State Experiences With Dynamic Revenue Analysis

by Peter Bluestone and Carolyn Bourdeaux

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In this report, the authors undertake an extensive examination of state experiences with dynamic scoring. Noting various strengths and weaknesses of this type of analysis, the authors conclude that state policymakers should carefully consider the type of information produced by this analysis as well as the resources required to develop and interpret the results.

Revenue analysis, as traditionally used by most states, estimates the direct, or static, effect of a tax policy change and may also include an estimate of behavioral responses to a tax change. Behavioral effects are usually calculated for tax changes in which elasticities (or the responsiveness to a tax change in the market directly affected) are well known or easy to estimate. For example, an analysis of a tobacco tax increase will typically estimate the increased revenue based on current tobacco sales, which is the static effect, and the offsetting revenue decrease from lower tobacco product sales as people respond to the increase in price, which is the behavioral effect. For simplicity, when the term "static revenue estimate" is used in this report, it refers to either a pure static effect or a static and direct behavioral effect.

Dynamic revenue analysis considers the behavioral implications in the market directly affected by the tax change but goes further, taking into account the subtle interactions and feedback effects on behavior within the entire economy. The dynamic analysis typically used at the state level considers how a tax change will affect the economic behavior of individuals and firms throughout the economy and then attempts to predict the effect of the change on economic variables and later on governmental tax revenue. For example, a dynamic model considers that a tobacco tax increase affects a smoker's choice of whether to buy a pack of cigarettes, but also how it affects the income that smokers have available to purchase other products, tobacco industry revenue, jobs provided through the industry, the purchase of products to support cigarette production, and the like. These economywide changes associated with one policy change may affect state tax revenue.[1]

This report examines the empirical evidence on the relationship between state-level tax changes and the economy, the theoretical economic interactions behind dynamic revenue analysis, the dynamic models that have been developed, and the states' experiences with these models.

Overall, we find that the empirical literature shows a negative effect of state-level tax increases on economic variables and a positive effect from tax cuts, but the size of the effect may be small or indeterminate. An important consideration is that state tax revenue is typically used for government spending on public services and that these expenditures also have dynamic effects that may mute or cancel a tax change's effects.

In terms of dynamic revenue estimation, states have found that dynamic analysis is considerably more costly and complex than traditional static revenue analysis and depends on the accuracy of thousands of parameters needed to estimate the interaction effects across various economic actors within and external to a state. The dynamic revenue models reviewed in this report show widely varying dynamic effects from tax changes, ranging from 1 percent to as much as 30 percent. (By dynamic effect, we mean the difference between the static estimate and a revenue estimate using a dynamic model.)

States appear to go into dynamic revenue estimation expecting to use the estimates for budgeting or forecasting, but not only are dynamic estimates highly sensitive to different specifications, but even with a sizable tax change and a large projected dynamic effect, the dynamic revenue generated (or lost) will still usually be within the average error rate for a state's overall revenue estimate. Many models also assume that the dynamic revenue adjustments take five to six years to fully materialize. The implications are that — at least for budgetary purposes — the difference between the

[1] In several places, this report refers to a hypothetical cigarette tax increase to illustrate the subtle differences between static and dynamic modeling. We use the cigarette tax because it is easy to understand. However, traditional excise taxes on specific products — such as cigarettes — are not readily analyzed using current dynamic modeling techniques because the dynamic effects are just too small.

dynamic and static effects of tax changes are too small, too imprecise, and too temporally distant to build into a state's revenue estimate and thus capture as a fiscal savings or loss. That said, dynamic analysis can be useful for comparing alternative policy choices and for examining their economic implications.

I. Literature Review

Dynamic models are grounded in economic theory and are abstractions of the economy, but research-based evidence from the *actual* performance of the economy provides an important guide in the development of dynamic models. This section briefly discusses the research-based findings on the impact of state tax policy on the economy, as well as the estimated magnitude of those effects.[2] The research, for the most part, concludes that while there is a negative effect of taxes on the economy, the effect's magnitude may be small or indeterminate and may be washed out in whole or in part depending on which expenditure categories are changed to maintain a balanced budget.

When analyzing state taxes' effects on state economic activity, there are some key considerations:

- **Balanced budget requirements and service mix:** Most states face some form of annual balanced budget requirement. While states may have some wiggle room (such as running deficits in their pensions or moving payments from year to year), they generally cannot run large multiyear deficits, and even if they could, they face the discipline of the credit markets. Because of the balanced budget constraints, a tax cut must be paired with an increase in other taxes or reduced expenditures, which in turn has dynamic effects on economic indicators. Thus, any empirical analysis must consider both taxes and expenditures.

  Further, state and local governments are heavily involved in funding services that are often found to have dynamic effects of their own. Those economically "productive" services are often identified as education, transportation, and other investments in human and physical capital. This implies that the composition of changes in expenditures needs to be considered in any empirical analysis.

- **Federalism:** There are several factors to consider in correctly measuring the economic impact of tax changes. Because firms and households within a state face state and local tax rates, any analysis must consider both. Also, some state taxes are deductible from federal taxes, and some states allow a deduction for federal taxes paid. The net effect of these deductions should be considered in an analysis of the economic impact of tax changes.

Last, states compete with one another. What often matters to firms in making location decisions are a state's taxes relative to those in other states. So any empirical analysis needs to consider taxes in competing states.

A. Effect of State Taxes on the Economy

In the 1990s, there were arguably two key reviews of the literature on the effect of taxes on the state economy: Timothy J. Bartik (1991) and Michael Wasylenko (1997).[3] The authors concluded that taxes had a statistically significant negative impact on state economic output — though the *size* of the effect was potentially subject to measurement error and most likely small. Bartik found across a set of 48 studies that a 10 percent decline in state and local taxes (holding constant governmental spending) induced between 1 and 6 percent growth (around 3 percent on average) in long-run economic activity indicators such as personal income, employment, or investment.[4] He noted that non-revenue-neutral tax changes typically must be accompanied by an expenditure increase or decrease — which in turn would have an offsetting economic effect.[5] Studies that failed to control for offsetting expenditure effects often found a much smaller tax effect since the expenditure effects were muting the tax effects.[6]

In updating and expanding Bartik's literature review, Wasylenko[7] found that the responsiveness of economic factors to tax changes ranged from an implausible 157 percent to negative 5 percent (in this case, tax increases promoted economic growth). However, Wasylenko reported that overall, results measuring the impact of state and local taxes tended to cluster around 1 percent (growth/decline) for a 10 percent (decline/growth) in taxes, and that business tax responsiveness ranged between 0 and 2.6 percent. In sum,

[2]Because state and local revenue and expenditure portfolios are heavily intertwined, most state-level research focuses on state and local revenue and expenditures. As a result, we will often refer to state and local taxes and expenditures, but are largely focused on policy changes and their implications at the state level.

[3]*See* Bartik, "Who Benefits From State and Local Economic Development Policies?" Upjohn Institute for Employment Research (1991); Wasylenko, "Taxation and Economic Development: The State of the Economic Literature," *New Eng. Econ. Rev.* 37 (1997).

[4]*See* Bartik, *supra* note 3.

[5]In this section, we are referring to the elasticities described in the papers. To make the numbers roughly comparable, we typically use a 10 percent tax change as the benchmark, although the elasticities in academic papers will typically reference a 1 percent change. So most of the actual reported elasticities have been adjusted (made larger by a decimal point) to reference a 10 percent change.

[6]Empirical analysis attempts to isolate an effect, but in the real world, expenditure effects cannot be held constant or isolated. A problem in dynamic models is that they sometimes do not include expenditure effects, which is to say, they simply model what would happen if "magic money" were given to a government to provide tax relief.

[7]*See* Wasylenko, *supra* note 3.

the two studies suggest that a 10 percent tax change would stimulate between a 1 and 3 percent change in a long-term economic growth measure.[8]

By and large, more recent studies continue to find an inverse or negative effect of tax changes on economic variables, but typically the effect is small and in some cases statistically insignificant.[9] Randall Holcombe and Donald Lacombe used a cross-border county matching technique to tease out the effect of different marginal income tax rates on state-level personal income from 1960 to 1990.[10] They found that for the average pair of states, the state with the higher marginal income tax rate would experience a 3.4 percent decline in personal income per capita by the end of the 30-year period.[11] Other findings of a negative effect of aggregate state and local taxes on revenue include John K. Mullen and Martin Williams (1994), John Deskins and Brian Hill (2008), and Brian Goff, Alex Lebedinsky, and Stephen Lile (2011), though Deskins and Hill find no effect after 2003.[12]

Examining specific taxes, Donald Bruce, Deskins, and William F. Fox (2007) find that personal income and sales taxes have a negative effect on the corporate income tax base but that corporate income tax changes have no effect on economic activity.[13] Interestingly, they show that this effect is largely driven by corporate tax sheltering — so while economic activity may stay the same, state tax *revenue* may decline. Mark Gius and Phillip Frese (2002) find a negative economic effect from the personal income tax but no effect from the corporate income tax (perhaps for the reasons described in Bruce et al., (2007)).[14] J. William Harden and William H. Hoyt (2003) find the effect of the corporate income tax is negative, but personal income and sales taxes have no effect.[15] Claudio A. Agostini (2007) finds a negative effect from corporate taxes on foreign direct investment.[16]

Paul A. Coomes and Hoyt (2008) find that the personal income tax has a small but statistically significant negative effect on migration out of a state.[17] Howard Chernick (1997) also finds that higher taxes on high-income individuals (tax progressivity) had a negative effect on long-run growth, but that this effect was largely driven by tax sheltering in a few northeastern states.[18] Revisiting the topic in 2010, he found no effect (Chernick 2010), a finding supported by Andrew Leigh (2008) and Cristobal Young and Charles Varner (2011).[19] Andrew Ojede and Steven Yamarik (2012) find that property and sales taxes have a negative effect on economic growth, but that the income tax has no effect.[20] W. Robert Reed and Cynthia L. Rogers (2004) find no effect from a New Jersey income tax cut on economic activity.[21] Bruce and Deskins (2012) show mixed (but small) effects of taxes on entrepreneurial activities, with sales tax being positive, corporate income tax negative, and income tax progressivity actually positive (but controlling for the top income tax rate in the state).[22]

One important outlier is a study by Reed (2008), which finds that the negative impact of taxes on the economy is robust to a number of specifications and that the effect is economically significant.[23] In one model, he finds that a 10 percent increase in aggregate state and local taxes at the state level would cause a relatively large 13.7 percent decline in the growth rate of personal income per capita after five years. The size of this effect is also notable given that he does not control for balanced budget requirements — and so is essentially finding that this growth number includes the potential offsetting effects of changes in government spending.[24]

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[8]*Id.*

[9]In a few cases it is even positive, but based on our review to date, this effect is often explained by failing to control for the expenditure side effects.

[10]Holcombe and Lacombe, "The Effect of State Income Taxation on Per Capita Income Growth," 32 *Pub. Fin. Rev.* 292 (2004).

[11]*Id.*

[12]Mullen and Williams, "Marginal Tax Rates and State Economic Growth," 24 *Reg'l Sci. & Urb. Econ.* 687 (1994); Deskins and Hill, "State Taxes and Economic Growth Revisited: Have Distortions Changed?" 44 *The Annals of Reg'l Sci.* 331 (2010); Goff, Lebedinsky, and Lile, "A Matched Pairs Analysis of State Growth Differences," 30 *Contemp. Econ. Pol'y* 293 (2011).

[13]Bruce et al., "On the Extent, Growth, and Efficiency Consequences of State Business Tax Planning," in *Taxing Corporate Income in the 21st Century* (James R. Hines Jr., Alan J. Auerbach Jr., and Joel Slemrod, eds., 2007).

[14]Gius and Frese, "The Impact of State Personal and Corporate Tax Rates on Firm Location," 9 *Applied Econ. Letters* 47 (2002).

[15]Harden and Hoyt, "Do States Choose Their Mix of Taxes to Minimize Employment Losses?" 7 *Nat'l Tax J.* 56 (2003).

[16]Agostini, "The Impact of State Corporate Taxes on FDI Location," 35 *Pub. Fin. Rev.* 335 (2007).

[17]Coomes and Hoyt, "Income Taxes and the Destination of Movers to Multistate MSAs," 63 *J. Urb. Econ.* 920 (2008).

[18]Chernick, "Tax Progressivity and State Economic Performance," 11 *Econ. Dev. Q.* 249 (1997).

[19]Leigh, "Do Redistributive State Taxes Reduce Inequality?" *Nat'l Tax J.* 81 (2008); Young and Varner, "Millionaire Migration and State Taxation of Top Incomes: Evidence From a Natural Experiment," 64 *Nat'l Tax J.* 255 (2011).

[20]Ojede and Yamarik, "Tax Policy and State Economic Growth: The Long-Run and Short-Run of It," 116 *Econ. Letters* 161 (2012).

[21]Reed and Rogers, "Tax Cuts and Employment Growth in New Jersey: Lessons From a Regional Analysis," 32 *Pub. Fin. Rev.* 269 (2004).

[22]Bruce and Deskins, "Can State Tax Policies Be Used to Promote Entrepreneurial Activity?" 38 *Small Bus. Econ.* 375 (2012).

[23]Reed, "The Robust Relationship Between Taxes and U.S. State Income Growth," 61 *Nat' Tax J.* 57 (2008).

[24]Another segment of the tax literature in which there are large and significant tax effects in intraregional studies — or studies of the impact of tax rates on metropolitan areas or localities in close geographic proximity that essentially share the same labor pool (for more discussion, see Stephen T. Mark, Therese J. McGuire, and Leslie E. Papke, "The Influence of Taxes on Employment and Population Growth: Evidence From the Washington, D.C. Metropolitan Area," 105 *Nat'l Tax J.* 53 (2000)). These studies suggest that localities in hot

(Footnote continued on next page.)

B. State Taxes Versus State Expenditures

There are a number of studies that show government spending on productive services will offset — or even overpower — the negative effects of taxes. Articles supporting the significant positive effects of these governmental expenditures include L. Jay Helms (1985), Alaeddin Mofidi and Joe Stone (1990), Marc Tomljanovich (2004), Neil Bania, Jo Anna Gray, and Stone (2007), and Todd M. Gabe and Kathleen P. Bell (2004).[25] In perhaps the most detailed examination of these effects, Gabe and Bell (2004) look at the effect of increasing taxes to fund selected educational expenditures among Maine counties and find a relatively large effect: A 10 percent tax-financed increase in spending on educational instruction and operations leads to a 6 to 7 percent increase in business openings in a jurisdiction and a 7 percent increase in additional investments per municipality.[26]

Surveys of business-location decisions often mirror these findings and show that while taxes are important, state taxes are only one of many characteristics firms and individuals consider when choosing a state. In the case of firm location, public safety, labor cost, quality of the workforce, and transportation may play a much more significant role than taxes.[27]

C. Conclusion

The general takeaway from the literature is that yes, taxes create a drag on the economy, but they cannot be considered in isolation. Taxes pay for something, and many of the services states provide can have just as much impact on the economy as taxes. Rather than considering taxes in isolation, policymakers should think of government as holding a portfolio of expenditures that are financed by a particular portfolio of revenue. The trick is to maintain a balanced portfolio. Importantly, the research presented here only considers the *economic* effects of taxes, not the ease of administration, fairness, or stability of a state's tax portfolio. These other criteria should also be considered when evaluating tax changes.

competition for business and investment would be well advised to keep an eye on their neighbors' tax rates.

[25]Helms, "The Effect of State and Local Taxes on Economic Growth: A Time Series — Cross Section Approach," 67 *The Rev. Econ. & Stat.* 574 (1985); Mofidi and Stone, "Do State and Local Taxes Affect Economic Growth?" 72 *The Rev. Econ. & Stat.* 986 (1990); Tomljanovich, "The Role of State Fiscal Policy in State Economic Growth," 22 *Contemp. Econ. Pol'y* 318 (2004); Bania et al., "Growth, Taxes, and Government Expenditures: Growth Hills for U.S. States," 60 *Nat'l Tax J.* 193 (2007); Gabe and Bell, "Tradeoffs Between Local Taxes and Government Spending as Determinants of Business Location," 44 *J. Reg'l Sci.* 21 (2004).

[26]*See* Gabe and Bell, *supra* note 25.

[27]Ronald C. Fisher, "The Effects of State and Local Public Services on Economic Development," *New Eng. Econ. Rev.* 53 (1997); Fahri Karakaya and Cem Canel, "Underlying Dimensions of Business Location Decisions," 98 *Indus. Mgmt & Data Sys.* 321 (1998).

II. Dynamic Revenue Analysis

This section briefly discusses the theoretical ideas that underpin dynamic models and then describes the models most commonly used by states.

A. Economic Theory

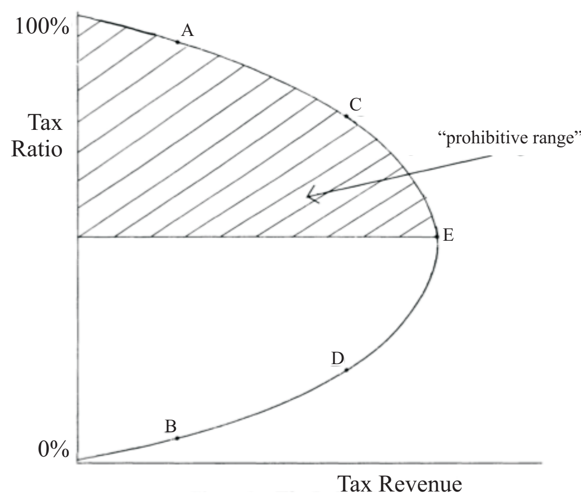
Perhaps no economist is as associated with the "dynamic effects" of tax changes in the popular imagination as Arthur Laffer and his famous Laffer curve.[28] The Laffer curve shows that it is possible for a government to lower its tax rate yet increase its tax revenue. The intuition is that there are two points for which the tax revenue on income or profit is certain. At a 0 percent tax rate, the tax revenue is zero. At the 100 percent tax rate, tax revenue is also zero because no work or production will occur if all revenue is taxed away. Given these two rates of taxation for which tax revenue raised is zero, there must be a third rate between 0 percent and 100 percent at which the maximum revenue would be generated. The Laffer curve suggests that when tax rates are too high, a government could actually increase tax revenue by lowering its taxes (the tax rate falls in the shaded region labeled "prohibitive range" of the diagram in Figure 1). In theory, the Laffer model is correct, though there is much debate over the "prohibitive range"; however, the relationships described by Laffer are but one small piece of the dynamic effects occurring in an economy.

The economic model from which the Laffer curve is derived is a simple, one-good model with two factors of production, labor and capital. Because of its simplicity, the Laffer model offers limited guidance in real-world applications. As noted in the research section, taxes are (typically) used to pay for something, such as wages for teachers or contracts with construction workers to build or repair roads, and this in turn has an effect on employment (labor) as well as on the relative productivity of labor and capital. Similarly, companies can substitute toward capital and away from labor if labor becomes more expensive; people can move into and out of a state; and businesses can invest in a state or invest elsewhere. People might choose to actually work *less* rather than work more in response to a tax cut (further reducing revenue) because they would experience an increase in after-tax wages and could work less while making the same amount of money. The effects of tax changes create complex ripple effects across an economy, which are not easily described by the simple relationship illustrated by the Laffer curve.

Dynamic revenue analysis, while informed by some of the basic economic tenets of Laffer's work, is a much richer analysis, involving a more complex set of economic relationships among households, firms, capital, and government. In describing the Dynamic Revenue Analysis Model (DRAM)

[28]Victor A. Canto, Douglas H. Joines, and Laffer, "Taxation, GNP and Potential GNP," proceedings of the Business and Economic Statistics Section, American Statistical Association (1978).

Figure 1.
The Laffer Curve



Source: Mirowski, 1982.

for California, the economists who developed the model used the diagram shown in Figure 2.

Dynamic models generally comprise a set of mathematical equations that represent the economic behaviors of firms and households, government, and the rest of the world (that is, the foreign firms and households described in Figure 2). In particular, the equations describe how firms and households respond to changes in prices. Firms and households are the central actors in the economy. Firms are assumed to want to maximize profits; households want to maximize utility, or the satisfaction received from consuming a bundle of goods and services. Firms purchase the services of factors of production — that is, capital and labor — and purchase inputs from other firms in order to produce goods and services they believe households demand. Households supply labor and capital and demand various goods and services that they consume. The decisions of firms and households are assumed to depend on prices, including the price of goods and services, the price of labor (wages), and the price of capital. An equilibrium in the model exists when prices are such that the quantity supplied of any good or service or any factor of production equals the quantity demanded.

When there is a "shock" to the system such as a tax change, the model will no longer be in equilibrium because prices — including the tax — will have changed. Firms and households will adjust their behavior based on the new economic signals, and as a result, prices will adjust. Eventually, the model will reach a new equilibrium. For example, for firms, if the price of an input has increased (perhaps because it is taxed), the firm may substitute a cheaper input or adjust the price of its product. Consumers react to price changes by consuming more of a good if the price goes down and less if the price goes up. Also, consumers may find a substitute for a good or service whose price has increased. These consumer decisions, in turn, influence the supply and demand for factors of production, such as the amount of labor and capital that firms employ. These dynamic relationships between consumers and firms are captured in a static fashion in the famous crossing supply and demand lines from Economics 101; however, in dynamic models, supply and demand depend — in differing levels of importance — on all prices across the economy, not just the price of one good or service.

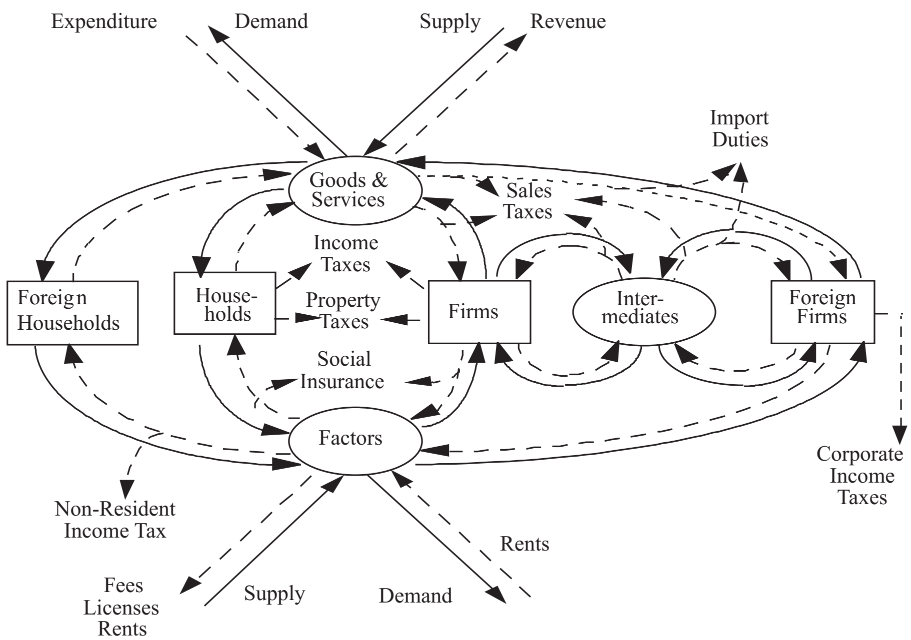
State-level dynamic models are largely "supply side" and are based on economic theories heavily concerned with the supply of labor and capital and their subsequent influence on the level of production or income in an economy. One key assumption of these models is that the economy is in equilibrium before any policy shock, and that over the long term the economy will adjust to accommodate various shocks and reach a new equilibrium. Of importance is that in equilibrium, there is no involuntary unemployment. This assumption does not mean that labor supply will not change — households can change the hours they work, and people can migrate into and out of an economy — but this change

'Demand-Side' Dynamic Effects

When the country faces a recession, typically macroeconomic discussion turns to a Keynesian form of dynamic modeling. John Maynard Keynes, a 19th century British economist, theorized that in certain situations, the economy would be in disequilibrium: Of primary importance, there might be an excess supply of willing labor (unemployment) and insufficient demand given the current wages. People who wanted to work would not be employed and capital might be sitting on the sidelines. He hypothesized that this was a problem of inadequate demand. For example, if the economy was stalled and unemployment was high, consumers might be anxious and would reduce demand for goods, which would mean that producers would cut production, which would cause wages to fall or unemployment to increase, further reducing demand for goods, and so on. To change this downward spiral and restore confidence, he argued that national governments should run deficits temporarily by either cutting taxes or increasing expenditures. A tax cut (or governmental expenditure) would give households more money to spend, which would then cause demand for goods to increase. As a result, companies would start to hire to meet demand, and unemployment would fall.

The effects of demand-side stimulus are generally considered to be short-run effects — putting the economy back on the path to equilibrium. So, the demand-side dynamic effects of a tax cut focus on the effect of a tax cut on aggregate demand and the resulting change in tax revenue.

Figure 2.
The Complete Circular Flow Diagram for DRAM



Source: Berck, Goland, and Smith 1996.

will occur only after an external shock, such as a tax change or productivity innovation. The shock will break the existing equilibrium and cause households to change the amount of labor and capital they provide and cause labor and capital to flow in and out of different sectors. These adjustments will continue until a new equilibrium is established.

In contrast, demand-side models, often associated with Keynesian macroeconomic theories, assume that there can be a disequilibrium in which there may not be full employment, such as in a recession. Demand-side models are concerned with policies that change demand in an economy for near-term effects (see Demand-Side Dynamic Effects on previous page for a more detailed description), while supply-side models are concerned with policies that change the long-term productivity of the economy.

Typically, dynamic models measure and will report employment, industry output (for example, gross state product), personal income, consumption, and the amount of labor and capital, both before and after a hypothetical external shock such as a tax change. These economywide shifts can then be translated into estimates of the impact on state (and local) governmental revenue.

The model described by Figure 2 shows the effect of taxes on different parts of the economy,[29] but as noted in the empirical literature, the economy is also influenced by changes in variables such as government expenditures and related benefits like the supply of qualified workers and low commute times. In fact, state-level dynamic models are actually more frequently used to project the economic impact of governmental investments such as building a new road or attracting a new business to a jurisdiction rather than projecting the impact of a tax change. For instance, many states regularly use dynamic modeling to project the economic impact of transportation projects. Forces unrelated to state government taxing or spending may also affect these models — including weather, natural disasters, or global economic forces such as the price of gasoline. Understanding that there is more than one lever is important in dynamic models assessing state-level taxation. Just as

[29]For detailed descriptions of the interacting effects that ripple through the economy, see Peter Berck, Elise Golan, and Bruce Smith, "Dynamic Revenue Analysis in California: An Overview," *State Tax Notes*, Oct. 28, 1996, p. 1227; and Alberta H. Charney and Marshall J. Vest, "Modeling Practices and Their Ability to Assess Tax/Expenditure Economic Impacts," AUBER Conference (2003).

empirical models can be biased by not including expenditures, dynamic models also need to accommodate the expenditure-side effects of an increase or decrease in taxes.[30]

B. Types of Dynamic Models

A common set of models used to assess dynamic effects are input-output (IO) models, computable general equilibrium (CGE) models, and blended models such as the proprietary Regional Economic Models Inc. (REMI).[31] All are models that policymakers can use to try to predict how various policy or economic changes might affect the regional or national economy.

1. IO Models

An IO model is built around matrices that mathematically describe the relationships between different industries and the associated factors of production in the economy. Key elements include sales by all industries to all other industries within a region (for example, a state), imports from outside the region by industry category, exports from the region by industry category, and household and government consumption patterns. These models were originally developed — and most of the data are collected — at the national level. However, a frequently used type of IO model, IMPLAN (IMpact analysis for PLANning), has scaled the national variables for regional (state-level) use.

An IO model can show how a change in the demand for the output of one industry, known as the direct effect, changes the output of industries that sell to that firm, known as the indirect effect. The income of workers in both the direct industry and the industries indirectly affected is spent locally, creating additional jobs and regional income, called the induced effect.

An IO model assumes the technology for making one unit of output requires fixed combinations of inputs, much like a recipe. For instance, to make output C, one unit of input A is combined with two units of input B. There are no inherent limits on the supply of inputs, A and B or the amount of C that can be produced. So for instance, if a new company comes to town, implicit in the model is that there are people available to hire at the current wage rate and therefore, wages do not increase as more labor is employed. IO models also assume that prices stay constant. Thus, to estimate the impact of a tax that affects prices, an analyst must first manually convert the price change into a change in demand and then feed the results back into the IO model. One of the great strengths of IO models is the high level of detail regarding industry interrelationships. Some contain 500 or more sectors of the economy and thousands of metrics that describe interlinkages between industries and their use of factors of production. IO models are generally used for impact analysis or to quantify the multiplier effects of exogenous changes to the economy, such as a new firm location in a region.[32]

However, IO models do not incorporate long-term or endogenous economic effects, such as price adjustments from economic shocks. Because of the rich interconnections described in IO models, they are often embedded in more complex CGE models or econometric simulation models, but they are generally not recommended for estimating the effects of economywide, long-term effects such as a tax reform or tax change.[33]

2. CGE Models

A CGE model is grounded in a series of equations intended to simulate the behavior of firms, households, government, and the rest of the world both in terms of their supply of goods and services and factors of production (labor and capital) and their consumption of goods and services and use of factors of production. These relationships are mediated by each actor's response to changes in prices, wages, and return on capital. Figure 2 shows the basic interrelationships that are mathematically described by a CGE model, but the model itself is actually even more complex. Each *sector* of the economy that is modeled has to have its own production function that will depend on the prices of all other produced goods and factor inputs. At the same time, each consumer category has its own utility function and endowment of assets. Because each sector has to be modeled in such detail, typically CGE models will draw on IO models but may significantly simplify or aggregate the number of sectors described, and as such are less useful in modeling the multiplier effects of a discrete industry or small economic change. For instance, the California DRAM, which had only 28 industry sectors, still required a set of approximately 1,100 equations that had to be solved to reach the new equilibrium.[34]

CGE models start with the premise that the economy is in equilibrium per the previous supply-side discussion. In other words, the demand for labor equals the supply of labor, the demand for capital equals the supply of capital, and so forth across the economy — with households maximizing their utility given budget and price constraints, and firms maximizing their profits given production functions and prices. The model simultaneously assesses the impact of

[30]Models of expenditure-side effects, such as the effect of a transportation project on the economy, have been rightly criticized for assuming these projects are paid for with "magic money" as well. In a balanced budget environment, non-revenue-neutral tax changes have expenditure effects, and non-revenue-neutral expenditure changes require revenue changes.

[31]*See* Charney and Vest, *supra* note 29, for an excellent in-depth technical discussion of these models.

[32]Exogenous changes are those that come from outside the economic system or model. This type of change is usually contrasted with endogenous, which is used in economics to describe evolving properties of the economic model that come from within the model itself.

[33]*See* Charney and Vest, *supra* note 29.

[34]*See* Berck et al., *supra* note 29. Note that DRAM also included other sectors such as governmental sectors, households, etc.

a particular external shock, such as a tax change, on prices, as well as on household and firm behavior, which would change as a result of the new prices. A new equilibrium is then determined. At this new equilibrium, supply and demand will once again be equal across the different sectors of the economy, but all goods and factor prices will have changed and production and demand will also have changed.

Other important considerations for CGE models include:

- CGE models may differ from one another in their assumptions and behaviors modeled. For example, some CGE models might assume that the goods in one state are perfectly substitutable for the same goods in another state. Some models may assume labor is perfectly mobile, while others assume complete immobility of labor.[35]
- The results from dynamic models are sensitive to the various elasticities that explain the interaction and responsiveness of one variable to another. Both California and Oregon CGE models found the elasticities describing population migration and trade flows to be particularly problematic.[36] Population migration, for instance, is likely to be dependent on differentials in housing costs across states,[37] but the differentials were not included in either the Oregon or California model specifications — both only included after-tax income and employment opportunities in their migration equations.[38]
- CGE models are also affected by the calibration of the model to a base year or, in more modern CGE models, a set of base years. The base-year calibration entails adjusting the limits of the model's equations using base-year economic conditions to produce an initial equilibrium that matches the actual, observed equilibrium. Notably, different limits can produce the same equilibrium, but may produce very different long-run effects in response to a policy shock. More modern calibration approaches will attempt to generate an in-sample dynamic simulation that approximates observed dynamic paths of macro endogenous variables over time. Thus, for example, the model will be calibrated so that the paths of GDP, investment, consumption, and so forth follow their historic paths.
- Many of the CGE models historically used by states (such as California's DRAM) do not give any time frame for when equilibrium will be reached. Typically, the assumption is that it would take five or six years to reach a new equilibrium.[39] Some newer CGE models allow an adjustment process so that the new equilibrium is reached through a series of steps, with each step representing changes after an additional year.

In sum, while these models might be helpful in generally understanding how a policy change will affect different sectors of the economy, because of their complexity, they are very sensitive to specification of equations and guideline values.

3. The REMI Model

The REMI model uses IO matrices, CGE techniques, and econometric models to attempt to ensure that dynamic effects more closely resemble historic patterns. REMI is notable for econometrically estimating labor flow and industry location.[40] Like standard IO models, REMI has interindustry linkages and can determine direct, indirect, and induced effects of tax changes. The REMI model determines these new wages and prices endogenously, unlike the standard IO model, which takes the supply of labor and materials and capital as infinite at current wages and prices.

REMI looks somewhat like CGE in modeling behavioral responses to economic changes. For instance, when a new firm locates in a region, the demand for labor increases, bidding up wages. But higher wages cause workers to migrate into the region, increasing the supply of labor, which tends to reduce wages, although not to their initial equilibrium value. The net effect on wages depends on industry-specific factors, such as the industry wage rate, worker productivity, rate of in- or out-migration of labor, and time. REMI, like CGE models, goes through a similar process in determining adjustments for the other factors of production.[41]

However, REMI and most CGE models differ in how these effects are calculated over time. In particular, rather than using short-term or long-term closure rules, REMI uses historic experience (panel data econometric models) to estimate labor response and production costs over time for each region. This econometric model allows REMI to capture "amenities," such as a good transportation network, and further allows the adjustment path in response to an external shock to be plotted over time rather than occurring at some indeterminate time in the future when equilibrium has been reached.[42] Because REMI uses some econometrically derived equations for key parts of their model, REMI

[35]The assumptions around the mobility of labor and capital are often referred to as closure rules in U.S. regional models (*see* Charney and Vest, *supra* note 29).

[36]*See* Berck et al., *supra* note 29; Oregon Legislative Revenue Office, "The Oregon Tax Incidence Model" (2001).

[37]Robert Tannenwald, Jon Shure, and Nicholas Johnson, "Higher State Taxes Bring More Revenue, Not More Migration," *State Tax Notes*, Sept. 12, 2011, p. 705.

[38]REMI has updated its migration equations to reflect new real estate pricing and homeowner lock-in due to declining home values.

[39]*See* Charney and Vest, *supra* note 29.

[40]*Id.*

[41]*Id.*

[42]*Id.*

also does not assume that all input and output markets necessarily clear at the end of the period analyzed.

4. REMI vs. CGE

REMI blends econometric and CGE models and also includes some macroeconomic modeling associated with demand-side dynamic estimation. REMI includes an estimated "time path" for economic effects to occur and incorporates more sectors of the economy than most CGE models. For instance, in 1996 REMI was modeling 53 industries, while sophisticated CGE models — such as DRAM in California — only included 28.[43] REMI's econometric grounding does mean that the model assumes past behavior predicts future behavior.

On the other hand, REMI is proprietary and expensive to use and maintain and may be less customizable than a CGE model. While REMI has extensive documentation, the model is enormously complex and, for proprietary reasons, it remains something of a black box. A CGE model will be more transparent, at least to those who use and design it. In the case of California's CGE model, for instance, the assumptions and equations have been published in extensive detail and are therefore subject to public scrutiny. Some REMI critiques, its modeling tax changes that affect the price of goods,[44] have been addressed with recent add-ons to the REMI model such as Tax PI, though this service comes at a price.

Both REMI and CGE models require some significant technical skill and understanding to operate and maintain. Obviously, building a CGE model requires even more extensive knowledge and skill. Importantly, even though REMI is an "off the shelf" solution, in some cases, limits must be calculated manually before being entered into REMI, and the operator often has to understand the economic theories behind these limits and the basic intuitions behind REMI in order to enter the limits correctly and then appropriately interpret the results.

III. Experience From the States

A. Overview

A review of the literature, other state surveys, and the responses to a Federation of Tax Administrators Listserv request suggests that at least 21 states have experimented with dynamic scoring of tax proposals.[45] The majority used or are using REMI for their analyses.[46] Three states are notable for developing complete CGE models for tax analysis: California, Oregon, and Nebraska. All these models are largely grounded in the California DRAM. Also, the Beacon Hill Institute at Suffolk University has developed the State Tax Analysis Modeling Program (STAMP).[47] According to the institute, STAMP has been used since 1994 and has been applied to tax policy in at least 24 states.[48]

States Experimenting With Dynamic Scoring (Model Used)

Arizona (REMI)
Arkansas (REMI)
California (CGE: DRAM)
Connecticut (REMI)
Kansas (REMI)
Kentucky (REMI)
Illinois (REMI)
Iowa (REMI)
Louisiana (REMI)
Massachusetts (REMI)
Michigan (REMI)
Minnesota (REMI)
Nebraska (CGE: TRAIN)
New Mexico (REMI)
New York (REMI)
Ohio (REMI)
Oregon (CGE: OTIM)
Rhode Island (REMI)
Texas (REMI)
West Virginia (IO)
Wyoming (REMI)

[43] *See* Berck et al., *supra* note 29.

[44] *See* Charney and Vest, *supra* note 29.

[45] Mickey Hepner and Reed, "Dynamic Scoring in the Public and Private Sectors," World Council on Economic Policy for the Heritage Foundation (2003). *See* Charney and Vest, *supra* note 29; Colorado Legislative Council Staff, "Dynamic Modeling in Other States" (2004); Mitchell E. Bean, Jay Wortley, and Mark P. Haas, "Dynamic Revenue Estimating — Will It Work for Michigan?" Joint Committee on Taxation (1997); Arizona Joint Legislative Budget Committee, "Overview of Dynamic Revenue Forecasting" (2006); and "STAMP Is an Unsound Tool for Gauging the Economic Impact of Taxes," Institute on Taxation and Economic Policy, Washington, D.C. (2014).

[46] In some states listed, the FTA Listserv responses suggest that all institutional memory of the use of dynamic scoring has been lost. Also, in some of these states, the results from dynamic models are not made public but are just presented to officials who request the analysis. For another different count of states using dynamic modeling, see John L. Mikesell, "Revenue Estimation/Scoring by States: An Overview of Experience and Current Practices With Particular Attention to the Role of Dynamic Models," 32 *Pub. Budgeting and Fin.* 1 (2012).

[47] Response to the ITEP critique of the BHI STAMP Model (2014), the Beacon Hill Institute at Suffolk University.

[48] The STAMP model, as well as other CGE models, is widely associated with advocacy for pro-growth/limited-government policies and is often developed at the behest of policymakers who want to see pro-growth results from tax reductions or tax reform. For an interesting exchange about the validity of the STAMP model and by extension CGE models more generally, see "The Beacon Hill Institute's Tax Analysis Modeling Program: A Response to Charney," the Beacon Hill

(Footnote continued on next page.)

Legislative staff in several states have published memos reviewing other state experiences with dynamic scoring of tax policy,[49] concluding the following:

- The models are expensive to purchase (REMI) or to develop (CGE) and require significant technical expertise to use in both cases. In 2004 Colorado legislative staff surveyed seven states and found REMI cost $46,000 to purchase and then $10,000 to $15,000 in annual fees. They also estimated that a customized CGE model costs approximately $300,000 to develop for a state.[50] Mikesell (2012) estimates that these models cost at least $200,000 to develop.[51]
- Policymakers are often disappointed in the results, particularly regarding the economic effects of tax reductions. The dynamic effects produced by these models are either not as large as expected or may even be negative once the expenditure-side effects have been taken into account. In New Mexico and California, policymakers ultimately found that the effects were not significantly different from static estimates;[52] Arkansas, Louisiana, and Texas staff also noted policymaker disappointment in the size of the effects.[53]
- Although states often attempt to model small tax changes, most economists recommend that dynamic modeling only be used for large changes that cut across many sectors of the economy. For instance, Texas required the policies to have $75 million or larger static effect,[54] and in California, economists recommended a similar threshold before applying dynamic scoring.[55]

The following section reviews seven states' experiences with dynamic scoring, including the results from each of the CGE models, results from REMI in Massachusetts in the early 1990s, and then more recently in New Mexico and Ohio, as well as results from the STAMP analysis of Kansas's recent tax reform. To the extent the data are available, we attempt to present comparable numbers such as the dynamic effects on state revenue and changes in employment, personal income, and investment; however, in several cases, these numbers are not reported or the analyses do not provide the baseline over which raw numbers are calculated, which limits comparability. In all cases, the dynamic revenue effects are available relative to the static estimated revenue change, and in general, the metrics should give the reader some sense of the range of effects that might be expected from dynamic scoring of tax changes.

B. State Case Studies

1. California DRAM

In 1994 California adopted legislation that required dynamic scoring for all tax proposals with a static revenue impact greater than $10 million annually. California chose to build its own CGE model, the DRAM. However, the law sunset after five years, and the model was largely phased out for tax purposes — though policymakers might still use it for some environmental analysis.[56] One problem with continuing the model for tax purposes was that "key personnel left the agency and were not replaced, and the results were not sufficiently different from static analysis to influence policy decisions."[57] Because the design of DRAM is particularly well documented and formed the foundation for most of the other current CGE models, we explore the basic mechanics of dynamic revenue effects at the state level using the California example.

DRAM modeled both the impact of tax changes on the economy and the economic effects of any offsetting expenditure changes. DRAM was developed with 75 distinct sectors: 28 industrial, two factors of production (labor and capital), seven household sectors divided by income levels, one investment sector, 36 government sectors, and one sector representing the rest of the world, both the United States and foreign countries.[58] On the governmental side, DRAM included federal, state, and local governments.

The state sector was most intensively modeled. Of the 36 governmental sectors, DRAM included 21 state government sectors, with 15 accounting for revenue flows and six for expenditure flows. The flows were in turn segmented by fund type (general fund, special revenue fund, etc.). The revenue flows were generated by specific taxes or fees, such as the personal income tax, sales tax, and corporate income tax. The state expenditure flows were further divided into key state government functions such as K-12 education,

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Institute at Suffolk University (2010); response to the ITEP critique of the BHI STAMP Model, *supra* note 47; Charney, "Sales Tax Increase vs. Expenditure Cuts: An Economic Impact Study," University of Arizona, Eller College of Management (2010a); Charney, "UA Estimates of Tax/Expenditure Impacts Compared to Those of the Goldwater Institute," University of Arizona, Eller College of Management (2010b); and "STAMP Is an Unsound Tool for Gauging the Economic Impact of Taxes," *supra* note 45.

[49]"Scoring" is a term that refers to estimating the revenue effect of some tax policy.

[50]*See* "Dynamic Modeling in Other States," *supra* note 45.

[51]*See* Mikesell, *supra* note 46.

[52]*See* "Overview of Dynamic Revenue Forecasting," *supra* note 45; Norton Francis, "Dynamic Scoring," Memorandum, New Mexico Legislative Finance Committee (2007); *see* "Dynamic Modeling in Other States," *supra* note 45; Billy Hamilton, "Big Black Box: Dynamic Scoring and Its Discontents," *State Tax Notes,* Jan. 26, 2015, p. 221.

[53]Comments on the FTA Listserv suggest that other state staff have found a similar response after presenting the results of dynamic models; others noted that disappointment was largely a function of whether someone supported a tax proposal or not.

[54]*See* Mikesell, *supra* note 46.

[55]*See* Berck et al., *supra* note 29; *see* "Dynamic Modeling in Other States," *supra* note 45.

[56]Jon David Vasché, "Whatever Happened to Dynamic Revenue Analysis in California?" *State Tax Notes,* Nov. 20, 2006, p. 493.

[57]*See* "Overview of Dynamic Revenue Forecasting," *supra* note 45.

[58]*See* Berck et al., *supra* note 29.

higher education, and transportation. A revenue change could be associated directly with a related expenditure change. So if the state raised income tax rates, the personal income tax funds generated were fed into the DRAM and allocated to the relevant expenditure flow categories. Personal income tax goes to the general fund in California, while transportation has its own dedicated revenue sources and does not receive general fund revenue.

Thus, an increase in personal income taxes collected was not distributed to the transportation sector of the state budget, but it flowed into other parts of the budget, increasing jobs in those sectors. The related ripple effects from these new jobs spread through the California economy. Importantly, the model largely focused on the jobs associated with government spending rather than the productivity gains that might be associated with some expenditure flows, such as gains associated with a more educated population or better transportation infrastructure.[59]

On the private sector side, the model then worked much as described in Section II of this report, with the model estimating the price for labor, the price for capital, and the price for goods across each of the 28 industry sectors. A change in personal income tax would mean California consumers would have less money to spend or invest in the private sector, but also that they might substitute leisure for work because the purchasing power of an additional hour of labor had declined. Some labor might migrate out of the state to another state where the after-tax wages were relatively more lucrative. Each of these actions had a ripple effect. As labor supply declined because of out-migration and a preference for leisure, pretax cost of labor rose; faced with higher labor costs, producers would increase wages but might also substitute capital for labor, demanding less labor and so forth through a series of reactions until the quantity of labor supplied was equal to the quantity demanded. Despite some of the countervailing forces, in all scenarios, the costs of doing business would have risen in response to a tax increase when the market reached equilibrium.[60] As noted in the general discussion of CGE models, DRAM solved for this equilibrium point without estimating effects at any time intervals along the way. The model simply calculated the prices, labor supply, investment inflows, and other economic variables at the new equilibrium, which was assumed to take five to six years to reach.[61]

California ran several tax policy simulations in 2000 to demonstrate the dynamic feedback effects of changes to the state's three major taxes: personal income tax, sales tax, and corporate income tax. The estimates were generated using an across-the-board $1 billion static revenue increase for each tax funded by a corresponding rate increase. A $1 billion change was around 1 percent of California's $72 billion general funds budget at the time.[62] The revenue increase (or decrease) in turn was assumed to affect state expenditures that were also modeled dynamically. The model showed that the personal income tax was the least responsive to the tax change; that is, the dynamic effect was the smallest, and the corporate income tax the most responsive. The results are summarized in Table 1a and include dynamic effects for the general fund revenue as well as special revenue funds. (We also present the results of 1996 model estimates of a $1 billion static decrease in Table 1b for comparative purposes.)[63]

Raising $1 billion (static revenue estimate) through the personal income tax required a 4 percent increase across all brackets. For instance, the brackets at the highest income level would rise from 9.3 percent to 9.7 percent. The resulting dynamic effect was around 4 percent from reduced economic activity because of the tax increase. (The dynamic feedback effect is usually expressed as a percentage of the initial static revenue estimate.) So after five or six years, the increase in personal income tax rates would only raise $960 million because of the dynamic adjustments ($40 million would be "lost").[64] Importantly, because income taxes are deductible from federal taxes, this mutes some of the effect of a state-level tax change. Also, higher-income groups hold a portion of their earnings outside the state, which can reduce the dynamic effects.[65]

Generating a $1 billion (static revenue estimate) increase in sales tax would require raising the rate by about 5 percent. The DRAM showed that such an increase in sales and use tax had a partially offsetting dynamic revenue reduction of about 12 percent.[66] As the sales tax rose, consumers might forgo purchases of some discretionary goods or substitute away from goods that were taxed, which now cost more because of the higher sales tax. Reduction in demand led to less production, and less demand for labor and capital, which in turn would cause wages to decline and the demand for capital to decline. The retail sales tax also affected

[59]*Id.*

[60]*Id.*

[61]*See* Vasché, *supra* note 56; *see* Charney and Vest, *supra* note 29.

[62]According to the California Department of Finance, California general fund revenue was $46.3 billion in 1996, so a $1 billion tax change would be 2 percent when the model was first run; general fund revenue was $71.9 billion in 2000, so a $1 billion tax change would be around 1.4 percent.

[63]Berck et al. report the dynamic effects from a rate decreases (*supra* note 29), while Vasché reports the equivalent rate increases (*supra* note 56). We use the Vasché estimates that were modeled in 2000 with the assumption that they represent a more current model, but we do not have the underlying documents to support these estimates. We also report the 1996 numbers since we have extensive documentation and the results are interesting for comparative purposes; however, we do not discuss this table extensively in the text. Note that the numbers in these two tables may not be directly comparable as the model parameters may have changed over time in response to different economic conditions.

[64]*See* Vasché, *supra* note 56.

[65]*See* Berck et al., *supra* note 29.

[66]*See* Vasché, *supra* note 56.

Table 1a.
California DRAM of Dynamic Effects of a $1 Billion Increase in Each Tax Type
(2000 model estimates, millions of dollars)

	Change in Individual Income Tax	**Change in Sales and Use Tax**	**Change in Bank and Corporation Tax**
Size of Static Increase	$1,000	$1,000	$1,000
Revenue Feedback	($40)	($120)	($180)
Percentage of Static Estimate	-4%	-12%	-18%
Employment Change (persons)	-18,000	-10,000	-11,000
Business Investment Change	($83)	($109)	($479)

Note: The changes assume a balanced budget and therefore have expenditure-side effects, which are modeled.
Source: Vasché, 2006.

Table 1b.
California DRAM of Dynamic Effects of a $1 Billion Decrease in Each Tax Type
(1996 model estimates, millions of dollars)

	Change in Individual Income Tax	**Change in Sales and Use Tax**	**Change in Bank and Corporation Tax**
Size of Static Increase	$1,000	$1,000	$1,000
Revenue Feedback	$10	$77	$184
Percentage of Static Estimate	1%	7.70%	18%
Employment Change (persons)	18,000	10,000	12,000
Employment Growth (percent change)	0.14%	0.08%	0.1%
Personal Income	($738)	$107	$1,600
Personal Income (percent change)	-0.1%	0.01%	0.21%
Wages (% change)	-0.21%	-0.04%	0.03%
Return on Capital (percent change)	0.01%	0.02%	-0.4%
Gross Investment Change	$6	$16	$147
Gross Investment (percent change)	0.01%	0.02%	0.22%

Note: The changes assume a balanced budget and therefore have expenditure-side effects, which are modeled.
Source: Berck, Goland, and Smith, 1996.

intermediate goods by increasing the production costs of goods. The sales tax increase caused exports to decline because the state's goods were more expensive and therefore less competitive. The overall net effect would be to depress economic activity.[67]

Finally, generating a $1 billion (static revenue estimate) increase in corporate income tax would require raising the rate by about 17 percent. The DRAM showed that such an increase in corporate income tax had a partially offsetting revenue reduction of about 18 percent.[68] Overall, the cost of doing business would increase; business would substitute labor for capital, causing wages to rise; but exports would decrease as the competitive position of the state worsened, which in turn would cause firms to purchase less capital and labor, which would have the effect of depressing wages, and so forth.[69]

2. Oregon Tax Incidence Model

In 1999 the Oregon legislature directed its Legislative Revenue Office to develop a dynamic revenue estimation model that included the capacity to analyze tax incidence. Key aspects of the model were intended to look at behavioral responses to tax changes and at how the tax burden would be distributed across different income levels. The Oregon Tax Incidence Model (OTIM) was based on the DRAM, but it was customized for Oregon's economy. In 2001 Oregon modeled the revenue and economic effects of a series of hypothetical tax changes from a $100 million tax increase or

[67] *See* Berck et al., *supra* note 29.
[68] *See* Vasché, *supra* note 56.
[69] *See* Berck et al., *supra* note 29.

Table 2.
Oregon OTIM of Dynamic Effects of a $100 Million Decrease in Each Tax Type
(millions of dollars)

	Change in Individual Income Tax	Corporate Income Tax	Business Property Tax
Size of Static Decrease	($100)	($100)	($100)
Revenue Feedback[a]	$9.65	$15.84	$10.98
State Revenue Portion	$6.70	$13.60	$8.10
Local Revenue Portion	$2.80	$2.20	$3.24
% of Static Estimate	9.65%	15.84%	10.98%
Employment (% change)	0.22%	0.06%	0.08%
Wages (% change)	-0.14%	0.07%	0.03%
Personal Income (% change)	0.12%	0.2%	0.17%
Return to Capital (% change)	0.01%	0.03%	0.01%
Investment (% change)	0.14%	0.53%	0.2%

Note: The changes assume a balanced budget and therefore have expenditure side effects, which are modeled.
[a] Some state and local revenue totals numbers do not sum to the total perhaps because of rounding issues. Oregon reported state and local revenues combined as their dynamic effect, but most other states would only report the state revenue portion.
Source: Oregon Legislative Revenue Office and Oregon State University (2001).

decrease across different tax types.[70] The effects of tax reductions and increases were largely symmetrical in the Oregon model for all the variables of interest. To give some sense of scale, a $100 million tax change was around 0.84 percent of Oregon's $12 billion annual state general and other funds budget at the time.[71] As with DRAM, OTIM required an expenditure side offset to a tax cut or increase.

Oregon modeled a proportional change in income tax liability, hence taxes would be increased or decreased by a fixed percentage for all taxpayers. The amount of additional tax owed would be determined by the previous year's tax liability. Similar to the DRAM results, the personal income tax was the least responsive compared with other tax changes (see Table 2). A $100 million tax cut would only cost $90.35 million after accounting for eventual dynamic effects. Notably, Oregon counted state *and local* revenue effects, while California and most other states only show state effects. The loss of income tax revenue would largely affect the state general fund, which would only recoup $3.2 million of the loss; the other gains would go to other state funds and to local governments. The total dynamic revenue effect across all state fund sources was $6.7 million, or 6.7 percent. An interesting result in this model — and also to some degree apparent in Table 1b for DRAM — is that these models project that income tax decreases may actually cause pretax wages and/or personal income to decline slightly, but will have a greater effect on employment than the other tax changes.

OTIM projected that the corporate income tax would have the strongest dynamic revenue effect, with a partially offsetting revenue increase of 16 percent for a tax cut. Again, the loss would largely be felt in the state's general fund, but only around $10 million would be recouped through dynamic effects and $13.6 million recouped by the state as a whole. Oregon has no sales and use tax, but it also modeled the impact of a cut or increase to business property taxes and found an approximately 11 percent revenue offset. Here, the loss in revenue would largely be absorbed by local governments, which would recoup $3 million from dynamic effects.[72]

3. Tax Revenue Analysis in Nebraska

In the late 1990s and early 2000s, Nebraska developed a CGE model, Tax Revenue Analysis in Nebraska (TRAIN), to assess the impact of tax revenue changes on the state economy. The Nebraska Legislative Fiscal Office then produced a Nebraska Tax Burden Study in 2003 that has been updated four times over the past decade, roughly every four years.

TRAIN, like OTIM, is heavily based on the DRAM model but is customized for Nebraska's economy. In the state's "2003 Nebraska Tax Burden Study," produced in 2007, TRAIN was modified to produce a household income incidence analysis along the lines of OTIM and included an analysis of the incidence across industry sectors. The 2003

[70] *See* "The Oregon Tax Incidence Model," *supra* note 36.
[71] This amount is based on the National Association of State Budget Officers' reported final fiscal 2001 expenditures for Oregon in the "2002 State Expenditure Report." The number adds state general funds to state other funds and does not include federal funds or bond financed expenditures.
[72] *See* "The Oregon Tax Incidence Model," *supra* note 36.

Table 3.
Nebraska Train Model of Dynamic Effects of a $100 Million Decrease in Each Tax Type
(millions of dollars)

	Change in Individual Income Tax	Sales and Use Tax
Size of Static Decrease	($100)	($100)
Revenue Feedback	$6.40	$20.60
% of Static Estimate	6.4%	20.6%
Employment Change Total (persons)	1,788	2,615
Employment Change Private Sector (persons)	1,594	2,538
Personal Disposable Income	$121.60	$181.20
Investment	$64.80	$123.34

Note: The changes assume a balanced budget and therefore have expenditure side effects, which are modeled.
Source: Nebraska Department of Revenue Research Services (2013)

study[73] and 2007 study[74] consider the hypothetical impact of a $10 million change in revenue collections from the income tax and from the sales and use tax.

The most recent report, the "2010 Nebraska Tax Burden Study," is presented here and assesses the impact of a $100 million tax change. To give a sense of scale, Nebraska's general fund and other state fund expenditures in fiscal 2010 were $6.9 billion,[75] so a $100 million tax change is around 1.4 percent of annual expenditures. As shown in Table 3, a $100 million hypothetical change in individual income tax from an across-the-board reduction in tax rates would produce a 6.4 percent feedback effect, while a change in the sales tax from an across-the-board reduction would produce a 21 percent feedback effect.[76] These are effects on state revenue only. The incidence analysis suggests that a sales tax cut has progressive effects and that income tax is somewhat regressive. The impact of the income tax changes is also more evenly distributed across industry sectors, while the sales tax change heavily affects the retail business sector.[77]

4. Massachusetts REMI

Massachusetts was one of the first states to use dynamic analysis to assess tax changes at the state level in 1993. The model used a combination of internally developed microsimulation, which calculated the direct impact of tax policy changes and then fed the result to the REMI model to assess larger dynamic effects. The model was used to assess various tax reform proposals between 1993 and 1995, including raising the state's investment tax credit.[78] The state, under then-Gov. William Weld, passed a series of aggressive business tax policy changes, including phasing out state capital gains taxes, in part arguing that the fiscal impact would not be as large as the static forecast because of projected dynamic effects. Ultimately, overall revenue came in *below* the static revenue forecast in fiscal 1995. Democrats accused the Republican governor of failing to appropriately account for the effects of the tax changes, and not long after, the dynamic model was abandoned.[79]

Initial runs of the REMI model did produce a series of dynamic effect tables that were reported in *State Tax Notes* and are shown below in Table 4.[80] These are hypothetical cuts of $100 million by tax types. Importantly, they are not balanced estimates; that is, they are *not* revenue neutral since the model did not account for any expenditure-side effects from revenue losses. The impact of the income tax is largely in alignment with the other state income tax estimates even though there is no balanced budget requirement in this model; the sales tax estimate, meanwhile, is small compared with the other states (12 percent in California and 21 percent in Nebraska), while the most significant dynamic effects are the changes in the corporate income tax at 30.4 percent, significantly higher than the California impact at 18 percent or Oregon at 15 percent.

5. Ohio REMI

In 2005 the Ohio Department of Development contracted with REMI to perform a comprehensive analysis of a broad tax reform package. REMI modeled six elements of the comprehensive tax package passed by the Ohio General Assembly: a 21 percent reduction in the state personal

[73] Nebraska Department of Revenue Research Services, "2003 Nebraska Tax Burden Study" (2007).

[74] Nebraska DOR Research Services, "2007 Nebraska Tax Burden Study" (2010).

[75] Expenditures based on the National Association of State Budget Officers' "2011 State Expenditure Report" final expenditure amounts reported for fiscal 2010.

[76] Nebraska Department of Revenue Research Services (2013), "2010 Nebraska Tax Burden Study," Lincoln, Nebraska.

[77] *Id.*

[78] Alan Clayton-Matthews, "The Massachusetts Dynamic Analysis Model," *State Tax Notes,* Sept. 20, 1993, p. 639.

[79] Martin A. Sullivan, "Practical Aspects of Dynamic Revenue Estimation," *Tax Notes*, Nov. 29, 2004, p. 1247; and Tom Moccia, "Debate Erupts Over Revenue Estimating in Massachusetts," *State Tax Notes*, Mar. 27, 1995, p. 1256.

[80] *See* Clayton-Matthews, *supra* note 78.

Table 4.
Massachusetts REMI Model Dynamic Effects of a $100 Million Decrease in Each Tax Type
(millions of dollars)

	Change in Individual Income Tax	Change in Sales and Use Tax	Change in Corporate Income Tax
Size of Static Increase	($100)	($100)	($100)
Revenue Feedback	$6.40	$4.90	$30.40
% of Static Estimate	6.4%	4.9%	30.4%
Employment Change (persons)	1,600	1,500	10,500
Personal Income	$66.20	$57.90	$409.40
Investment	$21.70	$31	$302.40

Note: The changes do not assume a balanced budget, and therefore the expenditure side effects are not modeled. This suggests that the revenue side effects are overstated.
Source: Clayton-Matthews (1993).

income tax; a 0.5 percentage point reduction in the state sales tax; elimination of the tangible personal property tax on machinery and equipment, inventory, and furniture and fixtures; elimination of the corporate franchise tax; increases in the excise tax on tobacco and alcohol; and the creation of a broad-based, low-rate commercial activities tax.

The REMI report concluded that the tax changes would reduce tax revenue by $3.06 billion in fiscal 2010, when the plan would be fully implemented. Dynamic positive effects of the tax changes were $216 million that year, approximately a 1 percent dynamic effect, offsetting some of the revenue losses. While the REMI report was favorably received by the governor and legislature, the model did not include expenditure implications that might have offset in whole or in part the dynamic effect from the tax cut.[81]

6. New Mexico REMI

New Mexico used a dynamic model to estimate the effects of an actual tax change. In 2003 New Mexico enacted a tax reform plan that reduced its top personal income tax rate from 8.2 percent to 4.9 percent over five years. The state also phased in a 50 percent cut in the state CGT over the same period. The New Mexico Legislative Finance Committee modeled these tax cuts in 2004 using a statewide REMI model that was developed as a pilot project.

While staff found the economic variables such as employment, personal income, and output interesting, ultimately regarding state revenue, the dynamic effects were not that much greater than the static estimates and well within the margin of error. For instance, as shown in Table 5, in fiscal 2004, the first year the cuts were to be implemented, the estimate from the static model showed the state losing $21.8 million in revenue, while the estimate from the REMI model, capturing the dynamic economic effects, showed a $21 million loss. (To put that in context, New Mexico's fiscal 2004 general fund revenue was $4.6 billion.) The static revenue estimate was just 3.7 percent less than the dynamic estimate. Over time, the percentage difference between the estimates from the static model and the estimates from the dynamic REMI model declined. By the end of the forecasting period, fiscal 2008, the estimate from the static model was 2.3 percent more than the estimate from the dynamic REMI model. The staff speculated that the dynamic effects were so small because the model required expenditure cuts to offset the revenue loss. Because the REMI model was costly to operate as a dynamic revenue estimation tool and seemed to provide little additional value over traditional static analysis, the pilot project was not renewed.[82]

Notably, the tax changes were projected to prompt investment in the state, not to improve employment or personal income. This effect is similar to the results found in 1996 runs of DRAM as well as in the OTIM results. The DRAM modelers noted that while the model showed wages declining, in actuality wages rarely do decline in nominal terms; instead, this should be interpreted as a drag on growth in wages and personal income.[83] While it is not clear what is driving the effect in New Mexico, the tax cuts caused a reduction in expenditures (or expenditure growth), which affected wages; notably, the model predicted that the loss of government jobs would not be offset by the gain in private sector jobs. Also, the gains from an income tax reduction may be shared by employees — and employers would have the effect of reducing or slowing the growth of pretax wages, even as employees have more after-tax wage income. (As shown in Table 5, personal income declines but total disposable personal income increases.) While not shown here, the

[81]Jon Honeck and Zach Schiller, "REMI Report Presents Just Half the Equation," Policy Matters Ohio (2005). Throughout the report, REMI stated that the necessary offsetting spending cuts were not modeled in the analysis. But without the full analysis, including the offsetting spending cuts, Policy Matters Ohio argued the report had very little value to policymakers and citizens (*id.*).

[82]*See* Francis, *supra* note 52; and New Mexico Legislative Finance Committee Staff, "2004 Post-Session Fiscal Review" (2004).

[83]*See* Berck et al., *supra* note 29.

Table 5. New Mexico REMI Model of Tax Reform (millions of dollars)					
	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Static Analysis	($21.8)	($83)	($167.2)	($275.2)	($360.3)
Dynamic Analysis	($21)	($80.8)	($163)	($268.7)	($352.2)
Difference	$0.8	$2.2	$4.2	$6.5	$8.1
Percentage Dynamic Effect	3.7%	2.7%	2.5%	2.4%	2.2%
Employment (thousands)	-0.031	-0.086	-0.156	-0.225	-0.242
Employment: Private Nonfarm	0.311	0.846	1.601	2.417	2.95
Employment: Government	-0.342	-0.932	-1.759	-2.641	-3.191
Personal Income	($1.5)	($5.00)	($9)	($11.5)	($9.5)
Disposable Personal Income	$30	$84	$165.5	$260	$332
Output	0.597	1.824	4.326	10.064	16.627

Source: New Mexico Legislative Finance Committee Staff, 2004.

Table 6. Kansas Legislative Research Department (KLRD) Estimates of Impact of 2012 HB 2117 and STAMP Dynamic Revenue Estimates (millions of dollars)							
	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	Cumulative FY 2013-FY 2018
KLRD Final Revenue (pre-tax changes)[a]	$6,394	$6,231	$6,466	$6,708	$6,980	$7,259	$40,038
KLRD Final Revenue (post-tax changes)	$6,163	$5,428	$5,642	$5,854	$6,087	$6,325	$35,499
KLRD Estimate of HB 2117 (2012 Tax Impact)	($231)	($803)	($824)	($854)	($893)	($934)	($4,539)
Percentage Decline From Original General Funds Budget	-4%	-13%	-13%	-13%	-13%	-13%	-11%
STAMP Dynamic Revenue (Pass-Through)	$18	$87	$93	$101	$111	$123	$533
STAMP Dynamic Revenue (Standard)	$27	$108	$110	$115	$122	$130	$612
Percentage Dynamic Effect (Standard)	11.72%	13.47%	13.37%	13.43%	13.70%	13.87%	13.48%
Percentage Dynamic Effect of Post-Tax General Funds Budget	0.44%	1.99%	1.95%	1.96%	2.01%	2.05%	1.72%

Sources: Policy Brief: Davidson et al. (2012), Kansas Legislative Research Department (2012).
[a] These are calculated by authors and are derived by restoring the projected HB 2117 static tax revenue declines to the post HB 2117 baseline.

New Mexico dynamic estimates projected a dynamic *decline* in income tax revenue relative to the static estimate, but also projected that this would be made up through increased economic activity and associated enhanced collections in gross receipts and corporate income taxes.[84]

7. Kansas STAMP

In 2012 and 2013, Kansas made a series of significant tax changes. Because the dynamic analysis pertains only to the 2012 changes (HB 2117), these are the ones discussed here. In 2012 the state reduced its income tax brackets from three to two and then reduced the rates, increased the standard deduction, cleared out a number of income tax credits, and most significantly exempted all non-wage income from a passthrough entity from the income tax (for instance, all limited liability corporations would now pay no tax on profits). This tax cut represented an estimated 13 percent static revenue loss to the state general fund (see Table 6). Although the state staff did not present a dynamic revenue analysis, the Kansas Policy Institute produced a report that used the Beacon Hill at Suffolk Institute's STAMP model to examine the dynamic effects of HB 2117 and the 2012 tax changes.

[84] *See* "2004 Post-Session Fiscal Review," *supra* note 82.

As shown in Table 6, STAMP estimated the dynamic effect from these tax changes modeling the tax cut on passthrough income in two different ways. In their passthrough model, the tax cut is treated as a cut in corporate income tax because this tax change was anticipated largely to affect small businesses. Then they modeled this cut using the standard model, which treated the reduction as an income tax cut applied to individuals. The passthrough model, in which the tax cuts are largely a benefit to businesses, predicted less of an employment gain (33,430 new jobs over six years) than the standard model that assumed the benefits were largely influencing household choices via the income tax (41,690 new jobs over six years), but gross investment in the economy would be higher in the standard model: $307 million in the passthrough model versus $85 million in the standard model.[85]

The STAMP model found large dynamic revenue effects ranging from 12 to 14 percent annually from the standard model. Although large for an income tax effect (which appears to range between 1 to 7 percent in the other models), the effects are not out of the range of corporate or business tax effects in other dynamic models. That said, even though the tax cut was relatively large, and the estimated dynamic effects are large, when considering the state budget in its entirety, the dynamic revenue effects are actually small, representing at most around 2 percent of the state's annual general fund revenue (see Table 6).[86]

Deciding that the tax cuts were too large to sustain, the following year, the Kansas governor and Legislature modified the tax reform proposals, which reduced the near-term impact on the state general fund from a $5.5 billion impact from fiscal 2013 through fiscal 2019 to a $5 billion impact, with some of the large effects pushed to the out years.[87] As of 2015, the Kansas Legislative Research Department has projected revenue falling *below* previous estimates that were grounded in the static revenue estimate of the tax changes.[88] This dilemma suggests that even if dynamic revenue effects are occurring, they are simply not visible given the likely error rates around the static revenue estimate. Notably, the more complex and exotic the tax change, the higher the static revenue estimate error rates are likely to be, and even if the static estimate was quite accurate, the average error rate nationally around static estimates is around 3.5 percent,[89] which is to say that even very large dynamic effects fall within this range.

C. Other Considerations

Several studies have attempted to model much more explicitly the choice between a tax increase and an expenditure cut, particularly in response to fiscal stress. Two studies, one in Michigan and one in Arizona, have used dynamic modeling to assess the trade-offs and found that although tax increases and expenditure cuts both cause job losses, the job losses are substantially higher when cutting government expenditures. The key argument behind this analysis is that the impact of tax increases is exported to other states and internationally, while expenditure cuts (laying off teachers, police, state workers, etc.) are much more likely to be entirely absorbed within a state's economy.[90]

A criticism of all dynamic models is that they do not account for any economic productivity gains from governmental investment in areas such as education and transportation. Instead governmental spending is largely modeled as just a "jobs" program.[91]

A final point is that state and local governments are institutionally divided, and a change in state tax policy can produce a countervailing change in local tax policy. Also, a tax change in one state can produce a reaction by another state. No current dynamic models account for those reaction effects, but those reactions to state policies are not uncommon and may have a significant impact on a state's economy.

IV. Conclusion: Pros and Cons of Dynamic Revenue Models

Dynamic modeling has some interesting applications to policy analysis and provides potentially useful information on how policies ripple through the economy. For instance, noting that some tax changes may cause job losses or declines in wages even while growing the productivity of the economy is helpful information if a policymaker is largely concerned about job growth. Also, the general trend that corporate tax changes have larger dynamic effects than income or sales tax changes may also be of interest to policymakers. Another key benefit is a more refined look at the incidence of tax policy changes. Both Oregon and Nebraska used their models to look at the impact across the state's income distribution, but Nebraska extended the incidence analysis further to look at the effects on industries across different sectors of the economy. The effects may vary

[85]Todd Davidson et al., "Tax Reform Gears Kansas for Growth: A Dynamic Analysis of Additional Revenue and Jobs Generated by Tax Reform," Kansas Policy Institute (2012).

[86]*Id*.

[87]Chris W. Courtwright, "Kansas State and Local Tax Structure Post-2012: Selected Observations and Implications of New Law," in *Principal Economist*, Kansas Legislative Research Department (2012); Joseph Henchman and Scott Drenkard, "Kansas Tax Reform Improves on Last Year's Efforts," in *Fiscal Fact,* Tax Foundation (2013); and Second Conference Committee Report Brief House Bill No. 2059 (Kansas Legislature, ed. 2013).

[88]Memo on SGF Receipts Estimates for fiscal 2015, fiscal 2016, and fiscal 2017 (Kansas Legislature, ed. 2014).

[89]"States' Revenue Estimating: Cracks in the Crystal Ball," The Nelson A. Rockefeller Institute and the Pew Charitable Trusts (2011).

[90]Bartik and George A. Erickcek, "Economic Impact of Various Budgetary Policy Options for the State of Michigan to Resolve Its Budget Deficit for FY 2004" (2004); *see* Charney, *supra* note 48.

[91]*See* "STAMP Is an Unsound Tool for Gauging the Economic Impact of Taxes," *supra* note 45; *see* Berck et al., *supra* note 29.

depending on the ratio of labor to capital that is used in that industry. Dynamic models may be also quite useful in comparing tax and expenditure trade-offs.

Where dynamic modeling falls short, and what apparently disappoints policymakers, is that it has not proved to be a particularly appropriate tool for budgetary decisionmaking or forecasting. The assumption that the models themselves precisely capture the working of a state's economy may be problematic. A state's economy is a vastly complex system. The results obtained from dynamic models rely heavily on assumptions made by the model builders and on the availability of data. Even with the advances in computing power and increased data availability, simplifying assumptions are needed. Further, the results from dynamic models are sensitive to the values used to explain the interaction and responsiveness of one variable to another, and at the subnational level in particular, actual data for a number of variables (for instance, trade flows) may themselves have to be estimated. Because of the high level of uncertainty in these and other limits, modelers have to rely on educated guesses. This lack of precision can significantly reduce the model's reliability and limit predictive power.

Perhaps not surprisingly, the models above show a significant range of dynamic revenue effects from 1 percent to an upper bound in the 20 to 30 percent range (the 30 percent number is likely overstated because the model did not include expenditure offsets). Notably, large economic effects predicted by some of these models are out of alignment with empirical research that generally finds that the effect of tax changes may be small.

Even assuming that the dynamic models are highly accurate, relatively large dynamic effects — such as those estimated in Kansas — take time to materialize and are ultimately small when compared with a state's general fund revenue (and even more minuscule when compared with the overall size of the economy). The practical effect is that dynamic effects are likely to be invisible to the average citizen, state policymakers, or state budget staff.

In light of these concerns, states contemplating the use of dynamic models should consider several issues. First, what do policymakers want to learn from dynamic revenue estimation? Based on this review of state experiences, policymakers and analysts need to recognize that dynamic revenue modeling can be useful for informing a policy debate, but policymakers should generally not expect large effects and should not budget to these effects. Policymakers in states such as Massachusetts in the 1990s and, more recently, Kansas, found that waiting for dynamic effects to materialize in state revenue streams was problematic. Second, states need to consider the resources required to develop, customize, and then interpret the results from a dynamic model. These models are expensive and complicated, and more than a few states have simply decided that added value of the information is simply not worth the money, time, and effort required to purchase, develop, and maintain the models. ✰