Research Report

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Texas-STAMP

(State Tax Analysis Modeling Program)

A Sophisticated Tax Model for Texas

Developed By
David G. Tuerck, Jonathon Haughton,
John S. Barrett, and Sorin Codreanu
Of the Beacon Hill Institute at Suffolk University

With a Forward and Overview By
Byron Schlomach, Ph.D.
Chief Economist, Texas Public Policy Foundation

Texas Public Policy Foundation
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ABOUT THE TEXAS PUBLIC POLICY FOUNDATION

The Texas Public Policy Foundation is a 501 (c)(3) non-profit, non-partisan research institute guided by the core principles of limited government, free enterprise, private property rights and individual responsibility.

The Foundation's mission is to improve Texas government by generating academically sound research and data on state issues, and by recommending the findings to opinion leaders, policy makers, the media and general public. The work of the Foundation is conducted by academics across Texas and is funded by hundreds of individuals, foundations and corporations.

FORWARD

Development of the Texas State Tax Analysis Model (Texas-STAMP) is an important part of a multi-faceted, comprehensive research initiative on public school finance that the Texas Public Policy Foundation began in 2003. The Foundation commissioned the Beacon Hill Institute at Suffolk University in Massachusetts to update and expand a computable general equilibrium model it constructed in 1999 for the Foundation.

This second-generation computer-based model is statistically more sophisticated, constructed as a *multi-year* computable general equilibrium model. It will provide highly detailed information of the economic effects over time about a wide variety of possible tax changes in Texas. How the model works and what information it can provide is described in this report.

The Foundation produced the Texas-STAMP to help Texas policymakers evaluate the economic benefits and costs of changes in the state tax code. Accessed through the Internet, Texas-STAMP can be used by laptop in the halls of the Capitol as legislators debate tax proposals, such as an increase in sales tax or the introduction of a business activity tax.

Texas-STAMP promises to be an extremely useful tool and it is easy to use, although like any economic model, it should be used with some caution since no such model completely accounts for everything. The information provided by this report and an enhanced understanding of this particular model will make Texas-STAMP more useful. Like all tools, it is wise to read before using.

For information about accessing Texas-STAMP or additional information beyond what is provided in this report, please contact the Foundation.

The Foundation is pleased to make this tool available for the purpose of informing policymakers about how their decision affect the state's economy and the livelihoods of all Texans.

Byron Schlomach, Ph.D.
Chief Economist
Texas Public Policy Foundation
Austin, Texas
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OVERVIEW

Answers to seven common questions about the Texas-STAMP, its operation, capabilities, limitations and uses.

1. *What is Texas-STAMP and what does it do?*

Texas-STAMP is a computer program developed to estimate the effects of specific changes in the state tax system. It is a dynamic general equilibrium model. As a dynamic model, Texas-STAMP estimates both primary and secondary effects of tax changes – for example, lowering a property tax might cause sale tax revenues to rise, offsetting some of the loss of government revenues from property tax reduction. As a general model, Texas-STAMP takes all the important markets and interactions into account, such as banking, retail, and utilities. As an equilibrium model, Texas-STAMP assumes demand will equal supply in every market. Texas-STAMP also estimates how changes in taxation affect various facets of the economy over five years, such as labor supply, consumer prices, immigration and growth of capital.

2. *How is Texas-STAMP constructed?*

Texas-STAMP was built to provide a mathematical description of the economic relationships among producers, households, government, and the rest of the world. Texas-STAMP has over 15,000 equations, 3,800 variables, and almost 1,000 lines of computer code. Every run of the model produces 920 pages of information, although the user does not have to wade through all of these pages to effectively use the model.

3. *What specific information will Texas-STAMP provide?*

Texas-STAMP will estimate how a specific change in the state tax system impacts:

- Gross wage rates,
- Number of private jobs,
- Number of government jobs,
- Disposable real income,
- Disposable real income per capita,
- Revenues generated by other state taxes, and
- Revenues generated by local taxes.

4. *How does Texas-STAMP work?*

The model will instantly produce the estimated impact of a tax reform after a specific tax and rate is keyed into the program, identifying change in state revenues for:

- Sales tax,
- State gross receipts tax,
- Franchise tax,
- Business activity tax,
- Motor fuels tax,
- Motor vehicle tax,
- State personal income tax,
- State cigarette tax,
- State professional services tax -- personal,
- State professional services tax -- business, and
- Local property tax.

5. *What are the limitations of Texas-STAMP?*

While this model is extremely useful, there are two important limitations to a computerized model of this type. First, the model cannot account for everything – tax or effect. Secondly, estimations are based on the assumption that economic behavior remains stable. This assumption is problematic because neither human nor computer estimations can predict the unforeseen in an economy. An unpredicted event, such as 9/11, could completely change trends.

6. *Who can use Texas-STAMP?*

The Foundation is making the model available to all members of the Texas Legislature and providing the training required to use the model.

7. *How can Texas-STAMP be accessed?*

The model can be accessed on the Foundation's web site. Using a laptop computer, policymakers can estimate the effect of tax proposals from the floor of the Capitol, or anywhere an internet connection is available.

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INTRODUCTION

Changes in tax rates have measurable effects on taxable activities. The weight of evidence shows that state-level tax increases have significant negative effects on state economic activity.[1] Yet it is not easy to quantify these effects, and the job can only be done satisfactorily with the help of a complete tax model.

In order to be able to analyze sweeping changes in the tax system, the solution is to build a *Computable General Equilibrium* (CGE) model of Texas. We have constructed a CGE model of Texas (Texas-STAMP), and in this report we explain the concept behind the CGE model, set out the individual components, and then use it to ask what would happen to the Texas economy under three competing tax packages being debated in the Texas Legislature.

CGE models are typically large, complex, and difficult to build; for instance Texas-STAMP has over 15,000 equations, 3,800 variables and almost a thousand lines of computer code, and every run of the model produces 920 pages of output. This provides one reason why CGE models are not used more widely at the state level. An important exception is the complete and well-documented CGE tax model for California.[2] The California CGE model was developed with state funding, after that state passed a law (SB 1837, 1994) requiring the Department of Finance to perform “dynamic revenue analysis” of any proposed legislation with a revenue impact of $10 million or more. In this context, a dynamic revenue analysis differs from a static revenue analysis in that it takes account of the secondary effects of tax changes; for instance, a lower property tax might leave more money in people’s pockets and so, as they spend more, revenue from the sales tax might rise, offsetting in part the initial cut in the property tax.

Tax Experiment

While an econometric model could be used to estimate effects of incremental changes in the tax levels, Texas-STAMP is the more appropriate tool when analyzing the effect of major changes at a high level of detail. 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 Texas. The key equations of the model are presented in detail in Section 4.

We then use the model to analyze the effects of two hypothetical tax changes. The first is instituting a Texas state income tax; the second expands the sales tax to include personal and corporate purchases of services.

WHAT IS TEXAS-STAMP?

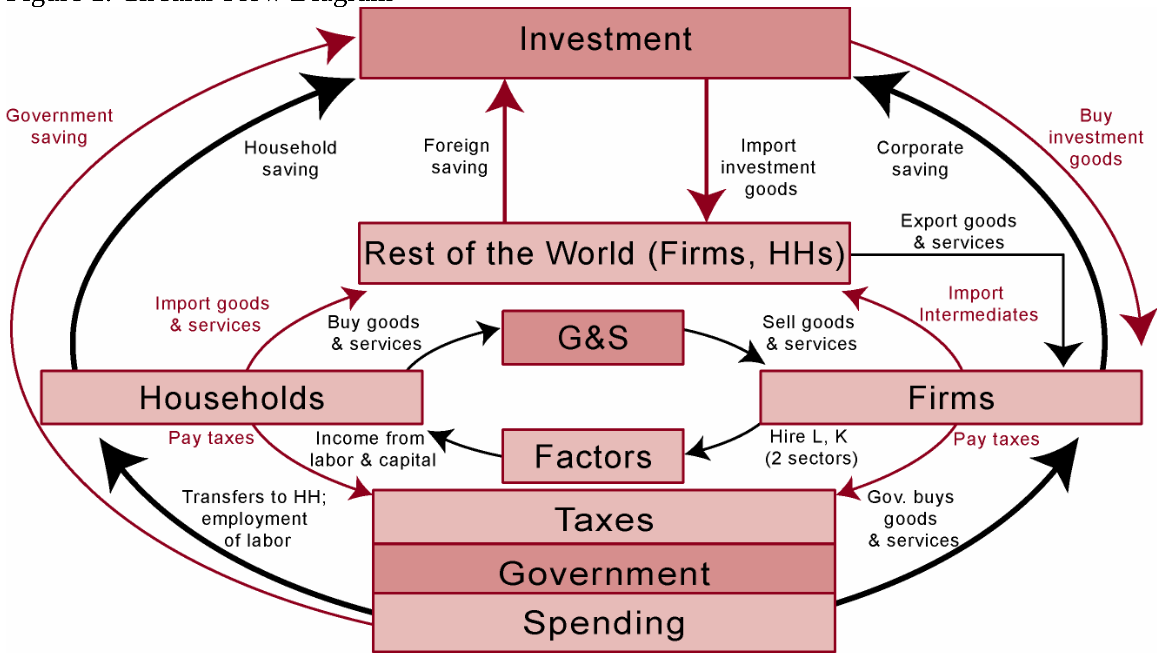
Texas-STAMP (State Tax Analysis Modeling Program) is a comprehensive model of the Texas economy, designed to capture the principal effects of state tax changes on that economy. Texas-STAMP is a five year dynamic computable general equilibrium (CGE) tax model. As such, it provides a mathematical description 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 (they are endogenous – i.e., price effects are calculated by the model). 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 Texas. 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 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*; Texas-STAMP has 78 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 23 types of taxes (16 of them at the state level) and 13 categories of government spending. To complete the model there are two factor sectors (labor, capital), an investment sector, four 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 Texas-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 Texas 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 Computable General Equilibrium Model

The construction of a CGE model involves several steps. First, one needs to organize the data needed by the model. Texas-STAMP starts with data for a single year, 2003, which the model uses to develop a steady state path through 2009. This steady state path is attained by applying a growth rate to investment, population and inflation over the time frame of the model. In Texas-STAMP the investment growth rate is assumed to be 7.44%.[4] The growth rate for population is assumed to be 0.0131%.[5] The growth rate for employment is assumed to be 2.2%[6] The inflation growth rate is assumed to be 1.5%. To attain a reasonable steady state path, the data for the base year, 2002, must be very detailed. Most of the data are organized into a *Social Accounting Matrix*, which in this case consists of a 78 by 78 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 is 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. These are set out in detail in Section 4 of this report. 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 Texas, 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 a way as to maximize utility, which is the discounted aggregate of state personal income over the time period of the model. The results for the base year are checked to see that they correspond with the actual values of the variables in the Social Accounting Matrix (taken to be 2003 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 steady state 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 Texas-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 as a result of the business cycle in coming years.

THE TEXAS-STAMP

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 for the base year. The Social Accounting Matrix that we developed for Texas is a 78 by 78 matrix. Each of the 6,084 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 Social Accounting Matrix 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 Texas-STAMP, we distinguish 27 industrial sectors, two factors (labor and capital), seven household categories, an investment sector, 40 government sectors (23 for taxes, 13 for spending, 4 government funds) 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

Texas-STAMP contains 27 industrial sectors. 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 some industries, such as 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.

Factor Sectors

We distinguish between two factors, labor and capital (where capital 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 Texas-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. 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.

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 Bureau of Economic Analysis has also produced a matrix, built for the U.S. for 1997, 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

Texas-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 in Table 3 (see page 18).

Table 1. 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.
USOTTX	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 Texas and to Federal defense fund.
USDEFF	Federal defense spending	Purchases goods and services, and pays labor for military purposes.
Texas Government Receipts		
STPITX	Possible Texas individual income tax	Revenues would go into Texas general fund.
STSATX	Texas Sales Tax	Sales tax, vehicle sales and use tax, utility taxes, hotel and motel tax. Revenues go into Texas general fund and other funds.
STFUTX	Texas tax on motor fuel	Revenues go into Texas general fund and highway fund.
STFRTX	Texas franchise tax	This is the tax on business; revenues go into the Texas general fund.
STALTX	Texas tax on alcohol	Revenues go into Texas general fund.
STMVTX	Texas tax on motor vehicle purchases	Revenues go into Texas special fund.
STTCTX	Texas tax on cigarettes	Revenues go into Texas general fund.
STIHTX	Texas tax on insurance occupation	Revenues go into Texas general fund.
STOPTX	Texas oil production tax	Revenues go into Texas general fund and other funds.
STMOTX	Motor vehicle fees	Revenues go into Texas general fund and highway fund.
STUTTX	Texas utility tax	Revenues go into Texas general fund.
STNGTX	Texas natural gas tax	Revenues go into Texas general fund.
STFEES	Texas fees, licenses, permits	Revenues go into all funds.

(Table 1 is continued on the next page.)

(Table 1 continued from previous page.)

STWKTX	Texas workers' compensation and disability	Sector combines workers compensation and unemployment funds. Receipts go into proprietary fund.
STSPCF	Texas special fund	An accounting device. Tax revenue is channeled into this fund before being distributed to other uses.
STHIWF	Texas highway fund	An accounting device. Tax revenue is channeled into this fund before being distributed to other uses.
STGENF	Texas general fund	An accounting device. Tax revenue is channeled into this fund before being distributed to other uses.
Texas Government Expenditure		
STGGSP	Texas general spending	General government spending.
STEDUC	Texas spending on education	Mainly purchases of goods and services and labor in the higher education sector.
STHELT	Texas spending on health & welfare	Buys some services; mainly transfers funds to local health spending fund.
STTRAN	Texas spending on transport	Mainly buys engineering services and construction.
STPBSF	Texas spending on public safety	Public safety and fire departments spending.
STOTHS	Texas 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.
LOPBSF	Local spending on public safety	Public safety and fire departments local spending.
LOOTHS	Local other spending	Includes spending on police and firefighters, road repair, and miscellaneous local government services.

The Texas state government collects revenue from taxes on sales, motor fuel, the income tax, excises on alcohol and tobacco, insurance and inheritance. It also collects a variety of fees.

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

In the model, the government of Texas pays directly for some education, mainly the University of Texas 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 Texas 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 (designated ROWSCT in the model). This refers to the rest of the United States as well as other countries. Information on flows between Texas and the rest of the world is difficult to piece together, and is an area where considerable professional judgment was required.

TEXAS-STAMP IN DETAIL

In this report we set out the model in detail. First we list our elasticity[7] assumptions used in the model. Second we introduce each equation, providing some context and a short description. Then we present each equation in mathematical form, and finish with information on the sources of data used.

Elasticity Assumptions For Texas-STAMP

The following elasticities are used in industry-specific equations:

ETAM[8]: Import elasticity with respect to domestic price for producers' purchase of intermediates. Most of the data on elasticities are borrowed from Reinert, Roland-Holst, and Shiells. The two most recent are Reinert and Roland-Holst (1992) and Roland-Holst, Reinert and Shiells (1994).

In the first study, the authors estimate an Armington model for 163 mining and manufacturing sectors. Two-thirds of the elasticities were positive and statistically significant, ranging from a low of 0.13 for chocolate to 3.49 for wine, brandy and brandy spirits. The second study looked at the impact of NAFTA. In this study many of the aggregate industries had an elasticity of 1.50. Since import data for goods between states is almost impossible to obtain, we made some assumptions and used 1.50 for most industries and a slightly lower elasticity of 0.50 for a handful of less traded industries such as service industries.

While these elasticities are slightly higher than the literature on national trade, we believe that goods in a state are more price sensitive to goods in the Rest of the World (including other states) than national goods. It is converted to a domestic share elasticity for each industry by virtue of the following equation. ETAD = ETAM * IMPORT / (DOM. DEMAND * DOM. SUPPLY SHARE OF DOM. DEMAND). The estimates for this elasticity were taken from the literature.

ETAE: Export elasticity with respect to domestic price for the sale of producers' goods. Used in the export demand equation. The NAFTA study was also helpful with exports. We used an elasticity of 1.65 for the industries which had an import elasticity of 1.50 and an export elasticity of 0.65 for those which had an import elasticity of 0.50.

ETAY: Income elasticity of demand for local goods and services. This elasticity appears in the household consumption equation. Estimates were taken from the literature. Literature values range from -0.24 to 2.93.

ETAOP: Cross-price elasticities for goods from different industries. This elasticity appears in the household consumption equation. Estimates were taken from the literature. Literature values from -0.06 to -1.72.

SIGMA: Elasticity of substitution capital and labor. Values in the literature range between 0.15 and 1.809 for industries with the majority close to 1. This measurement is used to calculate RHO, which is the exponent in the production function. The equation is: (1- SIGMA)/SIGMA.

Table 2. Industry Elasticities

	ETAM	ETAE	ETAY	ETAOP	SIGMA
AGRICF	1.50	-1.65	1.00	-1.00	0.90
MINING	1.50	-1.65	1.00	-1.00	0.80
CONSTR	1.50	-1.65	1.00	-1.00	0.90
FOODPR	1.50	-1.65	1.00	-1.00	0.90
APPARL	1.50	-1.65	1.00	-1.00	0.90
MFRCON	1.50	-1.65	1.00	-1.00	0.80
PPAPER	1.50	-1.65	1.00	-1.00	0.80
CHEMIC	1.50	-1.65	1.00	-1.00	0.80
ELECTR	1.50	-1.65	1.00	-1.00	0.90
MVOTRA	1.50	-1.65	1.00	-1.00	0.90
METALS	1.50	-1.65	1.00	-1.00	0.80
MACHIN	1.50	-1.65	1.00	-1.00	0.80
INSTRU	1.50	-1.65	1.00	-1.00	0.90
MFROTH	1.50	-1.65	1.00	-1.00	0.90
TRANSP	1.50	-1.65	1.00	-1.00	0.90
COMMUN	1.50	-1.65	1.00	-1.00	0.90
UTILIT	1.50	-1.65	1.00	-1.00	0.80
WHOLSA	0.50	-0.65	1.00	-1.00	0.90
RETAIL	0.50	-0.65	1.00	-1.00	0.90
BANKNG	1.50	-1.65	1.00	-1.00	0.90
INSURS	1.50	-1.65	1.00	-1.00	0.90
REALST	1.50	-1.65	1.00	-1.00	0.90
REPSVC	1.50	-1.65	1.00	-1.00	0.80
BSVCES	1.50	-1.65	1.00	-1.00	0.80
ENTRHO	0.50	-0.65	1.00	-1.00	0.80
HEALTH	0.50	-0.65	1.00	-1.00	0.80
OTHSVC	0.50	-0.65	1.00	-1.00	0.80

The following elasticities are used in household-specific equations:

ETAPIT: Labor supply elasticity with respect to taxes. This elasticity appears as an exponent in the labor supply equation. Measurements were based on estimates taken from the literature. The labor supply elasticities are widely divergent in the literature and suffer from a lack of disaggregation. They range from -0.4 to 2.3 for wages, with rather high positive values for women, particularly married woman.

ETATP: Household response to transfer payments. The transfer payment elasticities reflect a study by Robins (1985) on the effects of a negative income tax. It is also a reflection of observations that income received by upper income groups is unaffected by transfer payments.

ETARA: Labor supply elasticity with respect to average wage. Measurements were derived from literature estimates. This elasticity appears in the labor supply equation.

ETAYD: Responsiveness of immigration to after tax income. Not much literature exists that ties migration to disposable income or unemployment. Studies by Bartik (1991), Valiant (1994), and Treyz et al. (1993) put the range for response to change in wage rates between 0.835 and 2.39. We used these as a basis for our after tax earnings elasticities. This elasticity appears in the population equation.

ETAU: Responsiveness of immigration to unemployment. We made some assumptions based on the responsiveness to employment elasticities in the literature.

ETAMH: Income elasticity of demand for imports by household. This elasticity appears in the household import equation.

Table 3. Household-Related Elasticities

	ETAPIT	ETATP	ETARA	ETAYD	ETAU	ETAMH
LESS10	-0.15	-0.05	0.17	1.30	-0.80	0.70
LESS25	-0.18	-0.05	0.17	1.50	-0.80	0.70
LESS50	-0.20	-0.04	0.20	1.60	-0.80	0.70
LESS75	-0.25	-0.04	0.30	1.80	-0.80	0.70
LES100	-0.25	-0.03	0.40	2.00	-0.80	0.70
LES150	-0.30	-0.03	0.50	2.10	-0.80	0.70
MOR150	-0.35	-0.02	0.50	2.30	-0.80	0.70

Detailed Equations for Texas-STAMP

Texas-STAMP is a dynamic CGE model which assumes a steady state growth path. Absent any "shocks," the economy is assumed to remain on this path. If the economy experiences a shock, such as a tax change, the economy will diverge from this steady state path and eventually move to a new path. The size and length of the divergence will depend on the size of the shock to the economy. Below we set out the equations used in Texas-STAMP and the assumptions inherent in them.

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,

$$X_{t,i} = \lambda_i * \frac{I_t}{P_{t,i}}, \quad i = 1,...,n; t = 1,...n,$$

where $X_{t,i}$ is the quantity demanded of good *i* at time *t*, $P_{t,i}$ is the price of good *i* at time *t*, I_t is income at time *t*, 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.

$$y_{t,h} = \sum_{f \in F} \frac{\alpha_{hf} a^{w}_{t,h}}{\sum_{h \in H} \alpha_{hf} a^{w}_{t,h}} y_{t,f} \left(1 - \sum_{g \in GF} \tau^{h}_{t,g,f} \right) \quad \forall h \in H$$

Data: The information on earnings for each household group comes from household survey data for the Midwest of the U.S. for 2001-2002. Source: *BLS Consumer Expenditure Report 2001-2002 (Midwest).* Available at
ftp://ftp.bls.gov/pub/special.requests/ce/region/y0102/region.txt

Household Disposable Incomes

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

Eq.2.

$$y^{d}_{t,h} = y_{t,h} - \sum_{g \in GI} t_{t,g,h} a^{hh}_{t,h} - \sum_{g \in GH} \tau^{h}_{t,g,h} a^{hh}_{t,h} + \sum_{g \in G} w_{hg} a^{n}_{t,h} \tau^{pc}_{t,h,g} \quad \forall\, h \in H, t \in T$$

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.
$$c_{t,i,h} = \overline{c}_{t,i,h} \left(\frac{y^d_{t,h}}{\overline{y}^d_{t,h}} \div \frac{p_{t,h}}{\overline{p}_{t,h}} \right)^{\beta_{ih}} \prod_{i' \in I} \left[\frac{p_{t,i'} \left(1 + \sum_{g \in GS} \tau^c_{t,g,i'} \right)}{\overline{p}_{t,i'} \left(1 + \sum_{g \in GS} \tau^q_{t,g,i'} \right)} \right]^{\lambda_{i'i}} \quad \forall i \in I, h \in H, t \in T$$

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. The information on consumption for each household group comes from household survey data for the Midwest of the U.S. for 2001-2002. Source: *BLS Consumer Expenditure Report 2001-2002 (Midwest)*.
Available at
ftp://ftp.bls.gov/pub/special.requests/ce/region/y0102/region.txt

Direct Household Purchases of Imports

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

$$m_{t,h} = \overline{\overline{m_{t,h}}} \left(\frac{y^d_{t,h}}{\overline{\overline{y^d_{t,h}}}} \div \frac{p_{t,h}}{\overline{\overline{p_{t,h}}}} \right)^{\eta^m_h} \quad \forall h \in H, t \in T$$

Household Savings

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

Eq.4.
$$s_{t,h} = y^d_{t,h} - \sum_{i \in I} c_{t,i,h} p_{t,i} \left(1 + \sum_{g \in GS} \tau^c_{t,g,i} \right) - m_{t,h} \quad \forall h \in H, t \in T$$

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. For instance, a tax on foodstuffs would tend to hit poor households relatively hard, and the CPI for poor households would pick up this effect.

Eq.5.

$$p_{t,h} = \frac{\sum_{i \in I} p_{t,i} \left(1 + \sum_{g \in GS} \tau^{c}_{t,g,i}\right) c_{t,i,h}}{\sum_{i \in I} \overline{p}_{t,i} \left(1 + \sum_{g \in GS} \tau^{q}_{t,g,i}\right) c_{t,i,h}} \quad \forall\, h \in H, t \in T$$

Data: The consumption of each good by each household group (c_{ih}) is derived from Consumer Expenditure Survey data (2001-2002). 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 Midwest region of the US, which we took to be an adequate representation of spending patterns in Texas. The distribution of households by income group is also for the Midwest rather than Texas, but we applied the same proportions to the population of Texas.

Labor Supply

Comments: In Texas-STAMP we model the participation rate, 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.

$$a^{w}_{t,h} = \overline{a}^{w}_{t,h} \frac{a^{hh}_{t,h}}{\overline{a}^{hh}_{t,h}} \left(\frac{r^{a}_{t,L}}{\overline{r}^{a}_{t,L}} \div \frac{p_{t,h}}{\overline{p}_{t,h}} \right)^{\eta^{ls}_{h}} \left(\frac{\sum_{g \in GI} t^{pi}_{t,g,h}}{\sum_{g \in GI} \overline{t}^{pi}_{t,g,h}} \right)^{\eta^{PIT}_{h}} \left(\frac{\sum_{g \in G} \frac{w_{t,h',g}}{p_{t,h}}}{\sum_{g \in G} \frac{\overline{w}_{t,h',g}}{\overline{p}_{t,h}}} \right)^{\eta^{tp}_{h}} \quad \forall\, h \in H, t \in T$$

Data: The data on working households by income class came from the Consumer Expenditure Survey (2000-2001) for the South, as did the total number of households in each category. These were then adjusted to fit the total number of households in Texas.

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.

$$a_{t,h}^{hh} = \bar{a}_{t,h}^{hh} + \bar{a}_{t,h}^{i} \left(\frac{y_{t,h}^{d}}{a_{t,h}^{hh}} \div \frac{\bar{y}_{t,h}^{d}}{\bar{a}_{t,h}^{hh}} \div \frac{p_{t,h}}{\bar{p}_{t,h}} \right)^{\eta_h^{yd}} \left(\frac{a_{t,h}^{n}}{a_{t,h}^{hh}} \div \frac{\bar{a}_{t,h}^{n}}{\bar{a}_{t,h}^{hh}} \right)^{\eta_h^{u}} - \bar{a}_{h}^{o} \left(\frac{\bar{y}_{t,h}^{d}}{\bar{a}_{t,h}^{hh}} \div \frac{y_{t,h}^{d}}{a_{t,h}^{hh}} \div \frac{\bar{p}_{t,h}}{p_{t,h}} \right)^{\eta_h^{yd}} \left(\frac{\bar{a}_{t,h}^{n}}{\bar{a}_{t,h}^{hh}} \div \frac{a_{t,h}^{n}}{a_{t,h}^{hh}} \right)^{\eta_h^{u}}, \ \forall h \in H, t \in T$$

Data: 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. $$a_{t,h}^{n} = a_{t,h}^{hh} - a_{t,h}^{w} \quad \forall h \in H, t \in T$$

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 amounts 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. $$v_{t,i} = \sum_{i' \in I} \alpha_{t,i,i'} q_{t,i'} \qquad \forall\, i \in I, t \in T$$

Data: From the Texas 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 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. $$q_{t,i} = \gamma_{t,i} \left[\sum_{f \in F} \alpha_{t,f,i} \left(u^{d}_{t,f,i} \right)^{-\rho_i} + g\alpha_{t,i} \left(gk_t \right)^{-\rho_i} \right]^{-1/\rho_i} \qquad \forall\, i \in I, t \in T$$

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. $$p^{va}_{t,i} = p^{d}_{t,i} - \sum_{i' \in I} \alpha_{t,i',i}\, p_{t,i'} \left(1 + \sum_{g \in GS} \tau^{v}_{t,g,i'} \right) \qquad \forall\, i \in I, t \in T$$

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

Factor Demand

Comments: It is possible to construct a profit function that expresses profits as a function of factor inputs. Microeconomic theory shows 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. $$r_{t,f,i} r^{a}_{t,f} \left(1 + \sum_{g \in GF} \tau^{x}_{t,f,g,i}\right) u^{d}_{t,f,i} = p^{va}_{t,i} q_{t,i} \alpha_{t,f,i} \quad \forall\, i \in I, f \in F, t \in T$$

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 (i.e., wage differences across industries) 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 Texas.

Factor Income

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

Eq.13. $$y_{t,f} = \sum_{i \in I} r_{t,f,i} r^{a}_{t,f} u^{d}_{t,f,i} + \sum_{g \in G} r_{t,f,g} r^{a}_{t,f} u^{d}_{t,f,g} \quad \forall f \in F, t \in T$$

Trade With Other States and Countries

From a Texas 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 Texas are assumed to be close, but not perfect, substitutes for goods produced elsewhere. Thus if prices rise in Texas, 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 Texas. If the domestic price rises relative to the foreign price, exports will fall. Note that the elasticity here is negative.

Eq.14. $$e_{t,i} = \overline{e}_{t,i} \left[p^{d}_{t,i} \div \overline{p}^{w}_{t,i} \right]^{\eta^{e}_{i}} \quad \forall i \in I, t \in T$$

Data: The trade data for Texas are not particularly reliable; we have used our judgement, combined with Bureau of Economic Analysis 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 Texas.

Eq.15. $$d_{t,i} = \bar{d}_{t,i} \left[p_{t,i}^{d} \div \bar{p}_{t,i}^{w} \right]^{\eta_i^d} \quad \forall i \in I, t \in T$$

Data: As with export demand we have used our judgement, combined with Bureau of Economic Analysis 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. $$m_{t,i} = \left(1 - d_{t,i}\right) x_{t,i} \quad \forall i \in I, t \in T$$

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. $$p_{t,i} = d_{t,i} p_{t,i}^{d} + \left(1 - d_{t,i}\right) \bar{p}_{t,i}^{w} \quad \forall i \in I, t \in T$$

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). For instance, once investment by 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.[9]

Capital Stock

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. $$u_{t,K,i} = u_{t-1,K,i}\left(1-\delta_i\right)+n_{t,i} \quad \forall i \in I, t \in T$$

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 Texas.

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. $$n_{t,i} = \overline{n}_{t,i}\left[\frac{r_{t,K,i}\left(1-\sum_{g\in GK}\tau^{x}_{t,g,K,i}\right)u_{t,K,i}}{\overline{r}_{t,K,i}\left(1-\sum_{g\in GK}\tau_{t,g,K,i}\right)\overline{u}_{t,K,i}}\right]^{\eta^i} \quad \forall i \in I, t \in T$$

Data: The rate of return is computed as the property-type income for each sector (from Bureau of Economic Analysis) 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. $$p_{t,i}\left(1+\sum_{g\in GS}\tau^{n}_{t,g,i}\right)cn_{t,i}=\sum_{i'\in I}\beta_{i,i'}n_{t,i'} \qquad \forall i\in I, t\in T$$

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

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 deducted for state income tax purposes. The tax amounts are computed for each household group; households do not move from one tax bracket to the next in this model. Although Texas currently does not have an income tax, this equation allows for the imposition of one and the simulation of its effects in the model.

Eq.21.

$$t_{t,g,h}=\left\{\tau^{b}_{t,g,h}+\left[\frac{y_{t,h}}{a^{w}_{t,h}}-\tau^{d}_{t,g,h}-\tau^{s}_{t,g,h}-\left(\tau^{o}_{t,g,h}+\sum_{g'=G}\alpha^{\tau}_{t,g,g'}t_{t,g,h}\right)\tau^{i}_{t,g,h}\right]\tau^{m}_{t,g,h}\right\}\tau^{c}_{t,g,h} \qquad \forall g\in GI, h\in H, t\in T$$

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 Texas. Data on Texas state tax rates and itemizers were obtained form the Texas Department of Taxation.

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 Texas General Fund; they are then used in part to buy goods and services, but some are also transferred to local government units.

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.

$$y_{t,g} = \sum_{i \in I} \tau^{v}_{t,g,i} v_{t,i} p_{t,i} + \sum_{i \in I} \tau^{m}_{t,g,i} m_{t,i} pw^{0}_{t,i} + \sum_{h \in H} \sum_{i \in I} \tau^{c}_{t,g,i} c_{t,i,h} p_{t,i} + \sum_{i \in I} \tau^{n}_{t,g,i} cn_{t,i,n} p_{t,i} + \sum_{i \in I} \sum_{g' \in G} \tau^{g}_{t,g,i} c_{t,i,g'} p_{t,i}$$
$$+ \sum_{i \in I} \sum_{f \in F} \tau^{x}_{t,g,f,i} r_{t,f,i} r^{a}_{t,f} u^{d}_{t,f,i} + \sum_{g' \in G} \sum_{f \in F} \tau^{x}_{t,g,f,g'} r_{t,f,g'} r^{a}_{t,f} u^{d}_{t,f,g'} + \sum_{f \in F} \tau^{fh}_{t,g,f} y_{t,f} + \sum_{h \in H} \tau^{pi}_{t,h,g} a^{hh}_{t,h} + \sum_{h \in H} \tau^{h}_{t,h,g} a^{hh}_{h}$$
$$\forall g \in G, t \in T$$

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.

$$p_{t,i} \left(1 + \sum_{g \in GS} \tau^{g}_{t,g,i} \right) cg_{t,i,g} = \alpha_{i,g} \left(y_{t,g} + \sum_{g' \in G} b_{t,g,g'} - \sum_{g' \in G} b_{t,g',g} + b_{t,ussstx,g} - \sum_{h \in H} w_{t,h,g} a^{n}_{t,h} \tau^{pc}_{t,h,g} - \overline{s}_{t,g} \right)$$
$$\forall i \in I, g \in GN, t \in T$$

Data: The shares of spending going to these sectors are based on an analysis of the spending patterns of state and local government in Texas in 2002, 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.

$$u^{d}_{t,f,g} r^{a}_{t,f} r_{t,f,g} = \alpha_{f,g} \left(y_{t,g} + \sum_{g' \in G} b_{t,g,g'} - \sum_{g' \in G} b_{t,g',g} + b_{t,ussstx,g} - \sum_{h \in H} w_{t,h,g} a^{n}_{t,h} \tau^{pc}_{t,h,g} - \overline{s}_{t,g} \right) \quad \forall f \in F, g \in GN, t \in T$$

Government Savings

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

Eq.25.

$$s_{t,g} = y_{t,g} - \sum_{i \in I} cg_{t,i,g} p_{t,i} \left(1 + \sum_{g \in GS} \tau^{g}_{t,g,i} \right) - \sum_{f \in F} u^{d}_{t,f,g} r_{t,f,g} r^{a}_{t,f} \left(1 + \sum_{g' \in GF} \tau^{x}_{t,f,g',g} \right) - \left(\sum_{h \in H} w_{t,h,g} a^{n}_{t,h} \tau^{pc}_{hg} \right) - \sum_{g' \in G} b_{t,g',g} + b_{t,ussstx,g} + \sum_{g' \in G} b_{t,g,g'} \quad \forall g \in G, t \in T$$

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.

$$b_{t,g',g} = \mu_{t,g',g} \left(y_{t,g} - \left(\sum_{h \in H} w_{t,h,g} a^{n}_{t,h} \tau^{pc}_{t,h,g} - \overline{s}_{t,g} \right) \right) \quad \forall g, g' \in G$$

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

Endogenous Distribution of Texas Funds

Comments: This equation details the flows from state funds to state spending sectors and from state spending sectors to local spending sectors.

Eq.27.

$$b_{t,g,g'} = \mu_{t,g,g'} \left(\sum_{g''} b_{t,g',g''} \right) \quad \forall g, g' \in G$$

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

State Personal Income

Comments: This equation defines state personal income as earnings (from labor and capital) plus transfer payments.

Eq.28. $$spi = \sum_{h \in H} y_{t,h} + \sum_{h \in H} \sum_{g \in G} w_{t,h,g} a^{n}_{t,h} \tau^{pc}_{hg}$$

Model Closure

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.29. $$\sum_{h \in H} a^{w}_{t,h} = \left(\sum_{i \in I} u^{d}_{t,L,i} + \sum_{g \in G} u^{d}_{t,L,g} \right) \varepsilon$$

Capital Market Clearing

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

Eq.30. $$u^{s}_{t,K,i} = u^{d}_{t,K,i} \qquad \forall i \in I, t \in T$$

Goods Market Clearing

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

Eq.31. $$q_{t,i} = x_{t,i} + e_{t,i} - m_{t,i} \qquad \forall i \in I, t \in T$$

Domestic Demand Defined

Comments: These equations define domestic demand for each sector.

Eq.32. $$x_{t,i} = v_{t,i} + \sum_{h \in H} c_{t,i,h} + \sum_{g \in G} cg_{t,i,g} + cn_{t,i} \qquad \forall i \in I, t \in T$$

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 that ensures the solution to the model does not create income tax revenue in an inappropriate place.

Eq.33. $$t_{t,g,h} = 0 \qquad \forall h \in H, g \notin GI, t \in T$$

Set Intergovernmental Transfers to Zero if Not in Original Social Accounting Matrix

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

Eq.34. $$b_{t,g,g'} = 0 \quad \forall g, g' \in G, t \in T \quad \text{where } \bar{b}_{gg'} = 0$$

Federal Social Security Transfers to Texas

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

Eq.35. $$b_{\text{t,h,USSSTX}} = \bar{b}_{\text{t,h,USSSTX}} \times \left(\frac{\overline{a^n_{t,h}}}{a_{t,h}} \right)$$

Fix Exogenous Federal Transfers to Households

Comments: Federal transfers to households are assumed to vary with the number of households in the state.

Eq.36. $$b_{\text{t,h,USNOND}} = \bar{b}_{\text{t,h,USNOND}} \times \left(\frac{a^n_{t,h}}{\overline{a}^n_{t,h}} \right)$$

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.37. $$cg_{t,i,g} = \overline{cg}_{t,i,g} \quad \forall i \in I, g \in GX, t \in T$$

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.38. $$u^d_{t,f,g} = \bar{u}^d_{t,f,g} \quad \forall f \in F, g \in GX, t \in T$$

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.39. $r_{t,L,i} = \overline{r}_{t,L,i} \quad \forall i \in I, t \in T$

Fix Government Rental Rate for Capital to Initial Level

Comments: For Texas-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.40. $r_{t,K,g} = \overline{r}_{t,K,g} \quad \forall g \in G, t \in T$

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.41. $r^{a}_{t,K} = \overline{r}^{a}_{t,K} \quad \forall f \in F, t \in T$

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.42. $w_{t,h,g} = 0 \quad \forall\ h \in H, g \in GWX, t \in T$ where $\overline{w}_{t,h,g} = 0$

OBJECTIVE FUNCTION

Comments: This equation measures utility over the entire period of the dynamic model as measured by the sum of state personal income discounted. 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.

Eq. 43. $U = \sum_{t \in T} \beta_t statey_t \quad t \in T$

TAX EXPERIMENTS: INSTITUTING AN INCOME TAX AND TAXING SERVICES

In this section we use Texas-STAMP to analyze the effects of two hypothetical tax changes in the state of Texas. Each change creates unique incentives and deterrents for economic agents in the Texas economy. It is through the use of Texas-STAMP that these incentives and deterrents can be quantified and analyzed, and a clearer understanding of the effects on the economy obtained. Below we outline the main results of Texas-STAMP's analysis of each change.

Instituting A State Income Tax

This simulation looks at the effects on the Texas economy of instituting a state income tax. The levels of standard deductions are assumed to be the same as the federal levels. Single filers are allowed a standard deduction of $4,750, a head of household a $7,000 deduction, and married couples a $9,500 standard deduction. Progressive rates and tax brackets used are as follows:

- Taxable income less than $10,000 is subject to a 2% rate.
- Taxable income between $10,001 and $75,000 is subject to a 3% rate.
- Taxable income greater than $75,001 is subject to a 4% rate.

The main results are displayed in Table 4.

Table 4. Results of Instituting an Income Tax in Texas

	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Employment	**jobs**	**jobs**	**jobs**	**jobs**	**jobs**
Change in employment	**-482,935**	**-489,554**	**-496,634**	**-502,586**	**-508,605**
Out of which: Government employment	**-93,549**	**-93,805**	**-94,105**	**-94,456**	**-94,868**
% change in employment relative to baseline	**-4.51%**	**-4.47%**	**-4.42%**	**-4.38%**	**-4.34%**
Gross wage rates	**$/wkr/yr**	**$/wkr/yr**	**$/wkr/yr**	**$/wkr/yr**	**$/wkr/yr**
Change in wage rate, nominal $	**1,304**	**2,686**	**1,320**	**1,330**	**1,341**
% change in wage rate relative to baseline	**3.13%**	**6.30%**	**3.02%**	**2.96%**	**2.91%**
Investment	**$m**	**$m**	**$m**	**$m**	**$m**
Change in nominal investment ($m)	**(2,010)**	**(2,174)**	**(2,355)**	**(2,557)**	**(2,784)**
% change in capital stock relative to baseline	**-1.27%**	**-1.26%**	**-1.25%**	**-1.24%**	**-1.24%**
State Personal Income, nominal	**$m**	**$m**	**$m**	**$m**	**$m**
Change in nominal SPI ($mn)	**(12,111)**	**(12,975)**	**(13,902)**	**(14,911)**	**(16,043)**
% change in nominal SPI	**-1.57%**	**-1.58%**	**-1.58%**	**-1.59%**	**-1.60%**
Disposable Income, real	**$m**	**$m**	**$m**	**$m**	**$m**
Change in real DI ($mn)	**(31,965)**	**(34,186)**	**(36,567)**	**(39,127)**	**(41,950)**
% change in real DI	**-4.63%**	**-4.63%**	**-4.64%**	**-4.65%**	**-4.67%**
Disposable Income per capita, real	**$**	**$**	**$**	**$**	**$**
Change in real DI/capita ($)	**-957**	**-1,015**	**-1,075**	**-1,140**	**-1,209**
% change in real DI/capita	**-3.202%**	**-3.225%**	**-3.251%**	**-3.278%**	**-3.309%**

FINDINGS: The first effect to notice is the loss of employment due to the imposition of the income tax. The loss in jobs from 2005-2009 ranges from 482,935 to 508,605. These losses represent roughly 4.5% of the existing employment base. Investment also decreases by 1.28% during this period due to the new tax. Although Texans who remain employed are now earning a higher pre-tax wage, their real disposable income is dropping overall and on a per capita basis after the imposition of the tax. Overall the case for imposing an income tax is not economically compelling.

Expanding the Sales Tax To Include Household and Corporate Purchases of Services

This simulation looks at the effects on the Texas economy of expanding the sales tax to include purchases of services by both businesses and households. The results are displayed in Table 5.

Table 5. Expansion of the Sales Tax to Include Purchases of Services

	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Employment	**jobs**	**jobs**	**jobs**	**jobs**	**jobs**
Change in employment	**-64,873**	**-68,262**	**-71,881**	**-75,531**	**-79,549**
Out of which: Government employment	**105,449**	**110,890**	**116,907**	**123,198**	**129,870**
% change in employment relative to baseline	**-0.61%**	**-0.62%**	**-0.64%**	**-0.66%**	**-0.68%**
Gross wage rates	**$/wkr/yr**	**$/wkr/yr**	**$/wkr/yr**	**$/wkr/yr**	**$/wkr/yr**
Change in wage rate, nominal $	**187**	**392**	**211**	**223**	**236**
% change in wage rate relative to baseline	**0.45%**	**0.92%**	**0.48%**	**0.50%**	**0.51%**
Investment	**$m**	**$m**	**$m**	**$m**	**$m**
Change in nominal investment ($m)	**(1,706)**	**(1,895)**	**(2,112)**	**(2,361)**	**(2,645)**
% change in capital stock relative to baseline	**-1.08%**	**-1.10%**	**-1.12%**	**-1.15%**	**-1.17%**
State Personal Income, nominal	**$bn**	**$bn**	**$bn**	**$bn**	**$bn**
Change in nominal SPI ($mn)	**-3,411**	**-3,740**	**-4,118**	**-4,560**	**-5,078**
% change in nominal SPI	**-0.44%**	**-0.45%**	**-0.47%**	**-0.49%**	**-0.51%**
Disposable Income, real	**$bn**	**$bn**	**$bn**	**$bn**	**$bn**
Change in real DI ($mn)	**-13,990**	**-15,385**	**-16,922**	**-18,622**	**-20,549**
% change in real DI	**-2.03%**	**-2.09%**	**-2.15%**	**-2.21%**	**-2.29%**
Disposable Income per capita, real	**$**	**$**	**$**	**$**	**$**
Change in real DI/capita ($)	**-502**	**-544**	**-590**	**-640**	**-695**
% change in real DI/capita	**-1.680%**	**-1.730%**	**-1.784%**	**-1.841%**	**-1.902%**

FINDINGS: The loss of jobs during the period 2005-2009 ranges from 64,873 to 79,549. This represents between 0.61% and 0.68% of the existing employment base. Investment drops due to the added tax burden on businesses. The services purchases made by businesses are now more expensive. This extra cost is passed on to the consumer in the form of higher prices for goods and services. The CPI increases and real disposable income overall and on a per capita basis decreases, making most Texas households worse off because of the expansion of the tax.

ABOUT THE AUTHORS

David G. Tuerck is Executive Director of the Beacon Hill Institute for Public Policy Research at Suffolk University where he also serves as Chairman and Professor of Economics. He holds a Ph.D. in economics from the University of Texas and has written extensively on issues of taxation and public economics.

Jonathan Haughton is a Senior Economist at the Beacon Hill Institute and Assistant Professor of Economics at Suffolk University. He holds a Ph.D. in economics from Harvard University and has published widely on economic development and taxation.

John S. Barrett is Director of Research at the Beacon Hill Institute. He holds a M.S. in Economics from New Mexico State University.

Sorin Codreanu is an Economist at the Beacon Hill Institute. He holds a M.S. in International Economics from Suffolk University.

ENDNOTES

[1] *Who Benefits from State and Local Economic Development Policies?*
[2] P. Berck, E. Golan and B. Smith, with J. Barnhart and A. Dabalen. *Dynamic Revenue Analysis for California*. Summer 1996. University of California at Berkeley and California Department of Finance. On the Web at http://www.dof.ca.gov:8080/html/fs%5Fdata/dyna%2Drev/dynrev.htm.
[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).
[4] This figure is derived from taking the average nominal US gross domestic investment for the period 1929-2002 as published by the Bureau of Economic Analysis.
[5] This figure is the Census projection for Texas for the period 2005-2010.
[6] This figure represents the average growth rate in employment for Texas for 1969-2001 as published by the Bureau of Economic Analysis.
[7] An elasticity is a measure of the degree of response to a change in a variable. Demand price elasticities express the percentage change in demand given a percentage change in price. An elasticity with a value less than one means that a one percent change in price results in less than a one percent change in demand. An elasticity greater than one means that a one percent change in price results in more than a one percent change in demand.
[8] Convention in economic literature is to use the Greek letter, $\boldsymbol{\eta}$ (eta), as symbolic shorthand for elasticity. Thus, the elasticity for imports is symbolically identified as $\boldsymbol{\eta}^{\mathbf{M}}$ or ETAM in the programming.
[9] 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 Bureau of Economic Analysis capital flow tables.

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