Special Report / Viewpoint

The Massachusetts Dynamic Analysis Model

by Alan Clayton-Matthews

Alan Clayton-Matthews is with the Bureau of Analysis, Estimation, and Research, Department of Revenue, The Commonwealth of Massachusetts.

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Two classes of tax revenue and policy models are standard in state revenue agencies:

(1) Microsimulation models, based on a full or representative sample of tax filers: These models are used primarily to estimate the changes in revenues and distribution of the tax burden of proposed policy initiatives.

(2) Macroeconomic forecasting models: These time series models are used primarily for estimating the impact of changes in the economy on the future stream of revenues, given current tax regulations and rates.

Although these models are both essential and useful, they do not fulfill a critical need of the policy analyst: to be able to determine the effect of changes in the tax system on the economy and, therefore, the ultimate effect of the change on total tax revenues. From a policy perspective, both changes are important to quantify. Often, the chief goal of a policy initiative is to affect the state's economic growth. Without an objective and reliable measure of that change, fruitful policy discussion often degrades into divisive political debate. The ultimate change in tax revenues, inclusive of feedback effects from the economy, is important for budgetary planning. Especially in the context of a balanced-budget constraint, it is crucial to know, for example, the effect of a change in the corporate tax on current and future income and sales tax collections. Neither of the two standard classes of tax policy and revenue models can answer these questions well, if at all.

Characteristics of the Model

Massachusetts has one of a new generation of tax models that *does* address the critical needs of policy analysts in assessing the impact of tax proposals on the economy, and the dynamic feedback effects of the economy on revenues. The Dynamic Analysis Model accomplishes this goal by linking together the two preexisting classes of models, microsimulation and macroeconomic. The link is accomplished by two sets of handles that share information between the models. One set of handles in the architecture of the regional macroeconomic model takes direct-impact changes calculated by the simulation models. The handles include changes in individual tax liability, consumer purchases, corporate tax liability, and corporate credits. These inputs initiate exogenous "shocks" to the regional model that set in motion the dynamic macroeconomic relationships captured in the model's structure. The dynamic link is completed by the other set of handles in the simulation models. These handles accept changes in such economic measures as aggregate regional income, employment, output, and investment that are produced by the regional macroeconomic model. These inputs are used to grow or shrink the effective tax base embodied in the incomes, sales, purchases, and profits of the sample records that form the database of the microsimulation models.

The regional macroeconomic model for the commonwealth is a product of Regional Economic Models Inc. (REMI), of Amherst, Mass. This regional model has been under development since 1977, under the direction of George Treyz, an economics professor at the University of Massachusetts. A core version of the model was developed for the National Academy of Sciences. Subsequently, REMI has made the model available for each state and county in the United States. The methodology and development of the model is documented in many papers published in economic and regional science journals. Key elements of the model include:

- an input-output model of the state's economy, with interindustry transactions for 53 sectors;
- interregional trade is implemented in the input-output model, with regional purchase coefficients and export coefficients by industry sector — the values of these coefficients are endogenously determined as functions of the profitability of each regional industrial sector relative to the national average;
- a standard national and regional accounting framework;
- implementation of mainstream Keynesian and neoclassical theory in the model's equations, including econometrically estimated consumption functions and production functions;
- rational behavior on the part of workers, who migrate to regions with lower unemployment rates and higher after-tax real wages; and
- rational behavior on the part of firms who seek to minimize costs (maximize profits) in their employment and investment decisions, and who locate new plants or expand existing production in regions with higher returns to capital.

The simulation models were constructed by the Tax Economics Department of Price Waterhouse. The staff includes economists and former senior officials from the Office of Tax Analysis of the U.S. Treasury, the Congressional Joint Committee on Taxation, and the Congressional Budget Office. Price Waterhouse has been developing and using tax simulation models since 1984. The Massachusetts models include several "state of the art" characteristics, including:

- direct merging of state and federal personal income tax returns;
- grouping of individual tax filers into families.
- statistical merging, at the family level, of tax forms, the decennial census, and the Consumer Expenditure Survey;
- imputation of information onto state corporate tax returns using several databases, including the IRS's corporate SOI, Compustat, and the BEA Investment File;
- creation of a detailed, state input-output model for sales taxes, with 526 industry categories of intermediate purchases, and 174 categories of final demand — spending is further disaggregated by resident versus visitor spending;
- extrapolation of microsimulation databases to future years;
- incorporation of behavioral responses to changes in the tax structure, including price elasticities in the sales tax model, tax rate elasticities of capital gains realizations in the income tax model, and discounting of future credit carryovers in the corporate model; and
- incidence assumption parameters that distribute the burden of each tax to consumption, labor, and capital.

How It Works: Investment Tax Credit Example

To illustrate how the Dynamic Analysis Model works, we will follow the flow through the model in Figures 1 and 2 as the corporate investment tax credit (ITC) is increased from 1 to 3 percent. The proposed credit of 3 percent is entered as one of the parameters of the "Plan Y" corporate tax structure. The corporate simulation model then calculates two alternate corporate tax returns for each sample corporation, one for current, Plan X law, and one for the proposed, Plan Y, law. Credit limits and carryovers of unused credits from past years and to future years are significant yet complex issues that are specifically addressed on a firm-by-firm basis in this microsimulation model. For each firm, streams of unused credits that are carried over to future years are discounted, since the value of a probable credit received in a future year is worth less than a sure credit received in the current year. Credit limits, carryovers, and discounting significantly lower the *effective* change in the ITC relative to the *statutory* change in the ITC.

Two aggregate results from the corporate model are passed to the REMI state macroeconomic model:

(1) the effective increase in the ITC rate; and

(2) an increase in disposable personal income that reflects the part of the decrease in corporate taxes that is passed forward to owners of capital.

The effects of the ITC provision on the state's economy are best described by following the logic flow in the REMI state macroeconomic model in Figure 2. The economy is initially "shocked" in two places. First, real disposable income is increased, which, in turn, increases consumer purchases. Second, and most important, the optimal capital stock (plant and equipment) is increased. This change in the optimal (desired) capital stock is modeled by the model's cost of capital equation. An increase in the ITC lowers the cost of capital to firms by lowering the tax burden that must ultimately be paid from the profits that derive from the firms' investments in plant and equipment. This increases the desired capital stock, and with a lag, increases investment in building a new plant and acquiring new equipment. Funds for supplying the new plant and equipment are drawn into the state from national and international markets, as firms competing in the national market locate new plants in the state or expand existing facilities. The increases in investment and consumption increase output, or purchases, made by the state's residents and firms. Regional purchase coefficients allocate the purchases into those supplied by in-state firms, versus those that are supplied by firms located outside the state. The increase in output supplied by in-state firms directly increases employment, which, in turn, initiates a series of simultaneous changes in the economy. New or larger paychecks directly increase disposable income. The increase in demand for workers raises wages. The additional workforce increases firms' plant and equipment requirements. The increase in employment and the wage rate induces migration into the state, which, in turn, increases demand for state and local government services. The expansion of economic activity induces contractionary forces that dampen the overall net positive impact. Increased population increases housing prices and the inflation rate. This decreases the real wage and real disposable income. Increases in the wage rate increase production costs, which increases the output prices of firms competing in the regional market and decreases the profitability of firms competing in the national market. This dampens the initial increase in the profitability of firms resulting from the ITC. Changes in profitability of firms competing in the national market affect interregional location decisions of firms, as reflected in the model's industry-specific regional trade and purchase coefficients. These econometrically estimated coefficients are functions of the profitability of producing in Massachusetts relative to the average for the nation.

After the REMI model has been run, changes in several state economic aggregates are passed from it to the microsimulation models:

- employment by detailed industry;
- population;
- income by source, including wages and salaries, dividends, interest, rent, total personal income, and disposable personal income;
- business investment;
- the stock of nonresidential capital; and
- output by detailed industry.

These changes are used to extrapolate the tax base embodied in the databases of the corporate, individual, and sales tax microsimulation models. Each simulation model is then run (or rerun), producing estimates of changes in taxes that include the dynamic feedback effects of the initial proposed tax change on the economy.

The corporate and individual models are sophisticated tax calculators that fill out large representative samples of corporate and individual forms. The sales model relies on a specially constructed 526-sector input-output model of the Massachusetts economy. The model calculates purchases by detailed commodity from three sources: resident consumer final demand, visitor consumer final demand, and business. To determine sales tax collections, sales for each commodity are factored by the proportion of sales that are not exempt, and by the tax rate.

Tax Incidence Characteristics

Besides the economic impact and the feedback effects on revenue, the distributional consequences of a proposed policy are also often critical. The question of who bears the burden of a tax change is addressed by the model's incidence module. This module distributes corporate, sales, and other taxes to families based on the shares of consumption, labor income, and capital income of each family. Insofar as any of these taxes are allocated to labor, the apportionment to families is based on the distribution of earned income by filing unit in the individual model. The allocation to capital income is analogous, but based on the distribution of capital income in the individual model. The allocation based on consumption uses consumption by good for each family from information merged onto the family file from the Consumer Expenditure Survey. The incidence of each tax on consumption, labor, and capital is specific to each model. Final sales taxes are assumed to be fully borne by consumers. Indirect sales taxes are borne partly by business and partly by consumers. The shares are determined by income and price elasticities for 82 consumption items. The portion borne by business is distributed to capital and labor based on their existing factor shares. Income taxes are fully borne by individual taxpayers. The incidence of corporate and other business taxes on consumption, capital, and labor is a controversial subject. User-supplied parameters determine the allocation for these taxes, allowing analyses of alternative views.

Dynamic Characteristics of Selected Taxes

Different taxes affect the economy differently. The magnitude and nature of the economic impact, and the resulting dynamic feedback on revenue, depend on several factors. Among the most important are:

- Whose incomes or which prices are directly impacted by the tax change?
- How mobile is the factor or commodity that is being taxed?

The Dynamic Analysis Model is a useful tool for analyzing these impacts, as its structure specifically accounts for these factors.

To illustrate these differences, we simulated tax reductions for three major state taxes: personal income, sales (including excise taxes), and corporate. In each case, across-the-board tax rates were lowered to achieve a static liability reduction of approximately $500 million for the corresponding tax in the first year. The fiscal year impacts for 1994-2000 on revenue collections and a few key economic measures were deflated to real 1993 dollars, averaged over the seven fiscal years, and scaled to an initial static cut of $100 million. The scaling is purely for convenience of presentation. There is no guarantee that the impacts are linear with the magnitude of the initial static change, although they are likely to be close to linear. The exercise is not meant to represent any real proposal.

The model's results, presented in Table 1 and Figure 3, illustrate dramatic differences in the impacts of the three taxes. The economy is especially responsive to changes in corporate tax rates, and although the magnitude of the impact of income and sales taxes is similar, their impacts differ by economic sector. We briefly analyze these differences below, focusing on the Dynamic Analysis Model's transmission of changes in tax liability to changes in key economic measures.

Income taxes. Each $100 million reduction in income taxes accomplished through rate changes has the following estimated impacts on the Massachusetts economy:

- Private nonfarm employment increases by 1,600.
- Personal income rises by $66.2 million.
- Residential investment increases by $11.9 million.
- Business investment, including nonresidential investment and durable equipment purchases, rises by $9.8 million.
- Economic growth results in increased revenues of $6.4 million, resulting in a dynamic revenue reduction of $93.4 million, rather than the initial static change of $100 million.

Reductions in income taxes act on the economy by raising disposable personal income, which, in turn, increases consumer spending. Much of the increase in spending — very roughly half — leaks out of the state's economy through purchases of products produced in other regions or countries; but the remainder initiates a general demand-driven increase in the state's economic activity, with increases in employment, output, and investment.

Sales taxes. Each $100 million reduction in sales taxes accomplished through rate changes has the following estimated impacts on the Massachusetts economy:

- Private nonfarm employment increases by 1,500.
- Personal income rises by $57.9 million.
- Residential investment increases by $7.0 million.
- Business investment rises by $24.0 million.
- Economic growth results in increased revenues of $4.9 million, resulting in a dynamic revenue reduction of $95.1 million, rather than the initial static change of $100 million.

The transmission of sales tax reductions to the economy differs from income taxes in several important respects, and is similar to income taxes in one important respect. Like income taxes, reductions in sales taxes spurs the economy by increasing consumer spending. Increased spending is driven initially by lower prices rather than by increased disposable income. The Dynamic Analysis Model's price elasticities are used to estimate this initial increase in consumer spending. There is one important additional leakage, which does not occur with income tax changes, that dampens the magnitude of the economic impact of sales tax reductions. Roughly 16 percent of sales and excise revenues derive from nonresident and visitor spending. Thus, a significant proportion of the economic effects of sales tax changes is exported to other states and countries. The other major difference in the effect of the tax is on business costs. Massachusetts' businesses pay roughly 22 percent of total sales and excise tax revenues. This simulation assumes that 30 percent of these indirect taxes are shifted to capital, and 70 percent to labor. Thus, reductions in sales taxes increase incomes of workers and increase returns to capital. The former results in increased consumer spending; the latter to increased investment and business formation or expansion. This accounts for the much larger impact of sales tax reductions on business investment relative to income tax reductions.

Corporate taxes. Each $100 million reduction in corporate taxes accomplished through rate changes has the following estimated impacts on the Massachusetts economy:

- Private nonfarm employment increases by 10,500.
- Personal income rises by $409.4 million.
- Residential investment increases by $52.5 million.
- Business investment, including nonresidential investment and durable equipment purchases, rises by $249.9 million.
- Economic growth results in increased revenues of $30.4 million, resulting in a dynamic revenue reduction of $69.6 million, rather than the initial static change of $100 million.

The dramatic effect of reductions in corporate taxes on the economy works by increasing the after-tax rate of profit of corporations doing business in the state. In the Dynamic Analysis Model, the initial decrease in taxes lowers the cost of capital. This simultaneously lowers unit output costs, which increases profitability and the demand for capital inputs to produce any given level of output. Both draw investment into the state from other states and countries, leading to expansion of existing plants and construction of new plants. What follows is a demand-driven increase in the state's economic activity, but one spurred initially by investment spending rather than by consumption spending. As in the case of expansion stimulated by reductions in income taxes, much of the spending "leaks" to other regions. However, because construction spending is relatively more important in an investment-led expansion than in a consumer-led expansion, and because the construction industry is concentrated in-state, the leakage is less. All this industry detail is available in the model's output. The magnitude of the economic impact reflects the high degree of interstate mobility of capital embodied in the macroeconomic model's structure and its econometrically estimated coefficients.

A Revenue-Neutral Economic Stimulus Example

The implication of this simulation exercise is that a model such as the Dynamic Analysis Model can be a useful tool in the design of tax proposal packages to meet specific economic or redistributive objectives. As an example of an incremental tax package designed to modestly stimulate the economy, we simulated a revenue-neutral increase in the investment tax credit for corporations, financed by equal proportionate increases in tax rates for all state taxes, including income, sales and excise, corporation, other business taxes, and other nonbusiness taxes. In contrast to the above exercise, the magnitude of the tax changes is small. The two-point rise in the ITC to 3 percent gives a static decrease in corporate taxes of $28.4 million. Like the above exercise, the stimulation is merely illustrative, and is not meant to represent any actual proposal. The fiscal year impacts for 1994-2000 on revenue collections and key economic measures were deflated to real 1993 dollars and averaged over the seven fiscal years.

The model's results, presented in Table 2, illustrate the tax package's efficiency at achieving its goal. The proposal seemingly creates both jobs and revenues out of thin air. Although designed to be initially revenue-neutral, the dynamic feedback of the policy on the economy actually raises revenues by $20.2 million. Employment increases by 6,600, personal income rises by $260.1 million, residential investment increases by $30.9 million, and business investment increases by $177.4 million. Although the initial corporate tax reduction is less than a third of the corporate example above, the increase in business investment is roughly three-fourths that of the corporate example, and the employment impact is approximately two-thirds of the corporate example. The Dynamic Analysis Model indicates that the ITC may be an excellent tax lever for policies targeted at stimulating investment.

Caveats

In interpreting the results of these illustrative simulations, a few important caveats are in order:

- Effects of expectations to tax changes are not explicitly embodied in the model. This is especially important in the case of reductions in business taxes. If tax reductions are perceived to be only temporary, then the consequent economic impacts may not be forthcoming, or may be diminished in magnitude. A related consequence is that reductions and increases in taxes may not be symmetric in their effects. Tax reductions may be perceived to be temporary, while tax increases may be perceived to be permanent.
- The body of empirical research literature in the response of business location to tax incentives is not abundant. The research is fraught with difficult statistical problems and poor data. The effects implied by the coefficients embodied in the macroeconomic model seem to be in agreement with recent research, but much work is needed in this area.
- Interstate competition for business investment through tax incentives is roughly a zero-sum gain. One state's gain is a loss to other states. The simulation results assume that the tax structure and rates in other states remain unchanged.

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Table 1: Dynamic Impacts of a Static Reduction of $100 Million in Income, Sales, and Corporate Taxes

	Change in Individual Income Tax	Change in Sales Tax	Change in Corporate Tax
Revenue Feedback ($Mil)	6.4	4.9	30.4
Employment	1,600	1,500	10,500
Personal Income ($Mil)	66.2	57.9	409.4
Investment ($Mil)	21.7	31.0	302.4
Residential ($Mil)	11.9	7.0	52.5
Business ($Mil)	9.8	24.0	249.9

Dollar figures are in real 1993 dollars.
All figures are annual fiscal year averages, FY1994-FY2000.
Employment is private, nonfarm employment.

Table 2: Balanced Budget Investment Tax Credit Rise From 1 to 3 Percent

Economic Changes:	
Personal Income ($Mil)	260.1
Employment	6,600
Residential Investment ($Mil)	30.9
Business Investment ($Mil)	177.4
Tax Changes:	
Static ($Mil)	-0.6
Dynamic ($Mil)	20.2
Feedback ($Mil)	20.8
Static Change in Corporate Revenues ($Mil)	-28.4

Dollar figures are in real 1993 dollars.
All figures are annual fiscal year averages, FY1994-FY2000.
Employment is private, nonfarm employment.

Figure 1

Massachusetts Dynamic Analysis Model Overview

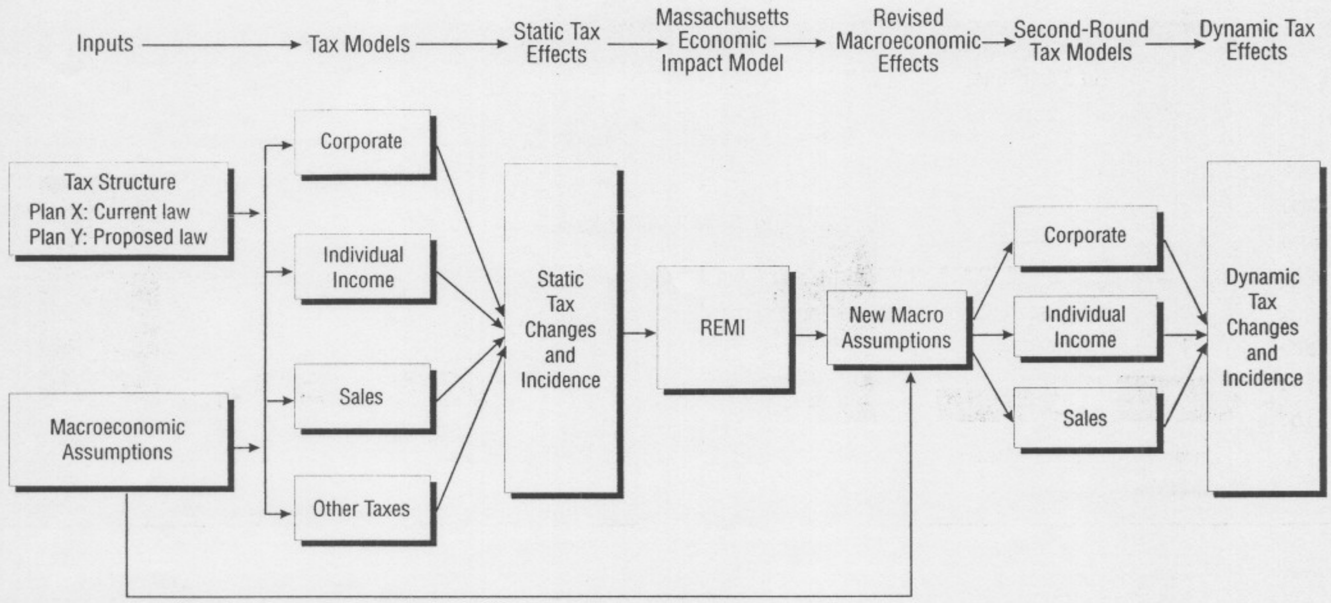

Figure 2

Linkages in the REMI Model

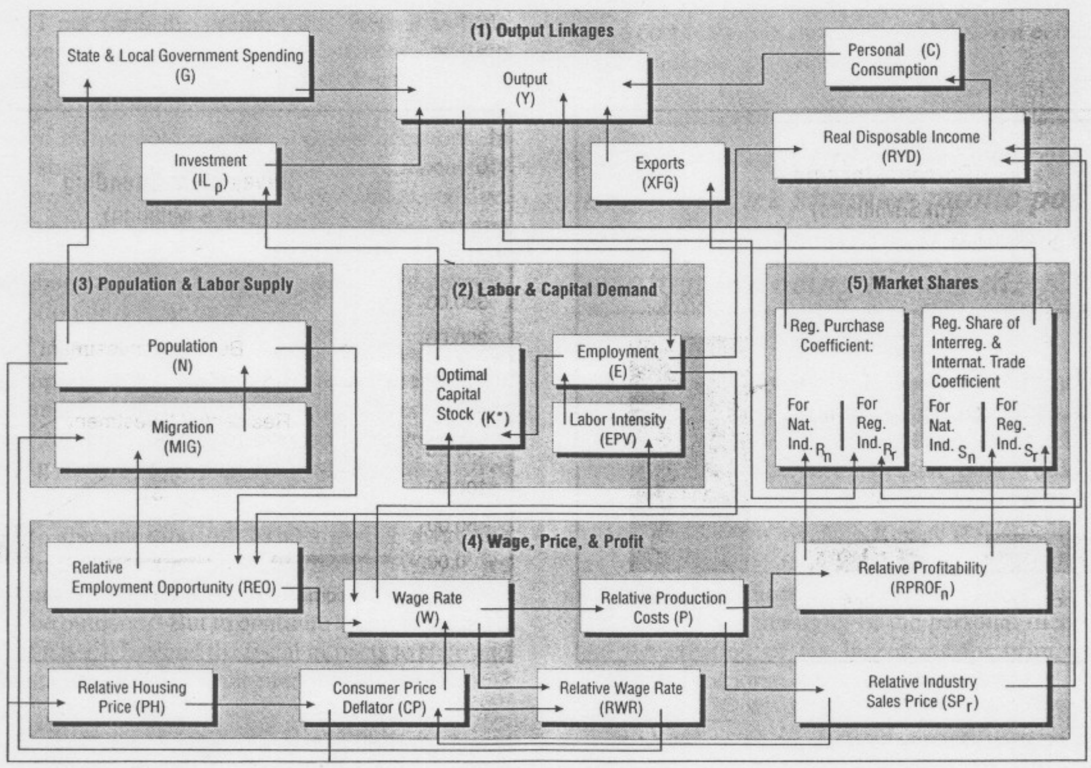

Figure 3
Dynamic Impacts of a Static Reduction of $100 Million in Income, Sales, and Corporate Taxes