

Virginia-STAMP
(State Tax Analysis Modeling Program)

A Sophisticated Tax Model for Virginia

Developed by:
The Beacon Hill Institute at
Suffolk University

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FOREWARD

Every state and local government faces the issue of prioritizing spending, making government programs more efficient and raising the necessary funds to pay for the services that government provides. The same problem faces the Virginia state government and our General Assembly.

This year the General Assembly is dominated by the “tax debate.” But it is more than just a tax debate. It is a discussion over what is the most affordable level of services and investments in infrastructure that can be provided and can they best be provided with additional taxes or without. And if taxes are agreed to, what taxes will be raised and cut, and what “mix” of taxes is best to provide whatever amount of additional spending our legislators determine is best.

The Thomas Jefferson Institute for Public Policy has expected this debate for some time. For over three years we have discussed the need to develop a tax model that will show, as best as a model can show, the impacts of various taxes on the state’s economy.

This model was not created to take sides in this year’s tax debate. Indeed, the Jefferson Institute recognized the need for such a model before Governor Mark Warner was elected in 2001. We began work on this model months before the Governor introduced his tax proposal.

This model is only one tool in the decision making process. It is neutral on the political value of the various proposals. It reflects the consequences on labor, capital, investments, and other categories. “What happens, happens” and that is what this model shows.

The tax model we created – known as the Virginia-STAMP (State Tax Analysis Modeling Program) – to provide important decision making information to our legislators, to the Warner Administration, to the business community, to the media, and to the public. It was built for the Jefferson Institute by economists at Suffolk University’s

Beacon Hill Institute in Boston, Massachusetts. The economic team was headed by the Chairman of Suffolk University's Economics Department, Dr. David Tuerck, a graduate from the University of Virginia.

This special model is known in economic circles as a Computable General Equilibrium (cge) model. Its purpose is to allow decision makers and others to identify, with a high level of detail, the economic effects of a wide variety of possible tax-policy changes in Virginia.

The Thomas Jefferson Institute's Virginia-STAMP model was designed to:

- 1) show how people's buying and investment habits change based on raising and lowering of specific taxes, and do so over a several year period of time;
- 2) show the impacts on a broad array of economic segments of the economy;
- 3) include the impact of general government spending when specific taxes are changed, and the impact on government spending of various tax changes;
- 4) show a realistic level of expected "new income" to the state from proposed tax increases or decreases;
- 5) be used on a computer by anyone interested in determining "what happens if" certain taxes are raised and lowered;
- 6) enable legislators and others to determine if one specific tax is "better" than as far as its impact on the economy and the revenue generated to the state government, and what the impact would be with various "mixes" of tax increases and decreases;
- 7) analyze various proposals on their economic impact and determine if there is a better mix of tax cuts and tax increases to reach a specific "bottom line of revenue" for the state.

This Virginia-STAMP cannot model the long-term "social good" of government spending on the economy. It is difficult, for instance, to put a specific dollar value on long term investment in education. But a "hard" output such as transportation infrastructure was able to be part of this model.

Indeed what this model does is to provide the economic consequences over a five year period of various tax proposals. And the policy makers and those who influence policy need to balance off the “social good” with these economic consequences. This model gives those decision makers and others interested in public policy the ability to make that decision with more information in front of them. The legislator can now have a better idea what he or she is being asked to vote on.

This model does not calculate how well government spends our money or whether government should be involved in specific programs. The discussion on the roll of government and how well government uses our money is terribly important but not one that this model can address.

The Thomas Jefferson Institute worked hard to bring a broad group of leaders together to work on this important model. We did not know what the model would show when various taxes were plugged into it. We did not know what the specific proposals would be when we initiated this effort. But we did know that the economic consequences of any tax proposal needed to be analyzed in a professional way so that this information would help our elected leaders make the best possible decision for our state’s future.

The Jefferson Institute brought together a working group to oversee the general direction of this model with the clear understanding that working on this model did not mean that any or all of these groups would politically like the results of the model from a policy point of view. We did not come together with a pre-conceived or pre-determined outcome in mind, only that we wanted a good model that could be an additional tool for our leaders. That working group included representatives of the Virginia Business Council, representing 30 of the largest companies in our state; the Coalition for Virginia’s Future representing several regional chambers of commerce and other statewide business groups; the Virginia chapter of the National Federation of Independent Businesses representing 9,000 small privately owned companies; the Heritage Foundation a respected national conservative think tank; and the Thomas Jefferson Institute, a

respected non-partisan “solutions tank” here in Virginia. The model does not necessarily reflect the opinions of these organizations nor of their individual members or governing bodies. This model was not created to support or defeat any specific piece of legislation. It was created and presented to the public in an effort to provide additional and reliable information that can be part of the decision making process now and in the future.

When the economic assumptions and the formulas for this model were complete, we sent them to over two dozen business, government and economic leaders to review and comment upon. Those who did comment provided good suggestions and questions.

This report outlines what the Virginia STAMP model shows when it analyzes the three major tax proposals that have been offered: Governor Mark Warner’s, Senator John Chichester’s, and Delegate Alan Louderback’s. The results of running these proposals through this model should not be viewed in isolation. The results need to be put into the decision-making process along with the other important pieces of information.

The Virginia-STAMP model can be used to show the economic consequences of other proposals as they are put forward by our legislative leaders and others. It can be used to see if alternative taxes and tax cuts can provide a better bottom line for Virginia.

Everyone can access this model by going to the Thomas Jefferson Institute’s website at [www:thomasjeffersoninst.org](http://www.thomasjeffersoninst.org).

This model is brought to Virginia as a public service of the Thomas Jefferson Institute. The conclusions of the model do not necessarily suggest support or opposition to any specific piece of legislation pending in the General Assembly by this foundation or its Board of Directors.

Michael W. Thompson
Chairman and President
Thomas Jefferson Institute for Public Policy
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1. 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 Virginia. We have constructed a CGE model of Virginia (Virginia-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 Virginia economy under three competing tax packages being debated in the General Assembly.

CGE models are typically large, complex, and difficult to build; for instance Virginia-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, Virginia-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

¹ *Who Benefits from State and Local Economic Development Policies?*

² P. Berck, E. Golan and B. Smith, with J. Barnhart and A. Dabalén. *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> .

computable general equilibrium models, and then set out the way in which we built the model for Virginia. The key equations of the model are presented in detail in Section 4.

We then use the model to analyze the effects of the three competing tax packages, Governor Warner's, Delegate Louderback's and Senator Chichester's, currently being debated in the General Assembly.

2. WHAT IS VIRGINIA-STAMP?

Virginia-STAMP (State Tax Analysis Modeling Program) is a comprehensive model of the Virginia economy, designed to capture the principal effects of state tax changes on that economy. Virginia-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 (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 Virginia. 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

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.

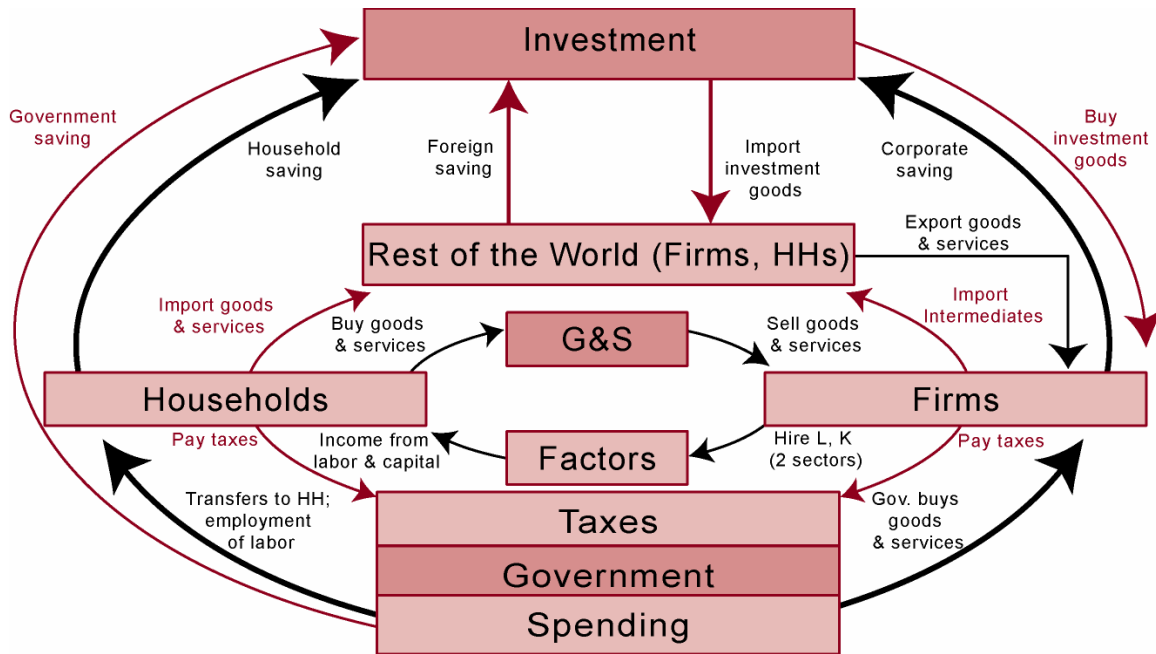


Figure 1. Circular Flow Diagram

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*; Virginia-STAMP has 77 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 22 types of taxes (14 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 Virginia-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 Virginia 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. Virginia-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, employment and inflation over the time frame of the model. In Virginia-STAMP the investment growth rate is assumed to be 7.44%.⁴ The growth rate for population is assumed to be 0.093%.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, 2003, must be very detailed. Most of the data are organized into a *Social Accounting Matrix (SAM)*, which in this case consists of a 77 by 77 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

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 Virginia for the period 2005-2010.

⁶ This figure represents the average growth rate in employment for Virginia for 1969-2001 as published by the BEA.

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 Virginia, 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 SAM (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 Virginia-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.

3. THE VIRGINIA-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 SAM for the base year. The SAM that we developed for Virginia is a 77 by 77 matrix. Each of the 5,929 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 Virginia-STAMP, we distinguish 27 industrial sectors, two factors (labor and capital), seven household categories, an investment sector, 39 government sectors (22 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

Virginia-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 (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 Virginia-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 BEA 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

Virginia-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 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 Virginia and to Federal defense fund.
USDEFF	Federal defense spending	Purchases goods and services, and pays labor for military purposes.
Virginia Government Receipts		
STPITX	Virginia individual income tax	Revenues go into Virginia general fund.
STSATX	Virginia Sales Tax	Sales tax, vehicle sales and use tax, utility taxes, hotel and motel tax. Revenues go into Virginia general fund and special.
STFUTX	Virginia tax on motor fuel	Revenues go into Virginia special fund and transportation fund.
STCITX	Virginia corporate income tax	This is the tax on business; revenues go into the Virginia general fund.
STALTX	Virginia tax on alcohol	Revenues go into Virginia general fund.
STMOTX	Virginia tax on motor vehicles	Revenues go into Virginia special fund.
STTCTX	Virginia tax on cigarettes	Revenues go into Virginia general fund.
STIHTX	Virginia tax on insurance occupation	Revenues go into Virginia general fund.
STPSTX	Virginia public service corporation tax	Revenues go into Virginia general fund and other funds.
STMVTX	Tax on motor vehicle purchases	Revenues go into Virginia special fund.
STINTX	Virginia estate tax	Revenues go into Virginia general fund.
STFEES	Virginia fees, licenses, permits	Revenues go into all funds.
STWKTX	Virginia workers' compensation and disability	Sector combines workers compensation and unemployment funds. Receipts go into proprietary fund.
STSPCF	Virginia special fund	An accounting device. Tax revenue is channeled into this fund before being distributed to other uses.
STPROF	Virginia proprietary fund	An accounting device. Tax revenue is channeled into this fund before being distributed to other uses.
STGENF	Virginia general fund	An accounting device. Tax revenue is channeled into this fund before being distributed to other uses.
Virginia Government Expenditure		
STGGSP	Virginia general spending	General government spending.
STEDUC	Virginia spending on education	Mainly purchases of goods and services and labor in the higher education sector.
STHELT	Virginia spending on health & welfare	Buys some services; mainly transfers funds to local health spending fund.
STTRAN	Virginia spending on transport	Mainly buys engineering services and construction.
STPBSF	Virginia spending on public safety	Public safety and fire departments spending.
STOTHS	Virginia 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 Virginia 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 Virginia pays directly for some education, mainly the University of Virginia 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 Virginia 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 (ROWSCT). This refers to the rest of the United States as well as other countries. Information on flows between Virginia and the rest of the world is difficult to piece together, and is an area where considerable professional judgment was required.

4. VIRGINIA-STAMP IN DETAIL

In this report we set out the model in detail. First we list our elasticity 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 VIRGINIA-STAMP

The following elasticities are used in industry-specific equations:

ETAM: 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 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: $(1 - \text{SIGMA})/\text{SIGMA}$.

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
BSVCS	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 (NIT). 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.

	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 VIRGINIA-STAMP

Virginia-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 return 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 Virginia-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,

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

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.

$$\text{Eq.1.} \quad y_{t,h} = \sum_{f \in F} \frac{\alpha_{hf} a_{t,h}^w}{\sum_{h \in H} \alpha_{hf} a_{t,h}^w} y_{t,f} \left(1 - \sum_{g \in GF} \tau_{t,g,f}^h \right) \quad \forall h \in H$$

Data: The information on earnings for each household group comes from household survey data for the South of the U.S. for 2000-2001. Source: *BLS Consumer Expenditure Report 2001-2002 (South)*.

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).

$$\text{Eq.2.} \quad y_{t,h}^d = y_{t,h} - \sum_{g \in GI} t_{t,g,h} a_{t,h}^{hh} - \sum_{g \in GH} \tau_{t,g,h}^h a_{t,h}^{hh} + \sum_{g \in G} w_{hg} a_{t,h}^n \tau_{t,h,g}^{pc} \quad \forall h \in H, t \in T$$

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.

$$\text{Eq.3.} \quad c_{t,i,h} = \bar{c}_{t,i,h} \left(\frac{y_{t,h}^d}{\bar{y}_{t,h}^d} \div \frac{P_{t,h}}{\bar{P}_{t,h}} \right)^{\beta_{ih}} \prod_{i' \in I} \left[\frac{P_{t,i'} \left(1 + \sum_{g \in GS} \tau_{t,g,i'}^c \right)}{\bar{P}_{t,i'} \left(1 + \sum_{g \in GS} \tau_{t,g,i'}^q \right)} \right]^{\lambda_{ti}} \quad \forall i \in I, h \in H, t \in T$$

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.

Direct household purchases of imports

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

$$m_{t,h} = \bar{m}_{t,h} \left(\frac{y_{t,h}^d}{\bar{y}_{t,h}^d} \div \frac{P_{t,h}}{\bar{P}_{t,h}} \right)^{\eta_h^m} \quad \forall h \in H, t \in T$$

Household Savings

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

$$\text{Eq.4.} \quad s_{t,h} = y_{t,h}^d - \sum_{i \in I} c_{t,i,h} P_{t,i} \left(1 + \sum_{g \in GS} \tau_{t,g,i}^c \right) - m_{t,h} \quad \forall h \in H, t \in T$$

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.

$$\text{Eq.5. } p_{t,h} = \frac{\sum_{i \in I} p_{t,i} \left(1 + \sum_{g \in GS} \tau_{t,g,i}^c \right) c_{t,i,h}}{\sum_{i \in I} \bar{p}_{t,i} \left(1 + \sum_{g \in GS} \tau_{t,g,i}^q \right) c_{t,i,h}} \quad \forall h \in H, t \in T$$

Data: The consumption of each good by each household group (c_{ih}) is derived from Consumer Expenditure Survey data (2000-2001). 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 Northeast region of the US, which we took to be an adequate representation of spending patterns in Virginia. The distribution of households by income group is also for the Northeast rather than Virginia, but we applied the same proportions to the population of Virginia.

LABOR SUPPLY

Comments: In Virginia-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.

$$\text{Eq.6.} \quad a_{t,h}^w = \bar{a}_{t,h}^w \frac{a_{t,h}^{hh}}{\bar{a}_{t,h}^{hh}} \left(\frac{r_{t,L}^a}{\bar{r}_{t,L}^a} \div \frac{P_{t,h}}{\bar{P}_{t,h}} \right)^{\eta_h^{ls}} \left(\frac{\sum_{g \in GI} t_{t,g,h}^{pi}}{\sum_{g \in GI} \bar{t}_{t,g,h}^{pi}} \right)^{\eta_h^{pIT}} \left(\frac{\sum_{g \in G} \frac{W_{t,h',g}}{P_{t,h}}}{\sum_{g \in G} \frac{\bar{W}_{t,h',g}}{\bar{P}_{t,h}}} \right)^{\eta_h^{IP}} \quad \forall h \in H, t \in T$$

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 Virginia.

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).

$$\text{Eq.7.} \quad a_{t,h}^{hh} = \bar{a}_{t,h}^{hh} + \bar{a}_{t,h}^i \left(\frac{y_{t,h}^d}{a_{t,h}^{hh}} \div \frac{\bar{y}_{t,h}^d}{\bar{a}_{t,h}^{hh}} \div \frac{P_{t,h}}{\bar{P}_{t,h}} \right)^{\eta_h^{yd}} \left(\frac{a_{t,h}^n}{a_{t,h}^{hh}} \div \frac{\bar{a}_{t,h}^n}{\bar{a}_{t,h}^{hh}} \right)^{\eta_h^{in}} - \bar{a}_h^o \left(\frac{\bar{y}_{t,h}^d}{\bar{a}_{t,h}^{hh}} \div \frac{y_{t,h}^d}{a_{t,h}^{hh}} \div \frac{\bar{P}_{t,h}}{P_{t,h}} \right)^{\eta_h^{yd}} \left(\frac{\bar{a}_{t,h}^n}{\bar{a}_{t,h}^{hh}} \div \frac{a_{t,h}^n}{a_{t,h}^{hh}} \right)^{\eta_h^{in}}, \quad \forall h \in H, t \in T$$

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.

$$\text{Eq.8.} \quad a_{t,h}^n = a_{t,h}^{hh} - a_{t,h}^w \quad \forall h \in H, t \in T$$

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.

$$\text{Eq.9.} \quad v_{t,i} = \sum_{i' \in I} \alpha_{t,i,i'} q_{t,i'} \quad \forall i \in I, t \in T$$

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

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

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.
$$r_{t,f,i} r_{t,f}^a \left(1 + \sum_{g \in GF} \tau_{t,f,g,i}^x \right) u_{t,f,i}^d = p_{t,i}^{va} q_{t,i} \alpha_{t,f,i} \quad \forall i \in I, f \in F, t \in T$$

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 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 Virginia.

Factor Income

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

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

TRADE WITH OTHER STATES AND COUNTRIES

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

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

Data: The trade data for Virginia 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 Virginia.

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

Data: As with export demand we have used our judgement, combined with 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.

$$\text{Eq.16.} \quad m_{t,i} = (1 - d_{t,i}) x_{t,i} \quad \forall i \in I, t \in T$$

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.

$$\text{Eq.17.} \quad p_{t,i} = d_{t,i} p_{t,i}^d + (1 - d_{t,i}) \bar{p}_{t,i}^w \quad \forall i \in I, t \in T$$

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.⁷

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.

$$\text{Eq.18.} \quad u_{t,K,i} = u_{t-1,K,i} (1 - \delta_i) + n_{t,i} \quad \forall i \in I, t \in T$$

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 Virginia.

⁷ 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.

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).

$$\text{Eq.19.} \quad n_{t,i} = \bar{n}_{t,i} \left[\frac{r_{t,K,i} \left(1 - \sum_{g \in GK} \tau_{t,g,K,i}^x \right) u_{t,K,i}}{\bar{r}_{t,K,i} \left(1 - \sum_{g \in GK} \tau_{t,g,K,i} \right) \bar{u}_{t,K,i}} \right]^{\eta^i} \quad \forall i \in I, t \in T$$

Data: The rate of return is computed as the property-type income for each sector (from 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.

$$\text{Eq.20.} \quad p_{t,i} \left(1 + \sum_{g \in GS} \tau_{t,g,i}^n \right) cn_{t,i} = \sum_{i' \in I} \beta_{t,i,i'} n_{t,i'} \quad \forall i \in I, t \in T$$

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

Eq.21.

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

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 Virginia. Data on Virginia state tax rates and itemizers were obtained from the Virginia 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 Virginia 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.

$$\begin{aligned}
 y_{t,g} = & \sum_{i \in I} \tau_{t,g,i}^v v_{t,i} p_{t,i} + \sum_{i \in I} \tau_{t,g,i}^m m_{t,i} p w_{t,i}^0 + \sum_{h \in H} \sum_{i \in I} \tau_{t,g,i}^c c_{t,i,h} p_{t,i} + \sum_{i \in I} \tau_{t,g,i}^n c n_{t,i,n} p_{t,i} + \sum_{i \in I} \sum_{g' \in G} \tau_{t,g,i}^g c_{t,i,g'} p_{t,i} \\
 & + \sum_{i \in I} \sum_{f \in F} \tau_{t,g,f,i}^x r_{t,f,i} r_{t,f,i}^a u_{t,f,i}^d + \sum_{g' \in G} \sum_{f \in F} \tau_{t,g,f,g'}^x r_{t,f,g'} r_{t,f,g'}^a u_{t,f,g'}^d + \sum_{f \in F} \tau_{t,g,f}^{fh} y_{t,f} + \sum_{h \in H} \tau_{t,h,g}^{pi} a_{t,h}^{hh} + \sum_{h \in H} \tau_{t,h,g}^h a_h^{hh} \\
 & \forall g \in G, t \in T
 \end{aligned}$$

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.

$$p_{t,i} \left(1 + \sum_{g \in GS} \tau_{t,g,i}^g \right) c g_{t,i,g} = \alpha_{i,g} \left(y_{t,g} + \sum_{g' \in G} b_{t,g,g'} - \sum_{g' \in G} b_{t,g',g} + b_{t,ussstx,g} - \sum_{h \in H} w_{t,h,g} a_{t,h}^n \tau_{t,h,g}^{pc} - \bar{s}_{t,g} \right)$$

$\forall i \in I, g \in GN, t \in T$

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

$$u_{t,f,g}^d r_{t,f}^a r_{t,f,g} = \alpha_{f,g} \left(y_{t,g} + \sum_{g' \in G} b_{t,g,g'} - \sum_{g' \in G} b_{t,g',g} + b_{t,usstx,g} - \sum_{h \in H} w_{t,h,g} a_{t,h}^n \tau_{t,h,g}^{pc} - \bar{s}_{t,g} \right) \quad \forall f \in F, g \in GN, t \in T$$

Government Infrastructure Capital Stock

Comments: The government adds to its infrastructure capital stock through its spending on the government transportation sector, STTRAN.

$$\text{Eq. 25} \quad gk_{t+1} = gk_t (1 - \delta) + m_{t+1,i} \quad t \in T$$

Data: The initial measure of Virginia infrastructure capital stock for 2003 was derived by applying actual Virginia transportation spending during the period 1983 to 2003 to Cohen and Morrison, 2004 estimate. The depreciation rate is 0.01667 as derived from Munnell, 1990 estimate of 60 year average service life.

Government Savings

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

Eq.26.
$$s_{t,g} = y_{t,g} - \sum_{i \in I} c g_{t,i,g} p_{t,i} \left(1 + \sum_{g \in GS} \tau_{t,g,i}^g \right) - \sum_{f \in F} u_{t,f,g}^d r_{t,f,g} r_{t,f}^a \left(1 + \sum_{g' \in GF} \tau_{t,f,g',g}^x \right) - \left(\sum_{h \in H} w_{t,h,g} a_{t,h}^n \tau_{hg}^{pc} \right) - \sum_{g' \in G} b_{t,g',g} + b_{t,usstx,g} + \sum_{g' \in G} b_{t,g,g'} \quad \forall g \in G, t \in T$$

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.27.
$$b_{t,g',g} = \mu_{t,g',g} \left(y_{t,g} - \left(\sum_{h \in H} w_{t,h,g} a_{t,h}^n \tau_{t,h,g}^{pc} - \bar{s}_{t,g} \right) \right) \quad \forall g, g' \in G$$

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

Endogenous Distribution of Virginia Funds

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

Eq.28.
$$b_{t,g,g'} = \mu_{t,g,g'} \left(\sum_{g''} b_{t,g',g''} \right) \quad \forall g, g' \in G$$

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

State Personal Income

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

Eq.29.
$$spi = \sum_{h \in H} y_{t,h} + \sum_{h \in H} \sum_{g \in G} w_{t,h,g} a_{t,h}^n \tau_{hg}^{pc}$$

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.30.
$$\sum_{h \in H} a_{t,h}^w = \left(\sum_{i \in I} u_{t,L,i}^d + \sum_{g \in G} u_{t,L,g}^d \right) \varepsilon$$

Capital Market Clearing

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

Eq.31.
$$u_{t,K,i}^s = u_{t,K,i}^d \quad \forall i \in I, t \in T$$

Goods Market Clearing

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

Eq.32.
$$q_{t,i} = x_{t,i} + e_{t,i} - m_{t,i} \quad \forall i \in I, t \in T$$

Domestic Demand Defined

Comments: These equations define domestic demand for each sector.

$$\text{Eq.33.} \quad x_{t,i} = v_{t,i} + \sum_{h \in H} c_{t,i,h} + \sum_{g \in G} cg_{t,i,g} + cn_{t,i} \quad \forall i \in I, t \in T$$

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.

$$\text{Eq.34.} \quad t_{t,g,h} = 0 \quad \forall h \in H, g \notin GI, t \in T$$

Set Intergovernmental Transfers to Zero if Not in Original SAM

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

$$\text{Eq.35.} \quad b_{t,g,g'} = 0 \quad \forall g, g' \in G, t \in T \quad \text{where } \bar{b}_{gg'} = 0$$

Federal Social Security Transfers to Virginia

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

$$\text{Eq.36.} \quad b_{t,h,USSTX} = \bar{b}_{t,h,USSTX} \times \left(\frac{\bar{a}_{t,h}^n}{a_{t,h}} \right)$$

Fix Exogenous Federal Transfers to Households

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

$$\text{Eq.37.} \quad b_{t,h,\text{USNOND}} = \bar{b}_{t,h,\text{USNOND}} \times \left(\frac{a_{t,h}^n}{a_{t,h}^n} \right)$$

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.

$$\text{Eq.38.} \quad cg_{t,i,g} = \bar{c}g_{t,i,g} \quad \forall i \in I, g \in GX, t \in T$$

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.

$$\text{Eq.39.} \quad u_{t,f,g}^d = \bar{u}_{t,f,g}^d \quad \forall f \in F, g \in GX, t \in T$$

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.

$$\text{Eq.40.} \quad r_{t,L,i} = \bar{r}_{t,L,i} \quad \forall i \in I, t \in T$$

Fix Government Rental Rate for Capital to Initial Level

Comments: For Virginia-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.

$$\text{Eq.41.} \quad r_{t,K,g} = \bar{r}_{t,K,g} \quad \forall g \in G, t \in T$$

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.

$$\text{Eq.42.} \quad r_{t,K}^a = \bar{r}_{t,K}^a \quad \forall f \in F, t \in T$$

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.

$$\text{Eq.43.} \quad w_{t,h,g} = 0 \quad \forall h \in H, g \in GWX, t \in T \quad \text{where} \quad \bar{w}_{t,h,g} = 0$$

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.

$$\text{Eq. 44.} \quad U = \sum_{t \in T} \beta_t \text{state}y_t \quad t \in T$$

5. ANALYZING THE WARNER, LOUDERBACK AND CHICHESTER PLANS

In this section we use Virginia-STAMP to analyze the effects of three competing tax proposals currently under consideration in the Virginia General Assembly. The three proposals, Governor Warner's, Senator Chichester's and Delegate Louderback's, use different mixes of tax increases, tax reductions and spending alternatives to achieve what each believes to be the best future fiscal path for Virginia. Each proposal creates unique incentives and deterrents for economic agents in the Virginia economy. It is through the use of Virginia-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 points of each proposal and display the results of Virginia-STAMP's analysis of each proposal.

GOVERNOR WARNER'S PROPOSAL

Individual Income Tax

- Raise the personal and dependent exemption from \$800 to \$1,000
- Raise the standard to \$4,000 single, \$8,000 married, \$4,000 separate
- Increase the filing threshold to \$7,000 single, \$14,000 married, \$7,000 separate
- Expand the 3% bracket to \$7,000 and 5% bracket to \$20,000
- Add a top bracket of 6.25% on taxable income above \$100,000
- Age deduction
 - For files who are at least 65 by January 1, 2005, retain the \$12,000 age deduction in its current form
 - For filers who are 65 on or after January 1, 2005, adjust the \$12,000 age deduction based on incomes:
 - For single filers, reduce age deduction by \$1 for every \$2 above \$50,000, phase out completely for those with incomes above \$74,000
 - For married filers where both are 65, reduce age deduction by \$1 for every \$2 above \$75,000, phase out completely for those with income above \$123,000
 - For filers who are at least 62 by January 1, 2005
- Conform to the provisions of the Military Family Relief Act

Personal Property Tax

- Increase the reimbursement percentage for personally owned vehicles assessed at \$20,000 or less on the following timetable, subject to the current revenue triggers
 - CY 2005 77.5%
 - CY 2006 85.0%
 - CY 2007 92.5%
 - CY 2008 100.0%

Sales Tax

- Increase the sales tax on non-food items by 1% (*July 1, 2004*)
- Reduce the sales tax on food by 1% (*July 1, 2004*)
- Reduce the sales tax on food by 0.5% (*July 1, 2005*)

Corporate Income

- Eliminate the corporate income tax loophole for intangible holding companies. Eliminate the “nowhere income” loophole for corporate income by ensuring that profits on products shipped from Virginia are taxed in Virginia, unless they are taxed by another state.

Other Business Taxes

- Conform to federal tax provisions which allow businesses to expense up to \$100,000 for purchases of equipment and similar goods
- Require that “pass through entities” file an annual information return with the Department of Taxation identifying their owners.
- Eliminate the requirement that businesses with more than \$1.3 million in annual sales accelerate their payment of sales taxes each June.

Tobacco Tax

- Increase cigarette tax by \$.225 cents per pack, dedicated for health care.

Estate Tax

- Provide a full exemption against the estate tax for all estates valued at \$10 million or less, all closely held businesses and all working farms.

Simulation Results

The results of entering Governor Warner’s proposal into Virginia-STAMP are listed in Table 4.

Table 4. Results of Governor Warner’s Proposal Simulation					
	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Employment	jobs	jobs	jobs	jobs	jobs
Change in employment	-2490	-2855	-3336	-4029	-4490
Out of which: Government employment	2970	1501	41	-1536	-833
% change in employment relative to baseline	-0.06%	-0.07%	-0.08%	-0.09%	-0.10%
Gross wage rates	\$/wkr/yr	\$/wkr/yr	\$/wkr/yr	\$/wkr/yr	\$/wkr/yr
Change in wage rate, nominal \$	-94	-106	-118	-131	-118
% change in wage rate relative to baseline	-0.22%	-0.24%	-0.26%	-0.29%	-0.25%
Investment	\$m	\$m	\$m	\$m	\$m
Change in nominal investment (\$m)	-133	-111	-115	-118	-125
% change in capital stock relative to baseline	-0.29%	-0.23%	-0.22%	-0.20%	-0.20%
State Personal Income, nominal	\$m	\$m	\$m	\$m	\$m
Change in nominal SPI (\$mn)	-448	-511	-587	-684	-654
% change in nominal SPI	-0.16%	-0.18%	-0.20%	-0.22%	-0.20%
Disposable Income, real	\$m	\$m	\$m	\$m	\$m
Change in real DI (\$mn)	-644	-548	-471	-396	-434
% change in real DI	-0.27%	-0.22%	-0.18%	-0.14%	-0.15%
Disposable Income per capita, real	\$	\$	\$	\$	\$
Change in real DI/capita (\$)	-72	-59	-47	-36	-38
% change in real DI/capita	-0.23%	-0.18%	-0.14%	-0.10%	-0.10%

SENATOR CHICHESTER'S PROPOSAL

Individual Income Tax

- Creates two income tax brackets
 - 6.25% for income between \$100-\$150K
 - 6.5% for income over \$150K

Sales Tax

- Removes 2% of sales tax on food in FY 2005.
- 1% more in sales tax for non-food items.

Tobacco Tax

- Increases cigarette tax to 35 cents per pack, allows counties to impose local tax and caps total combines tax at 90 cents per pack.
- 10% excise on tobacco at wholesale level.

Automobile Tax

- 100% car tax relief in FY 2005.
- Higher motor titling from 3.0% to 5.5% of general sales tax; credit for trade-in vehicle.
- Increases motor vehicle registration fee by \$10.

Motor Fuels Tax

- 20.5 cents per gallon gas tax.

The results of entering Senator Chichester's Proposal into Virginia-STAMP are listed in Table 5.

Table 5. Results of Senator Chichester's Proposal Simulation					
	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Employment	jobs	jobs	jobs	jobs	jobs
Change in employment	-11,606	-12,288	-10,692	-9,330	-8,029
Out of which: Government employment	565	1722	1937	2273	2673
% change in employment relative to baseline	-0.29%	-0.30%	-0.25%	-0.22%	-0.18%
Gross wage rates	\$/wkr/yr	\$/wkr/yr	\$/wkr/yr	\$/wkr/yr	\$/wkr/yr
Change in wage rate, nominal \$	-105	-107	-100	-91	-80
% change in wage rate relative to baseline	-0.25%	-0.25%	-0.22%	-0.20%	-0.17%
Investment	\$m	\$m	\$m	\$m	\$m
Change in nominal investment (\$m)	-197	-213	-203	-189	-175
% change in capital stock relative to baseline	-0.43%	-0.43%	-0.38%	-0.33%	-0.28%
State Personal Income, nominal	\$m	\$m	\$m	\$m	\$m
Change in nominal SPI (\$mn)	-875	-892	-781	-671	-553
% change in nominal SPI	-0.32%	-0.31%	-0.26%	-0.21%	-0.17%
Disposable Income, real	\$m	\$m	\$m	\$m	\$m
Change in real DI (\$mn)	-1,117	-1,056	-730	-419	-108
% change in real DI	-0.47%	-0.42%	-0.28%	-0.15%	-0.04%
Disposable Income per capita, real	\$	\$	\$	\$	\$
Change in real DI/capita (\$)	-108	-96	-58	-23	13
% change in real DI/capita	-0.34%	-0.29%	-0.17%	-0.06%	0.03%

DELEGATE LOUDERBACK'S PROPOSAL

Income Tax

- Eliminate all current subtractions deductions, tax credits, itemized and standard deductions and personal exemptions.
- Virginia taxable income is equal to federal adjusted gross income.
- 0.00% tax rate on the first \$15,000 of income earned for singles and \$30,000 for married persons.
- New income tax bracket of 6.25% for taxable income above \$50,000.

Sales Tax

- Repeal all current exemptions of the sales tax, except items currently subject to a separate excise tax.
- Reduce the state sales tax rate from 3.5% to 3%.
- Eliminate all sales tax on food.

Other Taxes

- Eliminate the BPOL tax and merchants' capital taxes.
- Eliminate the estate tax.

Table 5. Results of Delegate Louderback's Proposal Simulation					
	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Employment	jobs	jobs	jobs	jobs	jobs
Change in employment	17,317	17,435	17,352	17,177	16,769
Out of which: Government employment	6,761	6,779	6,740	6,692	6,603
% change in employment relative to baseline	0.43%	0.42%	0.41%	0.40%	0.38%
Gross wage rates	\$/wkr/yr	\$/wkr/yr	\$/wkr/yr	\$/wkr/yr	\$/wkr/yr
Change in wage rate, nominal \$	-315	-315	-315	-314	-311
% change in wage rate relative to baseline	-0.74%	-0.72%	-0.71%	-0.69%	-0.66%
Investment	\$m	\$m	\$m	\$m	\$m
Change in nominal investment (\$m)	184	361	209	221	233
% change in capital stock relative to baseline	0.40%	0.73%	0.39%	0.38%	0.37%
State Personal Income, nominal	\$m	\$m	\$m	\$m	\$m
Change in nominal SPI (\$mn)	-328	-337	-342	-349	-357
% change in nominal SPI	-0.12%	-0.12%	-0.11%	-0.11%	-0.11%
Disposable Income, real	\$m	\$m	\$m	\$m	\$m
Change in real DI (\$mn)	-97	-94	-95	-101	-115
% change in real DI	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%
Disposable Income per capita, real	\$	\$	\$	\$	\$
Change in real DI/capita (\$)	-34	-33	-33	-32	-31
% change in real DI/capita	-0.11%	-0.10%	-0.09%	-0.09%	-0.08%

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 PhD in economics from the University of Virginia 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 PhD 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 MS in Economics from New Mexico State University.

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