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POLICY BRIEF

The Economic Case Against a State Income Tax:

An Advanced Economic Analysis Using Washington-STAMP

By
David G. Tuerck, PhD, John S. Barrett, MS, Sorin Codreanu, MS

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This study is published in partnership with Beacon Hill Institute at Suffolk University.

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Executive Summary

The effects that tax rate changes have on taxable activities are real and can be quantified. Economic evidence indicates that state-level tax increases have significant negative effects on state economic activity.[1] Quantifying these negative effects, however, is difficult and requires the construction and use of a model of the state tax system

The purpose of a policy simulation model is to quantify the effects of proposed policy changes. The proper tool to provide the required level of detail and to analyze sweeping changes in the tax system is a *Computable General Equilibrium* (CGE) model. We have constructed a CGE model of Washington (Washington-STAMP). This report explains the concept behind the CGE model, sets out the individual components, and then uses this model to consider what would happen if Washington were to introduce a state income tax to replace part of the revenue that is currently raised by the state sales tax and also eliminate the state property tax.

A CGE tax model is a formal description of the economic relationships among Washington producers, households, government and the rest of the world. It is general in the sense that it takes all the important markets and flows into account. It is an equilibrium model because it assumes that demand matches supply in every market (goods and services, labor and capital); this is achieved by allowing prices to adjust within the model (i.e. they are endogenous). It is computable because, with the help of a computer, it can be used to generate numerical solutions to concrete policy and tax changes. And it is a tax model because it pays particular attention to identifying the role played by different taxes.

To provide the level of intricate detail that makes a CGE model so useful, it is necessary to create economic *sectors*; Washington-STAMP has 72 economic sectors. Each sector is an aggregate that groups together segments of the economy. We separate households into seven income classes and firms into 27 industrial sectors. In addition, we distinguish between 20 types of taxes (13 of them at the state level) and 11 categories of government spending. To complete

[1] Timothy J. Bartik, *Who Benefits from State and Local Economic Development Policies?* (Kalamazoo, Michigan: W.E. Upjohn Institute for Employment Research, 1991).

the model there are two factor sectors (labor, capital), an investment sector, three state fund sectors and a sector that represents the rest of the world.

In this report we illustrate the usefulness of Washington-STAMP by considering the effects of introducing a state income tax combined with a reduction in the state sales tax and elimination of the state property tax. Such an analysis allows us to make a side-by-side comparison of the economic effects and incentives of the current tax system as compared to this new system. The income tax we consider would be a flat rate of 3.8%, this would be coupled with a reduction in the sales tax rate from 6.5% to 3.5% and the elimination of the state property tax.

When we enter these changes into Washington-STAMP, and compare the new results with the baseline situation, a very interesting conclusion emerges: the tax change would make very little difference. In other words, *the case for introducing a personal income tax in Washington is not economically compelling*.

Looking at the results of this simulation in Table A below, the first point to note is that the combination of a state income tax, lower sales tax and elimination of the state property tax leads to an increase in the wage rate of 6.6%. This does not necessarily leave workers better off; it occurs because workers expect to be compensated for the increase in the income tax that they now have to pay.

The higher wage rate in turn leads firms to cut back the number of workers, causing employment to fall by 134,000. This represents a reduction of 3.75% in the number employed in Washington. The result is 71,000 formerly working, taxpaying households of Washington migrating out of the state. The higher wage rate also prompts firms to spend more on investment. They are in effect replacing (expensive) labor with machines.

Table A

Simulation Results of Introducing a State Income Tax, Reducing the State Sales Tax and Eliminating the State Property Tax		
	Estimated FY 2004	**Simulated FY 2004**
Employment		
Number employed ('000)	3,579	3,445
Change in labor	-	(134.2)
Change in labor relative to baseline (%)	-	-3.75
Gross wage rates		
Baseline wage rate, $/person/yr, nominal $	34,239	36,489
Change in wage rate, nominal $	-	2,249
Change in wage rate relative to baseline (%)	-	6.6
Investment		
Baseline investment, $m, nominal $	36,785	48,721
Change in nominal investment ($m)	-	11,936
Change in capital stock relative to baseline (%)	-	32.45
General Fund Revenues		
Nominal baseline WA revenues, $m	16,503	18,602
Change in state revenues, net tot.	-	2,099
Change in state revenue (%)	-	13.00

State Personal Income		
SPI ($bn)	210.771	215.416
Change in SPI ($bn)		4.645
Change in real GSP (%)		2.2
Disposable Income, real		
DI ($bn)	167.931	163.599
Change in real DI ($bn)		-4.332
Change in real DI (%)		-2.58
Disposable Income per capita, real		
DI/capita ($)	26,668	26,296
Change in real DI/capita ($)		-372
Change in real DI/capita (%)		-1.40

Alternatively one might look at real disposable income, which is earnings plus transfers (such as pensions) less taxes paid, adjusted for any change that occurs in the price level. Total real disposable income in Washington would decrease by 2.58%, which translates into a per capita real disposable income loss of 372 dollars. These results provide no justification for a major overhaul of the tax structure of the state.

INTRODUCTION

What makes a state tax system more progressive and stable, while at the same time provides enough revenue to meet the public needs of a state? This question has been asked in Washington State for decades and many citizens believe part of the answer involves instituting a state income tax. The issue of a Washington State income tax in recent decades has been the focal point of many fact-finding committees.

> In 1966 and 1968 then Republican Governor Dan Evans appointed a tax committee to investigate the state tax system. They recommended imposing a state income tax. A proposal was sent to voters on the 1970 ballot and was defeated by a margin of more than 2 to 1. In 1973 the Governor and lawmakers tried again and the voters overwhelmingly rejected it nearly 3 to 1.
>
> In 1982, Governor John Spellman appointed a new committee. Part of the committee's recommendation to lawmakers included an income tax proposal. There was no action taken by legislators.
>
> In 1988, Governor Booth Gardner appointed another committee. This committee recommended two tax reforms, one was an income tax. No bills were proposed in the legislature or referred to voters.

The Washington legislature, in 2001, approved the formation of the Washington Tax Structure Study Committee. The Committee, headed by William Gates, Sr., the father of Microsoft Corporation's co-founder, was asked to analyze how fair and stable the state's tax structure is currently. The Committee was also asked to present alternative tax schemes that it felt were fairer to the entire population.

The Committee felt that Washington's heavy reliance on their retail sales tax put an unfair burden on lower income citizens of Washington.[2] The Committee's goal was not to raise more revenue, but to shift the tax burden to a more equitable system. The Committee offered several alternatives, all of which included an income tax in one form or another.

In the sections that follow we first provide a brief description of computable general equilibrium models, and then set out the way in which we built the model for Washington. The key equations of the model are presented in detail in Section 4. We then use the model to analyze the effect of introducing one of the Committee's proposals. Specifically we will look at instituting a flat income tax rate of 3.8%, reducing the sales tax rate to 3.5% and eliminating the state property tax.

WHAT IS WASHINGTON STAMP?

Washington STAMP is a comprehensive model of the Washington economy, designed to capture the principal effects of state tax changes on that economy. Washington STAMP is computable general equilibrium (CGE) tax model. As such, it provides a mathematical description of the economic relationships among producers, households, government and the rest of the world. It is general in the sense that it takes all the important markets and flows into account. It is an equilibrium model because it assumes that demand equals supply in every market (goods and services, labor and capital); this is achieved by allowing prices to adjust within the model (i.e. they are endogenous). It is computable because it can be used to generate numeric solutions to concrete policy and tax changes, with the help of a computer. And it is a tax model because it pays particular attention to identifying the role played by different taxes.[3]

We begin by distinguishing between producers and consumers. Consumers/households earn income by supplying labor (wages and salaries) and capital (dividends and interest); they also receive transfer payments such as pensions. They are assumed to maximize their utility, which they do by using this income to buy goods and services, pay taxes and save. Their spending decisions are strongly influenced by the structure of prices they face; and the amount of labor that they are willing to provide depends to a substantial degree on the wage rates that they face.

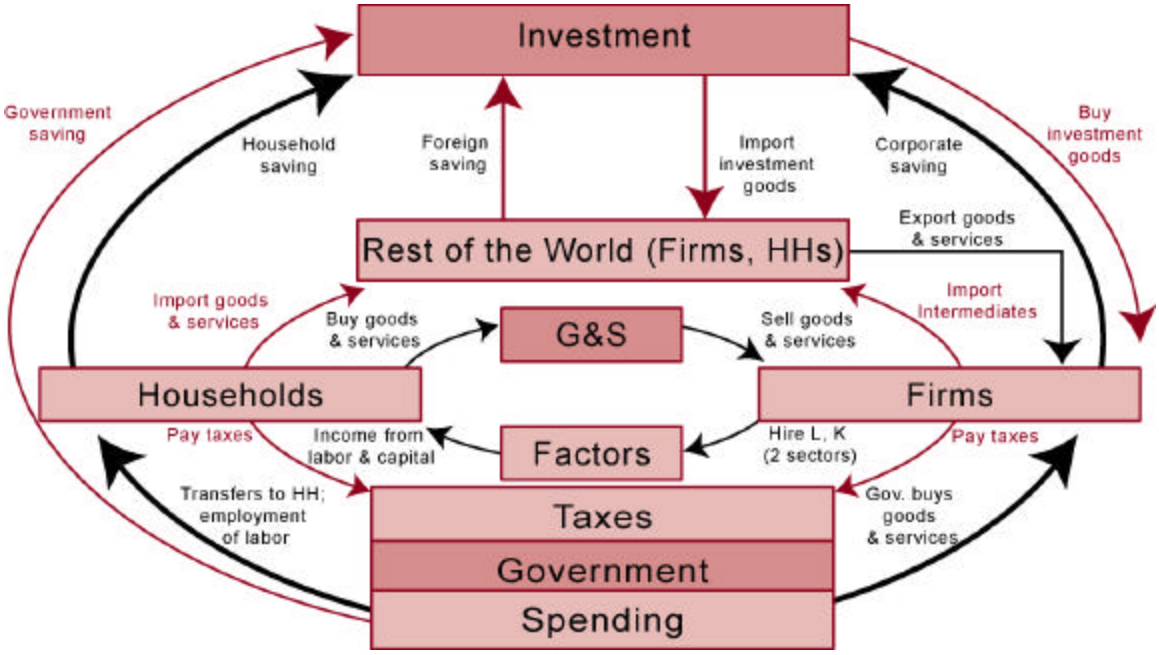
Producers/firms buy inputs (labor, capital and intermediate goods that are produced by other firms) and transform them into outputs. They are assumed to maximize profits and are likely to change their decisions about how much to buy or produce depending on the prices they face for inputs and outputs.

In addition there is a government sector that collects taxes and fees and provides services and transfers. The rest-of-the world sector consists of the entire world outside Washington. The relationships between these components are set out in the circular flow diagram shown in Figure 1. The arrows in the diagram represent flows of money (for instance, households purchase goods

[2] Washington State gets 64 percent of its budget from sales tax including business and occupation taxes.
[3] For a clear introduction to CGE tax models, see John B. Shoven and John Whalley, "Applied General-Equilibrium Models of Taxation and International Trade: An Introduction and Survey," *Journal of Economic Literature,* XXII (September, 1984), 1008. Shoven and Whalley have also written a useful book on the practice of CGE modeling entitled *Applying General Equilibrium* (Cambridge: Cambridge University Press, 1992).

and services), and flows of goods and services (for instance, households supply their labor to firms). The separate box for government shows the flows of funds to government in the form of taxes, as well as government purchases of goods and services and government hiring of labor and capital.

Figure 1 **- Circular Flow Diagram**



Complex as it may seem, the diagram in Figure 1 is still too simple, because it lumps all households into one group, and all firms into another. To provide further detail it is necessary to create *sectors*; Washington-STAMP has 72 economic sectors. Each sector is an aggregate that groups together segments of the economy. We separate households into seven income classes and firms into 27 industrial sectors. In addition, we distinguish between 20 types of taxes (13 of them at the state level) and 11 categories of government spending. To complete the model there are two factor sectors (labor, capital), an investment sector, three state fund sectors and a sector that represents the rest of the world. The choice of sectors was dictated by the availability of suitably disaggregated data (for households and firms), and the purposes of the model, which is why we provide considerable detail about taxes.

Regional models, such as Washington-STAMP, are similar in many respects to national and international CGE models. However they differ in a number of important respects, which are worth listing:

a. In a national model, most saving goes toward domestic investment; however this need not be true at the regional level. If citizens of Washington save more than they spend, then the excess saving will leak out of the state.
b. The smaller the unit under consideration, the greater the importance of trade with the rest of the world. This is an important consideration for state models.
c. Migration is likely to be larger and more responsive across states than across nations.

d. In regional models, taxes are interdependent. So, for instance, the amount of revenue collected by the Federal personal income tax depends significantly on whether there is a state income tax (which may be deducted from income before computing the Federal tax).
e. Data are less available at the regional than national level. This explains why scores of national CGE models have been built, but very few regional models.

Constructing a CGE model

The construction of a CGE model involves several steps. First, one needs to organize the data needed by the model. Washington STAMP is based on data for a single year, 2001, which the model then extrapolates to FY 2004. However the data from the base year, 2001, must be very detailed. Most of the data are organized into a *Social Accounting Matrix*, which in this case consists of a 72 by 72 matrix that accounts for the main economic and fiscal flows in the state. The model also requires some additional information – for instance data on employment and on the structure of the Federal income tax – which are put in separate files. And the model requires information on "elasticities;" these are the parameters, typically gleaned from the academic literature, that measure the responsiveness of households to changes in prices and wages, and of firms to changes in input costs and output prices. The economy is assumed to be competitive, and to run at full employment (by which we mean that there is no involuntary unemployment).

Second, the model needs to be specified in detail; the next section of this report sets out details of the model that we constructed for Washington, along with some comments explaining the choices made at each step.

The third step is to program the model. For this we used the specialized GAMS (General Algebraic Modeling System) software. In order to make the model easier to use, we also developed an interface in Microsoft Excel. This allows the user to enter tax changes on an Excel spreadsheet, click on the "Estimate CGE" button, and read the key output on the same spreadsheet; the heavy-duty computing occurs in the background.

Before use, the model has to be calibrated. This consists of running the model – i.e. asking it to solve for all the variables in such as way as to maximize state personal income – and then checking that the results correspond with the actual values of the variables in the base year (taken to be 2001 in our case). Once the model reproduces the base year values, it is considered calibrated. Calibration is a non-trivial step, and is essentially a way of checking that the model is working properly.

Finally, the model is ready to be used to quantify tax change effects. The procedure is straightforward: specify a new tax rate (or change in the tax), run the model, and compare the new results with the baseline ones. At this point it is also possible to test the sensitivity of the results to different assumptions – such as the values of elasticities – that are incorporated into the model. We note in passing that Washington STAMP is a policy model and not a forecasting model; in other words it is designed to answer "what if?" questions, not to estimate what is likely to occur in coming years.

Organizing the Data

The starting point in building a CGE model is to determine the degree of detail that is desired and to organize the collected data into the useful format of a Social Accounting Matrix (SAM). The SAM that we developed for Washington is a 72 by 72 matrix. Each of the 5,184 cells represents the dollar value of a flow from one sector of the economy to another – for instance, purchases of business services by the agricultural sector, or labor earnings flowing to middle-income households. Reading along a row one finds the payments received by that sector; reading down a column one sees the payments made by that sector. The SAM is balanced, which means that the sum of the entries in any given row equals the sum of the entries in the corresponding column. Thus, for instance, the revenue received by agriculture must equal spending by that sector, so that all incoming and outgoing funds are completely accounted for.

For Washington STAMP, we distinguish 27 industrial sectors, two factors (labor and capital), seven household categories, an investment sector, 34 government sectors (20 for taxes, 14 for spending) and a sector for the rest of the world. In sectoring the economy we sought to strike a balance between providing a high level of detail (especially on the tax side) and keeping the model to a manageable size. In addition there is a more pragmatic consideration, which is that the lack of finely disaggregated data limits the degree of detail that is possible. Data availability also determined some of the choices we made; for instance, it is possible to get a breakdown of households into seven income categories (see below for further details), and while we might have preferred a different set of categories, we were constrained by the nature of the data available.

"Industrial" sectors

A full list of the 27 industrial sectors that we used, along with employment in each industry, is shown in Table 1. Data from the Bureau of Economic Analysis would have allowed us to separate out 49 sectors. However some sectors were too small to merit separate attention, which is why, for instance, we combined textiles and apparel. In some other cases there were no matching employment figures, and so it was easier to work with aggregates. Further, only 37 sectors were distinguished for the input-output table.

Table 1: Industrial sectors used in Washington STAMP, with employment levels in 2001

	2001
Agriculture, forestry and fishing	97750
Mining	4572
Construction	247996
Food and food processing	41907
Apparel and clothing	10752
Building materials and furniture	54092
Paper and Publishing	42966
Chemicals, rubber, plastics	18523
Electronic and electrical equipment	19041
Motor vehicles	115707
Primary and fabricated metal	28218
Industrial machinery and equipment	25971

Instruments	14727
Other manufacturing	12034
Transportation	125494
Communications	29992
Electricity, gas, sanitary	18098
Wholesale trade	167381
Retail trade	581473
Banking	95433
Insurance	54587
Real estate	91637
Repair services	131280
Business services	424092
Hotels, amusements, motion pictures, entertainment	120297
Health services	232025
Other services	175115
Source: IMPLAN and Bureau of Economic Analysis.	

Factor Sectors

We distinguish between two factors, labor and capital (which includes land). Businesses pay wages and salaries to labor, and they generate profits. These are then distributed to household owners as factor income.

Household Sectors

In Washington STAMP, households receive wages, capital income and transfers; they use this income to buy goods and services; they pay taxes; and they save. We distinguish seven household sectors, which group households by their levels of income, as shown in Table 2. Expenditure data are available for households in each of these categories, which make it relatively straightforward to work with this structure. One purpose of this disaggregation of households is to allow one to trace the distributive effect of tax changes; another is to allow different groups to have different levels of sensitivity to labor market conditions. Of a total estimated real disposable income of $132.5 billion in 2001, a quarter (26%) accrues to the 9% of households that are in the top income category.

Table 2 Number of households by income bracket, 2001

Category of household	Income per household level $ p.a.	Total estimated real disposable income 2001, $bn	Number of households millions
LESS10	<$10,000	6.1	0.30
LESS20	$10,000 – 19,999	15.1	0.40
LESS30	$20,000 – 29,999	20.2	0.40
LESS40	$30,000 – 39,999	22.2	0.37
LESS50	$40,000 – 49,999	20.9	0.28
LESS70	$50,000 – 69,999	34.0	0.37
MORE70	$70,000 and up	40.8	0.20
All Washington		**159.3**	**2.31**

Investment Sector

There is one investment/savings sector. Households save, both directly out of their cash incomes, and indirectly because they own shares in businesses that save and reinvest profits. The government also saves and invests. Information is available from the Bureau of Economic Analysis on the pattern of gross investment by destination (i.e. how much gross investment went into adding to the stock of capital in agriculture, in mining, and so on). We have constructed measures of the capital stock in each sector; by applying published depreciation rates and adding gross investment, one arrives at the capital stock in the subsequent period. This permits the model to track the expansion of the economy over time. The BEA has also produced a matrix, built for the U.S. for 1992, that maps investment by destination with investment by source. In other words, it allows one to find out, for instance, how much of the investment destined for agriculture is spent on purchasing goods and services from the construction sector and the transport sector. Thus if investment rises, it is possible to identify which sectors would face an expansion in the demand for their output.

Government Sectors

Washington STAMP was designed primarily to analyze the effects of major changes in the structure of state taxes, and so we have paid particular attention to providing sufficient detail for government transactions. The sectoring is summarized below in Table 3.

Table 3 **- Government Sectors**

Federal Government Receipts		
USSSTX	Social Security	Receives payments from employers and households; pays out transfers to households.
USPITX	Federal personal income tax	Receives payments from households, which are put into the Federal normal spending account.
USCITX	Federal corporation income tax	Receives payments from corporations and channels them into the Federal normal spending account.
USOTTH	Other federal taxes	Includes excises on motor fuel, alcohol, and tobacco; estate and gift taxes. Also funneled into the Federal normal spending account.
Federal Government Expenditure		
USNOND	Federal normal spending	Federal government purchases goods and services, hires labor, and transfers money to Washington and to Federal defense fund.
USDEFF	Federal defense spending	Purchases goods and services, and pays labor for military purposes.
Washington Government Receipts		
STSATX	Washington sales tax	Sales tax, vehicle sales tax, utility taxes, hotel and motel tax. Revenues go into Washington general fund and special fund.
STMOTX	Washington tax on motor fuel	Revenues go into Washington general fund and special fund.
STCITX	Washington business and occupation tax	This is the tax on business; revenues to into the Washington general fund and special fund.
STALTX	Washington tax on alcohol	Revenues go into Washington general fund and special fund.
STCTTX	Washington tax on tobacco	Revenues go into Washington general fund and special fund.
STIHTX	Washington tax on insurance occupation	Revenues go into Washington general fund.
STINTX	Washington inheritance tax	Revenues go into Washington general fund and special fund.
STFEES	Washington fees, licenses, permits	Revenues go into Washington general fund and special fund
STWKTX	Washington workers' compensation and disability	Sector combines workers compensation and unemployment funds. Receipts from Federal government go directly to households.
STOGTX	Washington oil and gas tax	Revenues go into Washington general fund and special fund.
STGENF	Washington general fund	An accounting device. Tax revenue is channeled into this fund before being distributed to other uses.

Washington Government Expenditure		
STEDUC	Washington spending on education	Mainly purchases of goods and services and labor in the higher education sector.
STHELT	Washington spending on health & welfare	Buys some services; mainly transfers funds to local health spending fund.
STTRAN	Washington spending on transport	Mainly buys engineering services and construction.
STOTHS	Washington other spending	Miscellaneous other spending by the state on labor, goods and services.
Local Government Receipts		
LOPRTX	Local tax on residential property	Collected from households. Transferred to local government spending units.
LOPBTX	Local tax on business property	Collected from firms. Transferred to local government spending units.
LOOTTX	Local taxes, other	Local taxes such as sales tax. Transferred to local government spending units.
Local Government Expenditure		
LOEDUC	Local spending on education	Purchases goods and services and (mainly) pays teacher salaries.
LOHELT	Local spending on health & welfare	Purchases goods and services and pays labor; large transfers to the poorest category of households.
LOTRAN	Local spending on transportation	Mainly buys engineering services and construction.
LOOTHS	Local other spending	Includes spending on police and firefighters, road repair, and miscellaneous local government services.

The Washington state government collects revenue from taxes on sales, motor fuel, the business and occupation tax, excises on alcohol and tobacco, insurance and inheritance. It also collects a variety of fees. The relative importance of these courses of revenue is clear from Table 4, which summarizes state receipts in FY2002 and presents the most recent estimates (as of November 2002) of revenue for FY2003 through FY2005.

Table 4

Washington revenue by source, FY 2001	
	$million
Sales tax, including motor vehicles	5,934
Motor fuels taxe s	736
Business and occupation tax	2,018
Property tax	1,367
Insurance occupation taxes	280
Oil and gas production taxes	303
Alcohol and tobacco taxes	125
Inheritance taxes	106
Personal income tax	0
From Federal government	5,758
Fees and other income	3,252
Total	**17,879**
Source: Washington State Department of Revenue. http://dor.wa.gov/docs/reports/2001/Tax_Statistics_2001/Table_1.PDF	

All of the collections from these taxes and fees are deemed to go into one of the following funds, general fund, special fund or other fund, from whence they flow to different categories of spending.

In the model, the government of Washington pays directly for some education, mainly the University of Washington system. It also spends on public safety and transportation and general administration, mostly salaries for state workers. A major category of spending is health

and welfare, mostly in the form of transfers to local authorities. All remaining state spending is gathered into a residual category.

Local governments in Washington receive tax revenue from residential property and business and commercial property, as well as from a variety of other taxes and fees. These funds, augmented by transfers from the state level, flow to spending on education, health and welfare and other spending such as public safety.

Rest of the World

To complete the model we have included a sector for the rest of the world (ROW). This refers to the rest of the United States as well as other countries. Information on flows between Washington and the rest of the world is difficult to piece together, and is an area where considerable professional judgment was required.

WASHINGTON STAMP IN DETAIL

In this section we set out the model in detail. First we introduce each equation, providing some context and a short description. Then we present each equation in mathematical form, followed by the form used in the GAMS (General Analytical Modeling System) program and finishing with information on the sources of data used.

A. HOUSEHOLD DEMAND

Households are assumed to maximize their well being ("utility") by picking baskets of goods and services, subject to their budget constraints. The key set of equations in this section is labeled *Private Consumption*, and consists of a set of demand functions. These demand functions, based on a Cobb-Douglas utility function, take on the simple form,

$$X_i = \lambda_i * \frac{I}{P_i}, \quad i = 1,...,n,$$

where X_i is the quantity demanded of good i, P_i is the price of good i, I is income, and the λ_i are parameters that measure the share of income that is devoted to good i. This is the simplest specification that is theoretically satisfactory: it is additive (so spending equals income less taxes less saving), has downward-sloping demand (i.e. it ensures that when the price of a good rises the quantity demanded falls), is zero degree homogeneous in prices and income (so that if prices and incomes were to double, the quantity demanded would not change), and meets the technical requirement of symmetry of the Slutsky matrix. More complex formulations are possible, but there is a lack of reliable data on the elasticity parameters that would be needed in such cases.

Household Gross Factor Income

Comments: The gross income of households in each of the seven groups (indexed by h in the set H) is found by first summing factor income (y_f) from labor and capital, subtracting the social security contributions paid by employees, and then allocating the total to each group on the basis of fixed shares. Factor payments are allocated to each household group using the same fixed shares as were found in the base year.

Eq.1. $$y_h = \sum_{f \in F} \frac{\alpha_{hf} a_h^w}{\sum_{h \in H} \alpha_{hf} a_h^w} y_f \left(1 - \sum_{g \in GF} t_{gf}^h \right) \quad \forall h \in H$$

GAMS: Y(H) = E = SUM(F, A(H,F) * HW(H)/ SUM(H1, A(H1,F) * HW(H1))* Y(F) * (1 - SUM(G, TAUFH(G,F))));

Data: The information on earnings for each household group comes from household survey data for the West of the U.S. for 2000-2001. Source: *BLS Consumer Expenditure Report 2000-2001 (West)*. Available at ftp://ftp.bls.gov/pub/special.requests/ce/crosstabs/y0001/regbyinc/xregnmw.txt.

Household Disposable Incomes

Comments: Disposable household income is gross income, less taxes on household income and property (mainly personal income tax (USPIT) and residential property tax (LOPRP)), plus transfer payments (such as social security and unemployment benefits).

Eq.2.

$$y_h^d = y_h - \sum_{g \in GI} t_{gh} a_h^w - \sum_{g \in GH} t_{gh}^h a_h + \sum_{g \in G} w_{hg} a_h^n t_{hg}^{pc} - \sum_{g \in G} w_{hg} (a_h^n - \bar{a}_h^n) t_{hg}^{pc} SSIYES \quad \forall h \in H$$

GAMS: YD(H) = E = Y(H) - SUM(GI, PIT(GI,H)) * HW(H) - SUM(G, TAUH(G,H) * HH(H)) + (SUM(G, TP(H,G) * HN(H) * TPC(H,G)));

Private Consumption Expenditure

Comments: This is the simplest demand system that is consistent with theoretical first principles, and it requires only a limited number of parameters.

Eq.3. $$c_{ih} = \bar{c}_{ih} \left(\frac{y_h^d}{\bar{y}_h^d} \div \frac{p_h}{\bar{p}_h} \right)^{b_{ih}} \prod_{i' \in I} \left[\frac{p_i \left(1 + \sum_{g \in GS} t_{gi}^c \right)}{\bar{p}_i \left(1 + \sum_{g \in GS} t_{gi}^q \right)} \right]^{l_{fi}} \quad \forall i \in I, h \in H$$

GAMS: CH(I,H) = E = CH0(I,H) * ((YD(H) / YD0(H)) / (CPI(H) / CPI0(H))) ** BETA(I,H) * PROD(J, ((P(J) * (1 + SUM(GS, TAUC(GS,J)))) / (P0(J) * (1 + SUM(GS, TAUQ(GS,J))))) ** LAMBDA(J,I));

Data: By construction, this equation has zero cross price elasticities. In the absence of adequate estimates of demand elasticities we follow the approach taken by Berck et al., setting all income and own-price elasticities equal to unity.

Direct household purchases of imports

Some household spending goes directly to buy goods and services outside Washington.

$$m_h = \overline{m_h}\left(\frac{y_h^d}{\overline{y_h^d}} \div \frac{p_h}{\overline{p_h}}\right)^{\eta_h^m} \quad \forall h \in H$$

GAMS: M(H) =E= M0(H) * ((YD(H)/(YD0(H))/(CPI(H)/CPI0(H)))**ETAMH(H);

Household Savings

Comments: In Washington STAMP, household savings is the residual after spending and taxes have been subtracted from income. Thus savings are seen as occurring passively.

Eq.4. $$s_h = y_h^d - \sum_{i \in I} c_{ih}\, p_i \left(1 + \sum_{g \in GS} \tau_{gi}^c\right) - m_h \quad \forall h \in H$$

GAMS: S(H) =E= YD(H) - SUM(I, P(I) * CH(I,H)*(1+SUM(GS, TAUC(GS,I)))) – M(H);

Data: The savings rates for households at each income level were adjusted, based on professional judgement, to account for the imputed savings by corporations (which indirectly represents savings by the owners of the corporations).

Consumer Price Indexes

Comments: The price index in the reference period is set equal to 1. There is a separate price index for each household group. This allows one to compute the real (rather than nominal) income for each household group. A tax on, for instance, foodstuffs would tend to hit poor households relatively hard, and the CPI for poor households would pick up this effect.

Eq.5. $$p_h = \frac{\sum_{i \in I} p_i \left(1 + \sum_{g \in GS} \tau_{gi}^c\right) c_{ih}}{\sum_{i \in I} \overline{p}_i \left(1 + \sum_{g \in GS} \tau_{gi}^q\right) c_{ih}} \quad \forall\, h \in H$$

GAMS: CPI(H) = E = SUM(I, P(I) * (1 + SUM(GS, TAUC(GS,I))) * CH(I,H)) / SUM(I, P0(I) * (1 + SUM(GS, TAUQ(GS,I))) * CH(I,H));

Data: The consumption of each good by each household group (c_{ih}) is derived from Consumer Expenditure Survey data (1999-2000). Expenditures on each product group by household groups were allocated based on the types of products that were reported. For example expenditures on pork went to the Food sector and expenditures on vehicles went to the Transportation sector (TPORT). The numbers refer to the West region of the US, which we took to be an adequate

representation of spending patterns in Washington. The distribution of households by income group is also for the West rather than Washington, but we applied the same proportions to the population of Washington.

B. LABOR SUPPLY

Comments: In Washington STAMP, we model the participation rate, which is defined as the proportion of households in any given income category that work. The participation rate is assumed to rise if wage rates rise, if the taxes levied on earnings fall, or if the transfer payments paid out per non-working household fall. The participation rate for low-income households is assumed to be highly sensitive to the level of transfer payments, but relatively insensitive to changes in taxes or the wage rate. On the other hand high-income households are assumed to respond substantially to changes in the taxes and wage rates they face.

Eq.6.
$$\frac{a_h^w}{a_h} = \frac{\overline{a}_h^w}{a_h}\left(\frac{r_L^a}{\overline{r}_L^a} \div \frac{p_h}{\overline{p}_h}\right)^{h_h^{ls}} \left(\frac{\sum_{g\in GI} t_{gh}}{\sum_{g\in GI} \overline{t}_{gh}}\right)^{h_h^{PIT}} \left(\frac{\sum_{g\in G} \frac{w_{h'g}}{p_h}}{\sum_{g\in G} \frac{\overline{w}_{h'g}}{\overline{p}_h}}\right)^{h_h^{tp}} \quad \forall\, h \in H$$

GAMS: HW(H) / HH(H) = E = HW0(H) / HH(H) * ((RA('L') / RA0('L')) / (CPI(H) / CPI0(H))) ** ETARA(H) * (SUM(GI, PIT(GI,H)) / SUM(GI, PIT0(GI,H))) ** ETAPIT(H) * (SUM(G, TP(H,G) / CPI(H)) / SUM(G, TP0(H,G) / CPI0(H))) ** ETATP(H);

Data: The data on working households by income class came from the Consumer Expenditure Survey (1999-2000) for the West, as did the total number of households in each category. These were then adjusted to fit the total number of households in Washington.

C. MIGRATION

Population

Comments: The number of households in each income group depends first and foremost on the initial number of households. To this we add the natural growth of the population and net in-migration. Migration in turn depends on the level of after-tax income, and the proportion of households that are not working (which reflects the employment prospects facing new migrants). This formulation is in the spirit of the migration model popularized by Harris and Todaro (*American Economic Review, 1973)*.

Eq.7.
$$a_h = \overline{a}_h \cdot (1+\rho) + \overline{a}_h^i \left(\frac{y_h^d}{a_h} \div \frac{\overline{y}_h^d}{\overline{a}_h} \div \frac{p_h}{\overline{p}_h}\right)^{h_h^{yd}} \left(\frac{a_h^n}{a_h} \div \frac{\overline{a}_h^n}{\overline{a}_h}\right)^{h_h^u} - \overline{a}_h^o \left(\frac{\overline{y}_h^d}{\overline{a}_h} \div \frac{y_h^d}{a_h} \div \frac{\overline{p}_h}{p_h}\right)^{h_h^{yd}} \left(\frac{\overline{a}_h^n}{\overline{a}_h} \div \frac{a_h^n}{a_h}\right)^{h_h^u}, \quad \forall h \in H$$

GAMS: HH(H) = E = HHOLD0(H) * (1+NRPG(H)) + MI0(H) * ((YD(H) / HH(H)) / (YD0(H) / HH0(H)) / (CPI(H) / CPI0(H))) ** ETAYD(H) * ((HN(H) / HH(H)) / (HN0(H) / HH0(H))) ** ETAU(H) - MO0(H) * ((YD0(H) / HH0(H)) / (YD(H) / HH(H)) / (CPI0(H) / CPI(H))) ** ETAYD(H) * ((HN0(H) / HH0(H)) / (HN(H) / HH(H))) ** ETAU(H);

Data: The natural rate of population growth is taken to be 0.72% p.a., based on recent Washington experience. The elasticities used in this equation are the same as those used for California by Berck et al. (1996), and "reflect the middle ground found in the literature about migration" (p.117).

Number of Non-Working Households

Comments: This is a simple accounting equation; the number of non-working households is the total number of households, less the number that are working.

Eq.8. $a_h^n = a_h - a_h^w \qquad \forall h \in H$

GAMS: HN(H) = E = HH(H) - HW(H);

D. THE BEHAVIOR OF PRODUCERS/FIRMS

Producers are assumed to maximize profit. Combining intermediate inputs with labor and capital produces output. The amount of intermediate inputs required per unit of output is fixed, but firms have considerable leeway to vary the amounts of capital and labor that they use in production. The value of output less intermediate inputs is value added, and it is useful to compute a price for this value added; it is this price that determines factor demand – i.e. drives firms to hire more or less labor and capital. The amount of labor and capital inputs, in turn, drive the total value of output via the production function.

Intermediate Demand

Comments: Intermediate goods constitute a fixed share of the value of production.

Eq.9. $v_i = \sum_{i' \in I} a_{ii'} q_{i'} \qquad \forall i \in I$

GAMS: V(I) = E = SUM(J, AD(I,J) * DS(J));

Data: From the Washington input-output table, derived from data from IMPLAN, which in turn are based on data from by the Bureau of Economic Analysis.

Production Function

Comments: Output is determined by the quantities of labor and capital used in production; it is assumed that enough intermediate goods will be available. We use a Constant Elasticity of Substitution (CES) production function, which allows a degree of substitution between labor and capital; in other words, if the price of labor rises, firms will cut back on the number of workers they hire, and use more capital instead.

Eq.10. $$q_i = \gamma_i \left[\sum_{f \in F} \alpha_i \left(u_{fi}^d \right)^{-\rho_i} \right]^{-1/\rho_i} \quad \forall i \in I$$

GAMS: DS(I) = E = GAMMA(I)*SUM(F,ALPHA(F,I) * FD(F,I) ** (-RHO(I))) ** (-1/RHO(I));

Data: We use values for the elasticity of substitution that are close to, but slightly lower than, one. This is relatively standard in CGE models. Information on the shares of labor and capital in production come from the Bureau of Economic Analysis.

Price of Value Added

Comments: Define value-added as the value of output less the cost of intermediate inputs. One may then define a "price" of value added, which we then use below in the factor demand (i.e. labor demand, capital demand) equations.

Eq.11. $$p_i^{va} = p_i^d - \sum_{i' \in I} \alpha_{i'i} p_i \left(1 + \sum_{g \in GS} \tau_{gi'}^v \right) \quad \forall i \in I$$

GAMS: PVA(I) = E = PD(I) - SUM(J, AD(J,I) * P(J) * (1 + SUM(GS, TAUV(GS,J))));

Data: Prices are set equal to unit in the baseline case.

Factor Demand

Comments: It is possible to construct a profit function, which expresses profits as a function of factor inputs. From microeconomic theory it can be shown that the partial first derivative of the profit function, with respect to a given factor demand variable, gives the demand equation for that factor. The left hand side of the equation shows payments to labor (including the cost of factor taxes such as the employer share of social security contributions). The right hand side gives the amount of value added attributable to the factor. There is a separate equation for labor and for capital, for each of the 27 industrial sectors.

Eq.12. $$r_{fi} r_f^a \left(1 + \sum_{g \in GF} \tau_{fgi}^x \right) u_{fi}^d = p_i^{va} q_i \alpha_{fi} \quad \forall i \in I, f \in F$$

GAMS: R(F,I) * RA(F) * (1 + SUM(GF,TAUFX(GF,F,I))) * FD(F,I) = E = PVA(I) * DS(I) * ALPHA(F,I);

Data: Information on the wage bills comes from the Bureau of Economic Analysis. The total wage bill is divided by the numbers of workers (from the Bureau of Labor Statistics) to get measures of wage rates by industry. The intersectoral wage differentials are not allowed to vary within the model. The cost of capital was derived as property-type income divided by the capital stock. The capital stock was constructed by disaggregating the national aggregate level of capital using a series of proxy measures; further details of the methodology are provided in Appendix 2 of the *Texas State Tax Analysis Modeling Program: Texas-*

STAMP (1999) and although this refers to Texas, the same approach was taken in computing the capital stock for Washington.

Factor Income

Comments: The total income accruing to factors – i.e. to labor and capital – is computed here.

Eq.13. $$y_f = \sum_{i \in I} r_{fi} r_f^a u_{fi}^d + \sum_{g \in G} r_{fg} r_f^a u_{gi}^d \qquad \forall f \in F$$

GAMS: Y(F) =E= SUM(I, R(F,I) * RA(F) * FD(F,I))+ SUM(G, R(F,G) * RA(F) * FD(F,G));

E. TRADE WITH OTHER STATES AND COUNTRIES

From a Washington perspective, the "rest of the world" consists of the remainder of the United States as well as the world outside the U.S. Goods produced in Washington are assumed to be close, but not perfect, substitutes for goods produced elsewhere. Thus if prices rise in Washington, the state's exports will fall and its imports will rise, but the adjustment need not be very large. There is no need for trade to be balanced; capital flows simply adjust to cover the gap between exports and imports. In this section we also develop a measure of the average price faced by domestic households and firms for goods and services produced by each industry: the price is a weighted average of the price of locally produced and imported goods.

Demand for Exports

Comments: Exports depend on the price of goods within the state relative to the price outside Washington. If the domestic price rises relative to the foreign price, exports will fall. Note that the elasticity here is negative.

Eq.14. $$e_i = \overline{e}_i \left[p_i^d \div \overline{p}_i^w \right]^{h_i^e} \qquad \forall i \in I$$

GAMS: CX(I) = E = CX0(I)*(PD(I) / PW0(I)) ** ETAE(I);

Data: The trade data for Washington are not particularly reliable; we have used our judgement, combined with BEA data, to arrive at sensible estimates. The elasticities we use are similar to those employed by Berck et al.

Domestic Share of Domestic Consumption

Comments: The demand for imports is handled indirectly, by modeling the share of domestic consumption that is supplied by domestic firms (*d*), following the approach pioneered by Armington (1969). This share depends on the domestic price relative to the price of the same goods in the rest of the world. We ignore import tariffs on the grounds that they are a tiny fraction (less than 1%) of the value of goods imported into Washington.

Eq.15. $$d_i = \overline{d}_i \left[p_i^d \div \overline{p}_i^w \right]^{h_i^d} \qquad \forall i \in I$$

GAMS: D(I) = E = D0(I) * (PD(I) / PW0(I)) ** ETAD(I);

Data: As with export demand we have used our judgement, combined with BEA data, to arrive at sensible estimates.

Import Demand

Comments: Imports consist of the share of domestic consumption that is not supplied by domestic production.

Eq.16. $$m_i = (1 - d_i)\, x_i \qquad \forall i \in I$$

GAMS: M(I) = E = (1 - D(I)) * DD(I);

Average Prices by Industry

Comments: These aggregated prices are computed for each industry, and are weighted averages of the domestic price and the import price, with the weights consisting of the respective shares in consumption. The price is set to unity in the baseline situation.

Eq.17. $$p_i = d_i\, p_i^d + (1 - d_i)\, \overline{p}_i^w \qquad \forall i \in I$$

GAMS: P(I) = E = D(I) * PD(I) + (1 - D(I)) * PW0(I);

Net Capital Inflow

Comments: The net capital inflow is simply the value of imports less the value of exports. This is an unconstrained variable in Washington STAMP.

Eq.18. $$z = \sum_{i \in I} m_i \overline{p}_i + \sum_{h \in H} m_h - \sum_{i \in I} e_i p_i^d$$

GAMS: NKI = E = SUM(I, M(I) * PW0(I)) + SUM(H,M(H)) - SUM(I, CX(I) * PD(I));

F. INVESTMENT

We first constructed a measure of the capital stock for each industrial sector for 2000. This stock, less depreciation and plus gross investment gives the capital stock for 2001. Gross investment is determined, sector-by-sector, based on the net of tax rate of return (relative to the return in the base period). Once investment by, for instance, the agricultural sector has been determined, it is transformed with the help of the capital coefficient matrix into the demand for goods and services for each sector in the economy.[4]

Capital Stock

[4] The Capital Coefficient Matrix is a matrix of investments by using industries. It contains distribution ratios of new structures and equipment to using industries from the 1992 BEA capital flow tables.

Comments: The capital stock in time *t* is the capital stock from the previous period adjusted for depreciation, and augmented by gross investment.

Eq.18. $$u_{Ki}^{s} = \overline{u}_{Ki}^{s}\left(1-\delta_i\right)+n_i \quad \forall i \in I$$

GAMS: KS(I) = E = KSOLD0(I)*(1-DEPR(I)) + N(I) ;

Data: A complete discussion of the construction of capital stock figures is given in *Texas State Tax Modeling Program: Texas-STAMP* (1999); the same approach and the same data sources are used for Washington.

Gross Investment by Sector of Destination

Comments: The amount of gross investment in any given sector depends on the after-tax rate of return in that sector relative to the return in the base period. The terminology here can be confusing; investment destined for agriculture, for instance, consists of the purchases of goods that will add to the capital stock in the agricultural sector; the goods themselves will mainly come from other sectors (the sectors of source).

Eq.19. $$n_i = \overline{n}_i \left[\frac{r_{Ki}\left(1-\sum_{g\in GK} \tau_{gKi}^{x}\right)\overline{u}_{Ki}}{\overline{r}_{Ki}\left(1-\sum_{g\in GK} \tau_{gKi}\right)\overline{u}_{Ki}} \right]^{\eta_i} \quad \forall i \in I$$

GAMS: N(I) = E = N0(I) * ((R('K',I) * (1 - SUM(GK, TAUFX(GK,'K',I))) * KSOLD0(I)) / (R0('K',I) * (1 - SUM(GK, TAUF(GK,'K',I))) * KSOLD0(I))) ** ETAIX;

Data: The rate of return is computed as the property-type income for each sector (from BEA) divided by the capital stock (authors' computations). Based on the econometric results from STAMP models estimated for Texas and elsewhere, we estimated the investment demand elasticity to be about 0.6.

Gross Investment by Sector of Source

Comments: Given that investment has been determined for each sector of destination, this equation allows one to determine who will actually produce the investment goods. This is done with the help of a capital coefficient matrix.

Eq.20. $$p_i\left(1+\sum_{g\in GS} \tau_{gi}^{n}\right)c_{in} = \sum_{j\in I} \beta_{ij} n_i \quad \forall i \in I$$

GAMS: P(I) * (1 + SUM(GS, TAUN(GS,I))) * CN(I) = E = SUM(J, B(I,J) * N(J));

Data: Based on the 1992 capital coefficient matrix for the United States from the BEA/Department of Commerce.

G. TAXATION

Household Taxes

Comments: This equation computes the amount of direct taxes (on income and property) paid by households to local, state and Federal governments. It allows state and local income taxes to be deducted for Federal income tax purposes; and local property taxes to be deduced for state income tax purposes. Washington does not have a state income tax, but this equation is general enough to give one the freedom to simulate the effects of introducing such a tax. The tax amounts are computed for each household group; households do not move from one tax bracket to the next in this model.

Eq.21. $$t_{gh} = \left\{ \boldsymbol{t}^{b}_{gh} + \left[\frac{y_h}{a^{w}_{h}} - \boldsymbol{t}^{d}_{gh} - \boldsymbol{t}^{s}_{gh} - \left(\boldsymbol{t}^{o}_{gh} + \sum_{g'} \boldsymbol{a}^{t}_{gg'} t_{gh} \right) \boldsymbol{t}^{i}_{gh} \right] \boldsymbol{t}^{m}_{gh} \right\} \boldsymbol{t}^{c}_{gh} \quad \forall g \in GI, h \in H$$

GAMS: PIT(GI,H) = E = (TAXBASE(GI,H) + (Y(H) / HW(H) - TAXBM(GI,H) - TAXSD(GI,H) - (TAXOD(GI,H) + SUM(GI1, ATAX(GI1,GI) * PIT(GI1,H))) * TAXPI(GI,H)) * (MTR(GI,H))) * TAXCVC(GI,H);

Data: The Federal income tax rates came from tax forms, and the proportion of itemizers from *Statistics of Income* from the individual income and tax data for Washington.

H. GOVERNMENT

Government derives income from a wide range of taxes. It purchases goods and services and makes transfers (such as pensions) to individuals. Some government spending is assumed to remain unchanged even if tax revenues vary; the rest of spending is endogenous, in that it responds to the availability of funds. Notionally, most revenues flow into the Washington General Fund; they are then used in part to buy goods and services, but some are also transferred to local government units. The residual spending category, which ensures that all the government accounts balance, is local government spending on health and welfare payments directed to the poorest segment of society. A substantial proportion of incremental tax revenue flows to this group. It is debatable whether this is the most satisfactory way to endogenize government decision making, but it would be relatively straightforward to alter the model to accommodate other arrangements – for instance if a tax increase were specifically designed to boost spending on education.

Government Income

Comments: This equation adds up government income from multiple sources, including indirect taxes (sales, motor fuels) and direct taxes (income, franchise tax).

Eq.22.

$$y_g = \sum_{i\in I} \tau^{v}_{gi} v_i p_i + \sum_{i\in I} \tau^{m}_{gi} m_i pw^0_i + \sum_{h\in H}\sum_{i\in I} \tau^{c}_{gi} c_{ih} p_i + \sum_{i\in I} \tau^{n}_{gi} c_{in} p_i + \sum_{i\in I}\sum_{g'\in G} \tau^{g}_{gi} c_{ig'} p_i + \sum_{i\in I}\sum_{f\in F} \tau^{x}_{gfi} r_{fi} r^a_f u^d_{fi}$$
$$+ \sum_{g'\in G}\sum_{f\in F} \tau^{x}_{gfg'} r_{fg} r^a_f u^d_{fg'} + \sum_{f\in F} \tau_{gf} y_f + \sum_{h\in H} \tau_{hg} a_h + \sum_{h\in H} t_{gh} a^w_h + s_{gn} \quad \forall g \in G$$

GAMS: Y(G) = E = SUM(I, TAUV(G,I) * V(I) * P(I)) + SUM(I,TAUM(G,I) * M(I) * PW0(I)) + SUM((H,I), TAUC(G,I) * CH(I,H) * P(I)) + SUM(I, TAUN(G,I) * CN(I) * P(I)) + SUM((G1,I), TAUG(G,I) * CG(I,G1) * P(I)) + SUM((F,I), TAUFX(G,F,I) * RA(F) * R(F,I) * FD(F,I)) + SUM((F,G1), TAUFX(G,F,G1) * RA(F) * R(F,G1) * FD(F,G1)) + SUM(F, TAUFH(G,F) * Y(F)) + SUM(H, PIT(G,H) * HW(H)) + SUM(H, TAUH(G,H) * HH(H)) + SAM(G,'INV');

Government Endogenous Purchases of Goods and Services

Comments: Spending on these items is assumed to take a fixed fraction of total government receipts (from taxes and net intergovernmental transfers, less government savings). The endogenous sectors are state spending on education, health, safety, transport and "other," and local spending on education and health.

Eq.23.

$$p_i \left(1 + \sum_{g\in GS} \tau^{g}_{gi}\right) c_{ig} = \alpha_{ig} \left(y_g + \sum_{g'\in G} b_{gg'} - \sum_{g'\in G} b_{g'g} + b_{ussstxg} - \sum_{h\in H} w_{hg} a^n_h \tau^{pc}_{hg} - \overline{s}_g \right)$$
$$\forall i \in I, g \in GN$$

GAMS: P(I) * (1 + SUM(GS, TAUG(GS,I))) * CG(I,GN) = E = AG(I,GN) * (Y(GN) + SUM(G1, IGT(GN,G1)) - SUM(G1, IGT(G1,GN)) +IGT('USSSTX',GN) - SUM(H, TP(H,GN) * HN(H) * TPC(H,GN))- S0(GN));

Data: The shares of spending going to these sectors are based on an analysis of the spending patterns of state and local government in Washington in 2001, the latest year for which sufficiently detailed data were available.

Government Endogenous Rental of Factors

Comments: As in the case of goods and services, government is also assumed to devote a fixed share of its total spending to the purchase of labor and capital services for those sectors considered to be endogenous.

Eq.24. $$u^d_{fg} r^a_f r_{fg} = \alpha_{fg} \left(y_g + \sum_{g'\in G} b_{gg'} - \sum_{g'\in G} b_{g'g} - \sum_{h\in H} w_{hg} a^n_h \tau^{pc}_{hg} - \overline{s}_g \right) \quad \forall f \in F, g \in GN$$

GAMS: FD(F,GN) * RA(F) * R(F,GN) = E = AG(F,GN) * (Y(GN) + SUM(G1, IGT(GN,G1)) - SUM(G1, IGT(G1,GN)) - SUM(H, TP(H,GN) * HN(H) * TPC(H,GN)) - S0(GN));

Government Savings

Comments: Government saving is a residual, consisting of revenue less spending.

Eq.25.
$$s_g = y_g - \sum_{i \in I} c_{ig}\, p_i \left(1 + \sum_{g \in GS} \tau^{g}_{gi}\right) - \sum_{f \in F} u^{d}_{fg} r_{fg} r^{a}_{f} \left(1 + \sum_{g' \in GF} \tau^{x}_{fg'i}\right) - \left(\sum_{h \in H} w_{hg} a^{n}_{hg} \tau^{pc}_{hg}\right) - \sum_{g \notin G} b_{g'g} + \sum_{g \notin G} b_{gg'} \qquad \forall g \in G$$

GAMS: S(G) = E = Y(G) - SUM(I, CG(I,G) * P(I) * (1 + SUM(GS, TAUG(GS,I)))) - SUM(F, FD(F,G) * R(F,G) * RA(F) * (1 + SUM(GF, TAUFX(GF,F,G)))) - (SUM(H, TP(H,G) * HN(H) * TPC(H,G)) - SUM(G1, IGT(G1,G)) + SUM(G1, IGT(G,G1));

Distribution of Taxes to Spending and Transfers

Comments: Tax units, in this case those sectors collecting revenues, distribute some of their receipts to spending units, and others directly in the form of transfers to households. The matrix IGTD (in the miscellaneous input file) identifies which units pass on their revenues to other spending units, and the flows are recorded in this equation.

Eq.26.
$$b_{g'g} = \mu_{g'g}\left(y_g - \left(\sum_{h \in H} w_{hg} a^{n}_{h} \tau^{pc}_{hg} - \sum_{h \in H} w_{hg}\left(a^{n}_{h} - \bar{a}^{n}_{h}\right) \tau^{pc}_{hg} SSIYES\right)\right) \qquad \forall g, g' \in G$$

GAMS: IGTD(G1,G) = E = TAXS(G1,G) * (Y(G) - (SUM(H, TP(H,G) * HN(H) * TPC(H,G)) - SUM(H,TP(H,G) * (HN(H) - HN0(H)) * TPC(H,G) * SSIYES(G))) - S0(G));

Data: This equation is based on institutional arrangements in place in Washington.

Endogenous Balance Distribution of Washington General Funds

Comments: This equation ensures that the Washington General Fund is fully accounted for. The residual balance flows to the Washington health fund.

Eq.27.
$$b_{txhlt,txgf} = y_{txgf} + \sum_{g \in G} b_{txgf,g} - \sum_{g \in G} b_{g,txgf}$$

GAMS: IGT('STHLT','STGENF') = E = Y('STGENF') + SUM(G, IGT('STGENF',G)) - SUM(G$IGTD(G,'STGENF'), IGT(G,'STGENF'));

Data: Based on an analysis of the current pattern of state spending in Washington.

Endogenous Local Health and Welfare Transfer

Comments: This equation tracks the transfer from the Washington health and welfare sector to the local health and welfare sector. The change is proportional to changes in the Washington General Fund transfer to Washington health and welfare.

Eq.28. $b_{lohlt,txhlt} = \bar{b}_{lohlt,txhlt} + b_{txhlt,txgf} - \bar{b}_{txhlt,txgf}$

GAMS: IGT('LOHLT','STHELT') =E= IGT0('LOHLT','STHELT') + IGT('STHELT','STGENF') - IGT0('STHELT','STGENF');

Data: Based on an analysis of the current flows of intergovernmental funds in Washington.

Endogenous Transfer Payments

Comments: Endogenous transfers made by local health and welfare depend on the number of welfare families, and the transfers received from higher levels of government.

Eq.29. $w_{hg} a_h^n \boldsymbol{t}_{hg}^{pc} = \bar{w}_{hg} \bar{a}_h^n \boldsymbol{t}_{hg}^{pc} \left(\sum_{g' \in G} b_{gg'} \right) \div \left(\sum_{g' \in G} \bar{b}_{gg'} \right) \quad \forall g \in GWN$

GAMS: TP(H,GWN) * HN(H) * TPC(H,GWN) = E = TP0(H,GWN) * HN0(H) * TPC(H,GWN) * SUM(G, IGT(GWN,G)) / SUM(G, IGT0(GWN,G));

I. MODEL CLOSURE

State Personal Income

Comments: This equation defines state personal income as earnings (from labor and capital) plus transfer payments. The variable is of interest in its own right. However it also provides a convenient variable for GAMS to maximize (or minimize), because it is an unrestricted variable without a subscript. The equation holds social security transfers from the Federal government constant, which accounts for the presence of the SSIYES term.

Eq.30. $q = \sum_{h \in H} y_h + \sum_{h \in H} \sum_{g \in G} w_{hg} a_h^n \boldsymbol{t}_{hg}^{pc}$

GAMS: SPI = E = SUM(H, Y(H)) + SUM((H,G), TP(H,G) * HN(H) * TPC(H,G));

Labor Market Clearing

Comments: Labor supply equals labor demand. For this to occur, the wage rate must adjust to bring about this market clearing.

Eq.31. $\sum_{h \in H} a_h^w = \left(\sum_{i \in I} u_{Li}^d + \sum_{g \in G} u_{Lg}^d \right) \boldsymbol{e}$

GAMS: SUM(H, HW(H)) = E = SUM(Z, FD('L',Z)) * JOBCOR;

Capital Market Clearing

Comments: Capital markets also clear, for each sector. In other words, demand for capital by industries equals supply of capital.

Eq.32. $u^{s}_{Ki} = u^{d}_{Ki} \quad \forall i \in I$

GAMS: KS(I) =E= FD('K',I);

Goods Market Clearing

Comments: Domestic demand (intermediate, consumer, government and investment demand) plus exports less imports must equal domestic supply.

Eq.33. $q_i = x_i + e_i - m_i \quad \forall i \in I$

GAMS: DS(I) =E= DD(I) + CX(I) - M(I);

Domestic Demand Defined

Comments: These equations define domestic demand for each sector.

Eq.34. $x_i = v_i + \sum_{h \in H} c_{ih} + \sum_{g \in G} c_{ig} + c_{in} \quad \forall i \in I$

GAMS: DD(I) = E = V(I) + SUM(H, CH(I,H)) + SUM(G, CG(I,G)) + CN(I);

PIT for Non Income Tax Units

Comments: This equation sets the personal income tax for non-income tax units to zero; this is a technicality, which ensures that the solution to the model does not create income tax revenue in an inappropriate place.

Eq.35. $t_{gh} = 0 \quad \forall h \in H, g \notin GI$

GAMS: PIT.FX(G,H)$(NOT GI(G)) = 0;

Set Intergovernmental Transfers to Zero if Not in Original SAM

Comments: This is another housekeeping equation that ensures that the solution to the model does not create inter-governmental transfers where they should not occur.

Eq.36. $b_{gg'} = 0 \quad \forall g, g' \in G \quad \text{where } \bar{b}_{gg'} = 0$

GAMS: IGT.FX(G,G1)$(NOT IGT0(G,G1)) = 0;

Federal Social Security Transfers to Washington

Comments: Transfers paid to Washington households from the Federal social security system are assumed to be mainly determined by the number of households in the state.

Eq.37. $$b_{\mathrm{h,USSSTX}} = \overline{b}_{\mathrm{h,USSSTX}} \times \left(\frac{a_h^n}{\overline{a}_h^n} \right)^{-0.9}$$

GAMS: TP(H,'USSSTX') =E= TP0(H,'USSSTX') * ((HN(H)/HN0(H)) ** (-.9)) ;

Fix Exogenous Federal Transfers to Households

Federal transfers to households are assumed to be varying with the number of households in the state.

Eq.38. $$b_{\mathrm{h,USNOND}} = \overline{b}_{\mathrm{h,USNOND}} \times \left(\frac{a_h^n}{\overline{a}_h^n} \right)$$

GAMS: TP(H,'USNOND') =E= TP0(H,'USNOND') * (HN(H)/HN0(H)) ;

Fix Exogenous Intergovernmental Transfers

Comments: Some of the intergovernmental transfers are exogenous; these cases are shown with a 2 in the IGTD matrix (see TXCGE.MSC file). This equation fixes these flows at the levels found in the baseline case.

Eq.38. $b_{gg'} = \overline{b}_{gg'} \quad \forall g, g' \in G$, where defined.

GAMS: IGT.FX(G,G1)$(IGTD(G,G1) EQ 2) = IGT0(G,G1);

Fix Goods and Services Demand by Exogenous Government Units

Comments: The purchases of goods and services by some government sectors are considered to be exogenous to the model. This equation fixes these values.

Eq.39. $c_{ig} = \overline{c}_{ig} \quad \forall i \in I, g \in GX$

GAMS: CG.FX(I,GX) = CG0(I,GX);

Fix Factor Rentals Paid by Exogenous Government Units

Comments: The purchases of the services of labor and capital are considered to be exogenous to the model. This equation fixes these values.

Eq.40. $u_{fg}^d = \overline{u}_{fg}^d \quad \forall f \in F, g \in GX$

GAMS: FD.FX(F,GX) = FD0(F,GX);

Fix Intersectoral Wage Differentials

Comments: Although wage rates differ from sector to sector, these differentials are assumed to remain fixed, as set by this equation. Household labor supply responds to overall wage rates, and not to the wage rates in any particular sector.

Eq.41. $r_{Li} = \overline{r}_{Li} \quad \forall i \in I$

GAMS: R.FX('L',Z) = R0('L',Z);

Fix Government Rental Rate for Capital to Initial Level

Comments: For Washington STAMP, we have set these rental rates to zero, in the absence of viable information about the rental rates paid by government on the capital that it uses. However, the relevant equations are included, and so government rental rates could be incorporated in a future version of the model.

Eq.42. $r_{Kg} = \overline{r}_{Kg} \quad \forall g \in G$

GAMS: R.FX('K',G) = R0('K',G);

Fix Economy Wide Scalar for Capital

Comments: The model allows both for an overall cost of capital, and sector-specific returns. This equation sets the overall scalar to its original level, so that only the sector-specific returns vary endogenously.

Eq.43. $r_f^a = \overline{r}_f^a \quad \forall f \in F$

GAMS: RA.FX('K') = RA0('K');

Set Transfer Payments to Zero if Originally So

Comments: This equation ensures that if transfer payments to households were zero in the original social accounting matrix, they remain at zero.

Eq.45. $w_{hg} = 0 \quad \forall\ h \in H, g \in GWX$ where $\overline{w}_{hg} = 0$

GAMS: TP.FX(H,G)$(NOT TP0(H,G)) = 0;

THE ECONOMIC IMPACTS OF INSTITUTING AN INCOME TAX

Washington is one of just a handful of states that do not levy a state income tax. However the Washington Tax Structure Study Committee argues that the state would be better served with an income tax, enabling it to reduce its heavy reliance on sales taxation and to eliminate its state property tax.

Proponents of an income tax argue that, unlike the sales tax, it could be designed to weigh more heavily on rich than poor households. They also point out that a state income tax may be deducted from income before computing Federal income tax, for households that itemize their Federal tax returns; by reducing the net tax payments to the Federal government Washington would in effect be a beneficiary.

Income taxes also have their opponents, who emphasize the deterrent effect of high marginal tax rates. Suppose an income tax were introduced. If gross (i.e. pre-tax) wages do not rise, then the tax cuts the take-home pay of workers, and will deter some people from working, or from moving to Washington to work. If gross wages do rise, then the cost of employing labor will be higher, and so businesses will cut back on the number of workers they employ. Either way, state output will fall, and this may not offset the benefit of paying less tax to the Federal government.

Ultimately the debate about the desirability of an income tax cannot be settled by invoking theoretical or even moral arguments, because it is largely an empirical issue. A solution is to use a computable general equilibrium model; once it has been properly specified, it is straightforward to introduce an income tax and trace through the effects on the economy.

The Experiment

Consider the effects of introducing one of the Tax Structure Study Committee's alternative tax scenarios. Let us suppose the introduction of a flat state income tax rate of 3.8% combined with a reduction in the state sales tax from 6.5% to 3.5% and the elimination of the state property tax.

When we enter these changes into Washington-STAMP, and compare the new results with the baseline situation, a very interesting conclusion emerges: the tax change would hurt employment in the state and reduce the disposable income of those who remain emplyed.. In other words, *the case for introducing a personal income tax in Washington is not economically compelling*.

Having stated the conclusion, we turn to the detailed results. The key findings are set out in Table 6. The first point to note is that the combination of a state income tax, a lower sales tax and removal of the state property tax leads to an increase in the wage rate of 6.6%. This does not necessarily leave workers better off; it occurs because workers expect to be compensated for the increase in the income tax that they now have to pay.

The higher wage rate in turn leads firms to cut back the number of workers, so employment falls by 134,180. This represents a reduction of almost 3.75% in the number employed in Washington, which leads to 71,000 formerly working, taxpaying households migrating out of Washington State.

Alternatively one might look at real disposable income, which is earnings plus transfers (such as pensions) less taxes paid, adjusted for any change that occurs in the price level. Total real disposable income in Washington would fall by 2.58%, while per capita real disposable income would also shrink by a 1.40%. These results provide no justification for a major overhaul of the tax structure of the state.

Table 5

Simulation Results of Introducing a State Income Tax and Reducing the State Sales Tax		
	Estimated FY 2004	**Simulated FY 2004**
Employment		
Number employed ('000)	3,579	3,445
Change in labor	-	(134.2)
Change in labor relative to baseline (%)	-	-3.75
Gross wage rates		
Baseline wage rate, $/person/yr, nominal $	34,239	36,489
Change in wage rate, nominal $	-	2,249
Change in wage rate relative to baseline (%)	-	6.6
Investment		
Baseline investment, $m, nominal $	36,785	48,721
Change in nominal investment ($m)	-	11,936
Change in capital stock relative to baseline (%)	-	32.45
General Fund Revenues		
Nominal baseline WA revenues, $m	16,503	18,602
Change in state revenues, net tot.	-	2,099
Change in state revenue (%)	-	13.00
State Personal Income		
SPI ($bn)	210.771	215.416
Change in SPI ($bn)		4.645
Change in real GSP (%)		2.2
Disposable Income, real		
DI ($bn)	167.931	163.599
Change in real DI ($bn)		-4.332
Change in real DI (%)		-2.58
Disposable Income per capita, real		
DI/capita ($)	26,668	26,296
Change in real DI/capita ($)		-372
Change in real DI/capita (%)		-1.40

Washington-STAMP allows one to look at the effects of the tax change in even more detail. A sampling of interesting results is shown in Table 7. The third column (*TODAY*) shows the values of each variable in the baseline situation; the fourth column (*CHANGE*) shows the results for the case where the income tax is introduced, the sales tax reduced and property tax eliminated; the fifth column (*DIFFERENCE*) shows the difference between the baseline economy and the economy with the income tax, reduced sales tax and removal of the property tax in effect.

Table 6

The effects of changes in tax structure in the state of Washington, FY 2004

Explanation	*Units*	*TODAY*	*CHANGE*	*DIFFERENCE*
Labor and Employment				
State population	m	6.157900	6.083992	(0.073908)
Households	m	2.374010	2.345517	(0.028493)
Working households	m	1.891835	1.820912	(0.070923)
Non-working households	m	0.482175	0.524605	0.042430
Employment	m	3.579196	3.445016	(0.134180)

out of which: Government employment	m	0.569297	0.561515	(0.007782)
State population, <$10,000 income	m	0.795985	0.794545	(0.001440)
State population, $10,000-19,999 income	m	1.064782	1.057311	(0.007471)
State population, $20,000-29,999 income	m	1.069881	1.061393	(0.008488)
State population, $30,000-39,999 income	m	0.977422	0.966004	(0.011418)
State population, $40,000-49,999 income	m	0.746837	0.729449	(0.017388)
State population, $50,000-69,999 income	m	0.978156	0.959645	(0.018511)
State population, $70,000 income and up	m	0.524836	0.515644	(0.009192)
Total households, <$10,000 income	m	0.306870	0.306315	(0.000555)
Total households, $10,000-19,999 income	m	0.410498	0.407618	(0.002880)
Total households, $20,000-29,999 income	m	0.412463	0.409191	(0.003272)
Total households, $30,000-39,999 income	m	0.376818	0.372417	(0.004402)
Total households, $40,000-49,999 income	m	0.287923	0.281219	(0.006704)
Total households, $50,000-69,999 income	m	0.377102	0.369965	(0.007136)
Total households, $70,000 income and up	m	0.202336	0.198793	(0.003544)
Working households, <$10,000 income	m	0.199466	0.195335	(0.004131)
Working households, $10,000-19,999 income	m	0.287348	0.276268	(0.011081)
Working households, $20,000-29,999 income	m	0.309347	0.298879	(0.010469)
Working households, $30,000-39,999 income	m	0.301455	0.289507	(0.011948)
Working households, $40,000-49,999 income	m	0.262010	0.248831	(0.013179)
Working households, $50,000-69,999 income	m	0.345048	0.331462	(0.013586)
Working households, $70,000 income and up	m	0.187161	0.180631	(0.006530)
Income and Output				
Labor earnings, nominal	$bn	140.475955	143.924728	3.448772
Capital earnings, nominal	$bn	48.786952	49.967494	1.180542
Nominal Gross State Product	$bn	236.382165	228.836226	(7.545939)
Nominal GSP per capita	$'000	38.386815	37.612843	(0.773971)
State personal income	$bn	210.771001	215.416426	4.645425
Real disposable income	$bn	167.930628	163.598578	(4.332050)
Real disposable income, <$10,000 income	$bn	6.442850	6.478652	0.035802
Real disposable income, $10,000-19,999 income	$bn	15.915158	15.668168	(0.246989)
Real disposable income, $20,000-29,999 income	$bn	21.304527	20.887157	(0.417370)
Real disposable income, $30,000-39,999 income	$bn	23.350275	22.685881	(0.664393)
Real disposable income, $40,000-49,999 income	$bn	22.046706	21.175844	(0.870862)
Real disposable income, $50,000-69,999 income	$bn	35.825976	34.712410	(1.113566)
Real disposable income, $70,000 income and up	$bn	43.045136	41.990465	(1.054671)
Real disposable income/capita, overall	$'000	26.667899	26.295560	(0.372339)
Real disposable income/capita, <$10,000 income	$'000	7.915250	7.973661	0.058410
Real disposable income/capita, $10,000-19,999 income	$'000	14.616441	14.491282	(0.125159)
Real disposable income/capita, $20,000-29,999 income	$'000	19.472786	19.243975	(0.228811)
Real disposable income/capita, $30,000-39,999 income	$'000	23.361541	22.965089	(0.396452)
Real disposable income/capita, $40,000-49,999 income	$'000	28.867504	28.388170	(0.479334)
Real disposable income/capita, $50,000-69,999 income	$'000	35.816341	35.372485	(0.443857)
Real disposable income/capita, $70,000 income and up	$'000	80.203186	79.632782	(0.570404)
Government Revenue and Taxation				
US federal personal income tax collections	$bn	25.938057	26.266224	0.328167
State sales tax	$bn	6.239800	3.545722	(2.694078)
State tax on motor fuel	$bn	0.774011	0.765343	(0.008668)

State real estate tax	$bn	0.548722	0.544230	(0.004492)
State business & occupation tax	$bn	2.079239	2.205583	0.126344
State public utility	$bn	0.315046	0.308782	(0.006264)
State personal income tax	$bn	-	5.840465	5.840465
State property tax	$bn	1.361700	0.000756	(1.360944)
State General Fund	$bn	16.503107	18.602316	2.099209
State Special Funds	$bn	3.584193	3.597799	0.013606
Local tax on residential property	$bn	1.987453	1.957744	(0.029709)
Local tax on business property	$bn	2.907752	3.041452	0.133700
Investment, Wages, Prices, and Trade				
Net investment	$bn	36.785411	48.721539	11.936128
Capital stock	$bn	297.416602	309.352730	11.936128
out of which: Government capital stock	$bn	6.572658	6.572658	-
Wage rate index	Index	100.000000	106.568534	6.568534
Rate of return on capital index	Index	100.000000	101.629789	1.629789
Domestic demand	$bn	252.081412	254.748042	2.666630
Intermediate demand	$bn	104.510833	101.362960	(3.147873)
Private consumption	$bn	101.063225	97.023520	(4.039706)
Government purchases	$bn	13.833931	13.689540	(0.144391)
Investment demand	$bn	35.335418	46.148631	10.813213
Imports	$bn	121.370230	127.306200	5.935971
Exports	$bn	118.687138	112.358109	(6.329028)
CPI for households, <$10,000 income	Index	1.000000	1.017618	0.017618
CPI for households, $10,000-19,999 income	Index	1.000000	1.014166	0.014166
CPI for households, $20,000-29,999 income	Index	1.000000	1.014484	0.014484
CPI for households, $30,000-39,999 income	Index	1.000000	1.015580	0.015580
CPI for households, $40,000-49,999 income	Index	1.000000	1.013740	0.013740
CPI for households, $50,000-69,999 income	Index	1.000000	1.014197	0.014197
CPI for households, $70,000 income and up	Index	1.000000	1.014587	0.014587

As noted above, the combination of a state personal income tax, reduction of the state sales tax and elimination of the property tax would lead to less employment, a smaller state population, and a larger number of non-working households. Working households from across all income groups withdraw from the state and migrate elsewhere. Real disposable income falls for all income groups except the lowest. Middle-income families, which the Tax Structure Study Committee is trying to aid with these tax changes, find themselves worse off.

APPENDIX: DEFINITIONS AND GLOSSARY OF TERMS

Summary of Set Names

Sets	Dimension	Math	GAMS
Factors	2	f F	F
Governments - All	34	g G	G
Governments - Factor Taxes	6	g GF	GF
Governments - Per Household Taxes	8	g GH	GH
Governments - Income Taxes	2	g GI	GI
Governments - Capital Income Taxes	3	g GK	GK
Governments - Endogenous Spending	16	g GN	GN
Governments - Sales or Excise Taxes	10	g GS	GS
Governments - Endogenous Transfer Payments	4	g GWN	GWN
Governments - Exogenous Transfer Payments	2	g GWX	GWX
Governments - Exogenous Spending	6	g GX	GX
Households	7	h H	H
Industries	27	i I or j I	I
All Social Accounting Matrix Accounts	75	z Z	Z

Summary of Parameter Names

Parameters	Dimension	Math	GAMS
Input Output Coefficients	72 x 72	-	A(Z,Z1)
Domestic Input Output Coefficients	27 x 27	$_{ij}$	AD(Z,Z1)
Government Spending Shares of Net Income	34 x 34	$_{ig}$, $_{fg}$	AG(Z,G)
Factor Share Exponents in Production Function	2 x 27	$_{fi}$	ALPHA(F,I)
Initial Shares of Consumption	27 x 7	$_{ih}$	ALPHA(I,H)
Deductibility of Taxes	3 x 3	$_{gg}^{t}$	ATAX(G,G1)
Income Elasticities of Demand	27 x 7	$_{ih}$	BETA(I,H)
Capital Coefficient Matrix	27 x 27	$_{ij}$	CCM(I,J)
Depreciation Rate	27	$_{i}$	DEPR(I)
Export Price Elasticities	27	$_{i}^{e}$	ETAE(I)
Domestic Demand Elasticity	27	η_i^d	ETAD(I)
Investment Supply Elasticity	1	$_{i}$	ETAI
L Supply Elasticity with respect to Average Wage	7	$_{h}^{ls}$	ETARA(H)
Labor Supply Elasticity with respect to TP's[5]	7	$_{h}^{tp}$	ETATP(H)
Labor Supply Elasticity with respect to Taxes	7	$_{h}^{PIT}$	ETAPIT(H)
Responsiveness of In-Migration to Unemployment	7	$_{h}^{u}$	ETAU(H)
Responsiveness of In-Migration to Disp. Income	7	η_h^{yd}	ETAYD(H)
Production Function Scale	27	$_{i}$	GAMMA(I)
Types of Inter-Government Transfers	34 x 34	-	IGTD(G,G1)
Correction Factor between Households and Jobs	1		JOBCOR
Cross-Price Elasticities	27 x 27	$_{ii'}$	LAMBDA(I,J)
Miscellaneous Industry Parameters	27 x 10	-	MISC(Z,*)
Income Tax Table Data in Input File	7 x 8	-	MISCG(G,H,*)
Miscellaneous Household Parameters	7 x 8	-	MISCH(H,*)
Natural Rate of Population Growth	7	$_{h}$	NRPG(H)
Substitution Exponent in Production Function	27	$_{i}$	RHO(I)
Social Accounting Matrix	72 x 72	$\sigma_{zz'}$	SAM(Z,Z1)
Consumption Sales and Excise Tax Rates	9 x 27	$_{gi}^{c}$	TAUC(G,I)
Factor Tax Rates	5 x 2 x 72	$_{gfz}$	TAUF(G,F,Z)
Factor Taxes applied to Factors	5 x 2	-	TAUFF(GF,G)
Employee Portion of Factor Taxes	5 x 2	$_{gf}$	TAUFH(G,F)
Experimental Factor Tax Rates	5 x 2 x 72	$_{gfz}^{x}$	TAUFX(G,F,Z)
Government Sales and Excise Tax Rates	9 x 27	$_{gi}^{g}$	TAUG(G,I)
Household Taxes other than PIT	1 x 7	$_{gh}$	TAUH(G,H)
Investment Sales and Excise Tax Rates	9 x 27	$_{gi}^{n}$	TAUN(G,I)
Sales and Excise Tax Rates	9 x 27	$_{qi}^{q}$	TAUQ(G,I)
Intermediate Good Sales and Excise Tax Rates	9 x 27	$_{gi}^{v}$	TAUV(G,I)
Tax Bracket Base Amount	3 x 7	$_{gh}^{b}$	TAXBASE(G,H)
Tax Bracket Minimum Taxable Earnings	3 x 7	$_{gh}^{d}$	TAXBM(G,H)
Tax Constant to Correct Calculated to Observed	3 x 7	$_{gh}^{c}$	TAXCVC(G,H)
Tax Deduction other than Standard and other PIT	3 x 7	$_{gh}^{o}$	TAXOD(G,H)
Percentage Itemizing	3 x 7	$_{gh}^{i}$	TAXPI(G,H)
Tax Destination Shares	34 x 34	$_{gg'}$	TAXS(G,G1)
Tax Deduction for Standard Deductions	3 x 7	$_{gh}^{s}$	TAXSD(G,H)
Percent of Households Receiving TP's	7 x 6	$_{hg}^{pc}$	TPC(H,G)

[5] TP is abbreviation for transfer payments.

Summary of Variable Names

Variables	Dimension	Math	GAMS
Public Consumption	27 x 28	c_{ig}	CG(I,G)
Private Consumption	27 x 7	c_{ih}	CH(I,H)
Gross Investment by Sector of Source	27	c_{in}	CN(I)
Consumer Price Index	7	p_h	CPI(H)
Exports	27	e_i	CX(I)
Domestic Share of Domestic Consumption	27	d_i	D(I)
Domestic Demand	27	x_i	DD(I)
Domestic Supply	27	q_i	DS(I)
Sectoral Factor Demand	2 x 64	u_{fi}^d, u_{fg}^d	FD(F,Z)
Number of Households	7	a_h	HH(H)
Number of Non-Working Households	7	a_h^n	HN(H)
Number of Working Households	7	a_h^w	HW(H)
Household Out-Migration	7	a_h^o	MO(H)
Household In-Migration	7	a_h^i	MI(H)
Inter-Governmental Transfers	37 x 37	$B_{gg'}$	IGT(G,G1)
Capital Stock	27	u_{Ki}^s	KS(I)
Imports	27	m_i	M(I)
Gross Investment by Sector of Destination	27	n_i	N(I)
Net Capital Inflow	1	z	NKI
Aggregate Price	27	p_i	P(I)
Aggregate Price including Sales/Excise Taxes	27	p_i^c	PC(I)
Domestic Producer Price	27	p_i^d	PD(I)
Per Household Personal Income Taxes	3 x 7	t_{gh}	PIT(G,H)
Producer Price Index	1	p	PPI
Value Added Price	27	p_i^{va}	PVA(I)
World Price (Rest of US and Rest of World)	27	p_i^w	PW(I)
Sectoral Factor Rental Rates	2 x 27	r_{fi}, r_{fg}	R(F,I)
Economy Wide Scalar for Factor Rental Rates	2	r_f^a	RA(F)
Government Savings	37	s_g	S(G)
Private Savings	7	s_h	S(H)
State Personal Income	1	q	SPI
Transfer Payments	7 x 37	w_{hg}	TP(H,G)
Intermediate Goods	27	v_i	V(I)
Factor Income	2	y_f	Y(F)
Government Income	37	y_g	Y(G)
Household Income	7	y_h	Y(H)
Household after Tax Income including TP's	7	Y_h^d	YD(H)

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Beacon Hill Institute (BHI) is an independent, nonpartisan economic research organization that applies a market-clearing approach to the analysis of tax, fiscal and regulatory issues. BHI combines innovative solutions and state-of-the-art econometric and statistical methods in the analysis of public policy issues affecting the nation and the states.

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