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Taxes and Consequences

The Gotham STAMP 2006 Computable General Equilibrium Model

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Significant changes in state and local tax rates can have significant consequences for New York City's economy. But how do we measure and predict those consequences? To answer that question, the Manhattan Institute's Empire Center for New York State Policy has commissioned an updated and upgraded version of the State Tax Analysis Modeling Program (STAMP), developed by the Beacon Hill Institute at Suffolk University in Boston, Mass.

Our new model, known as **Gotham STAMP 2006**, is a Computable General Equilibrium (CGE) model. This means it is larger and more complex than the NYC-STAMP model first used by the Manhattan Institute to study the effects of tax policy in the late 1990s. (See Methodology for details.)

Applied to recent tax developments and potential future changes in tax policy, Gotham STAMP 2006 generates these findings:

- Federal tax rate increases would significantly undermine the city's recent growth trend. Even a federal income tax hike limited to restoring the pre-2001 top bracket would cost New York more than 8,000 jobs.
- Rolling back the city's record 2002 property tax rate hike would boost overall employment in the city by about 15,700 jobs.
- Eliminating the remaining Dinkins-era surcharge on New York City's resident income tax would increase overall employment in the city by nearly 26,300 jobs.
- Retaining the income tax surcharge and postponing the scheduled "sunset" of temporary higher rates in upper income brackets would reduce overall employment by 4,400 jobs.

These numbers are grounded in fundamental, generally accepted economic principles. Higher income taxes reduce the incentive to work, save and invest in New York; moreover, they can prompt some taxpayers (especially upper-income earners) to migrate to lower-taxed jurisdictions. Increases in sales taxes hurt the economy by increasing the relative cost of products sold in New York. Property taxes directly affect the cost of living and doing business in New York. In sum, taxes have pervasive economic effects, which Gotham STAMP 2006 is designed to capture.

Dodging a job-killing bullet

Faced with an enormous budget shortfall in late 2002, Mayor Michael Bloomberg and the New York City Council agreed to enact a record 18.5 percent increase in the city's property tax rates. This change was reflected in tax bills payable in January and July of 2003. On the heels of the property tax increase, in the spring of 2003, the State Legislature authorized a series of temporary increases in the city's income tax and sales tax rates.

The city income tax hikes, along with state income tax increases retroactive to Jan. 1, 2003, were first reflected in wage withholding tables during the first week in July. But that same week, New York taxpayers also began feeling the effects of a large new federal tax cut enacted at roughly the same time as the city increase. The new federal law included:

- Acceleration of tax cuts adopted in 2001 but not scheduled to become fully effective until 2006, including marginal rate reductions, marriage penalty relief and an increase in the child credit, making all of these provisions fully effective in 2003.
- Immediate reduction of tax rates on corporate dividend payments to 15 percent.
- Reduction of the tax rates on long-term capital gains from 20 percent in the top bracket and 10 percent in lower brackets to 15 percent and 5 percent, respectively.

The Gotham STAMP 2006 model was used to retrospectively estimate the combined impact of the 2003 changes in federal, state and city income tax rates (all of which were retroactive to Jan. 1, 2003), along with the increase in city property taxes (which became effective at the end of 2002) and sales taxes (which became effective in mid-2003).

Our tax model's finding: the combined effect in New York City of reduced federal tax rates and increased state and city taxes was a net *gain* of at least 16,000 jobs, including at least 6,000 private sector jobs and 10,000 public-sector jobs.[1]

It should be noted that the model's estimate of the combined impact of the federal, state and city tax changes in 2003 does *not* fully reflect the ancillary economic benefits of significant reductions in capital gains and dividends taxes, which boosted asset values and ignited a fresh Wall Street boom. Thus, if anything, the model significantly understates the countervailing economic effects of the 2003 federal tax cut in New York City.

If the 2003 federal tax cuts had not been enacted, the model indicates that the city and state tax hikes would have reduced private sector employment would have been reduced by 37,200 jobs — offset only partially by an added 16,300 government jobs (mostly city positions preserved by the decision to raise taxes instead of reducing spending). The net result would have been about 20,900 fewer total jobs.

These findings are not inconsistent with actual experience. In fiscal year 2004, New York City gained 20,400 total jobs, a growth rate of 0.6 percent. The city would have created nearly 24,000 more jobs if it had kept pace with the national rate of employment growth during this period, which was roughly 1.3 percent. The Gotham STAMP 2006 estimate thus suggests the relative slower growth in the city's economy could be attributed largely to the effects of state and city tax hikes. More recently, as the city and state have begun to phase out temporary tax hikes, employment growth in New York has come closer to (but still trails) the national average.[2] This pattern indicates New York's performance will continue to improve if the temporary taxes proceed to "sunset" on schedule.

Looking ahead

The city tax rate increase of 2002 came just when the tax assessments were beginning to soar as a result of the strongest commercial and residential real estate boom since the 1980s. The vagaries of New York's Byzantine property tax code are such that the growth in the tax base will need several more years to work its way through the assessment "pipeline."[3] By 2009, according to Mayor Bloomberg's latest financial plan, property tax receipts are expected to reach nearly $14.7 billion – an increase of nearly 50 percent over the 2003 level.

Less than half the projected increase in property tax collections over the balance of the decade will be attributable to the 2002 rate hike. So what might the city gain from rolling back the increase? The NYC-CGE-STAMP model estimates that a reduction of property tax rates phased in over four years would ultimately boost private sector employment by 26,400 jobs. Offset by a net reduction of 10,700 government jobs, the total employment baseline would grow by 15,700 jobs.

Another option would be to pursue opportunities to reduce the city's personal income tax. Under current law, the temporary rate hikes approved in 2003 are supposed to disappear at the end of 2005 (i.e., the middle of the city's 2006 fiscal year). However, even if the sunset occurs on schedule, the rate will still include a 14 percent surcharge, which was first enacted in 1990 and is next due to sunset at the end of 2008. Allowing this surcharge to expire would bring the top rate down to 3.2 percent from its currently scheduled level of 3.65 percent, with commensurate reductions in three lower brackets.

The Gotham STAMP 2006 model indicates that eliminating all income tax surcharges in effect as of 2005 would be a potent economic growth-booster. Private-sector employment would increase by 30,162 jobs and government employment would drop by 3,795, producing a net employment gain of 26,267.

Unfortunately, tax hikes appear to be the last thing on the minds of city officials. During the recent mayoral election campaign, Mayor Bloomberg's leading Democratic opponents all favored some form of broad-based tax increase. The mayor did not propose any tax increases and said he did not think tax hikes would be necessary if the economy continued to grow. However, his remarks fell well short of a commitment to holding the line on taxes.

Post-election, the mayor reiterated his desire to restore the city's commuter tax on the wages of people who commute to their jobs in the city. The Mayor has not said what form of commuter tax he might favor. Moreover, the initial version of our CGE model is not calibrated to estimate the economic effects of such a tax, which would affect wage-earners in multiple jurisdictions outside the city.

In any event, prominent Democrats and Republicans in both houses of the Legislature have flatly ruled out a commuter tax in any form. Thus, if any tax increase is actually considered for the city in the year ahead, it most likely would take the form of an extension in the higher rates that were imposed as a temporary measure in 2003.

Gotham STAMP 2006 estimates that, compared to the current baseline, extending these rates would reduce private-sector employment by 5,792 jobs while increasing public-sector jobs by 1,422, resulting in an overall loss of 4,370 jobs.

High future stakes

Despite a surge in tax collections fueled by the recent real estate boom and strong securities industry profits, New York City's recurring annual expenditures continue to outpace recurring city revenues by billions of dollars a year. The resulting "structural" imbalance is the reason why each economic slowdown threatens to ignite a financial crisis for city government.

Given strong organized resistance to spending restraint, budget gaps also become a source of pressure to raise taxes in what is already the nation's most heavily taxed big city.

Meanwhile, the federal tax picture is unsettled. The Bush tax cuts of 2001 and 2003 have not yet been made permanent, and continuing federal deficits will bring increased pressure in some quarters to reverse the pro-investment, pro-growth policies that have done so much to spur New York City's recovery.

Even seemingly small increases can have pronounced effects. For example, the model estimates that the city would lose over 8,000 jobs—including many in the well-paying financial sector—if the top federal tax rate was immediately returned to its pre-2001 level of 39.6 percent. Moreover, this would lead to a net $77 million reduction in the city's own fiscal 2007 tax revenues.

Gotham STAMP 2006 also estimated the effects of two more sweeping federal tax increase scenarios:

- Rolling back all federal income tax rates to the levels originally scheduled for 2003 under prior law would cost New York City at least 40,600 jobs, growing to at least 43,000 jobs by the end of the decade. This would have the further effect of reducing the city's own tax revenues by $468 million, growing to $542 million by 2010.

- Returning the federal income tax rate schedule to pre-2001 levels would cost New York City about 70,000 jobs, growing to nearly 77,000 by the end of the decade. This would reduce the city's own tax revenues by $820 million in 2007, growing to $935 million by 2010.

To be sure, taxes are hardly the only factor influencing economic growth, even in exceptionally high-taxed New York. But the Gotham STAMP 2006 model shows the high price the city can pay for ignoring the consequences of tax increases—and failing to exploit the potential of tax cuts.

ENDNOTES

[1] In all cases, the employment effects attributed to the STAMP model are not intended to represent actual net changes in employment; rather, they reflect changes from the *baseline* of actual and projected jobs. In other words, if the model estimates a given tax increase will result in a loss of 10,000 jobs in a given year, it doesn't mean that employment will decrease by that amount; but, rather, that the city will have 10,000 fewer jobs than would have been projected without the tax increase (which might still be a net increase).

[2] In fiscal 2005, New York City gained 34,000 total jobs, a growth rate of just under 1 percent; the national employment growth rate during the same period was 1.6 percent, according to the federal Bureau of Labor Statistics (www.bls.gov).

[3] Assessment increases for Class 1 properties, consisting of one-, two- and three-family residential property and small condominiums, are limited to six percent a year and 20 percent over five years. Market value changes for commercial properties are phased in through assessments over a five-year period.

Methodology
The Gotham STAMP 2006 Computable General Equilibrium Model

By David G. Tuerck, Jonathan Haughton, Alfonso Sanchez-Penalver, Vadym Slobodyanyuk and Sara Dinwoodie

Changes in tax rates have measurable effects on taxable activities. The weight of evidence shows that city and state-level tax increases have significant negative effects on city and 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 New York City tax system, the Beacon Hill Institute (BHI) has built a Computable General Equilibrium (CGE) model of New York City, called "NYC CGE STAMP 2005". STAMP stands for "State Tax Analysis Modeling Program." In this section, we explain the concept behind the CGE model and set out the individual components used in the model. The model's purpose is to answer questions about what would happen to the New York City economy under a variety of tax changes.

CGE models are typically large, complex, and difficult to build; for instance, NYC CGE STAMP 2005 has 3,800 variables and almost a thousand lines of computer code, and every run of the model produces 920 pages of output. A CGE tax model for California was a forerunner of the Model developed by BHI.[2] California developed its CGE model with state funding, after passing 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 levels of existing taxes, NYC CGE STAMP 2005 is the more appropriate tool when analyzing the effect of major changes at a high level of detail, or when evaluating new taxes (for which the lack of historical evidence makes econometric estimation impossible). In the sections that follow we first provide a brief description of CGE models, and then set out the way in which we built the model for New York City. The key equations of the model are presented in detail in Section 4.

What is NYC CGE STAMP 2005?

NYC CGE STAMP 2005 is a comprehensive model of the New York City economy, designed to capture the principal effects of city tax changes on that economy. NYC CGE STAMP 2005 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., prices are endogenous). The model 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 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. Producers 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 of New York City. The relationships between these components are set out in the circular flow diagram shown in Figure 1.[4] 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.

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; NYC CGE STAMP 2005 has 81 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 30 types of taxes and funds (four at the federal level, 14 at the state level, and 12 at the city level) and 13 categories of

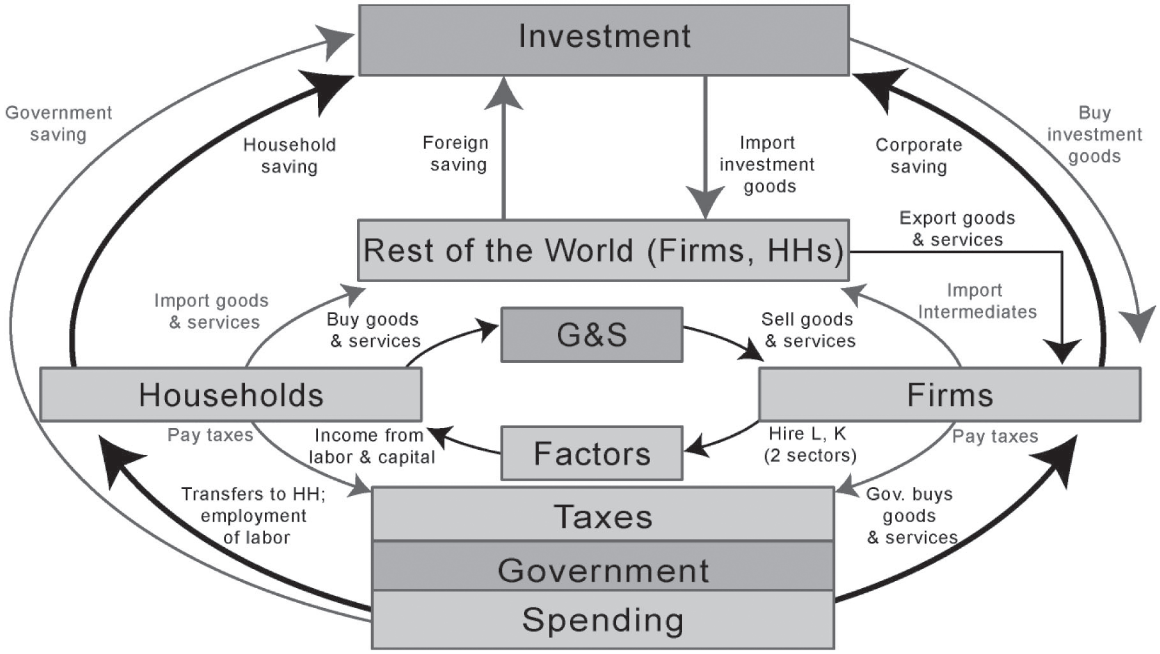

Figure 1. Circular Flow Diagram

government spending (two at the federal level, six at the state level, and five at the city level). To complete the model, there are two factor sectors (labor, capital), an investment sector 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.

Sub-national models, such as NYC CGE STAMP 2005, are similar in many ways to national and international CGE models. However, they differ in a number of important respects, which are as follows:

a. In a national model, most saving goes toward domestic investment; however, this need not be true at the regional level. If citizens of New York City save more than they spend, then the excess saving will leak out of the city.
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 city models.
c. Migration is likely to be larger and more responsive across cities and states than across nations.
d. In sub-national 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 or local income tax (which may be deducted from income before computing the Federal tax).
e. Data are less available at the sub-national than national level. This explains why scores of national CGE models have been built, but relatively few sub-national 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. NYC CGE STAMP 2005 starts with data for a single fiscal year, 2004, which we use as a basis to develop a steady state path through fiscal year 2010 in the model. This steady state path is attained by applying growth rates for investment, population, employment and inflation throughout the time frame of the model. In NYC CGE STAMP 2005, the investment growth rate is assumed to be 5.44 percent.[5] The growth rate for population is assumed to be 1.31 percent.[6] The inflation growth rate is assumed to be 2.34 percent[7]. To attain a reasonable steady state path, the data for the base year, fiscal year 2004, must be very detailed. Most of the data are organized into a Social Accounting Matrix (SAM), which in this case consists of a 81 by 81 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 taken 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 sections that follow. 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 sets out details of the model that we constructed for New York City, 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 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 must be calibrated. Calibration consists of running the model – i.e., asking it to solve for all the variables in such a way as to maximize (and minimize!) total personal income.[8] The results for the base year are checked to see that they correspond with the actual values of the variables in the SAM. Once the model reproduces the base year values, it is considered calibrated. Calibration is an important step, as it is essentially a way of checking that the model is working properly.

After it has been calibrated, 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. It is worth stressing that NYC CGE STAMP 2005 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 actually expected to occur in coming years.

Assembling the Model

The starting point in building a CGE model is to determine the degree of detail that is desired and to organize the collected data into the useful format of a Social Accounting Matrix (SAM) for the base year. The SAM that we developed for New York City is an 81 by 81 matrix. Each of the 5,929 cells in the matrix represents the dollar value of a flow from one sector of the economy to another – for instance, purchases of business services by the utilities 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 utilities must equal spending by that sector, so that all incoming and outgoing funds are completely accounted for.

For NYC CGE STAMP 2005, we distinguish 27 industrial sectors, two factors (labor and capital), seven household categories, an investment sector, 43 government sectors (26 for taxes, 13 for spending, four 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. An additional limitation 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

Although data for 49 sectors were actually available from the Bureau of Economic Analysis, NYC CGE STAMP 2005 contains only 27 industrial sectors. This is because some sectors were too small to merit separate attention. In these cases, we combined some industries, such as textiles and apparel. In other cases, there were no matching employment figures, and so it was easier to work with aggregates.

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 NYC CGE STAMP 2005, 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 (BEA) on the pattern of gross investment by destination (i.e., how much gross investment went into adding to the stock of capital in utilities, in industry, and so on). We have constructed measures of the capital stock in each sector, and by applying published depreciation rates and adding gross investment, arrived 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. This mapping allows one to determine, for example, how much of the investment destined for utilities 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

NYC CGE STAMP 2005 was designed primarily to analyze the effects of major changes in the structure of city taxes, and so we have paid particular attention to providing sufficient detail for government transactions. The sectoring is summarized below in Table 1.

The New York City government collects revenue from taxes and fees. Specific tax categories at the city level included in the model are: sales and use, cigarettes and tobacco, mortgage recording, corporate and personal incomes, and taxes both on residential and commercial properties. The rest of the city taxes are grouped into a residual category (other local taxes).

The revenues from the taxes go to either the NYC general fund, the NYC capital projects fund or to other funds, or a combination of them. Funds then allocate the money into the five spending categories: education, health and welfare, transportation, public safety or others. A main beneficiary of NYC's education expenditure is the City College of New York system.

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 NYC and to Federal defense fund.
USDEFF	Federal defense spending	Purchases goods and services, and pays labor for military purposes.
NY State Government Receipts		
STPITX	NY State individual income tax	Revenues go into NY State general fund.
STCBTX	NY State corporate business tax	Revenues go into NY State general fund.
STSATX	NY State Sales Tax	Sales tax, vehicle sales and use tax, utility taxes, hotel and motel tax. Revenues go into NY State general fund.
STFUTX	NY State tax on motor fuel	Revenues go into NY State special fund and transportation fund.
STALTX	NY State tax on alcohol	Revenues go into NY State general fund.
STPTTX	NY State tax on personal transfers.	Revenues go into NY State general fund.

STMOTX	NY State tax on motor vehicles	Revenues go into NY State general fund.
STTCTX	NY State tax on cigarettes	Revenues go into NY State general fund.
STOTTX	NY State other taxes.	Revenues go into NY State general fund and Other funds.
STFEES	NY State fees, licenses, permits	Revenues go into all funds.
STWKTX	NY State workers' compensation	Sector combines workers compensation and unemployment and disability funds. Receipts go into proprietary fund.
STSPCF	NY State special fund	An accounting device. Tax revenue is channeled into this fund before being distributed to other uses.
STGENF	NY State general fund	An accounting device. Tax revenue is channeled into this fund before being distributed to other uses.
STOTHF	NY State Other fund	An accounting device. Tax revenue is channeled into this fund before being distributed to other uses.

NY State Government Expenditure

STGGSP	NY State general spending	General government spending.
STEDUC	NY State spending on education	Mainly purchases of goods and services and labor in the higher education sector.
STHELT	NY State spending on health	Buys some services; mainly transfers funds to local and welfare health spending fund.
STTRAN	NY State spending on transport	Mainly buys engineering services and construction.
STPBSF	NY State spending on public safety	Public safety and fire departments spending.
STOTHS	NY State other spending	Miscellaneous other spending by the state on labor, goods and services.

NYC Government Receipts

LOPRTX	Local tax on residential property	Revenues go into the local general fund.

LOPBTX	Local tax on business property	Revenues go into the local general fund.
LOSATX	Local sales tax.	Revenues go to the local general fund.
LOTCTX	Local Cigarettes and Tobacco tax.	Revenues go to the local general fund.
LOMGTX	Local Mortgage Recording Tax.	Revenues go to the local general fund.
LOPITX	Local Personal Income Tax.	Revenues go to the local general and other funds.
LOCBTX	Local Corporate and Business tax.	Revenues go to the local general fund.
LOOTTX	Local taxes, other	Revenues go to the local general fund.
LOFEES	Local fees, permits and licenses.	Revenues go to all three funds (general, capital projects and other)
LOGENF	Local general fund.	An accounting device. Tax revenue is channeled into this fund before being distributed to other uses
LOCPRF	Local capital projects fund.	An accounting device. Tax revenue is channeled into this fund before being distributed to other uses
LOOTHF	Local other funds.	An accounting device. Tax revenue is channeled into this fund before being distributed to other uses.
NYC Government Expenditure		
LOEDUC	Local spending on education	Purchases goods and services and (mainly) pays teacher salaries.
LOHELT	Local spending on health and 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.

Rest of the World

To complete the model, we have included a sector for the rest of the world (ROWSCT). This refers to the world outside of New York City, i.e., the rest of the United States and other countries. Information on flows between New York City and the rest of the world is difficult to piece together, and is an area where considerable professional judgment was required.

The following section explains the NYC CGE STAMP 2005 model in detail. First, we introduce each equation, providing some context and a short description. Then we present each equation in mathematical form, provide information on the sources of data used, and summarize the elasticity assumptions used in the model.

Detailed Equations

NYC CGE STAMP 2005 is a dynamic CGE model that 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 turn onto 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 NYC CGE STAMP 2005 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,

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

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 l_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 (ensuring 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. We used historical data to estimate that approximately 24 percent of income earned in New York City is earned by non-residents (i.e., commuters from New Jersey, Long Island, etc.), and took account of this in the model.

Eq.1.

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

Description: Household income is the sum of income from each factor (labor and capital) less factor taxes, distributed by household groups according to their share of total.

Data: The information on earnings for each household group comes from NYC IMPLAN (an economic impact modeling system which allows users to perform in-depth regional analysis. See http://www.implan.com for more details).

Household Disposable Income

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.

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

Description: Disposable household income is the household income less income taxes and other household taxes (property taxes etc), plus the government transfer payments.

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.

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

Description: Consumption is a function of baseline consumption, adjusted to reflect the change in household disposable income (in constant prices), and the change in after-tax prices.

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 New York City.

Eq. 4

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

Description: Household imports will increase with the increase in disposable income, in constant prices.

Household Savings

Comments: In NYC CGE STAMP 2005, household savings is the residual after spending and taxes have been subtracted from income. Thus savings are seen as occurring passively.

Eq.5.

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

Description: See comments above.

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 Index

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.6.

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

Description: Price index by household group is a function of the baseline price index, adjusted by the change in after-tax prices by industry, according to their corresponding share of consumption.

Data: The consumption of each good by each household group (c_{ih}) is derived from New York City's State of the City's Economy and Finances 2004 Report. The model also generates some of its own values.

Labor Supply

Comments: In NYC CGE STAMP 2005 we model the labor 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.7.

$$a^{w}_{t,h} = \bar{a}^{w}_{t,h} \frac{a^{hh}_{t,h}}{\bar{a}^{hh}_{t,h}} \left(\frac{r^{a}_{t,L}}{\bar{r}^{a}_{t,L}} \div \frac{p_{t,h}}{\bar{p}_{t,h}} \right)^{\eta^{ls}_{h}} \left[\prod_{g \in GI} \left(\frac{t^{pi}_{t,g,h}}{\bar{t}^{pi}_{t,g,h}} \div \frac{p_{t,h}}{\bar{p}_{t,h}} \right)^{\eta^{PIT}_{h,g}} \right]^{1/GINUM} \left(\frac{\sum_{g \in G} \frac{w_{t,h,g}}{p_{t,h}}}{\sum_{g \in G} \frac{\bar{w}_{t,h,g}}{\bar{p}_{t,h}}} \right)^{\eta^{tp}_{h}} \qquad \forall t \in T, h \in H$$

Description: The supply of labor is a function of the baseline supply of labor adjusted by population growth, the net change in wages, income taxes, and government transfer payments. We used professional judgment in determining the proper elasticities for each household group.

Data: The data on working households by income class came from NYC IMPLAN.

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.8.

$$a^{hh}_{t,h} = \bar{a}^{hh}_{t,h} + \bar{a}^{i}_{t,h} \left(\frac{y^{d}_{t,h}}{a^{hh}_{t,h}} \div \frac{\bar{y}^{d}_{t,h}}{\bar{a}^{hh}_{t,h}} \div \frac{p_{t,h}}{\bar{p}_{t,h}} \right)^{\eta^{yd}_{h}} \left(\frac{a^{n}_{t,h}}{a^{hh}_{t,h}} \div \frac{\bar{a}^{n}_{t,h}}{\bar{a}^{hh}_{t,h}} \right)^{\eta^{u}_{h}}$$

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

Description: See comments above.

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.9. $$a^{n}_{t,h} = a^{hh}_{t,h} - a^{w}_{t,h} \qquad \forall h \in H, t \in T$$

Description: See comments above.

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

Description: See comments above.

Data: From the NYC 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.11 $$q_{t,i} = \gamma_{t,i} \left[\sum_{f \in F} \alpha_{t,f,i} \left(u^{d}_{t,f,i} \right)^{-\rho_i} + g\alpha_{t,i} \left(gk_t \right)^{-\rho_i} \right]^{-1/\rho_i} \quad \forall\, i \in I, t \in T$$

Description: In addition to labor and capital used in production, we account for infrastructure.

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

Description: Price of value-added by industry is the domestic price by industry minus the production prices by industry according to their share in domestic supply, including taxes on intermediates, if any.

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 are separate equations for labor and for capital, for each of the 27 industrial sectors.

Eq.13. $$r_{t,f,i}\, r^{a}_{t,f} \left(1 + \sum_{g \in GF} \tau^{x}_{t,f,g,i} \right) u^{d}_{t,f,i} = p^{va}_{t,i}\, q_{t,i}\, \alpha_{t,f,i} \quad \forall\, i \in I, f \in F, t \in T$$

Description: The factor demand at the current intra-industry rental rate (for labor and capital) times the overall rental rate, including factor taxes is a function of the price of value-added times the industry domestic supply.

Data: Information on the wage bills comes from the Bureau of Economic Analysis. The total wage bill is divided by the number 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 New York City.

Factor Income

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

Eq.14.

$$y_{t,f} = \sum_{i \in I} r_{t,f,i} r^a_{t,f} u^d_{t,f,i} + \sum_{g \in G} r_{t,f,g} r^a_{t,f} u^d_{t,f,g} \qquad \forall f \in F, t \in T$$

Description: The factor income is the sum of factor demand times rental rates, for all industries and government sectors.

Trade With Other States and Countries

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

Eq.15. $$e_{t,i} = \overline{e}_{t,i}\left[\frac{p^{d}_{t,i} \div \overline{p}^{w}_{t,i}}{1+\sum_{g\in G}\tau^{m}_{t,g,i}}\right]^{\eta^{e}_{i}} \quad \forall i \in I, t \in T$$

Description: Current exports are a function of baseline exports adjusted by the change in domestic prices versus fixed world prices.

Data: The trade data for New York City 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 percent) of the value of goods imported into New York City.

Eq.16. $$d_{t,i} = \overline{d}_{t,i}\left[\frac{p^{d}_{t,i} \div \overline{p}^{w}_{t,i}}{1+\sum_{g\in G}\tau^{m}_{t,g,i}}\right]^{\eta^{d}_{i}} \quad \forall i \in I, t \in T$$

Description: See comments above.

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

Intermediate Demand for Imports

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

Eq.17. $$m_{t,i} = \left(1-d_{t,i}\right)x_{t,i} \quad \forall i \in I, t \in T$$

Description: See comments above.

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

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

Description: See comments above.

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 New York City.

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.20.

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

Description: Gross investment is the baseline gross investment by industry adjusted to the change in after-tax capital rental rates.

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 0.3.

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.21.

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

Description: The gross investment by source in after-tax prices is a function of investment by destination according to the capital coefficient matrix.

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

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 New York City 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.

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

Description: Income by government sector is the sum of taxes on intermediates, imports, consumption, investment, government consumption, factors, income taxes and other household taxes.

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 city spending on education, health, safety, transport and "other," and local spending on education and health.

Eq.23.

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

Description: The government spending in after-tax prices computed according to their share of government income plus net inter-government transfers less government savings and transfer payments. Note that only state and local governments are endogenous in the model.

Data: The shares of spending going to these sectors are based on a careful analysis of New York City government budget and financial reports.

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.

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

Description: The government factor demand is computed according to the share of each government in total government spending, including net inter-government transfers, less savings and transfer payments.

Government Infrastructure Capital Stock

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

Eq. 25

$$gk_{t+1} = gk_{t}(1-\delta) + \sum_{g \in G} b_{t+1,STTRAN,g} - \sum_{g \in G} b_{t+1,g,STTRAN} + \sum_{g \in G} b_{t+1,LOTRAN,g} \quad \forall t \in T$$

Description: The infrastructure capital stock for the current year is the infrastructure for the previous year, less depreciation plus the net spending on transportation by state and local governments.

Data: The data for government infrastructure capital stock is based on national data from the BEA.

Government Savings

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

Eq.26.

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

Description: Government savings is the residual from government income, after spending and factor rental, transfer payments, plus net inter-governmental transfers.

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

Description: The intra-fund accounting to distribute the government income, less transfer payments and savings.

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

Endogenous Distribution of NYC Funds

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

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

Description: Some funds are fixed to the original share.

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

City Personal Income

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

Eq.29. $$y^{s}_{t} = \sum_{h\in H} y_{t,h} + \sum_{h\in H}\sum_{g\in G} w_{t,h,g} a^{n}_{t,h} \tau^{pc}_{h,g} \quad \forall t \in T$$

Description: City personal income is the sum of household income and government transfer payments.

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. $$\sum_{h \in H} a^{w}_{t,h} = \left(\sum_{z \in Z} u^{d}_{t,L,z} \right) \varepsilon_t \quad \forall t \in T$$

Description: Total working households equals the sum of private employment and government employment.

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

Description: See comments above.

Goods Market Clearing

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

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

Description: See comments above.

Domestic Demand Defined

Comments: These equations define domestic demand for each sector.

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

Description: Domestic demand is the sum of intermediate demand, household consumption, government consumption and investments.

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

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.

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

Federal Social Security Transfers to NYC

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

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

Description: Transfer payments are adjusted by the change in nonworking households.

Fix Exogenous Federal Transfers to Households

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

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

Description: Transfer payments are adjusted by the change in nonworking households.

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

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.

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

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

Fix Government Rental Rate for Capital to Initial Level

Comments: For NYC CGE STAMP 2005, 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.41. $r_{t,K,g} = \overline{r}_{t,K,g} \quad \forall g \in G, t \in T$

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

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.43. $w_{t,h,g} = 0 \quad \forall\ h \in H, g \in GWX, t \in T$ 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 city 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. 44. $$U = \sum_{t \in T} \beta_t statey_t \qquad t \in T$$

Description: Utility is defined as the net present value of future city personal income levels.

Elasticity Assumptions For NYC CGE STAMP 2005

For the model to work, one has to introduce values for the relevant elasticities. These are drawn from the existing literature, as follows:

ETAM: Import elasticity with respect to domestic price for producers' purchase of intermediates. Most of the data on elasticities are taken from Reinert, Roland-Holst, and Shiells. The two most recent are Reinert and Roland-Holst (1992)[10] and Roland-Holst, Reinert and Shiells (1994)[11].

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 city are more price-sensitive to goods in the Rest of the World (including other states) than national goods. Therefore, we converted the elasticities to a domestic share elasticity for each industry using 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 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.

SIGMA: Elasticity of substitution between capital and labor. Values in the literature range between 0.15 and 1.809 for industries with the majority close to 1, and we have used values of 0.90 for industries with substantial substitution and 0.8 in other cases (as shown in Table 2). This measurement is used to calculate RHO, which is the exponent in the production function. The equation is: RHO = (1-SIGMA)/SIGMA.

The following elasticities are used in household-specific equations:

ETAPIT: Labor supply elasticity with respect to income 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 (ETARA) are widely divergent

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
USNOND	0	0	0	0	0
USDEFF	0	0	0	0	0
STGGSP	0	0	0	0	0
STEDUC	0	0	0	0	0
STHELT	0	0	0	0	0
STPBSF	0	0	0	0	0
STTRAN	0	0	0	0	0
STOTHS	0	0	0	0	0
LOEDUC	0	0	0	0	0
LOHELT	0	0	0	0	0
LOPBSF	0	0	0	0	0
LOTRAN	0	0	0	0	0
LOOTHS	0	0	0	0	0

in the literature and suffer from a lack of disaggregation. They range from close to zero to 2.3 for net wages, with rather high positive values for women, particularly married woman. This means that the tax elasticities are negative. There is some evidence of greater (absolute) tax elasticities at higher income levels, which is why we assume a graduated scale from -0.15 for the lowest income category to -0.35 in the top category (see Table 3).[12]

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 the observation that income received by upper income groups is on average largely unaffected by transfer payments.

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 of responses to a change in wage rates at 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

THE BEACON HILL INSTITUTE GOTHAM STAMP 2006 DEVELOPMENT TEAM

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ENDNOTES

[1] Who Benefits from State and Local Economic Development Policies? Timothy Bartik, Upjohn Institute, 1991.
[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] Based on a similar diagram in Berck et al., Dynamic Revenue Analysis for California.
[5] 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.
[6] This figure is the Census projection for NYC for the period 2005-2010.
[7] This figure is based on data obtained from the U.S. Bureau of Labor Statistics. [JH: Still using 1.44%!] Using 2.34%
[8] The choice of variable to maximize has no substantive importance, and is a device for getting the model to solve.
[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 BEA capital flow tables.
[10]K.A. Reinert and D.W. Roland-Holst. "Armington Elasticities for United States Manufacturing Sectors". Journal of Policy Modeling. 14, no.5 (1992): 631-639.
[11] D.W. Roland-Holst K.A. Reinert, and C.R. Shiells. "A General Equilibrium Analysis of North American Economic Integration". Modeling Trade Policy: Applied General Equilibrium Assessments of North American Free Trade. Cambridge Univ. Press (1994): 47-82.
[12] Note that ETAPIT = -ETARA (t/(1-t)), where t is the income tax rate.

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