpha \left[\gamma L^{\frac{\sigma - 1}{\sigma}} + (1 - \gamma) K^{\frac{\sigma - 1}{\sigma}} \right]^{\frac{\sigma}{\sigma - 1}}$$

can be determined directly from the cost minimization, yielding

$$[4.14] \quad \gamma = \frac{w^* L^{\frac{1}{\sigma}}}{w^* L^{\frac{1}{\sigma}} + r^* K^{\frac{1}{\sigma}}}$$

The shift parameter is then easily calculated by substituting values for σ and γ into [4.13] and solving for α:

$$[4.15] \quad \alpha_R = \frac{q_R}{\left[\gamma L^{\frac{\sigma - 1}{\sigma}} + (1 - \gamma) K^{\frac{\sigma - 1}{\sigma}} \right]^{\frac{\sigma}{\sigma - 1}}}$$

where R identifies the region of interest. The calibrated values of γ and α for CES industries are shown in Table 4.12.

TABLE 4.12
Calibrated CES Production Function Parameters

Industry (Sector)	γ_N	α_N	γ_S	α_S
Agriculture (Corp)	0.6396	1.9270	0.6395	1.9250
Manufacturing (Corp)	0.5935	1.9595	0.5936	1.9572
Agriculture (NonCorp)	0.6664	1.9214	0.6668	1.9160
Manufacturing (NonCorp)	0.6071	1.9761	0.6079	1.9698

Cobb-Douglas Functions. For Cobb-Douglas industries, share parameters in the function reproduced here

$$[4.16] \quad q = \alpha L^{\gamma} K^{1-\gamma}$$

are given by

$$[4.17] \quad \gamma = \frac{w^* L}{w^* L + r^* K}$$

and the shift parameter is then calculated by substituting the calibrated value of γ into [4.16] and solving for α:

$$[4.18] \quad \alpha_R = \frac{q_R}{L^{\gamma} K^{1-\gamma}}$$

where again R identifies the region of interest. The calibrated values of γ and α for Cobb-Douglas industries are shown in Table 4.13.

TABLE 4.13
Calibrated Cobb-Douglas Production Function Parameters

Industry (Sector)	γ_N	α_N	γ_S	α_S
Mining (Corp)	0.2077	1.6586	0.2083	1.6654
Mining (NonCorp)	0.2077	1.6936	0.2083	1.6854
Construction (Corp)	0.7686	1.7087	0.7665	1.7055
Construction (NonCorp)	0.7666	1.7298	0.7679	1.7243
TPU (Corp)	0.3608	1.9121	0.3622	1.9207
TPU (NonCorp)	0.3612	1.9483	0.3618	1.9402
Trade (Corp)	0.6031	1.9469	0.6031	1.9446
Trade (NonCorp)	0.6026	1.9738	0.6035	1.9675
FIRE (Corp)	0.6369	1.9150	0.6362	1.9115
FIRE (NonCorp)	0.6361	1.9405	0.6370	1.9345
Services (Corp)	0.6399	1.9117	0.6393	1.9083
Services (NonCorp)	0.6391	1.9371	0.6401	1.9311

Aggregation Function. For corporations, it was also necessary to calibrate the Cobb-Douglas aggregation function reproduced here

$$[4.19] \quad q = \eta q_N^{\mu} q_S^{1-\mu}$$

Recalling that the per-unit cost of production by some industry in region i is given by $C_i^* = r_i^* K_i^* + w_i^* L_i^*$, where K_i^* and L_i^* are cost-minimizing input requirements per unit of output and r_i^* and w_i^* are factor prices cum tax distortions, the share parameter μ is then

$$[4.20] \quad \mu = \frac{C_N^* q_N}{C_N^* q_N + C_S^* q_S}$$

The shift parameter is then calculated by substituting the calibrated value of μ into [4.19] and solving for η:

$$[4.21] \quad \eta = \frac{q}{q_N^{\mu} q_S^{1-\mu}}$$

The calibrated values of μ and η are shown in Table 4.14.

TABLE 4.14
Calibrated Cobb-Douglas Aggregation Function Parameters

Industry	μ	η	Industry	μ	η
Agriculture	0.3928	1.9542	TPU	0.4640	1.9948
Mining	0.1071	1.4054	Trade	0.4673	1.9957
Construction	0.4285	1.9796	FIRE	0.5105	1.9996
Manufacturing	0.5143	1.9992	Services	0.4899	1.9996

Consumption Parameters

The calibration of the consumer utility function is straight-forward, given its simple Cobb-Douglas specification, which is reproduced below in its nested form:

$$[4.22] \quad \prod_{i=1}^{N} \left[X_{c,i}^{\psi} X_{nc,i}^{1-\psi} \right]^{\beta_i}$$

The sectoral share parameter ψ_i is found by simply calculating the corporate sector's share of each commodity in the consumer's budget:

$$[4.23] \quad \psi_i = \frac{p_{i,c}{}^{*} X_{i,c}}{p_{i,c}{}^{*} X_{i,c} + p_{i,nc}{}^{*} X_{i,nc}}$$

Similarly, the commodity share parameter β_i is found by dividing total expenditure on commodity i by total expenditure on all commodities:

$$[4.24] \quad \beta_i = \frac{p_{i,c}{}^{*} X_{i,c} + p_{i,nc}{}^{*} X_{i,nc}}{\sum_{j=1}^{N} \left[p_{j,c}{}^{*} X_{j,c} + p_{j,nc}{}^{*} X_{j,nc} \right]}$$

The calibrated values of β and ψ are shown in Table 4.15.

Computational Techniques

Computer Resources and Algorithms

The applied general equilibrium model specified in Chapter 3 is solved using the General Algebraic Modeling System (GAMS) Release 2.25 (Brooke *et al.*, 1992). Although the computer code is written in the GAMS language, much of the computation requires the use of an external solver, in this case the FORTRAN-based system MINOS5

TABLE 4.15
Calibrated Consumer Preference Parameters

Industry	ψ_N	ψ_S	β
Agriculture	0.7958	0.7104	0.0235
Mining	0.9533	0.6408	0.0166
Construction	0.4224	0.2956	0.0157
Manufacturing	0.9638	0.9686	0.1995
TPU	0.8954	0.8885	0.0870
Trade	0.9111	0.9070	0.1891
FIRE	0.9076	0.9188	0.2314
Services	0.6480	0.6641	0.2373

(Murtagh and Saunders, 1987).

Although MINOS5 is designed to solve large-scale optimization problems, it also can be utilized to solve large nonlinear systems of equations that include no objective function to optimize. In these cases, only one feasible solution exists, and once reached, the computer halts because it realizes that the token objective function can not be further optimized, and the solution is reported. Many of the calibration procedures in this study utilized the optimizing ability of GAMS/MINOS5 through the solution of linear and nonlinear programming problems, while the computation of equilibrium utilized a token objective function in every case. For linear programs, MINOS5 utilizes the primal simplex method (Dantzig, 1963), while in nonlinear cases MINOS5 uses a projected Lagrangian algorithm based on Robinson (1972). The GAMS code used in this study is included in Appendix II of the paper.

Ad Valorem Equivalents for Formula-Apportioned Corporate Income Taxes

The solution of the general equilibrium model discussed in Chapter 3 requires writing explicit factor demand functions for corporations, which is impossible with formula apportionment because the tax rates themselves are functions of the degrees of factor utilization across regions. For this reason, formula-apportioned corporate income taxes were programmed in their *ad valorem* equivalent form, which are given in equations [4.10a] - [4.11c]. Equilibrium was computed with firms optimizing behavior based on these *ad valorem* taxes. *Ad valorem* taxes were then recomputed, followed by another computation of equilibrium. This iterative procedure was repeated until the tax rates did not vary more than the tolerable level in the final period. In other words, tax rates were updated and equilibrium recomputed until the *ad valorem* equivalent tax rates in the last iteration (i+1) were very close to the *ad valorem* tax rates computed in iteration i. The tolerance criterion was set at

$$[4.25] \quad t_{i+1} - t_i < | \ 0.0000000001 \ |$$

In every case 4 iterations was sufficient to satisfy [4.25].

CHAPTER 5
POLICY SIMULATIONS AND ANALYSIS OF RESULTS

The applied general equilibrium model presented in Chapters 3 and 4 was used to conduct a variety of formula-apportioned corporate income tax policy experiments. This chapter describes those policy experiments, presents the simulation results, and discusses the implications.

Policy Experiments

Restricting the analysis to the three most common apportionment formulas: (1) equally weighted three-factor formula (EWF), (2) three-factor formula with double-weighted sales (DWS), and (3) single factor sales formula (SFS), there are nine possible policy "states of the world" that can prevail in a two-region economy. One state is an equally weighted three-factor apportionment formula in both regions, which is the benchmark case in this study. The other possible policy states are given by:[56]

A.	DWS, EWF	E.	DWS, SFS
B.	EWF, DWS	F.	SFS, EWF
C.	DWS, DWS	G.	EWF, SFS
D.	SFS, DWS	H.	SFS, SFS

In the analysis that follows, the economic impact of these alternative policies (A-H) are simulated, and the numerical results are then compared with the benchmark case in an effort to evaluate the implications of formula manipulation (*i.e.* heavier weights on the sales factor). Although the focus of the analysis is on economic development effects, impacts on government revenues and welfare are also highlighted.

[56] No state would be expected to employ an apportionment formula with heavier weights on payroll and property than on sales, so the equally weighted formula provides a lower bound for sales factor weights. Likewise, because a single-factor sales formula provides the heaviest possible weight on sales (100%), it serves as an upper bound for sales factor weights. The effects of any possible combination of factor weights between these two bounds can be inferred from the results of the policy experiments given by A-H.

The rest of this chapter presents and analyzes results from the simulations of the policy experiments described above. The focus of the first section is the economic development effects of these policies. First summary results are presented, which highlight aggregate effects for entire regions. Then results are discussed in more detail, focusing on specific issues, which include implications of situsing sales at origin *vs.* destination, variations in impacts across industries, implications for in-state *vs* national firms, and the importance of statutory tax rates and region size for the results. The following two sections then examine the effects of formula manipulation on government revenues and regional and national welfare. The final section of the chapter discusses the sensitivity of the simulation results to various assumptions that underlie the model.

Economic Development Effects

Summary Results

Factor Flows

Recall from the conceptual analysis of Chapter 2 that an increase in the sales factor weight decreases the implicit excise tax on capital, which should lead to an increase in the demand for capital, *ceteris paribus*. Thus, we should expect that the imposition of a double-weighted sales or single-factor sales formula by some region would lead to an inflow of capital to that region. As demonstrated in Table 5.1 (columns 4 and 5), in the policy experiments described above, a disproportionately heavy weight on the sales factor resulted in a net flow of capital in every case. Nevertheless, the magnitudes of these flows were extremely small. In no case did any of the policies result in greater than a 0.24 percent change in any region's capital stock. In cases where

TABLE 5.1
Summary Simulation Results
Factor Prices and Movements
(Percent Change from Benchmark)

Policy Experiment	P_K (1)	P_L North (2)	P_L South (3)	K North (4)	K South (5)
(A) DWS N, EWF S	-0.0120	0.0275	-0.0457	0.0600	-0.0540
(B) EWF N, DWS S	0.0097	-0.0169	0.0323	-0.0404	0.0363
(C) DWS N, DWS S	-0.0042	0.0087	-0.0153	0.0196	-0.0177
(D) SFS N, DWS S	-0.0284	0.1028	-0.1410	0.1995	-0.1797
(E) DWS N, SFS S	0.0272	-0.0397	0.0838	-0.1014	0.0914
(F) SFS N, EWF S	-0.0301	0.1260	-0.1636	0.2400	-0.2161
(G) EWF N, SFS S	0.0472	-0.0595	0.1373	-0.1614	0.1454
(H) SFS N, SFS S	-0.0151	0.0368	-0.0594	0.0784	-0.0706

the two regions pursued identical policies, the North region consistently came out the winner, primarily because of the higher statutory corporate income tax rate in the North.[57]

The reason for the small magnitudes can be found by appealing to equation [4.10a], which shows the tax-distorted price of capital for corporate firms (other than services) and is reproduced below

$$[5.1] \quad r_i^* = \left[1 + \frac{\pi^0}{R^0} \left[t_{ci}\, f_{Ri} - \sum_{h=1}^{2} \frac{R_h^0}{R^0} t_{ch}\, f_{Rh} \right] \right] r_i$$

Distortions in the gross price of capital (r^*) across regions arises because of differentials between the product of a region's property factor weight and statutory corporate tax rate and the national weighted average. Apportionment formula manipulation affects the

[57] This result is discussed in more detail in a later section of this chapter. See "Statutory Tax Rates and Region Size."

relative demand for capital across regions through changes in these weighted average tax differentials. To the extent that these differentials are small, we can expect that the effects of these apportionment policies to be small. Tables 5.2a and 5.2b show the values of these tax differentials in both the benchmark equilibrium (5.2a) and the counterfactual equilibrium associated with policy experiment A (5.2b). The implicit excise taxes are small relative to the implicit profits taxes, which are themselves small. More importantly, although a double-weighted sales factor can substantially increase or decrease these implicit excise taxes (close to 50 percent in some cases), they remain a very small portion of gross factor costs. Of course, this implies that if statutory tax rates were higher, capital flows would then expected to be somewhat greater. The corporate tax rates for the North and South regions were calibrated to 1.22 percent and 0.83 percent, respectively, which are significantly lower than the statutory corporate tax rates imposed by most states. The sensitivity of capital flows to statutory corporate tax rates is explored later in this chapter in the section "Sensitivity Analysis."

One might predict that a move to disproportionately heavy weights on the sales factor would result in some intraregional capital flows from the noncorporate to the corporate sector within the acting region in addition to interregional flows within the corporate sector. However, the results in Table 5.3 show inflows of capital in both sectors. This result is somewhat surprising given a decrease in the gross-of-tax cost of capital in the corporate sector relative to the noncorporate sector and evidence that there was a shift in production from the noncorporate to the corporate sector in the acting region (see Table 5.4).

TABLE 5.2
Implicit Corporate Tax Rates

Industry	All Regions	North Region			South Region		
	Profits	K Excise	L Excise	S Excise	K Excise	L Excise	S Excise
a. Benchmark Equilibrium (BASE)							
Agriculture	0.010199	0.000188	0.000116	0.000637	-0.000122	-0.000075	-0.000655
Mining	0.010227	0.000277	0.001042	0.001152	-0.000033	-0.000124	-0.001511
Construction	0.010261	0.000177	0.000053	0.000376	-0.000132	-0.000040	-0.000406
Manufacturing	0.010183	0.000150	0.000107	0.000732	-0.000159	-0.000114	-0.000677
Transportation	0.010174	0.000166	0.000291	0.001102	-0.000144	-0.000250	-0.001046
Trade	0.010155	0.000165	0.000108	0.000694	-0.000145	-0.000094	-0.000642
FIRE	0.010168	0.000152	0.000086	0.000640	-0.000158	-0.000089	-0.000582
Services	0.010201	0.000158	0.000088	0.000618	-0.000152	-0.000085	-0.000594

TABLE 5.2 (continued)

Industry	All Regions	North Region			South Region		
	Profits	K Excise	L Excise	S Excise	K Excise	L Excise	S Excise
b. North DWS, South EWF Counterfactual Equilibrium (BASE)							
Agriculture	0.009807	0.001236	0.000762	-0.000009	-0.000798	-0.000492	0.000010
Mining	0.008651	0.001815	0.006850	-0.000017	-0.000216	-0.000808	0.000022
Construction	0.009952	0.001166	0.000348	-0.000006	-0.000868	-0.000262	0.000006
Manufacturing	0.010298	0.000989	0.000706	-0.000011	-0.001045	-0.000746	0.000010
Transportation	0.010087	0.001093	0.001918	-0.000016	-0.000941	-0.001638	0.000015
Trade	0.010109	0.001085	0.000706	-0.000010	-0.000949	-0.000619	0.000009
FIRE	0.010284	0.000997	0.000562	-0.000009	-0.001037	-0.000587	0.000009
Services	0.010200	0.001039	0.000579	-0.000009	-0.000995	-0.000556	0.000009

TABLE 5.3
Summary Simulation Results
Capital Flows
(Percent Change from Benchmark)

Policy	K_C North	K_N North	K_C South	K_N South
DWS N, EWF S	0.0654	0.0236	-0.0596	-0.0185
EWF N, DWS S	-0.0442	-0.0147	0.0403	0.0113
DWS N, DWS S	0.0212	0.0089	-0.0193	-0.0072
SFS N, DWS S	0.2175	0.0792	-0.1980	-0.0628
DWS N, SFS S	-0.1113	-0.0352	0.1015	0.0266
SFS N, EWF S	0.2617	0.0936	-0.2383	-0.0744
EWF N, SFS S	-0.1767	-0.0590	0.1611	0.0448
SFS N, SFS S	0.0848	-0.1570	-0.0772	-0.0978

The reasoning behind this surprising result can be found by appealing to factor price changes, which are provided in columns (1) through (3) of Table 5.1.[58] Take the first policy experiment, for example. The imposition of a double-weighted sales factor formula in the North lead to a 0.0120 percent decline in the nation-wide price of capital, a 0.0275 percent increase in the price of labor in the North, and a 0.0457 percent decrease in the price of labor in the South. In the North region, the increase in the price of labor was significantly larger than the decline in the national price of capital, thereby increasing the p_L/p_K ratio and, subsequently, decreasing the demand for labor relative to the demand for capital. Likewise, the price of labor fell in the South relative to the price of capital, increasing the demand for labor relative to the demand for capital in that region.

The most efficacious policy, in terms of factor flows, was the imposition of a

[58] Policy-induced changes in factor prices are discussed in more detail in the following section.

single factor sales formula, especially when the other region employed an equally weighted three-factor formula. Take the cases where the North region imposed a more aggressive formula than the South, for example. Imposing a SFS formula yielded a 0.2400 percent change in the North's capital stock when the South maintained its benchmark EWF formula, but only a 0.1995 percent capital inflow when the South utilized a DWS formula. Imposing a DWS formula in the North (with the South maintaining an EWF), on the other hand, yielded only a 0.0600 percent gain in capital stock for the North region.

Factor Prices

As demonstrated above, the excise effects of disproportionate sales factor weighting lead to interregional capital flows, although not to a substantial degree. But formula manipulation also affects the weighted average corporate tax rate, and hence the profits tax burden of the formula-apportioned corporate income tax. Because the profits tax burden is borne by capital nation-wide, changes in the average tax rate do not affect the interregional distribution of capital, but instead are reflected in the price of capital.[59]

To see how the weighted-average corporate tax rate plays out as a "national" tax on capital, we let $t = \sum_i t_i \phi_i$ be the national weighted average tax rate for some firm and write the firm's profits as $\pi = (S - W)(1 - t) - R$, where S is national sales, W is national payroll, and R is national property payments. With a zero profit condition, we then have $S - W - R = \left(\frac{t}{1-t}\right) R$. Thus, the weighted average

[59] This result is not peculiar to formula-apportioned corporate income taxes. See Mieszkowski (1972) and McClure (1977) for a similar interpretation of the average and differential effects of property taxes.

corporate tax rate (t) taxes capital at a rate of t/(1-t).

In the policy experiments undertaken in this study, the nation-wide price of capital tended to fall when the North region employed a policy that was *at least* as aggressive as the South (see Table 5.1, column 1). This suggests that an aggressive formula apportionment policy in the North, relative to the South, resulted in an increase in the weighted average tax rate, and thus the overall tax burden. For example, in policy experiment (A), where the North region imposed a double-weighted sales formula and the South maintained an equally weighted formula, the North saw a $48.868 increase in corporate income tax revenues, while the South suffered a $0.468 loss, for a nation-wide corporate tax revenue gain of $48.400. Because the national tax base declined in the same experiment, we know that the average tax rate increased in the aggregate.[60]

As detailed in a later section of the paper, the primary reason for the increase in the weighted-average tax rate (t) with an aggressive policy in the North was that most corporations tended to have their taxable income over-apportioned ($\phi_N + \phi_S > 1$) when the North pursued the more aggressive policy, but under-apportioned ($\phi_N + \phi_S < 1$) when the South pursued the more aggressive policy. Also important was a higher statutory corporate income tax rate in the North. An aggressive policy in the North tended to increase ϕ_N relative to ϕ_S for most corporations. Because the North's statutory corporate income tax rate was higher, the weighted-average corporate tax rate ($t = t_N\phi_N + t_S\phi_S$)

[60] Because national property payments comprise the corporate tax base, the price of capital decreased, and the national capital stock is fixed, we know the national tax base fell. The revenue figures are in millions of dollars. The revenue effects of the various apportionment formula policies are discussed in detail in a later section of this chapter.

tended to increase for most firms as well.

The decline in implicit excise rates that occurred with increased sales factor weights also served to increase the demand for labor in the acting region at the expense of the other region. Because labor was fixed in regional supply, however, changes in the demand for labor were reflected in wage increases in the acting region and wage declines in the other region (see Table 5.1, columns 2 and 3). What little flow of capital did occur worked to further boost (depress) the price of labor in the gainer (loser) region. The magnitudes of these changes in the price of labor were even less substantial (in percentage terms) than those associated with capital flows. To some degree, these wage changes offset the capital flows caused by changes in implicit property excise taxes. Although a geographically mobile labor force and unemployment are not incorporated in the model, the increased demand for labor arising from disproportionate sales factor weighting suggests that an aggressive formula apportionment policy may be effective in reducing unemployment and/or increasing immigration.[61]

Shifts in the Location of Production

Not surprisingly, as shown in Table 5.4, changes in production levels were on the order of the changes in capital stocks.[62] Increased sales factor weights did lead to increased production in the corporate sector, but not to any substantial degree. In the noncorporate sector, rising prices for noncorporate goods in the acting region tended to

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[61] The sensitivity analysis provided later in this chapter shows a net inflow of labor with an aggressive formula apportionment policy and geographically mobile labor force.

[62] N subscripts indicate noncorporate firms, while C subscripts indicate corporate firms.

TABLE 5.4
Summary Simulation Results (BASE)
Changes in Location of Production
(Percent Change from Benchmark)

Policy	Q_C North	Q_N North	Q_C South	Q_N South
(A) DWS N, EWF S	0.0281	-0.0007	-0.0264	0.0018
(B) EWF N, DWS S	-0.0191	0.0016	0.0179	-0.0023
(C) DWS N, DWS S	0.0090	0.0010	-0.0084	-0.0005
(D) SFS N, DWS S	0.0932	-0.0014	-0.0876	0.0049
(E) DWS N, SFS S	-0.0483	0.0059	0.0454	-0.0075
(F) SFS N, EWF S	0.1123	-0.0031	-0.1056	0.0071
(G) EWF N, SFS S	-0.0764	0.0065	0.0717	-0.0093
(H) SFS N, SFS S	0.0360	0.0037	-0.0338	-0.0019

dampen noncorporate production there, while noncorporate production in the other region increased slightly. This result reflects a decline in the cost of production in the corporate sector relative to the noncorporate sector in the acting region.

Origin and Destination Issues

In the introduction to this paper (Chapter 1), it was noted that the calculation of the sales factor in corporate income apportionment formulas is complicated by situsing issues that generally do not arise in the context of payroll and property factors. Although sales generally are sitused at destination for the purposes of apportionment, it is administratively difficult to situs some gross receipts at destination, and hence sales of intangible products such as services generally are sitused on an origin basis, similar to the situsing of payroll and property. As demonstrated in the conceptual analysis of Chapter 2 and confirmed in the simulation results presented below, the situsing rule for the sales factor has enormous implications for the economic development impacts of disproportionate weighting of the sales factor.

Tables 5.5a and 5.5b, which show selected simulation results for policy experiments A and B, indicate that the impact of disproportionate weighting of the sales factor on the services industry is the opposite of the impact on the industries in which sales are sitused at destination.

TABLE 5.5
Factor Flows and Changes in the Location of Production, Services and All Other Industries

	%Δ K_N	%Δ K_S	%Δ $Q_{C,N}$	%Δ $Q_{C,S}$
a. Policy Experiment A (BASE)				
Services	-0.0079	0.0107	-0.0478	0.0477
All Other industries	0.0791	-0.0801	0.0446	-0.0448
b. Policy Experiment B (BASE)				
Services	0.0050	-0.0069	0.0309	-0.0308
All Other Industries	-0.0480	0.0486	-0.0280	0.0281

The reason for the reversal in policy impacts for the services industry is that the negative impact of an increased excise tax on gross receipts, which essentially is a tax on production with origin-based situsing of the sales factor, dominated the positive impact of decreased excise taxes on payroll and property, which work to reduce the cost of production. When gross receipts are sitused at destination, on the other hand, only the reduced excise taxes on payroll and property are considered in the production decision.

To illustrate, take the gross-of-tax cost of capital. Recall from Chapter 2 (equation 2.24) that an increased sales factor weight reduces the implicit excise tax on property payments in the acting region

$$[5.2] \qquad \frac{\partial\left[\frac{\pi_T}{R}\left(\rho_i t_i - \sum_{j=1}^{N}\frac{R_j}{R}\rho_j t_j\right)\right]}{\partial\sigma_i} = -\frac{1}{2}\left[\frac{\pi_T}{R}\left(1 - \frac{R_i}{R}\right)t_i\right] < 0$$

which, by reducing the cost of capital, encourages an increase in capital utilization in the acting region for all industries, including services. However, there is an additional impact on the cost of capital for the services industry. With an origin-based situsing of the sales factor, *the value of output* in the services industry is taxed at a higher (implicit) rate following an increase in the sales factor weight, which tends to increase the cost of capital (and labor) in the acting region. The results in Tables 5.5a and 5.5b indicate that the second effect dominated the first in these experiments, which explains why the services industry decreased its capital utilization in the acting region while other industries increased their capital utilization in the acting region. These counterveiling effects also serve to explain why the services industry saw effects of much smaller magnitude than did the other industries. Of course, it is theoretically possible for the "factor tax effect" to outweigh the "production tax effect," but such a result is unlikely. As demonstrated in Chapter 2 (equation 2.28), the "production tax effect" will outweigh the "factor tax effect" unless

$$[5.3] \qquad \frac{1}{2}\left[\frac{\pi_T}{R}\left(1 - \frac{R_i}{R}\right)\right] > \frac{\pi_T}{S}\left(1 - \frac{q_i}{q}\right)$$

which would require R_i/R to be much larger than q_i/q.

The Effects of Industry Concentration

This section examines differences in the economic development effects of disproportionate sales factor weighting across industries. In order to make the analysis tractable, the focus is on policy experiments A and B, where one region double-weights its sales factor and the other region maintains an equally weighted formula.[63]

Tables 5.6a and 5.6b show the (initial) capital-labor ratio, percentage changes in capital utilization, and percentage changes in output in the acting region by industry for policy experiments A and B, respectively. The degree to which an industry increases its use of capital in the acting region is determined in large part by two factors: the industry's capital-labor ratio and the change in the industry's gross-of-tax price of capital.

It is readily apparent from the simulation results that increases in factor utilization in the acting region are very strongly related to the initial capital-labor ratios. The industries with the greatest K/L ratios, mining and TPU, respectively, saw the largest capital flows, both positively and negatively. The industry with the smallest K/L ratio, construction, saw the smallest capital flows. For the North region, the corresponding correlation factor was approximately $|\rho| \approx 0.94$ across all industries, and for the South, $|\rho| \approx 0.92$ across all industries, both of which are significant at better than the $\alpha = 0.005$ level. These correlation coefficients were robust across policy experiments, ranging no more than ± 0.003 from the mean $|\rho|$ across policy experiments.

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[63] The results from other policy experiments can be readily inferred from these results. Effects are larger with SFS formulas, but the directions of changes in factor flows, factor prices, and location of output are the same as in policy experiments A and B.

TABLE 5.6
Factor Flows and Changes in the Location of Production, by Industry and Region

Industry	K^0/L^0	$\%\Delta K_N$	$\%\Delta K_S$	$\%\Delta Q_{C,N}$	$\%\Delta Q_{C,S}$
a. Policy Experiment A (BASE)					
Agriculture	0.609	0.055	-0.065	0.0346	-0.0275
Mining	**3.747**	**0.142**	**-0.108**	**0.2075**	**-0.0871**
Construction	0.294	0.038	-0.056	-0.0094	0.0072
Manufacturing	0.705	0.073	-0.061	0.0420	-0.0398
TPU	**1.734**	**0.109**	**-0.099**	**0.1121**	**-0.0978**
Trade	0.644	0.074	-0.067	0.0404	-0.0348
FIRE	0.558	0.073	-0.058	0.0294	-0.0271
Services	0.550	-0.008	0.010	-0.0478	0.0459
Correlation of $\%\Delta K$ with K/L		0.940	-0.923		
b. Policy Experiment B (BASE)					
Agriculture	0.609	-0.037	0.044	-0.0234	0.0187
Mining	**3.747**	**-0.095**	**0.073**	**-0.1391**	**0.0589**
Construction	0.294	-0.026	0.038	0.0062	-0.0047
Manufacturing	0.705	-0.049	0.041	-0.0285	0.0270
TPU	**1.734**	**-0.074**	**0.067**	**-0.0757**	**0.0661**
Trade	0.644	-0.050	0.045	-0.0274	0.0236
FIRE	0.558	-0.050	0.040	-0.0200	0.0184
Services	0.550	-0.005	-0.007	0.0321	-0.0308
Correlation of $\%\Delta K$ with K/L		-0.938	0.924		

The strong positive relationship between capital flows and the capital-labor ratio can be readily explained. Because capital is the only mobile factor in the model, more capital-intensive industries find it much easier, and less costly, to expand production than do the more labor-intensive industries. As seen in Tables 5.6a and 5.6b, the industries with the highest capital-labor ratios, such as mining and TPU, generally saw the greatest shifts of production to regions placing heavier weights on the sales factor.[64]

Of course, the change in the gross-of-tax price of capital following a change in policy also has significant implications for changes in capital utilization. The greater the decline (increase) in the gross-of-tax price of capital, the greater the increase (decrease) in capital utilization. Variations in the gross-of-tax price of capital across industries are a function of variations in the implicit excise tax/subsidy on capital across industries, which in turn are functions of the regional distribution of property payments. Recall from Chapter 2 that

$$[5.4] \qquad \frac{\partial \left[\frac{\pi_T}{R} \left(\rho_i t_i \; - \; \sum_{j=1}^{N} \frac{R_j}{R} \rho_j t_j \right) \right]}{\partial \sigma_i} \; = \; -\frac{1}{2} \left[\frac{\pi_T}{R} \left(\; 1 \; - \; \frac{R_i}{R} \right) t_i \right] < 0$$

which is strictly decreasing in R_i / R.

Table 5.7, which shows changes in gross-of-tax factor prices, gross-of tax factor price ratios, and capital-labor ratios by industry and region for policy experiment A, indicates a perfect negative correspondence between the change in the gross-of-tax price

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[64] In reality, mining activity depends heavily on region-specific capital, so this shift in production would likely be reduced. In this study, however, the mining industry represents any capital-intensive industry with regionally concentrated production activity.

of capital and the proportion of property payments located in the North (acting) region *vs.* the South region.

TABLE 5.7
Changes in Capital-Labor Ratios and Relative Factor Prices in North Region, by Industry
Policy Experiment A (BASE)

Industry	ϕ_N^0	R_N/R	%Δ K/L	%Δ p_L^*/p_K^*	%Δ p_L^*	%Δ p_K^*
Agriculture	0.4307	0.3924	0.0328	0.0395	-0.0350	-0.0745
Mining	0.2599	0.1070	-0.3120	-0.3120	-0.4154	-0.1038
Construction	0.4586	0.4260	0.0621	0.0621	-0.0089	-0.0709
Manufacturing	0.5027	0.5140	0.0527	0.0604	-0.0016	-0.0620
TPU	0.4702	0.4642	-0.0083	-0.0083	-0.0755	-0.0672
Trade	0.4715	0.4670	0.0555	0.0555	-0.0113	-0.0668
FIRE	0.4990	0.5097	0.0683	0.0683	0.0058	-0.0624
Services	0.4898	0.4891	0.0625	0.0625	-0.0021	-0.0645

All industries other than services tended to utilize more capital in the North region following the imposition of a double-weighted sales factor there, and also increased production and utilized relatively more capital than labor in their increased output. However, the most capital-intensive industries saw their capital-labor ratios decline in the acting region, while the more labor intensive industries saw their capital-labor ratios increase.[65] As seen in Table 5.7, the changes in capital-labor ratios across industries are entirely a function of changes in relative gross-of-tax factor prices (p_L^*/p_K^*).[66] The more

[65] This implies, of course, that although $\Delta K > \Delta L$ for capital-intensive industries, $\Delta K/\Delta L < K^0/L^0$.

[66] For industries with Cobb-Douglas technology, there was a perfect correlation between changes in the factor price ratio and the capital-labor ratio. The agriculture and manufacturing industries both face elasticities of substitution less than unity, however, so capital-labor ratios did not respond proportionately to changes in the factor price ratios.

capital-intensive industries saw substantially greater declines in the gross-of-tax price of labor than did labor-intensive industries, which served to push the p_L^*/p_K^* ratio down in those industries.

There are several factors that influence Δp_L^* across industries. First, as was the case with capital, industries with the least concentration of productive activity in the North (acting) region saw the greatest declines in the gross-of-tax price of labor, *ceteris paribus*. This effect tended to decrease the gross cost of labor in the agriculture and mining industries relative to other industries. Secondly, because labor costs are deductible in the calculation of taxable profits, but property payments are not, the imposition of a DWS formula in the North tended to depress p_L^* for industries that saw the largest increases in the overall corporate income tax burden, $t_N\phi_N + t_S\phi_S$.[67] As shown in Chapter 2, industries with a strong "market" relative to "production" presence in the North region saw an increase in their overall tax liability, while regions with a relatively high production presence saw a decrease in their overall tax liability.[68] For example, the mining industry, which produces almost entirely all of its product in the South but has sales that are fairly evenly distributed across regions, saw its overall tax burden increase by 10.13 percent after the North imposed a DWS formula. The FIRE industry, on the other hand, which produces relatively more product in the North region than it sells there, saw its overall tax burden decrease by 0.68 percent. As seen in Table 5.7, changes in the

[67] Recall that the excise effects cancel out nationally and that the base of the formula-apportioned corporate income tax is nation-wide normal profits, S - W. See Chapter 2 for details.

[68] This issue is discussed in great detail in the "Government Revenues" section of this Chapter. See also equation 2.22.

gross-of-tax price of labor were much greater in magnitude for those industries seeing the largest increase in their overall tax burden. Finally, another important determinant of Δp_L is the K/L ratio. The explanation is that the more capital-intensive industries saw the greatest shift of production to the North region, which tended to raise ϕ_N for these industries relative to the more labor-intensive industries. Because the North is the high-tax region, an increase in ϕ_N tends to raise the overall tax burden, which in turn tends to lower the gross-of-tax price of labor. As mentioned above, industries with a K/L > 1 saw an overall decline in the p_L^*/p_K^* ratio, while labor-intensive industries saw increases in p_L^*/p_K^*. This result highlights the importance of the K/L ratio on changes in the gross-of-tax price of labor.

Treatment of Production vs. Market and Local vs. National Firms

This section examines the treatment of "market" *vs.* "production" firms and in-state *vs.* national firms with respect to formula manipulation. A firm has a market presence in a region j, as opposed to a production presence, if region j's share of the firm's total sales is greater than its share of the firm's total production, as given by the arithmetic mean of its payroll and property shares, or

$$[5.5] \quad \frac{S_j}{S} > \left(\frac{1}{2}\right)\frac{R_j}{R} + \left(\frac{1}{2}\right)\frac{W_j}{W}$$

A firm is a local firm if 100 percent of its income-producing activities (sales property, and payroll) occur in a single state, while national firms have income-producing activities in more than one state. The analysis begins with an examination of differences in tax burdens and changes in tax burdens for market and production firms and local and national firms, then proceeds to discusss the economic development effects of formula manipulation across industries of varying degrees of activity in one region *vs*. another.

Market- vs. Production-Concentrated Industries

Tables 5.8a and 5.8b show the market *vs*. production presence in the acting region, percent changes in ϕ_N and ϕ_S, and percent change in overall tax liability (%Δt) by industry and region for policy experiments A and B, respectively.

Industries that sell relatively more than they produce in a given region saw their tax liabilities increase with a greater weight on the sales factor in that region, which suggests that placing a disproportionately heavy weight on the sales factor favors firms that are relatively production-intensive in the acting region. Tax liabilities in the nontaxing region decreased because industries shifted production to the acting region following the policy change.[69] Because the percentage changes in tax liabilities in the acting region were greater in magnitude than the percentage changes in tax liabilities in the nonacting region, the total apportionment of firm profits was something other than 100 percent following a policy change. For market-intensive industries in the acting region, the imposition of a double-weighted sales factor lead to an over-apportionment of taxable income (*i.e.*, $\Sigma\phi_i > 1$) , thus leading to an increase in their overall (national) tax burden. Likewise, for production-intensive industries in the acting region, a double-weighted sales factor resulted in an under-apportionment of taxable income (*i.e.*, $\Sigma\phi_i < 1$),

[69] Recall that the apportionment formula did not change in the other region.

TABLE 5.8
Differential Impacts on Tax Burdens and Market Presence in the North Region, by Industry

Industry	$\frac{S_N}{S} - \left(\frac{1}{2}\right)\frac{R_N}{R} - \left(\frac{1}{2}\right)\frac{W_N}{W}$	$\%\Delta(t_N\phi_N)$	$\%\Delta(t_S\phi_S)$	$\phi_N + \phi_S$	$\%\Delta t$
a. Policy Experiment A (BASE)					
Agriculture	0.1145	4.474	-0.037	1.0191	2.347
Mining	0.4609	29.678	-0.040	1.0768	10.130
Construction	0.0908	3.312	-0.025	1.0151	1.832
Manufacturing	- 0.0339	-1.083	-0.050	0.9943	-0.669
TPU	0.0240	0.956	-0.087	1.0040	0.506
Trade	0.0133	0.512	-0.045	1.0022	0.272
FIRE	- 0.0342	-1.109	-0.043	0.9942	-0.679
Services	0.0007	-0.012	0.029	1.0001	0.005
b. Policy Experiment B (BASE)					
Agriculture	-0.1145	-0.325	-3.331	0.9796	-1.742
Mining	-0.4609	-0.076	-10.361	0.9231	-6.841
Construction	-0.0908	-0.020	-2.764	0.9849	-1.237
Manufacturing	0.0339	-0.033	1.166	1.0056	0.447
TPU	-0.0240	-0.066	-0.728	0.9958	-0.352
Trade	-0.0133	-0.034	-0.391	0.9978	-0.188
FIRE	0.0342	-0.029	1.168	1.0057	0.454
Services	-0.0007	0.020	-0.043	0.9999	-0.006

and hence, to a decline in the overall tax burden for these industries.[70] Thus, disproportionate sales factor weighting, when pursued unilaterally (or more generally, not unanimously), leads to the over-taxation of market-intensive industries in the acting region, which gives strong support to the argument that formula manipulation violates the constitutional restriction on interference with interstate commerce.[71]

As noted in the previous section, firms seeing an increase in their overall tax burden are expected to substitute some labor for capital in production, *ceteris paribus*, although it is difficult to differentiate these effects from other factors influencing the gross-of-tax factor price ratio. In the policy experiments, firms seeing an increase in their overall tax burden generally decreased production nationally.

Local vs. National Industries

The models utilized thus far in the analysis assumes that all corporations are national firms that produce and sell in both regions and that only (and all) unincorporated firms are entirely local firms. Therefore, to consider the impacts of formula manipulation on entirely in-state corporations ($\phi_i = 1$) *vs.* national corporations ($\phi_i < 1 \; \forall$ i), it was necessary to alter the model to allow for local corporations. This was accomplished very simply by assuming that unincorporated firms in the previous model were entirely local corporations in the new model, and then making any appropriate adjustments to tax revenues, tax rates, and parameters (recalibration).

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[70] Lopez (1996) calculates the degree of over- and under-apportionment by industry and state in his more extensive study of this issue.

[71] See Simafranca (1995) for a detailed discussion of the legal issues surrounding the double-weighted sales factor. With uniform apportionment formulas across regions, 100 percent of firms' income is apportioned, regardless of the specific factor weights in the (uniform) formula.

In the previous specification the only difference between corporations and unincorporated firms, other than regional *vs*. national autonomy, is the rate at which their (normal) profits are taxed. Because formula manipulation does not impact the effective tax rate for local corporations (ϕ =1 regardless of the formula used), we would expect formula manipulation to impact local corporations in the same way in which it impacted unincorporated firms previously, *i.e.* only through changes in relative factor prices and output prices. As shown in Table 5.9, this expectation was realized in the simulations.

TABLE 5.9
Factor Prices and Capital Flows, National vs. Local Corporations (ALLCORP)
(percent change from benchmark)

Policy	All Regions	North Region			South Region		
	p_K	$K_{National}$	K_{Local}	p_L	$K_{National}$	K_{Local}	p_L
(A) DWS N, EWF S	-0.0288	0.0707	0.0255	0.0138	-0.0645	-0.0200	-0.0645
(B) EWF N, DWS S	0.0223	-0.0476	-0.0159	-0.0063	0.0435	0.0122	0.0461
(C) DWS N, DWS S	-0.0010	0.0230	0.0097	0.0041	-0.0210	-0.0078	-0.0218
(D) SFS N, DWS S	-0.0758	0.2353	0.0855	0.0653	-0.2144	-0.0680	-0.1953
(E) DWS N, SFS S	0.0606	-0.1199	-0.0379	-0.0115	0.1094	0.0287	0.1216
(F) SFS N, EWF S	-0.0841	0.2830	0.1012	0.0851	-0.2579	-0.0805	-0.2279
(G) EWF N, SFS S	0.1033	-0.1905	-0.0637	-0.0117	0.1739	0.0484	0.1983
(H) SFS N, SFS S	-0.0367	0.0922	0.0385	0.0195	-0.0840	-0.0310	-0.0839

Comparing Table 5.9 with Table 5.3, it is readily apparent that the results from the "all corporate" specification are virtually identical to those of the BASE specification. Local corporations do utilize more capital in the acting region when a heavier weight is placed on the sales factor, but the increased capital utilization for these firms is a response only to changes in realtive factor prices in the acting region (p_K falls relative to p_L). For national corporations, the increased capital utilization arises not only from changes in relative factor prices, but also from the shift in production to the acting region that corresponds to changes in the implicit excise tax differentials on property.

Production levels stayed about the same for local corporations following a policy change. Although there generally was some shift of production, the percentage change in location of production for local corporations overall was negligible, less than one-hundredth of one percent. High K/L (>1) local corporations, such as mining and TPU, tended to produce marginally more in the more aggressive (higher sales factor weight) region, while low K/L (<1) corporations tended to produce marginally more in the less aggressive region.

Statutory Tax Rates and Region Size

Looking at the results from a single regional specification, it is difficult to explore the effects of region size in isolation from the effects of statutory corporate tax rate differences on the results because the two effects cannot be separated. For example, in the North-South model used thus far, the South region is larger *and* has a lower statutory corporate tax rate. Any policy impact differences across the two regions could be explained by either differences in tax rates or region size. The analysis would be blurred. For this reason, two additional regional specifications were employed to examine the issues of region size and variance in tax rates: SWROUS and FWROUS.[72]

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[72] The North-South regional specification is referred to as the BASE model in the rest of the document.

In the SWROUS specification, regions consist of the Southwest BEA region (Texas, Oklahoma, New Mexico, and Arizona) and the rest of the U.S. (ROUS). The Southwest region (SW) is characterized by a small size and a low statutory corporate income tax rate relative to the ROUS. In the FWROUS specification, regions consist of the Far West BEA region (Washington, Oregon, California, Nevada, Alaska, and Hawaii) and the rest of the U.S. (ROUS). The Far West region (FW) is characterized by relatively small size and a relatively high corporate tax rate. The most relevant regional characteristics of all three specifications are provided in Table 5.10.

TABLE 5.10
Regional Characteristics in Alternative Model Specifications

	SWROUS Model		FWROUS Model		BASE Model	
	SW	ROUS	FW	ROUS	North	South
Corporate Income Tax Rate (%)	0.201	1.107	1.283	0.958	1.223	0.825
Personal Income Tax Rate (%)	0.459	1.759	1.724	1.610	1.990	1.299
Share of National GDP (%)	9.75	90.25	18.14	81.86	48.13	51.87

Comparing the results of these two specifications, we can discern the relative importance of region size and statutory tax rate differences on the results. To the extent that policies affect the FW and SW regions in the same way, but differently than the ROUS regions, it can be inferred that the incongruities are due to differences in region size. Likewise, to the extent that policies impact the SW and ROUS(FW) regions in similar ways, but impact the FW and ROUS(SW) regions differently, the incongruities are likely due to differences in statutory tax rates.[73]

Summary factor price and flow results from simulations with these two alternative regional specifications are presented in Tables 5.11 and 5.12. Although the direction of impacts on capital flows are the same as in the BASE model, the magnitudes of the impacts tell a story that is not apparent in the BASE model's results.

The first salient result from comparing the SWROUS and FWROUS specifications is that small regions gain relatively more capital when they employ the more aggressive formula apportionment policy, and lose relatively more when they impose the less aggressive policy, than do large regions. This result suggests that capital is more elastic in small regions than in large regions, which supports similar arguments made by Murphy (1984) in his analysis of capital mobility in the OECD countries.

To illustrate, consider policy experiments A and B, where one region imposes a DWS formula and the other region maintains an equally weighted formula. The results from these simulations are provided in Table 5.13 below in both absolute and relative terms. In the SWROUS specification, ROUS gains 0.0119 percent in capital when it is the DWS region, but the smaller SW region gains relatively more when it is the DWS region, 0.0182 percent. Similarly, the SW suffers a 0.1006 percent loss when it is the EWF region, while the ROUS loses only 0.0021 percent. The same pattern emerges in the FWROUS results: gains for the FW and ROUS with DWS are 0.0961 percent and

[73] The results from alternative BEA-ROUS regional specifications were examined for consistency with the SW-ROUS and FW-ROUS results, but are not reported here. The results from these alternative specifications support the statements made in this section regarding the effects of region size and statutory tax rates.

TABLE 5.11
Summary Simulation Results (SWROUS)
Factor Prices and Movements
(Percent Change from Benchmark)

Policy	P_K	P_L ROUS	P_L SW	K ROUS	K SW
DWS ROUS, EWF SW	-0.0243	-0.0158	-0.0878	0.0119	-0.1006
EWF ROUS, DWS SW	0.0046	0.0030	0.0159	-0.0021	0.0182
DWS ROUS, DWS SW	-0.0200	-0.0130	-0.0721	0.0098	-0.0824
SFS ROUS, DWS SW	-0.0848	-0.0526	-0.3268	0.0453	-0.3831
DWS ROUS, SFS SW	-0.0068	-0.0044	-0.0248	0.0033	-0.0280
SFS ROUS, EWF SW	-0.0883	-0.0546	-0.3416	0.0475	-0.4012
EWF ROUS, SFS SW	0.0186	0.0124	0.0641	-0.0086	0.0726
SFS ROUS, SFS SW	-0.0741	-0.0464	-0.2821	0.0389	-0.3290

Table 5.12
Summary Simulation Results (FWROUS)
Factor Prices and Movements
(Percent Change from Benchmark)

Policy	P_K	P_L ROUS	P_L FW	K ROUS	K FW
DWS ROUS, EWF FW	-0.0197	-0.0104	-0.0660	0.0154	-0.0714
EWF ROUS, DWS FW	0.0282	0.0156	0.0907	-0.0208	0.0961
DWS ROUS, DWS FW	0.0070	0.0038	0.0231	-0.0053	0.0246
SFS ROUS, DWS FW	-0.0498	-0.0253	-0.1727	0.0410	-0.1894
DWS ROUS, SFS FW	0.0991	0.0577	0.3031	-0.0678	0.3134
SFS ROUS, EWF FW	-0.0720	-0.0352	-0.2572	0.0617	-0.2850
EWF ROUS, SFS FW	0.1248	0.0730	0.3711	-0.0834	0.3853
SFS ROUS, SFS FW	0.0288	0.0157	0.0933	-0.0213	0.0984

TABLE 5.13
Absolute and Relative Changes in Capital Stocks, Small vs. Large Regions

Policy Experiment	SWROUS				FWROUS			
	Rest of U.S.		Southwest		Rest of U.S.		Far West	
	ΔK	%ΔK	ΔK	%ΔK	ΔK	%ΔK	ΔK	%ΔK
A	261.6	0.0119	-261.6	-0.1006	312.2	0.0154	-312.2	-0.0714
B	-47.2	-0.0021	47.2	0.0182	-420.3	-0.0208	420.3	0.0961

0.0154 percent, respectively, and losses with the EWF are 0.0714 percent in the FW and 0.0208 percent in the ROUS.

Much of the reason for the greater elasticity of capital in small regions can be explained very simply. For any given shift in capital, the inflows are necessarily equal to the outflows with a fixed national capital stock. Because the initial capital stock is smaller in the small region, the percentage change in capital is necessarily larger. To illustrate, let the inter-regional flow of capital induced by some policy be given by ΔK^* and let the initial capital stock in the small region and large region be given by K_S^0 and K_L^0, respectively. Because $K_L^0 > K_S^0$ we know it must be the case that $\frac{\Delta K^*}{K_S^0} > \frac{\Delta K^*}{K_L^0}$.

Although the level of initial capital stocks explain part of the greater elasticity of capital in small regions, it remains the case that an aggressive formula apportionment policy in a small region produces a relatively greater inflow of capital than does an aggressive formula apportionment policy in a large region, and that imposing the less aggresive policy results in greater capital losses in small regions relative to large regions. The idea that relatively small regions have more to gain from lowering tax rates is hardly a novel concept.[74] For example, Kanbur and Keen (1993) make this argument for sales tax rates, Markusen and Wigle (1989) for tariffs, and Wilson (1991) for production taxes. The argument is best explained by extending Kanbur and Keen's (1993) analysis to the present case. The degree to which capital flows from one region to another depends crucially on its gross-of-tax price elasticity. From the perspective of an entire region, and with a fixed national capital stock, this elasticity comes from inter-regional shifts in capital. A small region has a much greater potential for capital inflow (*e.g.*, take the case of a complete shift) than does the large region, and hence perceives a greater elasticity.

Another result apparent in the SWROUS and FWROUS specifications is that high-tax regions tend to gain more capital when they impose the more aggressive formula apportionment policy than they lose when imposing the less aggressive policy. As shown in Table 5.13, this is true in both absolute and relative terms. To demonstrate, again consider policy experiments A and B, where one region imposes a DWS policy and the other region maintains an EWF policy. In the SWROUS specification, the lower tax region SW gains 47.2 units of capital (0.0182 percent) when it is the DWS region, but loses a substantially greater amount, 261.6 units (0.1006 percent), when it is the EWF region. The high-tax region ROUS, however, gains 0.0119 percent when it is the DWS region, but suffers a loss of only 0.0021 percent when it is the EWF region. A similar pattern is evident in the FWROUS specification. For the high-tax region FW, gains with DWS and losses with EWF are 0.0961 percent and 0.0714 percent, respectively, while for

[74] Here, of course, the tax rates being lowered are the implicit excise taxes on capital and labor that arise from weighted-average tax differentials.

the low-tax ROUS region, gains with DWS are 0.0154 percent, but losses with EWF are a significantly greater 0.0208 percent.

The explanation for this result can be found by looking at the impacts of policy experiments A and B on tax differentials. When a high-tax region double-weights its sales factor (or more generally, increases its sales factor weight), existing tax differentials on property are diminished, and therefore, excise effects become smaller relative to total factor costs. Likewise, when a low-tax region double-weights its sales factor, tax differentials are exacerbated, and hence excise effects become larger relative to total factor costs. To illustrate, assume that these implicit excise taxes (subsidies) are actually collected from (paid to) firms. Then in the benchmark SWROUS case, $584.00 would have been collected as excise taxes in the high-tax ROUS, and the low-tax SW would have paid out an equal amount in subsidies.[75] In policy experiment A, where the high tax ROUS region imposes a DWS formula, this shift would be reduced to $405.16, which indicates that the implicit excise taxes/subsidies are reduced by the ROUS's DWS policy. In policy experiment B, on the other hand, where the low-tax SW region imposes a DWS

[75] It is always the case that the magnitude of "excise tax collections" is equal to the magnitude of "excise subsidy pay-outs." Let TD_i be the tax rate differential in region i and TD_j be the tax rate differential in region j. With a little manipulation, it becomes clear that tax collections and subsidy pay-outs are equal in magnitude.

$$\begin{aligned} TD_i + TD_j &= [\,\rho_i t_i - \frac{R_i}{R}\rho_i t_i - \frac{R_j}{R}\rho_j t_j\,]\,R_i + [\,\rho_j t_j - \frac{R_i}{R}\rho_i t_i - \frac{R_j}{R}\rho_j t_j\,]\,R_i \\ &= \rho_i t_i(1 - \frac{R_i}{R})R_i - \frac{R_j}{R}\rho_j t_j R_i + \rho_j t_j(1 - \frac{R_j}{R})R_j - \frac{R_i}{R}\rho_i t_i R_j \\ &= \rho_i t_i\frac{R_j R_i}{R} - \rho_j t_j\frac{R_i R_j}{R} + \rho_j t_j\frac{R_j R_i}{R} - \rho_i t_i\frac{R_j R_i}{R} = 0 \end{aligned}$$

formula, the property excise tax/subsidy shift would increase from the benchmark case to $616.54, suggesting an increase in implicit property excise tax/subsidy rates.

Government Revenue Effects

Although the impetus of most states for altering their corporate income tax apportionment formulas has been economic development, the revenue consequences also deserve careful attention. Table 5.14 shows the impacts of increased sales factor weights on government revenues.

TABLE 5.14
Summary Simulation Results
Government Revenues (BASE)
(Percent Change from Benchmark)

Policy	CIT North (1)	PIT North (2)	LST North (3)	CIT South (4)	PIT South (5)	LST South (6)
(A) DWS N, EWF S	0.3953	0.0123	0.0093	-0.0505	-0.0311	-0.0486
(B) EWF N, DWS S	-0.0212	-0.0066	-0.0218	-0.3085	0.0224	0.0513
(C) DWS N, DWS S	0.3774	0.0038	-0.0149	-0.3538	-0.0106	0.0003
(D) SFS N, DWS S	1.4991	0.0518	0.0303	-0.4728	-0.0930	-0.1349
(E) DWS N, SFS S	0.3319	-0.0141	-0.0793	-1.3148	0.0587	0.1582
(F) SFS N, EWF S	1.5069	0.0659	0.0618	-0.1846	-0.1079	-0.1768
(G) EWF N, SFS S	-0.0769	-0.0190	-0.0791	-1.2847	0.0973	0.2162
(H) SFS N, SFS S	1.4836	0.0170	-0.0558	-1.3880	-0.0405	0.0018

The revenue consequences of altering apportionment formulas can be considerable relative to the economic development effects. For example, the introduction of a single-factor sales formula by both regions lead to a 0.0784 percent capital gain for the North and a 0.0706 percent capital loss for the South, compared to revenue changes of 1.4836 percent -1.3880 percent in the North and South, respectively. Throughout the range of policy experiments, it was generally the case that revenue consequences were substantially larger (in percentage terms) than were the economic development consequences.

The North region consistently enhanced its corporate tax coffers by placing a larger weight on the sales factor, while the South region generally saw revenue losses. The magnitudes of any region's gains/losses had more to do with its own policy decision than the decision of the other region. For example, the North region enjoyed a revenue gain of approximately 1.5 percent every time it employed a SFS formula, regardless of the formula employed by the South. Nevertheless, for both regions there was a marginal improvement in revenue position when the competitor region imposed a less aggressive formula. For example, take the case of the South imposing a SFS formula. When the North also pursued a SFS formula, the South's revenue loss was 1.3880 percent, but when the North pursued a DWS formula or EWF formula, the South's revenue losses were only 1.3148 percent and 1.2847 percent, respectively.

This result begs the question, "what determines whether a region gains or loses revenues when it places a heavier weight on its sales factor? Recall that any region j's corporate tax collections are given by

$$[5.6] \quad T_j = t_j \sum_{i=1}^{N} \phi_j^{\,i} \, \pi^i$$

which means that the change in tax revenues from a given change in its sales factor weight (and therefore the property and payroll factor weights as well) is given by

$$[5.7] \quad \frac{\partial T_j}{\partial \sigma_j} = t_j \sum_{i=1}^{N} \left[\frac{\partial \phi_j^{\,i}}{\partial \sigma_j} \bar{\pi}^i + \bar{\phi}_j^{\,i} \frac{\partial \pi^i}{\partial \sigma_j} \right]$$

where the superscore represents an initial value. For any given change in σ_j, we know that the revenue gains/losses arising from the $\partial \pi^i / \partial \sigma_j$ terms will be shared across regions according to their $\bar{\phi}_j^{\,i\prime}s$. That being the case, we must look to the $\partial \phi_j^{\,i} / \partial \sigma_j$ terms for an explanation of differences in revenue impacts of formula manipulation across regions.

There are several ways in which apportionment formula manipulation may affect a region's ϕ's. First, if the acting region is a "market" region *vs.* a "production" region, then placing a heavier weight on the sales factor will lead to greater tax revenues.[76] Second, to the extent that placing a heavier weight on the sales factor drives away sales in the region, corporate tax revenues will be diminished because a reduction in S_j/S implies a reduction in ϕ_j, *ceteris paribus*. Finally, to the extent that a weightier sales factor encourages an inflow of capital or increases wages, corporate tax revenues will be enhanced through increases in R_j / R and W_j / W.

To demonstrate how these effects played out numerically in the policy simulations, we look at policy experiment H, where both regions employ a SFS formula. Consider the second term of [5.7]. The total change in corporate taxable profits was

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[76] A market *region* is meant as a region in which most firms are "market firms," as defined previously, and the effect of an increase in the sales factor weight, exclusive of policy-induced shifts in sales and production, is to apportion more taxable profits to the region. Of course, it remains the case that sales must be equal to income net of taxes in all regions. That is, budget constraints are always met with equality in every region.

$\sum_i \Delta\pi^i = -\$266.72$, and the loss was shared across regional tax bases with $\sum_i \bar{\Phi}_N{}^i \Delta\pi^i = -\$130.65$ going to the North and $\sum_i \bar{\Phi}_S{}^i \Delta\pi^i = -\$136.07$ going to the South.

Now consider the first term of [5.7]. As seen in Table 5.15, the North region enjoyed a substantial corporate tax base boost of \$15,433.32 from apportionment factor effects [*i.e.*, $\Sigma\ (\Delta\phi)\pi$], while the South suffered a corporate tax base drain of equal magnitude.

A large majority (\$15,120) of the apportionment factor effects shifted from the South to the North because of the relatively greater market presence in the North. As Table 5.16 demonstrates, six of eight industries had a greater market presence than production presence in the North, and when weighted by initial (taxable) profit levels, the combined positive impact of these six market industries on the North's tax base outweighed the combined negative impact of the two production industries. Of course, the reverse held true for the South.

The remainder of the apportionment factor effects, \$313.54 and -\$314.54 for the North and South, respectively, arose because of changes in regional shares of sales, payroll, and property.[77] The magnitude of apportionment factor effects relative to profits factor effects explains why the revenue changes associated with formula manipulation by some region are much more dependent on that region's choice of formula than on the

[77] Specifically, the last three terms of the following equation defining changes in ϕ_i :

$$\Delta\phi_i = \left[\frac{S_i}{S} - \left(\frac{1}{2}\right)\frac{R_i}{R} - \left(\frac{1}{2}\right)\frac{W_i}{W}\right] + \bar{\sigma}_i\left[\frac{\Delta S_i}{S} - \frac{S_i}{S}\frac{\Delta S}{S}\right] + \bar{\rho}_i\left[\frac{\Delta R_i}{R} - \frac{R_i}{R}\frac{\Delta R}{R}\right] + \bar{\lambda}_i\left[\frac{\Delta W_i}{W} - \frac{W_i}{W}\frac{\Delta W}{W}\right]$$

TABLE 5.15
Tax Base Effects and Apportionment Effects on Corporate Tax Collections (BASE)

Region	Apportionment Factor Effects $\Sigma(\Delta\phi/\Delta\sigma)\pi$	Profits Factor Effects $\Sigma\phi(\Delta\pi/\Delta\sigma)$	Total Effects $\Sigma(\Delta\phi/\Delta\sigma)\pi+\Sigma\phi(\Delta\pi/\Delta\sigma)$
North	15,433.32	-130.65	15,302.67
South	-15,433.32	-136.08	-15,569.40

TABLE 5.16
Effects of Being a Market Region on North's Corporate Tax Base (BASE)

Industry	$\frac{S_i}{S} - \left(\frac{1}{2}\right)\frac{R_i}{R} - \left(\frac{1}{2}\right)\frac{W}{W}$	$\Delta\sigma$	$\bar{\pi}$	Market Region Effect
Agriculture	0.1145	2/3	38,430	2,934
Mining	0.4609	2/3	68,332	20,996
Construction	0.0908	2/3	51,677	3,128
Manufacturing	- 0.0339	2/3	491,863	- 11,131
TPU	0.0240	2/3	347,160	5,554
Trade	0.0133	2/3	389,019	3,437
FIRE	- 0.0342	2/3	436,446	- 9,947
Services	0.0007	2/3	330,520	149
Total				15,120

policy choices of other regions.

Simulations with alternative regional specifications suggest that region size is an important factor in determining the magnitude of revenue impacts with disproportionate sales factor weighting, but is not a factor in determining the direction of the impacts.[78] As shown in Table 5.17, in almost every experiment the smaller regions saw revenue impacts of much larger magnitude than did the large regions, almost 40 times the magnitude in some cases.

TABLE 5.17
Region Size and Government Revenue Effects

Experiment	Southwest Specification		Far West Specification		Great Lakes Specification	
	SW	ROUS	FW	ROUS	GL	ROUS
(A) DWS L, EWF S	-0.1037	0.1989	-0.0751	-0.1704	-0.0820	0.0421
(B) EWF L, DWS S	-1.8824	0.0026	0.8220	0.0135	-0.2050	0.0202
(C) DWS L, DWS S	-1.9707	0.2016	0.7550	-0.1556	-0.2786	0.0636
(D) SFS L, DWS S	-2.2262	0.7860	0.5611	-0.6818	-0.4930	0.1769
(E) DWS L, SFS S	-7.6081	0.2098	3.1081	-0.0100	-1.0198	0.1386
(F) SFS L, EWF S	-0.4053	0.7831	-0.2931	-0.7004	-0.3216	0.1517
(G) EWF L, SFS S	-7.5664	0.0105	3.1507	0.0656	-0.9718	0.0914
(H) SFS L, SFS S	-7.7248	0.7949	2.9874	-0.6144	-1.1576	0.2634

This result is consistent with the theoretical findings of Kanbur and Keen (1993), who argue that small regions perceive a more elastic response to tax policy, and hence have

[78] A new regional specification given by the Great Lakes BEA region and the rest of the U.S. is included here because results from the SW-ROUS and FW-ROUS specifications alone were not sufficient to either assert or to rule out an important role for region size. The Great Lakes region consists of Illinois, Indiana, Michigan, Ohio, and Wisconsin.

more to gain or lose from a given tax policy than do large regions. Nevertheless, there does not appear to be a clear pattern relating region size to the direction of revenue impacts. As was the case in the BASE specification, whether a region gained or lost corporate tax revenues with an aggressive formula apportionment policy depended on the relative "market presence" *vs.* "production presence" of industry in that region. As demonstrated in Table 5.17, the more "market-intensive" regions (SW, FW, and ROUS-GL) improved their corporate tax revenue position with a heavier weight on the sales factor, while the more "production-intensive" regions suffered revenue losses when they pursued an aggressive policy.

Welfare Effects

Thus far the analysis of simulation results has concentrated on the economic development and revenue aspects of formula manipulation; however, central to any economic analysis of government policy is a discussion of welfare impacts, which are the subject of this section.

As mentioned in the model development section of the paper (Chapter 3), an endogenous lump sum tax adjustment mechanism was put in place to balance the government's (constant) budget. The choice of a lump sum adjustment was an effort to isolate the effects of apportionment formula policies from the effects of the adjustment mechanism. Nevertheless, it was also argued that lump sum adjustments are not realistic because states are likely to recoup any lost revenues *via* some other distortionary tax. For this reason, in the welfare analysis that follows, simulation results are presented for cases of both lump sum tax and personal income tax adjustments.

Endogenous Lump Sum Tax Adjustment

Table 5.18 shows welfare changes in each region and changes in national welfare (as measured by the percentage change in the sum of regional welfare; see Chapter 3) for all of the policy experiments undertaken in this analysis.

TABLE 5.18
Summary Simulation Results
Regional and National Welfare (BASE)

Policy	North		South		National
	EV*	%ΔV**	EV	%ΔV	%ΔV
(A) DWS N, EWF S	-35,063	-0.0131	35,283	0.0121	0.000033
(B) EWF N, DWS S	26,765	0.0100	-27,118	-0.0093	-0.000042
(C) DWS N, DWS S	8,030	-0.0030	8,165	0.0028	0.000015
(D) SFS N, DWS S	-114,020	-0.0426	113,722	0.0390	-0.000022
(E) DWS N, SFS S	72,802	0.0272	-73,482	-0.0252	-0.000135
(F) SFS N, EWF S	-141,053	-0.0527	140,840	0.0483	-0.000073
(G) EWF N, SFS S	107,597	0.0402	-108,765	-0.0373	-0.000260
(H) SFS N, SFS S	-32,654	-0.0122	32,659	0.0112	0.000037

* EV is equivalent variation, measured in thousands of dollars. See Chapter 3.
** V is the indirect utility function evaluated at equilibrium prices and income. See Chapter 3.

Although the equivalent variations seem quite substantial, over $100 million in many cases, the magnitude of welfare changes was actually very small when considered in relative terms. While this result is not surprising given the small economic development and revenue impacts, the direction of welfare changes deserves some comment.

Heavier weights on the sales factor benefitted the North region both in terms of economic development and revenues, yet the welfare consequences were negative in every case where the North's policy was at least as aggressive as the South's policy. The South also suffered welfare losses when it pusued the more aggressive policy, despite its economic development gains. These welfare losses with heavier sales factor weights can be explained by looking to policy-induced changes in consumer prices and government revenues.

Table 5.19 compares changes in regional welfare with changes in the Könus cost-of-living index, disposable income, and corporate income tax collections. Because heavier weights on the sales factor push up consumer prices in the acting region, as predicted by Mieszkowski and Zodrow (1985), the cost-of-living index tended to rise in the acting region. Consumers suffer utility losses with a rise in the general price level if income does not keep pace. As seen in Table 5.19, changes in the Könus index were consistently larger, usually 100 percent larger, than changes in income for the South region, which provides much of the explanation for why the South suffered welfare losses with heavier sales factor weights and welfare gains otherwise. For the North, changes in income were larger in magnitude than changes in the Könus index in five of the eight policy experiments (A,B,C,E, and H); however, changes in income and the cost-of-living were generally of the same magnitude in the North. In cases C, E, and H, the North replaced non-distorting lump sum tax revenues with distortionary corporate income tax revenues, which explains some of the welfare losses in those cases.

Perhaps more important than the change in the overall price level (as compared to changes in income) was the policy-induced change in relative consumer prices. Changes in relative prices brought on by a change in tax structure tend to have substitution effects

TABLE 5.19
Comparison of Welfare Changes to Changes in the Cost-of-Living and Corporate Tax Revenues

Policy	North				South			
	%$\Delta\kappa$	%ΔY	%ΔCITR	%ΔV	%$\Delta\kappa$	%ΔY	%ΔCITR	%ΔV
(A) DWS N, EWF S	0.0112	0.0119	0.3953	-0.0131	-0.0621	-0.0307	-0.0505	0.0121
(B) EWF N, DWS S	-0.0046	-0.0052	-0.0212	0.0100	0.0447	0.0212	-0.3085	-0.0093
(C) DWS N, DWS S	0.0031	0.0048	0.3774	-0.0030	-0.0209	-0.0115	-0.3538	0.0028
(D) SFS N, DWS S	0.0550	0.0517	1.4991	-0.0426	-0.1636	-0.0921	-0.4728	0.0390
(E) DWS N, SFS S	-0.0071	-0.0085	0.3319	0.0272	0.1169	0.0542	-1.3148	-0.0252
(F) SFS N, EWF S	0.0753	0.0646	1.5069	-0.0527	-0.2178	-0.1055	-0.1846	0.0483
(G) EWF N, SFS S	-0.0046	-0.0013	-0.0769	0.0402	0.1928	0.0927	-1.2847	-0.0373
(H) SFS N, SFS S	0.0156	0.0208	1.4836	-0.0122	-0.0803	-0.0440	-1.3880	0.0112

(efficiency losses) that reduce consumer welfare. In all cases for both regions, there was likely some utility loss associated with changes in relative consumer prices and the substitution of corporate and noncorporate goods.

Another salient result from Table 5.19 is that the North region suffered more severe welfare losses with heavier sales factor weights than did the South, while the South generally enjoyed greater welfare gains than did the North. This result again points to changes in revenue structure: the North saw corporate income tax revenue gains with heavier sales factor weights, while the South saw corporate income tax revenue losses.

Welfare Impacts with an Endogenous Personal Income Tax Rate Adjustment

In order to see how the choice of budget-balancing tax adjustment instrument affected the welfare impacts of formula manipulation, the policy simulations were run with a personal income tax adjustment rather than a lump sum tax adjustment. Surprisingly, there was virtually no difference in welfare impacts, at most fifth or sixth order differences in percentage terms. This result suggests that changes in relative consumer prices and the overall price level had much greater effects on welfare than did changes in tax structure. Perhaps an even greater reason for similarity of results in the two models is that with a fixed labor supply and no savings, the personal income tax played out much like a lump sum tax, except to the extent that personal income tax revenues are derived from the profits of unincorporated firms.[79]

[79] Endogenizing labor supply and/or incorporating an investment sector and dynamics is beyond the scope of this model and the paper. Marginally larger welfare effects would be expected with an endogenously adjusting personal income tax rate and labor supply.

Sensitivity Analysis

Elasticity of Substitution in Location of Production

In the discussion of the model's details (Chapter 3), it was noted that there are no empirical estimates of the elasticity of substitution between production locations (δ). That being the case, a value of δ=1 was assumed in the ensuing policy analysis. The parameter δ may have nontrivial consequences for the results presented above, however, in which case there is a need to explore those consequences. A sensitivity analysis was performed on δ, and the results are presented and discussed below.

As mentioned in Chapter 3, the sensitivity analysis provided a more general functional form for the regional aggregation function q, reproduced below

$$[5.8] \quad q = \eta \left[\mu q_N^{\frac{\delta-1}{\delta}} + (1-\mu) q_S^{\frac{\delta-1}{\delta}} \right]^{\frac{\delta}{\delta-1}}$$

Various alternative values of δ were selected, then [5.8] was calibrated as follows:

$$[5.9] \quad \mu = \frac{c_N^* q_N^{\frac{1}{\delta}}}{c_N^* q_N^{\frac{1}{\delta}} + c_S^* q_S^{\frac{1}{\delta}}}$$

and

$$[5.10] \quad \eta = \frac{q}{\left[\mu q_N^{\frac{\delta-1}{\delta}} + (1-\mu) q_S^{\frac{\delta-1}{\delta}} \right]^{\frac{\delta}{\delta-1}}}$$

Keeping in mind that

$$[5.11] \quad \lim_{\delta \to 0} q = \min \{ q_N , q_S \} \qquad and \qquad \lim_{\delta \to \infty} q = q_N + q_S$$

test values for δ were chosen in such a way as to provide an idea of how the results would play out anywhere in the range (0,∞).

The results of the sensitivity analysis are presented in Table 5.20. Only one policy experiment was considered in the sensitivity analysis: North double weights the sales factor and South maintains an equally weighted formula.[80]

TABLE 5.20
Sensitivity of Policy Impacts to the Elasticity of Substitution in Location of Production
(Percent Change from Benchmark)

Elasticity of Substitution (all firms)	Sensitivity of Capital Flows		Sensitivity of Changes in the Location of Corporate Production	
	%ΔK North	%ΔK South	$\%\Delta Q_C$ North	$\%\Delta Q_C$ South
δ = 0.5	0.0528	-0.0476	0.0248	-0.0233
δ = 1.0	0.0600	-0.0540	0.0281	-0.0264
δ = 2.0	0.0710	-0.0640	0.0332	-0.0312
δ = 10.0	0.1301	-0.1172	0.0604	-0.0568

As expected, the sensitivity analysis shows that the responses of capital and production to changes in sales factor weights are sensitive to the choice of δ, but not remarkably so. Nevertheless, the sensitivity analysis suggests that we must be careful in making specific numerical estimates of policy responses based on these results in light of the absence of a reliable empirical estimate of δ. Of course, prudence is the rule for any

[80] The sensitivity in other policy experiments is obvious given the results from policy experiment A, thus all the results are not presented here.

applied general equilibrium analysis because the values of specific parameters are never known with certainty. Qualitatively the results are the same regardless of δ's value, and we can safely argue that heavier weights on the sales factor do lead to gains in capital and production, and that the magnitudes of these gains are *somewhat* dependent on the elasticity of production across regions.

Regional Mobility of Labor

As noted in earlier chapter, labor was chosen to be interregionally immobile for several reasons: (1) assures that lump sum taxes will be non-distorting, (2) provides a concise and noncontroversial measure of changes in regional welfare, (3) allows the analysis to pick up the effects of policies on fixed as well as mobile factors, and (4) provides a convenient way to capture the mobility of capital relative to labor in the real world. Nevertheless, as discussed above, a fixed labor supply restricts to some degree the change in output that is possible from an inflow of capital because any change in output is likely to push up wages. As a result, the inflow of capital from a given policy change is likely to be smaller in the immobile labor case than in mobile case.

To explore the implications of a fixed regional labor supply for the policy impacts analyzed above, policy experiments A and B (where one region imposes a double-weighted sales factor formula and the other region maintains an equally weighted formula) were simulated with a fully mobile labor supply using the BASE model. Tables 5.21 and 5.22 compare the results for the mobile labor case with the same experiments in the immobile case.

TABLE 5.21
Sensitivity of Policy Impacts to the Degree of Labor Mobility
Immobile Case
(Percent Change from Benchmark)

Policy Experiment	P_K (1)	P_L North (2)	P_L South (3)	K North (4)	K South (5)
(A) DWS N, EWF S	-0.0120	0.0275	-0.0457	0.0600	-0.0540
(B) EWF N, DWS S	0.0097	-0.0169	0.0323	-0.0404	0.0363

TABLE 5.22
Sensitivity of Policy Impacts to the Degree of Labor Mobility
Mobile Case
(Percent Change from Benchmark)

Policy Experiment	P_K (1)	P_L (2)	L North (3)	L South (4)	K North (5)	K South (6)
(A) DWS N, EWF S	-0.0024	-0.0005	0.0579	-0.0546	0.0804	-0.0724
(B) EWF N, DWS S	0.0095	0.0082	-0.0389	0.0367	-0.0540	0.0487

Allowing labor to be geographically mobile resulted in capital flows of larger magnitude than in the immobile labor case; however, differences were not substantial. Based on these results, we can argue that increased sales factor weights will yield greater inflows of capital to the acting region when labor is also mobile, or more generally, in the relatively longer run because all factors are increasingly mobile with time. Perhaps more importantly, these results show that disproportionate sales factor weighting is likely to result in a net inflow of labor to the acting region. Finally, although this analysis utilizes a full-employment model of the economy and therefore cannot explicitly consider the implications of disproportionate sales factor weighting for unemployment, the results suggest that some unemployment may be alleviated with an aggressive formula apportionment policy.

Statutory Corporate Income Tax Rates

A common theme throughout the discussion of simulation results is that the effects of placing heavier weights on the sales factor in corporate income apportionment formulas are very small. Much of the reason for these small effects is the small portion of total factor costs made up by the excise effects of formula-apportioned corporate income taxes.

As mentioned in Chapter 4, shares of total gross receipts were used as the basis for assigning shares of industrial activity to corporations and unincorporated businesses. The calibrated statutory corporate income tax rates for the North and South regions, 1.22 percent and 0.83 percent, respectively, are lower than the tax rates imposed by most states. To examine the sensitivity of economic development effects to statutory tax rates, policy experiment A was simulated with higher statutory rates. The results of the sensitivity analysis are presented in Table 5.23.

TABLE 5.23
Sensitivity of Policy Impacts to Statutory Corporate Tax Rates
Policy Experiment A (BASE)

Experiment	North		South	
	%Δ K	%Δ Q_C	%Δ K	%Δ Q_C
Original Corporate Tax Rate	0.0600	0.0281	-0.0540	-0.0264
Corporate Tax Rate Doubled	0.1212	0.0567	-0.1090	-0.0532
Corporate Tax Rates Tripled	0.1837	0.0859	-0.1649	-0.0805
Corporate Tax Rates Quadrupled	0.2476	0.1157	-0.2219	-0.1083

As expected, the sensitivity analysis shows that the responses of capital and production to changes in sales factor weights are somewhat sensitive to statutory corporate income tax rates. Appearances suggest that percentage changes in capital stocks and corporate production following a policy change are proportional to the corporate tax rate. Hence, for any tax rate θt, we would expect the magnitude of the vector economic development effects to be $\theta\vec{\epsilon}$ if the effects with a tax rate of t are given by $\vec{\epsilon}$.

CHAPTER 6
OPTIMAL FORMULA-APPORTIONMENT POLICIES: A GAME-THEORETIC APPROACH

This chapter sets out to find the optimal formula apportionment policy for a state, given the likely responses of other states. Optimality is explored from several angles, including economic development, revenues, and welfare. The data for the analysis are the simulation results presented and discussed in Chapter 5. When relevant, the optimal policy is related to important regional characteristics to provide a more general analysis.

Economic Development Perspective

The first question we pose is: "Which formula apportionment policy provides the greatest economic development gains, given the likely responses of other states. Table 6.1 presents the capital inflow payoff matrix, in relative terms, for all possible policy states.

TABLE 6.1
Game Matrix, Capital Stocks
BASE Model

		South Region		
		EWF	DWS	**SFS**
North Region	EWF	0,0	-0.0404,0.0363	-0.1614,0.1454
	DWS	0.0600,-0.0540	0.0196,-0.0177	-0.1014,0.0914
	SFS	0.2400,-0.2161	0.1995,-0.1797	**0.0784,-0.0706**

The game matrix in Table 6.1 shows that from an economic development perspective, a dominant-strategy equilibrium exists at (SFS,SFS). In other words, North's best policy is a SFS formula regardless of the policy chosen by South. Likewise, South's best policy is a SFS formula regardless of the strategy chosen by North. This result provides a strong explanation for the recent trends in states moving to heavier weights on the sales factor and suggests that over the long-run, all states will eventually move to a SFS formula. Because the payoffs in terms of output differ from the payoffs in Table 6.1 only in scale, we know that (SFS,SFS) is a dominant-strategy equilibrium in the output case as well. Tables 6.2 and 6.3 shows that the (SFS,SFS) equilibrium holds regardless of region size or differences in statutory tax rates across regions.

TABLE 6.2
Game Matrix, Capital Stocks
SWROUS Model

		Southwest Region		
		EWF	DWS	**SFS**
Rest of U.S.	EWF	0,0	-0.0021,0.0182	-0.0086,0.0726
	DWS	0.0119,-0.1006	0.0098,-0.0824	0.0033,-0.0280
	SFS	0.0475,-0.4012	0.0453,-0.3831	**0.0389,-0.3290**

TABLE 6.3
Game Matrix, Capital Stocks
FWROUS Model

		Far West Region		
		EWF	DWS	**SFS**
Rest of U.S.	EWF	0,0	-0.0208,0.0961	-0.0213,0.0984
	DWS	0.0154,-0.0714	-0.0053,0.0246	-0.0678,0.3134
	SFS	0.0617,-0.2850	0.0410,-0.1894	**-0.0213,0.0984**

Revenue Perspective

We now turn to optimal formula apportionment policies taking a revenue perspective. That is, if a state wants to maximize its corporate income tax revenues, what is its optimal policy, given the likely responses of other states? Table 6.4 presents the revenue payoff matrix, in relative terms, for all possible policy states.

TABLE 6.4
Game Matrix, Corporate Income Tax Revenues
BASE Model

		South Region		
		EWF	DWS	SFS
North Region	EWF	0,0	-0.0212,-0.3085	-0.0769,-1.2847
	DWS	0.3953,-0.0505	0.3774,-0.3538	0.3319,-1.3148
	SFS	**1.5069,-0.1846**	1.4991,-0.4728	1.4836,-1.3880

As was the case for economic development, we see from the payoff matrix in Table 6.4 that a dominant-strategy equilibrium exists from the perspective of corporate income tax revenues. In this case, however, the equilibrium is at (SFS,EWF). The North region is always best off with a single-factor sales formula, and the South is always best off with an equally weighted formula. We know from the discussion in Chapter 5 that the magnitudes of any region's revenue gains/losses has more to do with own policy decision than the decision of the other region. It is not surprising, therefore, that both regions have a dominant revenue strategy. We also know from the discussion in Chapter 5 that the North benefitted with higher weights on the sales factor because the corporate sector has a larger market presence in the North than it does a production presence. Of course, the reverse holds true for the South. Based on the result from Table 6.4, we can assert that the optimal strategy from a revenue perspective is SFS for market states and EWF for production states.

Welfare Perspective

Finally, we now look at optimal formula apportionment policies from the perspective of regional welfare, where the pertinent question is: "Given the likely responses of other states, what formula apportionment policy maximizes the general welfare of the region?" Table 6.5 presents the welfare payoff matrix, in relative terms, for all possible policy states.

TABLE 6.5
Game Matrix, Welfare
BASE Model

		South Region		
		EWF	DWS	SFS
North Region	**EWF**	**0,0**	0.0100,-0.0093	0.0402,-0.0373
	DWS	-0.0131,0.0121	-0.0030,0.0028	0.0272,-0.0252
	SFS	-0.0527,0.0483	-0.0426,0.0390	-0.0122,0.0112

Again we have a dominant-strategy equilibrium, this time at (EWF,EWF). Welfare is highest in the North region with an equally weighted formula, regardless of the policy chosen by South, and welfare is highest in the South region with an equally weighted formula, regardless of the policy chosen by North. This result suggests that state governments are pursuing goals other than the general well-being of their constituents when choosing a formula apportionment policy. Most likely, they have not adequately considered the impact of rising prices, product substitution, and possibly changing revenue structure (due to revenue effects) on general welfare in their states. Although national welfare was more or less unchanged, regardless of the policy state-of-the-world, (SFS,SFS) actually maximized national welfare (%Δ = 0.000037). In general, national welfare was enhanced when regions pursued identical policies.

Summary

The results from the game-theoretic analysis indicate that state governments must weigh conflicting objectives when deciding on an apportionment formula for their states. The best policy from an economic development perspective may be very different from the optimal policy from revenue and welfare perspectives. It is interesting to note, however, that the most common policy in force today is the double-weighted sales factor formula, which is never optimal. Most likely, states are attempting to balance these conflicting objectives when making their policy choices.

CHAPTER 7
CONCLUSIONS AND DIRECTIONS FOR FUTURE RESEARCH

Having presented the theoretical foundations, developed and calibrated a model, simulated policy changes, and interpreted the results, the goal of this chapter is to tie the analysis together with some general conclusions. The first section highlights themes from the simulation results in an effort to put the results and their interpretation in perspective. A summary statement is then presented, followed by directions for future research.

Major Themes

A substantial number of policy experiments and model specifications were utilized in the preceding analysis. While such a broad analysis allows for richer interpretation and a comprehensive examination, it is easy to become lost in the detail. This section presents generalizations of the results in an effort to provide a more concise account of the impacts of formula manipulation on economic development, government revenues, and regional and national welfare. Moreover, because the numerical results from *any* applied general equilibrium model are sensitive to structure, data, and parameter values, we should put more faith in the general conclusions than in specific numerical estimates of policy impacts.

Economic Development Impacts

Magnitudes of the Policy Impacts

Perhaps the most important result from this dissertation is that the magnitudes of economic development impacts are small, regardless of the specific formula apportionment policy chosen. In no case did any of the policy experiments result in an inflow (outflow) of capital or increase (decrease) in production of greater than 0.24

percent. The reason for the small magnitudes is that tax differentials are a very small portion of total production costs, and as a result, changes in these tax differentials have very little impact on the costs of production across regions. It is important to keep in mind, however, that economic development impacts are greater the greater are the elasticities of substitution in location of production, the more mobile is the labor force, and the higher is the average statutory corporate income tax rate.

Factor Prices and Factor Substitution

The direction of changes in the nation-wide price of capital depend on whether the acting region is a market region or a production region. For regions in which corporations have a greater market presence, a heavier weight on the sales factor tends to over-apportion total corporate income ($\Sigma\phi > 1$), raise the average corporate income tax rate, and subsequently, depress the nation-wide return to capital. Likewise, for production regions, a heavier weight on the sales factor tends to under-apportion total corporate income ($\Sigma\phi < 1$), lower the average corporate tax rate, and raise the nation-wide price of capital. All else equal, disproportionate sales factor weighting in a high-tax region tends to also raise the average corporate tax rate, but this effect is not as important as the relative sales and production intensities of the acting region.

Lower implicit excise taxes on labor result in an increase in the demand for labor in the acting region, as do the capital inflows. Because labor is immobile, the price of labor in the acting region rises. The factor price ratio (p_L/p_K) rises in the acting region even in cases where the price of capital increases, which tends to cause some substitution of capital for labor in the acting region, even for unincorporated firms.

Origin and Destination

For industries in which gross receipts are sitused at destination, heavier weights on the sales factor unequivocally decrease the cost of production in the acting region, encouraging capital inflows and increased production there (factor tax effect). For industries in which gross receipts are sitused at origin, however, the cost-decreasing effects of lower implicit excise taxes on capital and labor are countered by the increased "production tax" that arises from the sales portion of the apportionment formula. If the "production tax" effect dominates, as is likely to be the case, production is discouraged for origin-based firms when heavier weights are placed on the sales factor. Because of the counter-veiling effects, however, the negative impacts on origin-based firms generally are much smaller in magnitude than the positive impacts on destination-based firms.

Variations Across Industries

The degree to which an industry increases its use of capital in the acting region is determined in large part by two factors: the industry's capital-labor ratio and the change in the industry's gross-of-tax price of capital. Capital-intensive firms and firms with the smallest shares of their total property in the acting region see the largest gains from heavier sales factor weights. Capital-intensive industries also tend to substitute labor for capital in the acting region, while labor-intensive industries are likely to see their capital-labor ratios increase in the acting region.

Treatment of Local and National Industries

Industries that sell relatively more than they produce in a given region see their tax liabilities increase with a greater weight on the sales factor in that region, which suggests that placing a disproportionately heavy weight on the sales factor favors firms that are relatively production-intensive in the acting region. Nevertheless, all firms are encouraged to produce more in the acting region, regardless of the distribution of their sales and production activities across regions. Tax liabilities in the non-acting region decrease for all firms because of shifts in production to the acting region.

Because formula manipulation does not directly impact the effective tax rate for entirely local firms ($\phi_i = 1$), heavier sales factor weights affect local corporations in the same way that they affect unincorporated firms. Local corporations do utilize more capital in the acting region with heavier sales factor weights, but the increased capital utilization is a response only to changes in relative factor prices (p_K falls relative to p_L). For national corporations, the increased capital utilization arises not only from changes in relative factor prices, but also from the shift in production to the acting region that corresponds to changes in the implicit excise tax differentials on property.

Region Size and Statutory Corporate Income Tax Rates

Small regions gain relatively more capital when they employ the more aggressive formula apportionment policy, and lose relatively more when they impose the less aggressive policy, than do large regions. This result suggests that capital is more elastic in small regions than in large regions. Small regions also tend to see greater shifts in production.

High-tax regions tend to gain more capital when they employ the more aggressive policy than they lose when imposing the less aggressive policy. When a high-tax region increases its sales factor weight, existing tax differentials on property are diminished, and therefore excise effects become smaller relative to total factor costs. Likewise, when a low-tax region increases its sales factor weight, tax differentials are exacerbated, and hence excise effects become larger relative to total factor costs.

Revenue Impacts

Perhaps the most important result from this analysis is that the revenue effects of formula manipulation are much more substantial than are economic development and welfare effects. For example, with single-factor sales formulas, revenue changes in the simulations were on the order of ± 1.5 percent for both regions, while economic development impacts were less than 0.24 percent in all cases, and welfare impacts were even smaller. This result suggests that states may have over-estimated the impact that these apportionment formula policies have on economic development, while at the same time, states may be paying too little attention to the revenue consequences.

There are several factors that determine the revenue position of a region following a change in its apportionment policy. First, if the acting region is a market region, then placing a heavier weight on the sales factor will lead to greater corporate income tax revenues. Second, to the extent that placing a heavier weight on the sales factor drives away sales in the region, corporate tax revenues will be diminished because a reduction in S_j/S implies a reduction in ϕ_j. Finally, to the extent that a weightier sales factor encourages an inflow of capital or increases wages, corporate tax revenues will be enhanced through increases in R_j/R and W_j/W.

Welfare

Although they encourage economic development and in some cases may increase corporate tax revenues, heavier sales factor weights tend to decrease the general welfare of the acting region. The main culprit in these welfare losses, which are small in magnitude, is consumer prices. Heavier sales factor weights push up consumer prices in the acting region, thereby increasing the cost-of-living. Consumers in the acting region suffer utility losses to the extent that income does not rise proportionately. Moreover, changes in relative prices generally reduce welfare through efficiency losses. Changes in tax structure also have a role in the welfare losses for some regions. For regions seeing corporate tax gains, any substitution away from less distortionary tax instruments is likely to diminish welfare. Welfare losses in one region tend to be offset by gains in other regions, so the impact of formula manipulation on national welfare is approximately nil.

Conclusion

The reasoning behind the push to greater weights on the sales factor in corporate income apportionment formulas is sound, as the effects of these policies are clearly positive from the economic development perspective of a single region. What probably is unreasonable is the belief by proponents that double-weighting the sales factor or switching to a single-factor sales formula will be a *substantial*, or even noticeable boon to economic development. Moreover, for states that would see revenue losses, the policy is likely to do more harm than good. If states decide that economic development is a goal which they want to pursue, they may find more efficacious alternatives outside of the corporate tax arena.

As mentioned in the introduction to this paper, the competition among states and localities for economic development has been intense in recent years, and the competition is not likely to diminish. As states continue to clamor for businesses, they should be careful not to rush into the latest economic development craze unheeded. Most tax reductions are going to encourage economic development, but to what degree and at what cost? These are the questions that policy makers should be addressing.

Directions for Future Research

Although this dissertation is a rather comprehensive study of the economic effects of apportionment formula manipulation, important work remains to be done. Many of the results presented and discussed in this document lend themselves readily to extensions. First, the results of this analysis suggest that double-weighted sales factors and single-factor sales formulas have very little impact on regional economic development, especially relative to revenue impacts. That being the case, one must wonder about the efficacy of other tax policies intended to encourage industrial location and expansion. A natural extension of this paper would be to broaden the analysis to a portfolio of tax incentives to see which tax policies are likely to be most effective in terms of economic development. A further extension would compare tax incentive with direct expenditure policies such as workforce development, infrastructure, and marketing.

In the introduction to the paper, it was noted that formula apportionment has the benefits of being less conducive to income shifting and administratively less costly than separate accounting, and that thoughts have been given to using formula apportionment at the federal level to tax the income of multinational corporations. The CGE model developed for this paper could easily be altered to examine the impact of a federal shift to formula apportionment.

Finally, the relationship between region size and tax policy has received much attention recently in the economics literature, but little or no attention has been paid to the role of region size in the efficacy of economic development initiatives. The results from this analysis suggest that small regions may have much more to gain from aggressive economic development policies than large regions, and perhaps much more to lose from being left on the downside of an uneven playing field. An interesting extension would be to explore the consequences of regions size for other economic development policies.

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APPENDICES

APPENDIX I
DERIVATION OF FACTOR DEMAND FUNCTIONS

CES Functions

We begin by writing down the profit maximization condition

$$[AI.1] \quad \max \ \pi = p\,\alpha \left[\gamma L^{\rho} + (1-\gamma) K^{\rho} \right]^{\frac{1}{\rho}} - rK - wL$$

Differentiating with respect to K gives

$$[AI.2] \quad \frac{\partial \pi}{\partial K} = p\,\alpha\,[\,\cdot\,]^{\frac{1}{\rho}} (1-\gamma) K^{\rho-1} - r = 0$$

Next we take both sides of the second equality to the $\frac{1}{1-\rho}$ power, giving

$$[AI.3] \quad [\, p\,\alpha (1-\gamma)\,]^{\frac{1}{1-\rho}} [\,\cdot\,]^{\frac{1}{\rho}} K^{-1} = r^{\frac{1}{1-\rho}}$$

We then rewrite α as $\alpha^{\frac{1}{1-\rho}} = \alpha \cdot \alpha^{\frac{\rho}{1-\rho}}$, substitute into [AI.3], and solve for K:

$$[AI.4] \quad K = \left[\frac{p(1-\gamma)}{r} \right]^{\frac{1}{1-\rho}} \alpha^{\frac{\rho}{1-\rho}} q = \left[\frac{p(1-\gamma)}{r} \right]^{\sigma} \alpha^{1-\sigma} q$$

where $\sigma = \frac{1}{1-\rho}$. By similar manipulation, we find the labor demand function is

$$[AI.5] \quad L = \left[\frac{p\,\gamma}{w} \right]^{\sigma} \alpha^{1-\sigma} q$$

Cobb-Douglas Functions

We begin by writing down the profit maximization condition

$$[AI.6] \quad \max \ \pi = p\,\alpha L^{\gamma} K^{1-\gamma} - rK - wL$$

Differentiating with respect to K gives

$$[AI.7] \quad \frac{\partial \pi}{\partial K} = p\,\alpha (1-\gamma)\,\alpha L^{\gamma} K^{1-\gamma} - r = 0$$

Solving [AI.7] for K gives

$$[AI.8] \quad K = \left[\frac{p(1-\gamma)}{r} \right] q$$

By similar manipulation, we find the labor demand function is

$$[AI.9] \quad L = \left[\frac{p\gamma}{w} \right] q$$

APPENDIX II
SAMPLE GAMS PROGRAMS

Main program [base.gms]

```
* base.gms

$OFFSYMLIST OFFSYMXREF OFFUELLIST OFFUELXREF
OPTIONS LIMCOL=0, LIMROW=0;
OPTION decimals=8;
OPTION SOLPRINT=OFF;

* CALIBRATE THE MODEL

$INCLUDE /u02/edmiston/calbase.inc

POSITIVE VARIABLES
        PCC(I,R), DEM(I,S,R), CDEM(I), DL(I,S,R), DK(I,S,R), CAPY, PCY(R), PITR(R), CPR(I),
        CITR(R), GREV(R), SLK(R), QN(I,R), QCR(I,R), QC(I), PL(R), PK, PC(I), PN(I,R)
        KSTAR(I,R), LSTAR(I,R), CSTAR(I,R), QSTAR(I,R);

FREE VARIABLES
        OMEGAM
        HTAX(R);

PL.L(R) = 1.0000;
PK.L = 1.0000;
PL.LO(R) = 0.01;
PK.LO = 0.01;
PC.L(I) = 1.0000;
PC.LO(I) = 0.01;
PCC.L(I,R) = PC.L(I)/(1-TT(I,'CORP')-TG(I,'CORP',R));
PCC.LO(I,R) = 0.01;
PN.L(I,R) = 1.0000;
PN.LO(I,R) = 0.01;
HTAX.L(R) = BHTAX(R);
DEM.L(I,S,R) = CON(I,S,R)+GOV(I,S,R);
CDEM.L(I) = SUM(R, DEM.L(I,'CORP',R));
KSTAR.L(I,R) = BKST(I,'CORP',R);
KSTAR.LO(I,R) = 0.01;
LSTAR.L(I,R) = BLST(I,'CORP',R);
LSTAR.LO(I,R) = 0.01;
CSTAR.L(I,R) = BCST(I,'CORP',R);
CSTAR.LO(I,R) = 0.01;
QSTAR.L(I,R) = BQST(I,R);
QSTAR.LO(I,R) = 0.01;
DL.L(I,S,R) = BLB(I,S,R);
DL.LO(I,S,R) = 1.0000;
DK.L(I,S,R) = BKP(I,S,R);
DK.LO(I,S,R) = 1.0000;
CAPY.L = BTOTKAP;
PCY.L(R) = BPCY(R);
PITR.L(R) = PITRe(R);
```

```
CITR.L(R) = CITRe(R);
GREV.L(R) = PITR.L(R)+CITR.L(R)+HTAX.L(R);
QN.L(I,R) = BOP(I,'NONC',R);
QCR.L(I,R) = BOP(I,'CORP',R);
QCR.LO(I,R) = 1.0000;
QC.L(I) = ZET(I)*(QCR.L(I,'NORTH')**MU(I))*(QCR.L(I,'SOUTH')**(1-MU(I)));
OMEGAM.L = SUM(R, HTAX.L(R));


EQUATIONS
        EM0(I,R), EM1(I,R), EM2(I,R), EM3(I), EM4(I,R), EM5(I,R), EM6(I,R), EM7(I,R), EM8a(I,R),
        EM8b(I), EM8c(I), EM9(I,R), EM10(I,R), EM11a(I,R),
        EM11b(I,R), EM12(I,R), EM13(I,R), EM14a(I,R), EM14b(I,R), EM15, EM16(R),
        EM17(R), EM18(I), EM19(R), EM20(R), EM21a(I,R), EM21b(I,R), EM22a(I,R), EM22b(I,R),
        EM23(I), EM24(R), EM25, EM26(I), EM27(I,R), EM28(R), EMOBJ;

* Definitions

EM0(I,R).. PCC(I,R) =E= PC(I)/(1-TT(I,'CORP')-TG(I,'CORP',R));
EM1(I,R).. DEM(I,'CORP',R) =E= ((PSI(I,'CORP',R)*BET(I,R)*PCY(R))/PCC(I,R))+GOV(I,'CORP',R);
EM2(I,R).. DEM(I,'NONC',R) =E= ((PSI(I,'NONC',R)*BET(I,R)*PCY(R))/PN(I,R))+GOV(I,'NONC',R);
EM3(I).. CDEM(I) =E= SUM(R, DEM(I,'CORP',R));
EM4(I,R)$(SIG(I) NE 1.0000).. KSTAR(I,R) =E= ((1/ALP(I,'CORP',R))*(((GAM(I,'CORP',R)*((((1-
        GAM(I,'CORP',R))*PL(R)*(1-TT(I,'CORP')+TL(I,'CORP',R)))/(GAM(I,'CORP',R)*PK*(1+
        TK(I,'CORP',R))))**(1-SIG(I))))+(1-GAM(I,'CORP',R)))**(SIG(I)/(1-SIG(I)))));
EM5(I,R)$(SIG(I) EQ 1.0000).. KSTAR(I,R) =E= ((1/ALP(I,'CORP',R))*((((1-GAM(I,'CORP',R))*
        PL(R)*(1-TT(I,'CORP')+TL(I,'CORP',R)))/(GAM(I,'CORP',R)*PK*(1+TK(I,'CORP',R))))**
        GAM(I,'CORP',R)));
EM6(I,R)$(SIG(I) NE 1.0000).. LSTAR(I,R) =E= ((1/ALP(I,'CORP',R))*((((1-GAM(I,'CORP',R))*

(((GAM(I,'CORP',R)*PK*(1+TK(I,'CORP',R)))/((1-GAM(I,'CORP',R))*PL(R)*(1-TT(I,'CORP')+
        TL(I,'CORP',R))))**(1-SIG(I))))+GAM(I,'CORP',R))**(SIG(I)/(1-
        SIG(I)))));
EM7(I,R)$(SIG(I) EQ 1.0000).. LSTAR(I,R) =E= ((1/ALP(I,'CORP',R))*(((GAM(I,'CORP',R)*PK*(1+
        TK(I,'CORP',R)))/((1-GAM(I,'CORP',R))*PL(R)*(1-TT(I,'CORP')+TL(I,'CORP',R))))**
        (1-GAM(I,'CORP',R))));
EM8a(I,R).. CSTAR(I,R) =E= (((1+TK(I,'CORP',R))*PK*KSTAR(I,R))+((1-TT(I,'CORP')+
        TL(I,'CORP',R))*PL(R)*LSTAR(I,R)))/(1-TX(I,R));
EM8b(I).. QSTAR(I,'SOUTH') =E= (1/ZET(I))*(((1-MU(I))*CSTAR(I,'NORTH'))/(MU(I)*
        CSTAR(I,'SOUTH')))**MU(I);
EM8c(I).. QSTAR(I,'NORTH') =E= (1/ZET(I))*((MU(I)*CSTAR(I,'SOUTH'))/((1-MU(I))*
        CSTAR(I,'NORTH')))**(1-MU(I));
EM9(I,R)$(SIG(I) EQ 1.0000).. DL(I,'CORP',R) =E= (PC(I)*(1-TX(I,R))*GAM(I,'CORP',R)*
        QSTAR(I,R)*QC(I))/(PL(R)*(1-TT(I,'CORP')+TL(I,'CORP',R)));
EM10(I,R)$(SIG(I) NE 1.0000).. DL(I,'CORP',R) =E= (((PC(I)*(1-TX(I,R))*GAM(I,'CORP',R))/
        (PL(R)*(1-TT(I,'CORP')+TL(I,'CORP',R))))**SIG(I))*(ALP(I,'CORP',R)**
        (SIG(I)-1))*QSTAR(I,R)*QC(I);
EM11a(I,R)$(SIG(I) EQ 1.0000).. DL(I,'NONC',R) =E= (PN(I,R)*GAM(I,'NONC',R)*QN(I,R))/PL(R);
EM11b(I,R)$(SIG(I) NE 1.0000).. DL(I,'NONC',R) =E= (((PN(I,R)*GAM(I,'NONC',R))/PL(R))**
        SIG(I))*(ALP(I,'NONC',R)**(SIG(I)-1))*QN(I,R);
EM12(I,R)$(SIG(I) EQ 1.0000).. DK(I,'CORP',R) =E= (PC(I)*(1-TX(I,R))*(1-GAM(I,'CORP',R))*
        QSTAR(I,R)*QC(I))/(PK*(1+TK(I,'CORP',R)));
```

```
EM13(I,R)$(SIG(I) NE 1.0000).. DK(I,'CORP',R) =E= (((PC(I)*(1-TX(I,R))*(1-GAM(I,'CORP',R)))/
        (PK*(1+TK(I,'CORP',R))))**SIG(I))*(ALP(I,'CORP',R)**(SIG(I)-1))*QSTAR(I,R)*QC(I);
EM14a(I,R)$(SIG(I) EQ 1.0000).. DK(I,'NONC',R) =E= (PN(I,R)*(1-GAM(I,'NONC',R))*QN(I,R))/
        (PK*(1+TK(I,'NONC',R)));
EM14b(I,R)$(SIG(I) NE 1.0000).. DK(I,'NONC',R) =E= (((PN(I,R)*(1-GAM(I,'NONC',R)))/
        (PK*(1+TK(I,'NONC',R))))**SIG(I))*(ALP(I,'NONC',R)**(SIG(I)-1))*QN(I,R);
EM15.. CAPY =E= PK*BTOTKAP;
EM16(R).. PCY(R) =E= (PL(R)*BTOTLAB(R)+THE(R)*CAPY)*(1-PTAX(R))-HTAX(R);
EM17(R).. PITR(R) =E= (PTAX(R)*(PL(R)*BTOTLAB(R)+THE(R)*CAPY))+SUM(I,
(TK(I,'NONC',R)*
        DK(I,'NONC',R)));
EM18(I).. CPR(I) =E= SUM(R, (PCC(I,R)*DEM(I,'CORP',R)-PL(R)*DL(I,'CORP',R)));
EM19(R).. CITR(R) =E= CTAX(R)*SUM(I, (PHI(I,R)*CPR(I)));
EM20(R).. GREV(R) =E= PITR(R)+CITR(R)+HTAX(R);
EM21a(I,R)$(SIG(I) EQ 1.0000).. QN(I,R) =E=
ALP(I,'NONC',R)*(DL(I,'NONC',R)**GAM(I,'NONC',R))*
        (DK(I,'NONC',R)**(1-GAM(I,'NONC',R)));
EM21b(I,R)$(SIG(I) NE 1.0000).. QN(I,R) =E=
ALP(I,'NONC',R)*(((GAM(I,'NONC',R)*(DL(I,'NONC',R)**
        ((SIG(I)-1)/SIG(I))))+((1-GAM(I,'NONC',R))*(DK(I,'NONC',R)**((SIG(I)-1)/SIG(I)))))**
        (SIG(I)/(SIG(I)-1)));
EM22a(I,R)$(SIG(I) EQ 1.0000).. QCR(I,R) =E= ALP(I,'CORP',R)*(DL(I,'CORP',R)**
        GAM(I,'CORP',R))*(DK(I,'CORP',R)**(1-GAM(I,'CORP',R)));
EM22b(I,R)$(SIG(I) NE 1.0000).. QCR(I,R) =E= ALP(I,'CORP',R)*(((GAM(I,'CORP',R)*
        (DL(I,'CORP',R)**((SIG(I)-1)/SIG(I))))+((1-GAM(I,'CORP',R))*(DK(I,'CORP',R)**
        ((SIG(I)-1)/SIG(I)))))**(SIG(I)/(SIG(I)-1)));
EM23(I).. QC(I) =E= ZET(I)*(QCR(I,'NORTH')**MU(I))*(QCR(I,'SOUTH')**(1-MU(I)));

* Equilibrium Conditions

EM24(R).. BTOTLAB(R) =E= SUM((I,S), DL(I,S,R));
EM25.. BTOTKAP =E= SUM((I,S,R), DK(I,S,R));
EM26(I).. CDEM(I) =E= QC(I);
EM27(I,R).. DEM(I,'NONC',R) =E= QN(I,R);
EM28(R).. GREV(R) =E= SUM(I, (PCC(I,R)*GOV(I,'CORP',R)+PN(I,R)*GOV(I,'NONC',R)));

* Objective Function

EMOBJ.. OMEGAM =E= SUM(R, HTAX(R));

OPTION NLP=MINOS5;
OPTION BRATIO=1;
OPTION ITERLIM=2500;

MODEL CGE /EM0, EM1, EM2, EM3, EM4, EM5, EM6, EM7, EM8a, EM8b, EM8c, EM9, EM10,
        EM11a, EM11b, EM12, EM13, EM14a, EM14b, EM15, EM16, EM17, EM18, EM19, EM20,
        EM21a, EM21b, EM22a, EM22b, EM23, EM24, EM25, EM26, EM27, EM28, EMOBJ/;

SOLVE CGE USING NLP MINIMIZING OMEGAM;

* UPDATE IMPLICIT TAXES AND RESOLVE THE MODEL
$INCLUDE /u02/edmiston/ctax92.inc
```

```
SOLVE CGE USING NLP MINIMIZING OMEGAM;
* UPDATE IMPLICIT TAXES AND RESOLVE THE MODEL
$INCLUDE /u02/edmiston/ctax92.inc
SOLVE CGE USING NLP MINIMIZING OMEGAM;
* UPDATE IMPLICIT TAXES AND RESOLVE THE MODEL
$INCLUDE /u02/edmiston/ctax92.inc
SOLVE CGE USING NLP MINIMIZING OMEGAM;
* UPDATE IMPLICIT TAXES AND RESOLVE THE MODEL
$INCLUDE /u02/edmiston/ctax92.inc
SOLVE CGE USING NLP MINIMIZING OMEGAM;

$INCLUDE /u02/edmiston/policy92.inc
```

Calibration Subroutine [calbase.inc]

```
* calbase.inc

OPTION decimals=8;

SET     I       Industries
                / AGRI  Agriculture
                  MINI  Mining
                  CONT  Construction
                  MANU          Manufacturing
                  TRAN  Transportation and Utilities
                  TRAD  Wholesale and Retail Trade
                  FIRE  Finance Insurance and Real Estate
                  SERV  Services /

        Q       Inputregions
                / NE    New England
                  ME    Mideast
                  GL    Great Lakes
                  PL    Plains
                  SE    Southeast
                  SW    Southwest
                  RM    Rocky Mountain
                  FW    Far West /

        R       Regions
                / NORTH North and Northeast Census Bureau Regions
                  SOUTH South and West Census Bureau Regions /

        S       Sectors
                / CORP  Corporate
                  NONC Noncorporate /

ALIAS(R,M);
```

```
PARAMETER J(Q)       Indicator for Agregation
               / NE    1
                 ME    1
                 GL    1
                 PL    1
                 SE    2
                 SW    2
                 RM    2
                 FW    2 /;

PARAMETER
     SIG(I)   Elasticities of Substitution in Production
              / AGRI  0.8312
                MINI  1.0000
                CONT  1.0000
                MANU  0.8719
                TRAN  1.0000
                TRAD  1.0000
                FIRE  1.0000
                SERV  1.0000 /;

PARAMETER    rho(I)    Short cut var for CES functions;

rho(I)$(SIG(I) NE 1.0000) = (SIG(I)-1)/SIG(I);

TABLE QSALES(I,S,Q)   Gross Receipts of Firms

        CORP.NE          CORP.ME          CORP.GL          CORP.PL
AGRI    6690.0202        23923.7619       17164.5540       3333.8926
MINI    6154.9955        20680.4017       15978.5442       6455.7374
CONT    16539.0829       49658.1566       35819.4195       14237.0183
MANU    68072.8369       235514.8379      186098.1571      78019.4645
TRAN    33232.2469       109876.8895      87610.4854       35595.0455
TRAD    55911.2091       195593.1989      157275.8627      65255.3074
FIRE    66879.8957       231496.8731      195425.8478      81940.9584
SERV    49131.2373       169681.6968      154352.6509      65005.6810

+       CORP.SE          CORP.SW          CORP.RM          CORP.FW
AGRI    21034.9196       10038.9692       1177.2399        17435.6037
MINI    18273.3134       1339.0572        1207.5812        16751.0684
CONT    46392.4860       18733.8860       2622.7517        40081.3578
MANU    250689.2580      115827.8580      32183.9064       216003.8900
TRAN    114442.4360      51069.6348       15171.1454       100226.7883
TRAD    209445.1646      97023.0434       27373.6772       178981.6150
FIRE    262252.7308      121729.0999      32937.5829       216565.1395
SERV    205726.6344      94965.1253       24651.1072       160010.7195

+       NONC.NE          NONC.ME          NONC.GL          NONC.PL
AGRI    848.6933         2350.7893        4153.9594        5560.7246
MINI    51.2964          492.3049         969.8049         573.5170
CONT    2576.1206        9616.9080        8574.7375        3611.2387
MANU    2187.0970        6137.9383        8349.6383        2813.3017
```

```
TRAN   2411.1754      10331.7412     7899.7731      3885.4871
TRAD   5332.7652      17596.0531     15567.9340     6835.2875
FIRE   7751.1894      28458.1924     15416.9232     6013.6633
SERV   29382.1383     102769.2565    66107.7081     26866.6750

+      NONC.SE        NONC.SW        NONC.RM        NONC.FW
AGRI   7510.3136      3159.3732      2414.1993      6871.1737
MINI   4355.4594      8952.5083      1661.6141      2525.2213
CONT   12010.2307     5523.0461      5080.3934      9769.6639
MANU   9217.5341      3139.3186      672.2627       5364.0689
TRAN   12875.4744     6295.4671      1041.7285      8252.3681
TRAD   21953.3054     9869.2730      1752.6195      18062.6303
FIRE   20041.1968     8735.8926      2586.9445      23815.7354
SERV   89298.5427     40999.4474     12525.2459     91227.9563;

PARAMETER SALES(I,S,R)      Aggregate Gross Receipts;

SALES(I,S,'NORTH') = SUM(Q, QSALES(I,S,Q)$(J(Q) EQ 1));
SALES(I,S,'SOUTH') = SUM(Q, QSALES(I,S,Q)$(J(Q) NE 1));

TABLE QBLB(I,S,Q)     Benchmark Employee Compensation

       CORP.NE        CORP.ME        CORP.GL        CORP.PL
AGRI   1662.1198      4604.4758      8135.5792      10909.8655
MINI   47.2302        453.3379       892.9599       528.9999
CONT   7794.0538      29099.6402     25943.7486     10945.3552
MANU   40476.2642     113608.2463    154530.6880    52158.5078
TRAN   8990.5469      38528.8258     29456.8705     14513.7366
TRAD   32691.5441     107883.0445    95439.6078     41977.4664
FIRE   52835.9398     194009.6588    105092.9264    41065.4570
SERV   37759.0781     132085.8067    84958.0967     34588.2325

+      CORP.SE        CORP.SW        CORP.RM        CORP.FW
AGRI   14740.0246     6214.9257      4741.8664      13457.5312
MINI   4018.7911      8279.4420      1534.3615      2325.1728
CONT   36414.7343     16784.1496     15415.5562     29559.6822
MANU   170952.6074    58356.7689     12477.7428     99277.2324
TRAN   48111.5260     23578.0955     3895.6191      30772.2194
TRAD   134868.7980    60770.3310     10775.4465     110735.5066
FIRE   136903.1155    59812.4841     17685.3172     162348.4005
SERV   115003.4710    52922.3906     16143.1728     117243.5232

+      NONC.NE        NONC.ME        NONC.GL        NONC.PL
AGRI   541.9956       1501.4595      2652.9063      3557.5648
MINI   10.6499        102.2232       201.3537       119.2843
CONT   1974.2972      7371.1754      6571.7624      2772.5474
MANU   1296.7478      3639.6946      4950.7367      1671.0146
TRAN   870.6442       3731.1299      2852.6021      1405.5097
TRAD   3212.3074      10600.7077     9378.0018      4124.7524
FIRE   4929.5387      18100.9012     9805.0617      3831.3648
SERV   18773.8305     65673.1223     42241.2037     17197.2847
```

```
+       NONC.SE         NONC.SW         NONC.RM         NONC.FW
AGRI    4806.5298       2026.6062       1546.2608       4388.3254
MINI    906.1980        1866.9330       345.9835        524.3037
CONT    9224.1482       4251.5615       3904.8857       7487.7078
MANU    5476.8497       1869.5898       399.7524        3180.5685
TRAN    4659.1182       2283.3018       377.2516        2979.9805
TRAD    13252.3577      5971.3602       1058.8073       10880.9937
FIRE    12772.9195      5580.4431       1650.0219       15146.9384
SERV    57179.7773      26313.0363      8026.3927       58293.5322;

PARAMETER BLB(I,S,R)    Aggregate Benchmark Employee Compensation;

BLB(I,S,'NORTH') = SUM(Q, QBLB(I,S,Q)$(J(Q) EQ 1));
BLB(I,S,'SOUTH') = SUM(Q, QBLB(I,S,Q)$(J(Q) NE 1));

TABLE QIKP(I,S,Q)    Initial Guesses at Property

        CORP.NE         CORP.ME         CORP.GL         CORP.PL
AGRI    926.8172        2567.5090       4536.4931       6083.4672
MINI    179.0586        1718.6910       3385.3826       2005.5405
CONT    2322.2346       8670.2238       7729.9275       3261.1633
MANU    27431.1320      76993.3406      104726.8512     35348.2946
TRAN    15776.7350      67610.9119      51691.3203      25468.9040
TRAD    21293.6826      70269.7706      62164.7209      27342.0809
FIRE    29805.0745      109442.0267     59283.5580      23165.2737
SERV    21024.5004      73546.2368      47305.2212      19258.9530

+       CORP.SE         CORP.SW         CORP.RM         CORP.FW
AGRI    8219.2083       3465.5145       2644.1196       7504.0751
MINI    15236.0098      31388.9564      5817.0594       8815.1773
CONT    10849.7526      5000.8293       4593.0576       8807.2931
MANU    115856.1352     39548.9125      8456.2797       67281.0823
TRAN    84426.7656      41375.1654      6836.0859       53999.5127
TRAD    87846.9785      39582.8394      7018.6020       72127.7258
FIRE    77227.8788      33740.5855      9976.3948       91581.7186
SERV    64034.6811      29467.5315      8988.6237       65281.9567

+       NONC.NE         NONC.ME         NONC.GL         NONC.PL
AGRI    302.2230        837.2312        1479.2912       1983.7393
MINI    40.3760         387.5480        763.3706        452.2297
CONT    588.2409        2196.2382       1958.0535       826.0792
MANU    878.8178        2466.6541       3355.1593       1132.4618
TRAN    1527.8184       6547.4380       5005.7853       2466.4076
TRAD    2092.3409       6904.7856       6108.3744       2686.6632
FIRE    2780.7827       10210.8283      5531.0948       2161.2962
SERV    10453.3910      36567.2219      23520.1772      9575.5600

+       NONC.SE         NONC.SW         NONC.RM         NONC.FW
AGRI    2680.1766       1130.0591       862.2129        2446.9810
MINI    3435.5708       7077.9019       1311.6899       1987.7361
CONT    2748.3305       1266.7507       1163.4588       2230.9589
MANU    3711.7108       1267.0380       270.9159        2155.5002
```

TRAN	8175.8845	4006.7693	662.0063	5229.3106
TRAD	8631.9416	3889.4537	689.6556	7087.3504
FIRE	7205.2815	3147.9618	930.7874	8544.4799
SERV	31838.0721	14651.2699	4469.1477	32458.2181;

PARAMETER IKP(I,S,R) Aggregate Benchmark Property;

IKP(I,S,'NORTH') = SUM(Q, QIKP(I,S,Q)$(J(Q) EQ 1));
IKP(I,S,'SOUTH') = SUM(Q, QIKP(I,S,Q)$(J(Q) NE 1));

TABLE QCVLP(I,Q) Corporate VA by Location of Production

	NE	ME	GL	PL
AGRI	2602.6594	7209.0871	12738.8088	17052.8889
MINI	227.4882	2183.2652	4300.8740	2543.4232
CONT	10169.9090	37965.2561	33851.0159	14256.3078
MANU	68267.3342	191587.6119	260622.8989	87813.4860
TRAN	24898.5590	106688.8225	81575.5514	40122.7670
TRAD	54271.3714	179074.4397	158434.3397	69562.4903
FIRE	83079.0469	305021.5094	165242.1604	64455.8390
SERV	59095.1565	206695.8245	132959.8724	54035.9027

+	SE	SW	RM	FW
AGRI	23031.6285	9688.7446	7403.5446	21071.5992
MINI	19315.5157	39702.4279	7368.8973	11198.8074
CONT	47413.5225	21803.6671	20056.1800	38568.3002
MANU	287713.1150	97989.6699	20983.7887	167432.3040
TRAN	132956.2146	65008.9811	10757.2173	85216.5588
TRAD	223418.0494	100439.2585	17836.3501	183822.7792
FIRE	214806.1975	93633.3242	27727.4720	255262.5787
SERV	179602.6996	82460.6004	25191.5420	183483.2545;

PARAMETER CVLP(I,R) Aggregate Corporate Value Added;

CVLP(I,'NORTH') = SUM(Q, QCVLP(I,Q)$(J(Q) EQ 1));
CVLP(I,'SOUTH') = SUM(Q, QCVLP(I,Q)$(J(Q) NE 1));

TABLE QCEPG(I,Q) Consumer Benchmark Exp on Producer Goods

	NE	ME	GL	PL
AGRI	7427.8554	25946.0034	21081.0604	8800.8514
MINI	5249.9210	18338.3305	14899.8459	6220.3384
CONT	4956.1640	17312.2174	14066.1317	5872.2822
MANU	63138.6224	220547.4954	179194.2668	74809.4306
TRAN	27527.9075	96156.8503	78127.1910	32616.2816
TRAD	59845.9308	209045.9001	169849.2505	70908.1041
FIRE	73240.0802	255832.5736	207863.3011	86778.0844
SERV	75110.2087	262365.0593	213170.9287	88993.8952

+	SE	SW	RM	FW
AGRI	28235.4761	13076.7378	3549.6715	24042.0686
MINI	19956.5028	9242.4847	2508.8661	16992.6517

```
CONT  18839.8457      8725.3256       2368.4837       16041.8355
MANU  240008.5831     111155.5304     30173.0926      204363.5748
TRAN  104641.7207     48462.8750      13155.2142      89100.7973
TRAD  227492.0883     105358.7476     28599.5599      193705.9741
FIRE  278407.2130     128939.1446     35000.4425      237059.4107
SERV  285516.1244     132231.5053     35894.1515      243112.5383;

PARAMETER CEPG(I,R)         Aggregate Consumer Benchmark Exp on Producer Goods;

CEPG(I,'NORTH') = SUM(Q, QCEPG(I,Q)$(J(Q) EQ 1));
CEPG(I,'SOUTH') = SUM(Q, QCEPG(I,Q)$(J(Q) NE 1));

TABLE QGEPG(I,Q)     Government Benchmark Exp on Producer Goods

      NE              ME              GL              PL
AGRI  110.8581        328.5477        237.4530        93.7658
MINI  956.3708        2834.3761       2048.5033       808.9160
CONT  14159.0395      41962.8471      30328.0253      11975.9747
MANU  7121.3115       21105.2808      15253.5286      6023.3356
TRAN  8115.5148       24051.7804      17383.0675      6864.2510
TRAD  1398.0435       4143.3520       2994.5462       1182.4908
FIRE  1391.0049       4122.4918       2979.4698       1176.5374
SERV  3403.1669       10085.8940      7289.4303       2878.4608

+     SE              SW              RM              FW
AGRI  309.7571        121.6046        41.7677         264.7087
MINI  2672.2700       1049.0807       360.3292        2283.6379
CONT  39562.8710      15531.6065      5334.6615       33809.1862
MANU  19898.2090      7811.6462       2683.0765       17004.3841
TRAN  22676.1898      8902.2269       3057.6597       19378.3591
TRAD  3906.3818       1533.5688       526.7369        3338.2711
FIRE  3886.7147       1525.8479       524.0850        3321.4642
SERV  9509.0527       3733.0674       1282.2016       8126.1376;

PARAMETER GEPG(I,R)         Aggregate Government Benchmark Exp on Producer Goods;

GEPG(I,'NORTH') = SUM(Q, QGEPG(I,Q)$(J(Q) EQ 1));
GEPG(I,'SOUTH') = SUM(Q, QGEPG(I,Q)$(J(Q) NE 1));

TABLE IGBOPC(I,R,M) Initial Guesses at Output Loc Var 72DAT

      NORTH.NORTH         NORTH.SOUTH         SOUTH.NORTH         SOUTH.SOUTH
AGRI  39603.4442          1.0000              11508.7845          49686.7323
MINI  9255.0506           1.0000              40014.6282          37571.0201
CONT  96242.4888          1.0000              20011.1884          107830.4815
MANU  567705.2963         40586.0348          1.0000              574118.8777
TRAN  253285.6999         1.0000              13028.9673          280910.0046
TRAD  461342.6410         1.0000              12692.9370          512823.5002
FIRE  575743.5750         42054.9808          1.0000              591429.5724
SERV  438171.2660         14615.4900          1.0000              470738.0964;
```

```
* Calculate Corporate Property and tax rates

PARAMETER QCITRe(Q)         Corporate Income Tax Collections
                 / NE        1595.5130
                   ME        5334.0700
                   GL        4451.5700
                   PL        1221.8070
                   SE        3546.4650
                   SW        437.7520
                   RM        325.6870
                   FW        4938.3720 /;

PARAMETER CITRe(R) Aggregate Corporate Income Tax Collections;

CITRe('NORTH') = SUM(Q, QCITRe(Q)$(J(Q) EQ 1));
CITRe('SOUTH') = SUM(Q, QCITRe(Q)$(J(Q) NE 1));

PARAMETER PY(I), GR(I), PR(I), GRS(I,R), PYS(I,R), PRS(I,R), PI(I), ARS(I), ARR(I), ARW(I);

PY(I) = SUM(R, BLB(I,'CORP',R));
GR(I) = SUM(R, SALES(I,'CORP',R));
GRS(I,R) = SALES(I,'CORP',R)/GR(I);
GRS('SERV',R) = CVLP('SERV',R)/GR('SERV');
PYS(I,R) = BLB(I,'CORP',R)/PY(I);
PI(I) = GR(I)-PY(I);

POSITIVE VARIABLES
        PROPN(I)
        TPROP(I)
        PHIN(I)
        TN
        TS;

FREE VARIABLES
        OMEGA1;

PROPN.L(I) = IKP(I,'CORP','NORTH');
TPROP.L(I) = SUM(R, IKP(I,'CORP',R));
PHIN.L(I) = (1/3)*GRS(I,'NORTH')+(1/3)*PYS(I,'NORTH')+(1/3)*(PROPN.L(I)/TPROP.L(I));
TN.L = CITRe('NORTH')/SUM(I, PI(I)*PHIN.L(I));
TS.L = CITRe('SOUTH')/SUM(I, PI(I)*(1-PHIN.L(I)));
OMEGA1.L = SUM(I, TPROP.L(I));

EQUATIONS EQ11(I), EQ12(I), EQ13(I), EQ14, EQ15, OBJ1;

EQ11(I).. PROPN(I)/TPROP(I) =E= 3-SUM(R, GRS(I,R))-SUM(R, PYS(I,R))-((TPROP(I)-
        PROPN(I))/TPROP(I));
EQ12(I).. PHIN(I) =E= (1/3)*GRS(I,'NORTH')+(1/3)*PYS(I,'NORTH')+(1/3)*(PROPN(I)/TPROP(I));
EQ13(I).. TPROP(I) =E= PI(I)*(1-(TN*PHIN(I))-(TS*(1-PHIN(I))));
EQ14.. TN =E= CITRe('NORTH')/SUM(I, PI(I)*PHIN(I));
EQ15.. TS =E= CITRe('SOUTH')/SUM(I, PI(I)*(1-PHIN(I)));
OBJ1.. OMEGA1 =E= SUM(I, TPROP(I));
```

```
MODEL CORPTAX /EQ11, EQ12, EQ13, EQ14, EQ15, OBJ1/;
SOLVE CORPTAX USING NLP MAXIMIZING OMEGA1;

* Parameterize Results from CORPTAX

PARAMETER
        PHI(I,R)        Initial PHI Values
        CTAX(R)         Corp Tax Rates
        CTAX0(R)        Used For Adjusting Tax Rates
        TCPROP(I)       National Prop Corp
        BKP(I,S,R)      Benchmark Property
        PPS(I,R)        Regional Shares of Corp Prop
        SFW(R)          Sales Factor Weights
        RFW(R)          Property Factor Weight
        WFW(R)          Payroll Factor Weight
        ARS(I)          Weighted Avg Imp Sales Tax
        ARR(I)          Weighted Avg Imp Prop Tax
        ARW(I)          Weighted Avg Imp Payroll Tax
        TT(I,S)         Implicit Profits Tax
        TX(I,R)         Implicit Origin Based S Excise Tax
        TK(I,S,R)       Implicit K Excise Tax
        TL(I,S,R)       Implicit L Excise Tax
        TG(I,S,R)       Implicit Destination Based S Excise Tax;

SFW('NORTH') = 1/3;
SFW('SOUTH') = 1/3;
RFW('NORTH') = 1/3;
RFW('SOUTH') = 1/3;
WFW('NORTH') = 1/3;
WFW('SOUTH') = 1/3;
PHI(I,'NORTH') = PHIN.L(I);
PHI(I,'SOUTH') = 1-PHIN.L(I);
CTAX('NORTH') = TN.L;
CTAX('SOUTH') = TS.L;
CTAX0(R) = CTAX(R);
TCPROP(I) = TPROP.L(I);
BKP(I,'CORP','NORTH') = PROPN.L(I);
BKP(I,'CORP','SOUTH') = TPROP.L(I)-PROPN.L(I);
PPS(I,R) = BKP(I,'CORP',R)/TCPROP(I);
ARS(I) = CTAX('NORTH')*SFW('NORTH')*GRS(I,'NORTH')+
CTAX('SOUTH')*SFW('SOUTH')*GRS(I,'SOUTH');
ARR(I) = CTAX('NORTH')*RFW('NORTH')*PPS(I,'NORTH')+
CTAX('SOUTH')*RFW('SOUTH')*PPS(I,'SOUTH');
ARW(I) = CTAX('NORTH')*WFW('NORTH')*PYS(I,'NORTH')+
CTAX('SOUTH')*WFW('SOUTH')*PYS(I,'SOUTH');
TT(I,'CORP') = CTAX('NORTH')*PHI(I,'NORTH')+CTAX('SOUTH')*PHI(I,'SOUTH');
TG(I,'CORP',R) = (PI(I)/GR(I))*((CTAX(R)*SFW(R))-ARS(I));
TK(I,'CORP',R) = (PI(I)/TCPROP(I))*((CTAX(R)*RFW(R))-ARR(I));
TL(I,'CORP',R) = (PI(I)/PY(I))*((CTAX(R)*WFW(R))-ARW(I));
TX(I,R) = 0;
TX('SERV',R) = TT('SERV','CORP')+TG('SERV','CORP',R);
TG('SERV','CORP',R) = 0;
```

```
TL('SERV','CORP',R) =
(PI('SERV')/PY('SERV'))*((CTAX(R)*WFW(R))-ARW('SERV'))-(CTAX('NORTH')*
        PHI('SERV','NORTH')+CTAX('SOUTH')*PHI('SERV','SOUTH'));
TT('SERV','CORP') = 0;

* Calculate Personal Income Tax Rates, NonCorp Prop,
*         and Regional Prop Shares

PARAMETER QPCE(Q)          Personal Consumption Expenditure
                   / NE    316496.6900
                     ME    1105544.4300
                     GL    898251.9760
                     PL    374999.2680
                     SE    1203097.5540
                     SW    557192.3510
                     RM    151249.4820
                     FW    1024418.8510 /;

PARAMETER QBHTAX(Q)        Benchmark Head Tax Collections
                   / NE    26480.7930
                     ME    76191.0470
                     GL    56100.3550
                     PL    21922.0130
                     SE    81702.6240
                     SW    36867.0410
                     RM    10234.4740
                     FW    62429.9230 /;

PARAMETER QPITRe(Q)        Benchmark Personal Income Tax Collections
                   / NE    8579.0040
                     ME    27109.4530
                     GL    17962.0990
                     PL    7859.9120
                     SE    17172.3570
                     SW    2903.8560
                     RM    3250.3570
                     FW    20157.8540 /;

PARAMETER
        EMPCOMP(R)  Employee Compensation
        NPI(I,R)    NonCorp Taxable Profits
        PCE(R)      Personal Consumption Exp
        BHTAX(R)    Head Taxes
        CPRET       Corp Prop Returns
        PITRe(R)    Personal Income Tax Revenues;

EMPCOMP(R) = SUM((I,S), BLB(I,S,R));
NPI(I,R) = SALES(I,'NONC',R)-BLB(I,'NONC',R);
PCE('NORTH') = SUM(Q, QPCE(Q)$(J(Q) EQ 1));
PCE('SOUTH') = SUM(Q, QPCE(Q)$(J(Q) NE 1));
BHTAX('NORTH') = SUM(Q, QBHTAX(Q)$(J(Q) EQ 1));
BHTAX('SOUTH') = SUM(Q, QBHTAX(Q)$(J(Q) NE 1));
```

```
PITRe('NORTH') = SUM(Q, QPITRe(Q)$(J(Q) EQ 1));
PITRe('SOUTH') = SUM(Q, QPITRe(Q)$(J(Q) NE 1));
CPRET = SUM(I, TCPROP(I));

POSITIVE VARIABLES
        THETA
        PROPRET
        TP(R)
        NK(I,R);

FREE VARIABLES
        OMEGA2;

THETA.L = 0.4936158379;
PROPRET.L = CPRET+SUM((I,R), IKP(I,'NONC',R));
TP.L('NORTH') = 0.0161;
TP.L('SOUTH') = 0.0118;
NK.L(I,R) = IKP(I,'NONC',R);

EQUATIONS EQ21a, EQ21b, EQ22a, EQ22b, EQ23(I,R), OBJ2;

EQ21a.. PCE('NORTH') =E=
((EMPCOMP('NORTH')+(THETA*PROPRET))*(1-TP('NORTH')))-BHTAX('NORTH');
EQ21b.. PCE('SOUTH') =E=
((EMPCOMP('SOUTH')+((1-THETA)*PROPRET))*(1-TP('SOUTH')))-BHTAX('SOUTH');
EQ22a.. TP('NORTH') =E= PITRe('NORTH')/(SUM(I,
NPI(I,'NORTH'))+EMPCOMP('NORTH')+(THETA*PROPRET));
EQ22b.. TP('SOUTH') =E= PITRe('SOUTH')/(SUM(I,
NPI(I,'SOUTH'))+EMPCOMP('SOUTH')+((1-THETA)
        *PROPRET));
EQ23(I,R).. NK(I,R) =E= NPI(I,R)*(1-TP(R));
OBJ2.. OMEGA2 =E= (1+(PROPRET-CPRET-SUM((I,R), NK(I,R))))**2;

MODEL PITAX /EQ21a, EQ21b, EQ22a, EQ22b, EQ23, OBJ2/;
SOLVE PITAX USING NLP MINIMIZING OMEGA2;

* Parameterize Results from PITAX

SCALAR        BTOTKAP             National Capital Stock;

PARAMETER
        PTAX(R)             Personal Income Tax Rates
        THE(R)        Regional Shares of Property Returns
        BTOTLAB(R)    Benchmark National Labor Supply;

PARAMETER DISTT(I,S), DISTG(I,S,R), DISTK(I,S,R), DISTL(I,S,R);

BTOTKAP = PROPRET.L;
PTAX('NORTH') = TP.L('NORTH');
PTAX('SOUTH') = TP.L('SOUTH');
THE('NORTH') = THETA.L;
THE('SOUTH') = 1-THETA.L;
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```
BKP(I,'NONC',R) = NK.L(I,R);
BTOTLAB(R) = SUM((I,S), BLB(I,S,R));
TT(I,'NONC') = 0;
TK(I,'NONC',R) = PTAX(R)/(1-PTAX(R));
TL(I,'NONC',R) = 0;
TG(I,'NONC',R) = 0;
DISTT(I,'NONC') = TT(I,'NONC');
DISTK(I,'NONC',R) = TK(I,'NONC',R);
DISTL(I,'NONC',R) = TL(I,'NONC',R);
DISTG(I,'NONC',R) = TG(I,'NONC',R);

* Units Conversion 2

PARAMETER    PG0(I,S,R)        Benchmark Price of Goods;

PG0(I,'NONC',R) = 1/(1-TT(I,'NONC')-TG(I,'NONC',R));
PG0(I,'CORP',R) = 1/(1-TT(I,'CORP')-TG(I,'CORP',R)-TX(I,R));

VARIABLES
        BOPC(I,R,M)     Benchmark Corp Output by Loc of Prod and Loc of Sale
        OMEGA4                  Transportation Cost Minimizing Variable;

BOPC.LO(I,R,M) = 0;
BOPC.L(I,R,M) = IGBOPC(I,R,M);
OMEGA4.L = SUM(I, (BOPC.L(I,'NORTH','NORTH')+BOPC.L(I,'SOUTH','SOUTH')));

EQUATIONS
        EQ41(I), EQ42(I), EQ43(I), EQ44(I), EQ4OBJ;

EQ41(I).. PG0(I,'CORP','NORTH')*(BOPC(I,'NORTH','NORTH')+BOPC(I,'SOUTH','NORTH')) =E=
        SALES(I,'CORP','NORTH');
EQ42(I).. PG0(I,'CORP','SOUTH')*(BOPC(I,'NORTH','SOUTH')+BOPC(I,'SOUTH','SOUTH')) =E=
        SALES(I,'CORP','SOUTH');
EQ43(I).. PG0(I,'CORP','NORTH')*BOPC(I,'NORTH','NORTH')+PG0(I,'CORP','SOUTH')*
        BOPC(I,'NORTH','SOUTH') =E= CVLP(I,'NORTH');
EQ44(I).. PG0(I,'CORP','NORTH')*BOPC(I,'SOUTH','NORTH')+PG0(I,'CORP','SOUTH')*
        BOPC(I,'SOUTH','SOUTH') =E= CVLP(I,'SOUTH');
EQ4OBJ.. OMEGA4 =E= SUM(I, (BOPC(I,'NORTH','NORTH')+BOPC(I,'SOUTH','SOUTH')));

MODEL UNITS2 /EQ41, EQ42, EQ43, EQ44, EQ4OBJ/;
SOLVE UNITS2 USING LP MAXIMIZING OMEGA4;

* Parameterize Results from UNITS2

PARAMETER    BOP(I,S,R)        Benchmark Output by Region and Sector;

BOP(I,'CORP',R) = SUM(M, BOPC.L(I,R,M));
BOP(I,'NONC',R) = SALES(I,'NONC',R);

* Calculate Production Parameters

PARAMETER    GAM(I,S,R)        Capital and Labor Shares
```

```
                ALP(I,S,R)        Production Shift Parameter;

GAM(I,S,R)$(SIG(I) NE 1.0000) = ((1-TT(I,S)+TL(I,S,R))*(BLB(I,S,R)**(1/SIG(I))))/(((1-TT(I,S)+
        TL(I,S,R))*(BLB(I,S,R)**(1/SIG(I))))+((1+TK(I,S,R))*(BKP(I,S,R)**(1/SIG(I)))));
GAM(I,S,R)$(SIG(I) EQ 1.0000) = ((1-TT(I,S)+TL(I,S,R))*BLB(I,S,R))/(((1-TT(I,S)+TL(I,S,R))*
        BLB(I,S,R))+((1+TK(I,S,R))*BKP(I,S,R)));
ALP(I,S,R)$(SIG(I) NE 1.0000) = BOP(I,S,R)/(((GAM(I,S,R)*(BLB(I,S,R)**((SIG(I)-1)/SIG(I))))+
        ((1-GAM(I,S,R))*(BKP(I,S,R)**((SIG(I)-1)/SIG(I)))))**(SIG(I)/(SIG(I)-1)));
ALP(I,S,R)$(SIG(I) EQ 1.0000) = BOP(I,S,R)/((BLB(I,S,R)**GAM(I,S,R))*(BKP(I,S,R)**(1-
        GAM(I,S,R))));

PARAMETER   TQR(I,S,R), TPROD(I,S,R);

TQR(I,S,R)$(SIG(I) NE 1.0000) = ALP(I,S,R)*(((GAM(I,S,R)*(BLB(I,S,R)**rho(I)))+((1-GAM(I,S,R))*
        (BKP(I,S,R)**rho(I))))**(1/rho(I)));
TQR(I,S,R)$(SIG(I) EQ 1.0000) =
ALP(I,S,R)*(BLB(I,S,R)**GAM(I,S,R))*(BKP(I,S,R)**(1-GAM(I,S,R)));
TPROD(I,S,R) = BOP(I,S,R)-TQR(I,S,R);

PARAMETER
                BKST(I,S,R)       Benchmark Cost-Min Capital Req
                BLST(I,S,R)       Benchmark Cost-Min Labor Req
                BCST(I,S,R)       Benchmark Min Cost per Unit of Output
                BQST(I,R)
                SQST(I)
                MU(I)             Qn and Qs Shares Corp
                ZET(I)            Location Shift Parm;


BKST(I,S,R)$(SIG(I) NE 1.0000) = ((1/ALP(I,S,R))*(((GAM(I,S,R)*((((1-GAM(I,S,R))*(1-TT(I,S)+
        TL(I,S,R)))/(GAM(I,S,R)*(1+TK(I,S,R))))**(1-SIG(I))))+(1-GAM(I,S,R)))**(SIG(I)/(1-
        SIG(I)))));
BKST(I,S,R)$(SIG(I) EQ 1.0000) = ((1/ALP(I,S,R))*((((1-GAM(I,S,R))*(1-TT(I,S)+TL(I,S,R)))/
        (GAM(I,S,R)*(1+TK(I,S,R))))**GAM(I,S,R)));
BLST(I,S,R)$(SIG(I) NE 1.0000) = ((1/ALP(I,S,R))*((((1-GAM(I,S,R))*(((GAM(I,S,R)*(1+TK(I,S,R)))/
        ((1-GAM(I,S,R))*(1-TT(I,S)+TL(I,S,R))))**(1-SIG(I))))+GAM(I,S,R))**(SIG(I)/(1-
        SIG(I)))));
BLST(I,S,R)$(SIG(I) EQ 1.0000) = ((1/ALP(I,S,R))*(((GAM(I,S,R)*(1+TK(I,S,R)))/((1-GAM(I,S,R))*
        (1-TT(I,S)+TL(I,S,R))))**(1-GAM(I,S,R))));
BCST(I,S,R) = ((1+TK(I,S,R))*BKST(I,S,R))+((1-TT(I,S)+TL(I,S,R))*BLST(I,S,R));
MU(I) = (BCST(I,'CORP','NORTH')*BOP(I,'CORP','NORTH'))/(BCST(I,'CORP','NORTH')*
        BOP(I,'CORP','NORTH')+BCST(I,'CORP','SOUTH')*BOP(I,'CORP','SOUTH'));
ZET(I) = SUM(R, BOP(I,'CORP',R))/((BOP(I,'CORP','NORTH')**MU(I))*(BOP(I,'CORP','SOUTH')**
        (1-MU(I))));
BQST(I,'SOUTH') =
(1/ZET(I))*(((1-MU(I))*BCST(I,'CORP','NORTH'))/(MU(I)*BCST(I,'CORP','SOUTH')))
        **MU(I);
BQST(I,'NORTH') =
(1/ZET(I))*((MU(I)*BCST(I,'CORP','SOUTH'))/((1-MU(I))*BCST(I,'CORP','NORTH')))
        **(1-MU(I));
SQST(I) = SUM(R, BQST(I,R));
```

```
PARAMETER TQ(I);

TQ(I) = SUM(R,
BOP(I,'CORP',R))-(ZET(I)*(BOP(I,'CORP','NORTH')**MU(I))*(BOP(I,'CORP','SOUTH')**
        (1-MU(I))));

POSITIVE VARIABLES
        CONv(I,S,R)     Consumer Consumption
        GOVv(I,S,R)     Government Consumption;

FREE VARIABLES
        OMEGA3;

CONv.L(I,'NONC',R) = SALES(I,'NONC',R);
CONv.L(I,'CORP',R) = (CEPG(I,R)-GEPG(I,R)-CONv.L(I,'NONC',R))/PG0(I,'CORP',R);
GOVv.L(I,'NONC',R) = 1.00;
GOVv.L(I,'CORP',R) = (CEPG(I,R)-CONv.L(I,'CORP',R))/PG0(I,'CORP',R);


EQUATIONS    EQ31(I,R), EQ32(I,R), EQ33(I,R), EQ34(I,R), EQ35;

EQ31(I,R).. PG0(I,'NONC',R)*GOVv(I,'NONC',R)+PG0(I,'CORP',R)*GOVv(I,'CORP',R) =E=
GEPG(I,R);
EQ32(I,R).. PG0(I,'NONC',R)*CONv(I,'NONC',R)+PG0(I,'CORP',R)*CONv(I,'CORP',R) =E=
CEPG(I,R);
EQ33(I,R).. PG0(I,'NONC',R)*(GOVv(I,'NONC',R)+CONv(I,'NONC',R)) =E= SALES(I,'NONC',R);
EQ34(I,R).. PG0(I,'CORP',R)*(GOVv(I,'CORP',R)+CONv(I,'CORP',R)) =E= SALES(I,'CORP',R);
EQ35.. OMEGA3 =E= SUM((I,R), GOVv(I,'CORP',R));

MODEL CONSUMP /EQ31, EQ32, EQ33, EQ34, EQ35/;
SOLVE CONSUMP USING LP MAXIMIZING OMEGA3;

* Parameterize Results from CONSUMP

PARAMETER
        GOV(I,S,R)      Fixed Government Demands
        CON(I,S,R)      Benchmark Consumer Demands;

GOV(I,S,R) = GOVv.L(I,S,R);
CON(I,S,R) = CONv.L(I,S,R);

* Calculate Consumption Parameters

PARAMETER

        BET(I,R)        Consumer Exp Shares
        BPCY(R)                 Benchmark Pers Cons Exp
        TCON(I,S,R)     Cons Check Var
        TCEPG(R)        Used to Calculate Betas
        CEPGE(I,S,R)    Benchmark Exp by Sector
        CPSI(I,R)       Used to Calculate psi
        PSI(I,S,R)      Share Parms for Corp v. Noncorp;
```

```
TCEPG(R) = SUM(I, CEPG(I,R));
BET(I,R) = (CEPG(I,R)/TCEPG(R));
CEPGE(I,S,R) = PG0(I,S,R)*CON(I,S,R);
CPSI(I,R) = CEPGE(I,'CORP',R)/CEPG(I,R);
PSI(I,'CORP',R) = CPSI(I,R);
PSI(I,'NONC',R) = 1-CPSI(I,R);

BPCY(R) = (EMPCOMP(R)+THE(R)*BTOTKAP)*(1-PTAX(R))-BHTAX(R);
TCON(I,S,R) = ((PSI(I,S,R)*BET(I,R)*BPCY(R))/PG0(I,S,R))-CON(I,S,R);
```

Corporate Income Tax Calculation Subroutine [ctax92.inc]

```
* ctax92.inc

GR(I) = SUM(R, PCC.L(I,R)*DEM.L(I,'CORP',R));
PY(I) = SUM(R, PL.L(R)*DL.L(I,'CORP',R));
PR(I) = SUM(R, PK.L*DK.L(I,'CORP',R));
GRS(I,R) = (PCC.L(I,R)*DEM.L(I,'CORP',R))/GR(I);
GRS('SERV',R) = (PC.L('SERV')*QCR.L('SERV',R))/GR('SERV');
PYS(I,R) = (PL.L(R)*DL.L(I,'CORP',R))/PY(I);
PRS(I,R) = (PK.L*DK.L(I,'CORP',R))/PR(I);
PI(I) = GR(I)-PY(I);

PHI(I,R) = SFW(R)*GRS(I,R)+RFW(R)*PRS(I,R)+WFW(R)*PYS(I,R);

ARS(I) = CTAX('NORTH')*SFW('NORTH')*GRS(I,'NORTH')+
CTAX('SOUTH')*SFW('SOUTH')*GRS(I,'SOUTH');

ARR(I) = CTAX('NORTH')*RFW('NORTH')*PRS(I,'NORTH')+
CTAX('SOUTH')*RFW('SOUTH')*PRS(I,'SOUTH');

ARW(I) = CTAX('NORTH')*WFW('NORTH')*PYS(I,'NORTH')+
CTAX('SOUTH')*WFW('SOUTH')*PYS(I,'SOUTH');

TT(I,'CORP') = CTAX('NORTH')*PHI(I,'NORTH')+CTAX('SOUTH')*PHI(I,'SOUTH');
TG(I,'CORP',R) = (PI(I)/GR(I))*((CTAX(R)*SFW(R))-ARS(I));
TK(I,'CORP',R) = (PI(I)/PR(I))*((CTAX(R)*RFW(R))-ARR(I));
TL(I,'CORP',R) = (PI(I)/PY(I))*((CTAX(R)*WFW(R))-ARW(I));
DISTT(I,'CORP') = TT(I,'CORP');
DISTG(I,'CORP',R) = TG(I,'CORP',R);
DISTK(I,'CORP',R) = TK(I,'CORP',R);
DISTL(I,'CORP',R) = TL(I,'CORP',R);
TX(I,R) = 0;
TX('SERV',R) = TT('SERV','CORP')+TG('SERV','CORP',R);
TG('SERV','CORP',R) = 0;
TL('SERV','CORP',R) =
(PI('SERV')/PY('SERV'))*((CTAX(R)*WFW(R))-ARW('SERV'))-TT('SERV','CORP');
TT('SERV','CORP') = 0;
```

Policy Experiments Subroutine [policy92.inc]

```
* policy92.inc

OPTION SOLPRINT=OFF;

PARAMETER    TTS(R), TTK(R), TTL(R), CPI0R(I,R), CPI0(I), NPI0(I,R);

CPI0R(I,R) = (PCC.L(I,R)*DEM.L(I,'CORP',R)-PL.L(R)*DL.L(I,'CORP',R));
CPI0(I) = SUM(R, CPI0R(I,R))*(1-SUM(R, CTAX(R)*PHI(I,R)))-SUM(R, PK.L*DK.L(I,'CORP',R));
NPI0(I,R) = PN.L(I,R)*DEM.L(I,'NONC',R)-PK.L*(1+TK(I,'NONC',R))*DK.L(I,'NONC',R)-
        PL.L(R)*DL.L(I,'NONC',R);
TTS(R) = SUM(I, TG(I,'CORP',R)*PCC.L(I,R)*DEM.L(I,'CORP',R));
TTK(R) = SUM(I, TK(I,'CORP',R)*PK.L*DK.L(I,'CORP',R));
TTL(R) = SUM(I, TL(I,'CORP',R)*PL.L(R)*DL.L(I,'CORP',R));

DISPLAY      PCC.L, DEM.L, CDEM.L, DL.L, DK.L, CAPY.L, PCY.L, PITR.L, CPR.L, CITR.L,
             GREV.L, QN.L, QCR.L, QC.L, PL.L, PK.L, PC.L, PN.L, KSTAR.L, LSTAR.L,
             CSTAR.L, QSTAR.L, HTAX.L, BOPC.L;

DISPLAY      CTAX, PHI, PPS, GRS, PYS, PTAX, THE, BTOTKAP, BTOTLAB, GOV, GAM,
             ALP, rho, MU, ZET, BET, PSI, TPROD, TCON, CPI0, NPI0, TTS, TTK, TTL;

PARAMETER    KLRAT0(I,S,R), KLRAT1(I,S,R), dKLRAT(I,S,R), ddKLRAT(I,S,R), DTT0(I),
             DTT1(I), dDTT(I), ddDTT(I), DTG0(I,R), DTG1(I,R), dDTG(I,R), ddDTG(I,R),
             DTK0(I,R), DTK1(I,R), dDTK(I,R), ddDTK(I,R), DTL0(I,R), DTL1(I,R), dDTL(I,R),
             ddDTL(I,R);

PARAMETER    PKs0(I,S,R), PKs1(I,S,R), dPKs(I,S,R), ddPKs(I,S,R), PLs0(I,S,R), PLs1(I,S,R),
             dPLs(I,S,R), ddPLs(I,S,R), PRAT0(I,S,R), PRAT1(I,S,R), dPRAT(I,S,R),
             ddPRAT(I,S,R);

PARAMETER    CON0(I,S,R), TRUT0(I,R), RUTIL0(R), NUTIL0, PCC0(I,R), PC0(I), PN0(I,R),
             PK0, PL0(R), HTAX0(R), DK0(I,S,R), DL0(I,S,R), QN0(I,R), CITR0(R),
             PITR0(R), QCR0(I,R), QC0(I), PHI0(I,R), PIC0(I), COLIC0(R), COLIN0(R),
             COLI0(R), CITBASE0(R);

PARAMETER    CON1(I,S,R), TRUT1(I,R), RUTIL1(R), NUTIL1, PCC1(I,R), PC1(I), PN1(I,R),
             PK1, PL1(R), HTAX1(R), DK1(I,S,R), DL1(I,S,R), QN1(I,R), CITR1(R),
             PITR1(R), QCR1(I,R), QC1(I), SUMDK0(R), SUMDK1(R), SUMDKc0(R),
             SUMDKc1(R), SUMDKn0(R), SUMDKn1(R), SUMQCR0(R), SUMQCR1(R),
             SUMQN0(R), SUMQN1(R), PHI1(I,R), PIC1(I), COLIC1(R), COLIN1(R), COLI1(R),
             CITBASE1(R);

PARAMETER    dCON(I,S,R), dRUTIL(R), dNUTIL, dPC(I), dPN(I,R), dPCC(I,R), dPK, dPL(R),
             dHTAX(R), dDK(I,S,R), dDL(I,S,R), dQN(I,R), dQCR(I,R), dQC(I), dCITR(R),
             dPITR(R), dSUMDK(R), dSUMDKc(R), dSUMDKn(R), dSUMQCR(R), dSUMQN(R)
             dCOLIC(R), dCOLIN(R), dCOLI(R), dPHI(I,R), dPIC(I), dCITBASE(R);
```

```
PARAMETER     ddCON(I,S,R), ddRUTIL(R), ddNUTIL, ddPC(I), ddPN(I,R), ddPCC(I,R), ddPK,
              ddPL(R), ddHTAX(R), ddDK(I,S,R), ddDL(I,S,R), ddQN(I,R), ddQCR(I,R), ddQC(I),
              ddCITR(R), ddPITR(R), ddSUMDK(R), ddSUMDKc(R), ddSUMDKn(R),
              ddSUMQCR(R), ddSUMQN(R), ddPHI(I,R), ddPIC(I), ddCOLIC(R), ddCOLIN(R),
              ddCOLI(R), ddCITBASE(R);

KLRAT0(I,S,R) = DK.L(I,S,R)/DL.L(I,S,R);
DTT0(I) = DISTT(I,'CORP');
DTG0(I,R) = DISTG(I,'CORP',R);
DTK0(I,R) = DISTK(I,'CORP',R);
DTL0(I,R) = DISTL(I,'CORP',R);
CON0(I,S,R) = DEM.L(I,S,R)-GOV(I,S,R);
TRUT0(I,R) = (CON0(I,'CORP',R)**PSI(I,'CORP',R))*(CON0(I,'NONC',R)**PSI(I,'NONC',R));
RUTIL0(R) = PROD(I, (TRUT0(I,R)**BET(I,R)));
NUTIL0 = SUM(R, RUTIL0(R));
PC0(I) = PC.L(I);
PCC0(I,R) = PCC.L(I,R);
PN0(I,R) = PN.L(I,R);
PK0 = PK.L;
PKs0(I,S,R) = PK0*(1+TK(I,S,R));
PL0(R) = PL.L(R);
PLs0(I,S,R) = PL0(R)*(1-TT(I,S)+TL(I,S,R));
PRAT0(I,S,R) = PLs0(I,S,R)/PKs0(I,S,R);
HTAX0(R) = HTAX.L(R);
DK0(I,S,R) = DK.L(I,S,R);
DL0(I,S,R) = DL.L(I,S,R);
QN0(I,R) = QN.L(I,R);
QCR0(I,R) = QCR.L(I,R);
QC0(I) = QC.L(I);
CITR0(R) = CITR.L(R);
PITR0(R) = PITR.L(R);
SUMDK0(R) = SUM((I,S), DK.L(I,S,R));
SUMDKc0(R) = SUM(I, DK.L(I,'CORP',R));
SUMDKn0(R) = SUM(I, DK.L(I,'NONC',R));
SUMQCR0(R) = SUM(I, QCR.L(I,R));
SUMQN0(R) = SUM(I, QN.L(I,R));
PIC0(I) = CPR.L(I);
PHI0(I,R) = PHI(I,R);
CITBASE0(R) = SUM(I, PHI(I,R)*CPR.L(I));
COLI0(R) = 1;
COLIC0(R) = 1;
COLIN0(R) = 1;

PARAMETER     CHTK0(I,R), CHTK1(I,R), CHTK2(I,R), CHTK3(I,R), CHKTK1(I,R),
              CHKTK2(I,R), CHKTK3(I,R);

$TITLE COUNTERFACTUAL EQUILIBRIA

**** SPECIFY POLICY CHANGE #1

SFW('NORTH') = 1/2;
SFW('SOUTH') = 1/3;
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```
RFW('NORTH') = 1/4;
RFW('SOUTH') = 1/3;
WFW('NORTH') = 1/4;
WFW('SOUTH') = 1/3;

$INCLUDE /u02/edmiston/ctax92.inc
CHTK0(I,R) = TK(I,'CORP',R);
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK1(I,R) = TK(I,'CORP',R);
CHKTK1(I,R) = CHTK1(I,R)-CHTK0(I,R);
DISPLAY CHKTK1;
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK2(I,R) = TK(I,'CORP',R);
CHKTK2(I,R) = CHTK2(I,R)-CHTK1(I,R);
DISPLAY CHKTK2;
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK3(I,R) = TK(I,'CORP',R);
CHKTK3(I,R) = CHTK3(I,R)-CHTK2(I,R);
DISPLAY CHKTK3;
SOLVE CGE USING NLP MINIMIZING OMEGAM;

$INCLUDE /u02/edmiston/report92.inc

**** SPECIFY POLICY CHANGE #2

SFW('NORTH') = 1/3;
SFW('SOUTH') = 1/2;
RFW('NORTH') = 1/3;
RFW('SOUTH') = 1/4;
WFW('NORTH') = 1/3;
WFW('SOUTH') = 1/4;

$INCLUDE /u02/edmiston/ctax92.inc
CHTK0(I,R) = TK(I,'CORP',R);
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK1(I,R) = TK(I,'CORP',R);
CHKTK1(I,R) = CHTK1(I,R)-CHTK0(I,R);
DISPLAY CHKTK1;
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK2(I,R) = TK(I,'CORP',R);
CHKTK2(I,R) = CHTK2(I,R)-CHTK1(I,R);
DISPLAY CHKTK2;
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK3(I,R) = TK(I,'CORP',R);
CHKTK3(I,R) = CHTK3(I,R)-CHTK2(I,R);
DISPLAY CHKTK3;
```

```
SOLVE CGE USING NLP MINIMIZING OMEGAM;

$INCLUDE /u02/edmiston/report92.inc

**** SPECIFY POLICY CHANGE #3

SFW('NORTH') = 1/2;
SFW('SOUTH') = 1/2;
RFW('NORTH') = 1/4;
RFW('SOUTH') = 1/4;
WFW('NORTH') = 1/4;
WFW('SOUTH') = 1/4;


$INCLUDE /u02/edmiston/ctax92.inc
CHTK0(I,R) = TK(I,'CORP',R);
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK1(I,R) = TK(I,'CORP',R);
CHKTK1(I,R) = CHTK1(I,R)-CHTK0(I,R);
DISPLAY CHKTK1;
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK2(I,R) = TK(I,'CORP',R);
CHKTK2(I,R) = CHTK2(I,R)-CHTK1(I,R);
DISPLAY CHKTK2;
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK3(I,R) = TK(I,'CORP',R);
CHKTK3(I,R) = CHTK3(I,R)-CHTK2(I,R);
DISPLAY CHKTK3;
SOLVE CGE USING NLP MINIMIZING OMEGAM;

$INCLUDE /u02/edmiston/report92.inc

**** SPECIFY POLICY CHANGE #4

SFW('NORTH') = 1;
SFW('SOUTH') = 1/2;
RFW('NORTH') = 0;
RFW('SOUTH') = 1/4;
WFW('NORTH') = 0;
WFW('SOUTH') = 1/4;


$INCLUDE /u02/edmiston/ctax92.inc
CHTK0(I,R) = TK(I,'CORP',R);
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK1(I,R) = TK(I,'CORP',R);
CHKTK1(I,R) = CHTK1(I,R)-CHTK0(I,R);
DISPLAY CHKTK1;
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```
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK2(I,R) = TK(I,'CORP',R);
CHKTK2(I,R) = CHTK2(I,R)-CHTK1(I,R);
DISPLAY CHKTK2;
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK3(I,R) = TK(I,'CORP',R);
CHKTK3(I,R) = CHTK3(I,R)-CHTK2(I,R);
DISPLAY CHKTK3;
SOLVE CGE USING NLP MINIMIZING OMEGAM;

$INCLUDE /u02/edmiston/report92.inc

**** SPECIFY POLICY CHANGE #5

SFW('NORTH') = 1/2;
SFW('SOUTH') = 1;
RFW('NORTH') = 1/4;
RFW('SOUTH') = 0;
WFW('NORTH') = 1/4;
WFW('SOUTH') = 0;


$INCLUDE /u02/edmiston/ctax92.inc
CHTK0(I,R) = TK(I,'CORP',R);
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK1(I,R) = TK(I,'CORP',R);
CHKTK1(I,R) = CHTK1(I,R)-CHTK0(I,R);
DISPLAY CHKTK1;
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK2(I,R) = TK(I,'CORP',R);
CHKTK2(I,R) = CHTK2(I,R)-CHTK1(I,R);
DISPLAY CHKTK2;
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK3(I,R) = TK(I,'CORP',R);
CHKTK3(I,R) = CHTK3(I,R)-CHTK2(I,R);
DISPLAY CHKTK3;
SOLVE CGE USING NLP MINIMIZING OMEGAM;

$INCLUDE /u02/edmiston/report92.inc

**** SPECIFY POLICY CHANGE #6

SFW('NORTH') = 1;
SFW('SOUTH') = 1/3;
RFW('NORTH') = 0;
RFW('SOUTH') = 1/3;
WFW('NORTH') = 0;
```

WFW('SOUTH') = 1/3;

$INCLUDE /u02/edmiston/ctax92.inc
CHTK0(I,R) = TK(I,'CORP',R);
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK1(I,R) = TK(I,'CORP',R);
CHKTK1(I,R) = CHTK1(I,R)-CHTK0(I,R);
DISPLAY CHKTK1;
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK2(I,R) = TK(I,'CORP',R);
CHKTK2(I,R) = CHTK2(I,R)-CHTK1(I,R);
DISPLAY CHKTK2;
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK3(I,R) = TK(I,'CORP',R);
CHKTK3(I,R) = CHTK3(I,R)-CHTK2(I,R);
DISPLAY CHKTK3;
SOLVE CGE USING NLP MINIMIZING OMEGAM;

$INCLUDE /u02/edmiston/report92.inc

**** SPECIFY POLICY CHANGE #7

SFW('NORTH') = 1/3;
SFW('SOUTH') = 1;
RFW('NORTH') = 1/3;
RFW('SOUTH') = 0;
WFW('NORTH') = 1/3;
WFW('SOUTH') = 0;

$INCLUDE /u02/edmiston/ctax92.inc
CHTK0(I,R) = TK(I,'CORP',R);
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK1(I,R) = TK(I,'CORP',R);
CHKTK1(I,R) = CHTK1(I,R)-CHTK0(I,R);
DISPLAY CHKTK1;
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK2(I,R) = TK(I,'CORP',R);
CHKTK2(I,R) = CHTK2(I,R)-CHTK1(I,R);
DISPLAY CHKTK2;
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK3(I,R) = TK(I,'CORP',R);
CHKTK3(I,R) = CHTK3(I,R)-CHTK2(I,R);
DISPLAY CHKTK3;
SOLVE CGE USING NLP MINIMIZING OMEGAM;

```
$INCLUDE /u02/edmiston/report92.inc

**** SPECIFY POLICY CHANGE #8

SFW('NORTH') = 1;
SFW('SOUTH') = 1;
RFW('NORTH') = 0;
RFW('SOUTH') = 0;
WFW('NORTH') = 0;
WFW('SOUTH') = 0;


$INCLUDE /u02/edmiston/ctax92.inc
CHTK0(I,R) = TK(I,'CORP',R);
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK1(I,R) = TK(I,'CORP',R);
CHKTK1(I,R) = CHTK1(I,R)-CHTK0(I,R);
DISPLAY CHKTK1;
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK2(I,R) = TK(I,'CORP',R);
CHKTK2(I,R) = CHTK2(I,R)-CHTK1(I,R);
DISPLAY CHKTK2;
SOLVE CGE USING NLP MINIMIZING OMEGAM;
$INCLUDE /u02/edmiston/ctax92.inc
CHTK3(I,R) = TK(I,'CORP',R);
CHKTK3(I,R) = CHTK3(I,R)-CHTK2(I,R);
DISPLAY CHKTK3;
SOLVE CGE USING NLP MINIMIZING OMEGAM;

$INCLUDE /u02/edmiston/report92.inc
```

Solution Report Subroutine [report92.inc]

```
* report92.inc

CPI0R(I,R) = (PCC.L(I,R)*DEM.L(I,'CORP',R)-PL.L(R)*DL.L(I,'CORP',R));
CPI0(I) = SUM(R, CPI0R(I,R))*(1-SUM(R, CTAX(R)*PHI(I,R)))-SUM(R, PK.L*DK.L(I,'CORP',R));
NPI0(I,R) = PN.L(I,R)*DEM.L(I,'NONC',R)-PK.L*(1+TK(I,'NONC',R))*DK.L(I,'NONC',R)-
        PL.L(R)*DL.L(I,'NONC',R);
TTS(R) = SUM(I, TG(I,'CORP',R)*PCC.L(I,R)*DEM.L(I,'CORP',R));
TTK(R) = SUM(I, TK(I,'CORP',R)*PK.L*DK.L(I,'CORP',R));
TTL(R) = SUM(I, TL(I,'CORP',R)*PL.L(R)*DL.L(I,'CORP',R));

DISPLAY DISTL, DISTK, DISTG, DISTT, TTS, TTK, TTL, CPI0, NPI0;

KLRAT1(I,S,R) = DK.L(I,S,R)/DL.L(I,S,R);
DTT1(I) = DISTT(I,'CORP');
DTG1(I,R) = DISTG(I,'CORP',R);
DTK1(I,R) = DISTK(I,'CORP',R);
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```
DTL1(I,R) = DISTL(I,'CORP',R);
CON1(I,S,R) = DEM.L(I,S,R)-GOV(I,S,R);
TRUT1(I,R) = (CON1(I,'CORP',R)**PSI(I,'CORP',R))*(CON1(I,'NONC',R)**PSI(I,'NONC',R));
RUTIL1(R) = PROD(I, (TRUT1(I,R)**BET(I,R)));
NUTIL1 = SUM(R, RUTIL1(R));
PC1(I) = PC.L(I);
PCC1(I,R) = PCC.L(I,R);
PN1(I,R) = PN.L(I,R);
PK1 = PK.L;
PL1(R) = PL.L(R);
PKs1(I,S,R) = PK1*(1+TK(I,S,R));
PLs1(I,S,R) = PL1(R)*(1-TT(I,S)+TL(I,S,R));
PRAT1(I,S,R) = PLs1(I,S,R)/PKs1(I,S,R);
HTAX1(R) = HTAX.L(R);
DK1(I,S,R) = DK.L(I,S,R);
DL1(I,S,R) = DL.L(I,S,R);
QN1(I,R) = QN.L(I,R);
QCR1(I,R) = QCR.L(I,R);
QC1(I) = QC.L(I);
CITR1(R) = CITR.L(R);
PITR1(R) = PITR.L(R);
SUMDK1(R) = SUM((I,S), DK.L(I,S,R));
SUMDKc1(R) = SUM(I, DK.L(I,'CORP',R));
SUMDKn1(R) = SUM(I, DK.L(I,'NONC',R));
SUMQCR1(R) = SUM(I, QCR.L(I,R));
SUMQN1(R) = SUM(I, QN.L(I,R));
PHI1(I,R) = PHI(I,R);
PIC1(I) = CPR.L(I);
CITBASE1(R) = SUM(I, PHI(I,R)*CPR.L(I));
COLI1(R) = PROD(I, ((((PCC1(I,R)/PCC0(I,R))**PSI(I,'CORP',R))*((PN1(I,R)/PN0(I,R))**
        PSI(I,'NONC',R)))**BET(I,R)));
COLIC1(R) = PROD(I, (PCC1(I,R)/PCC0(I,R))**(PSI(I,'CORP',R)*BET(I,R)));
COLIN1(R) = PROD(I, (PN1(I,R)/PN0(I,R))**(PSI(I,'NONC',R)*BET(I,R)));

dKLRAT(I,S,R) = KLRAT1(I,S,R)-KLRAT0(I,S,R);
dDTT(I) = DTT1(I)-DTT0(I);
dDTG(I,R) = DTG1(I,R)-DTG0(I,R);
dDTK(I,R) = DTK1(I,R)-DTK0(I,R);
dDTL(I,R) = DTL1(I,R)-DTL0(I,R);
dPK = PK1-PK0;
dPL(R) = PL1(R)-PL0(R);
dPKs(I,S,R) = PKs1(I,S,R)-PKs0(I,S,R);
dPLs(I,S,R) = PLs1(I,S,R)-PLs0(I,S,R);
dPRAT(I,S,R) = PRAT1(I,S,R)-PRAT0(I,S,R);
dPC(I) = PC1(I)-PC0(I);
dPCC(I,R) = PCC1(I,R)-PCC0(I,R);
dPN(I,R) = PN1(I,R)-PN0(I,R);
dDK(I,S,R) = DK1(I,S,R)-DK0(I,S,R);
dDL(I,S,R) = DL1(I,S,R)-DL0(I,S,R);
dQN(I,R) = QN1(I,R)-QN0(I,R);
dQCR(I,R) = QCR1(I,R)-QCR0(I,R);
dQC(I) = QC1(I)-QC0(I);
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dCON(I,S,R) = CON1(I,S,R)-CON0(I,S,R);
dHTAX(R) = HTAX1(R)-HTAX0(R);
dCITR(R) = CITR1(R)-CITR0(R);
dPITR(R) = PITR1(R)-PITR0(R);
dRUTIL(R) = RUTIL1(R)-RUTIL0(R);
dNUTIL = NUTIL1-NUTIL0;
dSUMDK(R) = SUMDK1(R)-SUMDK0(R);
dSUMDKc(R) = SUMDKc1(R)-SUMDKc0(R);
dSUMDKn(R) = SUMDKn1(R)-SUMDKn0(R);
dSUMQCR(R) = SUMQCR1(R)-SUMQCR0(R);
dSUMQN(R) = SUMQN1(R)-SUMQN0(R);
dPHI(I,R) = PHI1(I,R)-PHI0(I,R);
dPIC(I) = PIC1(I)-PIC0(I);
dCITBASE(R) = CITBASE1(R)-CITBASE0(R);
dCOLI(R) = COLI1(R)-COLI0(R);
dCOLIC(R) = COLIC1(R)-COLIC0(R);
dCOLIN(R) = COLIN1(R)-COLIN0(R);

ddKLRAT(I,S,R) = dKLRAT(I,S,R)/KLRAT0(I,S,R);
ddDTT(I) = dDTT(I)/DTT0(I);
ddDTG(I,R) = dDTG(I,R)/DTG0(I,R);
ddDTK(I,R) = dDTK(I,R)/DTK0(I,R);
ddDTL(I,R) = dDTL(I,R)/DTL0(I,R);
ddPK = dPK/PK0;
ddPL(R) = dPL(R)/PL0(R);
ddPKs(I,S,R) = dPKs(I,S,R)/PKs0(I,S,R);
ddPLs(I,S,R) = dPLs(I,S,R)/PLs0(I,S,R);
ddPRAT(I,S,R) = dPRAT(I,S,R)/PRAT0(I,S,R);
ddPC(I) = dPC(I)/PC0(I);
ddPCC(I,R) = dPCC(I,R)/PCC0(I,R);
ddPN(I,R) = dPN(I,R)/PN0(I,R);
ddDK(I,S,R) = dDK(I,S,R)/DK0(I,S,R);
ddDL(I,S,R) = dDL(I,S,R)/DL0(I,S,R);
ddQN(I,R) = dQN(I,R)/QN0(I,R);
ddQCR(I,R) = dQCR(I,R)/QCR0(I,R);
ddQC(I) = dQC(I)/QC0(I);
ddCON(I,S,R) = dCON(I,S,R)/CON0(I,S,R);
ddHTAX(R) = dHTAX(R)/HTAX0(R);
ddCITR(R) = dCITR(R)/CITR0(R);
ddPITR(R) = dPITR(R)/PITR0(R);
ddRUTIL(R) = dRUTIL(R)/RUTIL0(R);
ddNUTIL = dNUTIL/NUTIL0;
ddSUMDK(R) = dSUMDK(R)/SUMDK0(R);
ddSUMDKc(R) = dSUMDKc(R)/SUMDKc0(R);
ddSUMDKn(R) = dSUMDKn(R)/SUMDKn0(R);
ddSUMQCR(R) = dSUMQCR(R)/SUMQCR0(R);
ddSUMQN(R) = dSUMQN(R)/SUMQN0(R);
ddPHI(I,R) = dPHI(I,R)/PHI0(I,R);
ddPIC(I) = dPIC(I)/PIC0(I);
ddCITBASE(R) = dCITBASE(R)/CITBASE0(R);
ddCOLI(R) = dCOLI(R)/COLI0(R);
ddCOLIC(R) = dCOLIC(R)/COLIC0(R);
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ddCOLIN(R) = dCOLIN(R)/COLIN0(R);

DISPLAY ddKLRAT, ddDTT, ddDTG, ddDTK, ddDTL;
DISPLAY         dPK, ddPK;
DISPLAY dPL, ddPL;
DISPLAY ddPKs, ddPLs, ddPRAT;
DISPLAY dPC, ddPC;
DISPLAY dPN, ddPN;
DISPLAY dPCC, ddPCC;
DISPLAY dDK, ddDK;
DISPLAY dDL, ddDL;
DISPLAY dQN, ddQN;
DISPLAY dQCR, ddQCR;
DISPLAY dQC, ddQC;
DISPLAY dCON, ddCON;
DISPLAY dHTAX, ddHTAX;
DISPLAY dCITR, ddCITR;
DISPLAY dPITR, ddPITR;
DISPLAY dRUTIL, ddRUTIL;
DISPLAY dNUTIL, ddNUTIL;
DISPLAY dSUMDK, ddSUMDK;
DISPLAY dSUMDKc, ddSUMDKc;
DISPLAY dSUMDKn, ddSUMDKn;
DISPLAY dSUMQCR, ddSUMQCR;
DISPLAY dSUMQN, ddSUMQN;
DISPLAY dPHI, ddPHI;
DISPLAY dPIC, ddPIC;
DISPLAY dCITBASE, ddCITBASE;
DISPLAY dCOLIC, ddCOLIC;
DISPLAY dCOLIN, ddCOLIN
DISPLAY dCOLI, ddCOLI;
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VITA

Kelly D. Edmiston was born in Roanoke, Virginia on January 11, 1971. He attended schools in the Roanoke County, VA and Horry County, SC school systems and graduated from Socastee High School, Myrtle Beach, SC in May, 1989. He entered Furman University (Greenville, SC) in August, 1989, and later transferred to the University of Tennessee in August, 1991. He graduated *Summa Cum Laude* from the University of Tennessee in May, 1993 and was honored as valedictorian of the College of Liberal Arts -- Social Sciences. After spending a year working and taking mathematics courses in Huntsville, Alabama, he re-entered the University of Tennessee to begin doctorate studies in economics. While at Tennessee, he held assistantships with the Center for Business and Economic Research and the Department of Economics, and worked for a short time as a consultant to the World Bank in Bosnia and Herzegovina. He received the Doctor of Philosophy degree in Economics in August, 1998 and accepted a position at Georgia State University as Assistant Professor of Economics and Senior Research Associate, Policy Research Center.