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Dynamic Revenue Analysis: Experience of the States

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THE
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FINANCE

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Dynamic Revenue Analysis: Experience of the States

Peter Bluestone
Carolyn Bourdeaux

Working Paper 19-11



ANDREW YOUNG SCHOOL
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ANDREW YOUNG SCHOOL
CENTER FOR STATE & LOCAL FINANCE

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The Center for State and Local Finance

WORKING PAPER 19-11

Dynamic Revenue Analysis: Experience of the States

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April

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The Center for State and Local Finance

Andrew Young School of Policy Studies

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Introduction

Revenue analysis, as traditionally employed 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 most often calculated for tax changes where 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 an increase in the tobacco tax will typically estimate 1) the increased revenue based on current tobacco sales, which is the static effect, and 2) 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 subsequently on governmental tax revenues. For example, a dynamic model considers that an increase in tobacco taxes 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, the revenues of the tobacco industry, the jobs provided through the industry, the purchase of products to support cigarette production, etc. These economy-wide changes associated with one policy change may affect state tax revenues.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 different types of dynamic models that have been developed, and then 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 effect size may be small or indeterminate. An important consideration is that state tax revenues are typically used to pay for government spending on public services, and these expenditures also have dynamic effects which may mute or cancel the effects of a tax change.

In terms of state experiences with dynamic revenue estimation, states have found that dynamic analysis is considerably more costly and complex than traditional static revenue analysis and

¹ In several places this report refers to a hypothetical increase in the tax on cigarettes in an effort to illustrate the subtle differences between static and dynamic modeling. We use the tax on cigarettes because it is easy conceptually to understand. However, please note that 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.

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 with the expectation that they can 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 revenues 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 year to fully materialize. The implications are that at least for budgetary purposes the difference between the 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 being said, dynamic analysis can provide useful information for comparing alternative policy choices and for examining the economic implications of different policies.

Literature Review: The Effects of State-Level Tax Changes on the Economy

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 such effects.² The research, for the most part, concludes that while there is a negative effect of taxes on the economy, the magnitude of the effect may be small or indeterminate and may be washed out in whole or in part depending on which expenditures categories are changed in order to maintain a balanced budget.

In conducting an analysis of the effect of state taxes 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), states generally cannot run large multi-year deficits, and even if they could, they face the discipline of the credit markets.

² Because state and local revenue and expenditure portfolios are heavily intertwined, most state level research focuses on state and local revenues 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.

Because of the balanced budget constraints, a cut in taxes must be paired with an increase in other taxes or a cut in 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. Such 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. Firms and households within a state not only face state tax rates but local tax rates as well. Thus, any analysis needs to consider both. Additionally, some state taxes are deductible from federal taxes and some states allow a deduction for federal taxes paid. The net effect of these deductions needs to 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.

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: Bartik (1991) and Wasylenko (1997). 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 (1991) 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.³ 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. 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.⁴

In updating and expanding Bartik’s literature review, Wasylenko (1997) found that the responsiveness of economic factors to tax changes ranged from an implausible 157 percent to

³ 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.

⁴ 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.

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 business tax responsiveness ranged between 0 and 2.6 percent. In sum, 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.

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.⁵ Holcombe and 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 1960-1990. They found that for the average pair of states, the state with the higher marginal income tax rate would experience a per 3.4 percent decline in personal income per capita by the end of the 30-year period (Holcombe and Lacombe 2004). Other findings of a negative effect of aggregate state and local taxes revenues include Mullen and Williams (1994), Deskins and Hill (2008), and Goff, Lebedinsky and Lile (2011), though Deskins and Hill find no effect after 2003.

Examining specific taxes, Bruce, Deskins and 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. Interestingly, they show that this effect is largely driven by corporate tax sheltering—so while economic activity may stay the same, state tax *revenues* may decline. Gius and 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, Deskins and Fox 2007). Harden and Hoyt (2003) find the effect of the corporate income tax is negative, but personal income and sales taxes have no effect. Agostini (2007) finds a negative effect from corporate taxes on foreign direct investment.

Coomes and Hoyt (2008) find the personal income tax has a small but statistically significant negative effect on migration out of a state. 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. Revisiting the topic in 2010, he found no effect (Chernick 2010), a finding supported by Leigh (2008) and Young and Varner (2011). Ojede and Yamarik (2012) found property and sales taxes have a negative effect on economic growth, but the income tax has no effect. Reed and Rogers (2004) find no effect from a New Jersey income tax cut on economic activity. Bruce and Deskins (2012) show mixed (but small) effects of taxes on entrepreneurial activities, with sales tax being positive, corporate income tax negative, and progressivity in the income tax actually positive (but controlling for the top income tax rate in the state).

⁵ 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.

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 the effect is economically significant. 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.⁶

STATE TAXES VERSUS STATE GOVERNMENT 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 Helms (1985), Mofidi and Stone (1990), Tomljanovich (2004), Bania, Gray and Stone (2007), and Gabe and Bell (2004). In perhaps the most detailed examination of these effects, Gabe and Bell (2004) look at the impact 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.

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 (Fisher 1997, Karakaya and Canel 1998).

CONCLUSION

The general take away from the literature is that, yes, taxes create a drag on the economy, but taxes cannot be considered in isolation. Taxes pay for something, and many of the services state governments 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 revenues. 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.

⁶ Another segment of the tax literature where there are large and significant tax effects occur in "intra-regional" 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 Mark, McGuire and Papke 2000). These studies suggest that localities in hot competition for business and investment would be well advised to keep an eye on their neighbors' tax rates.

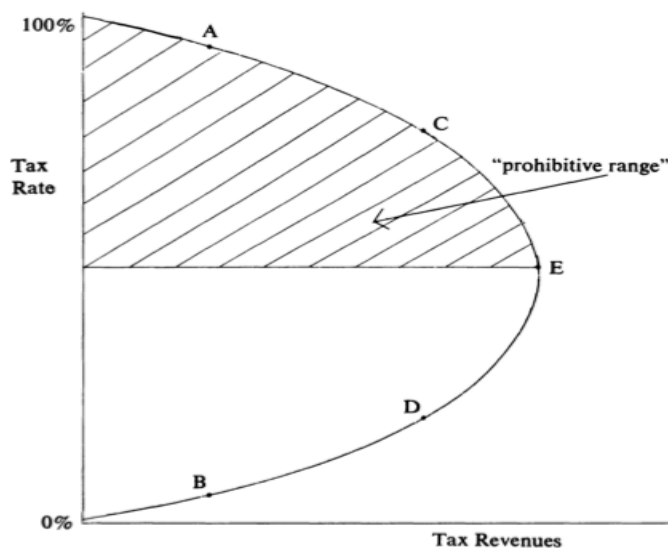
Dynamic Revenue Analysis

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

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 (Canto, Joines, and Laffer 1978). 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.

Figure 1. The Laffer Curve



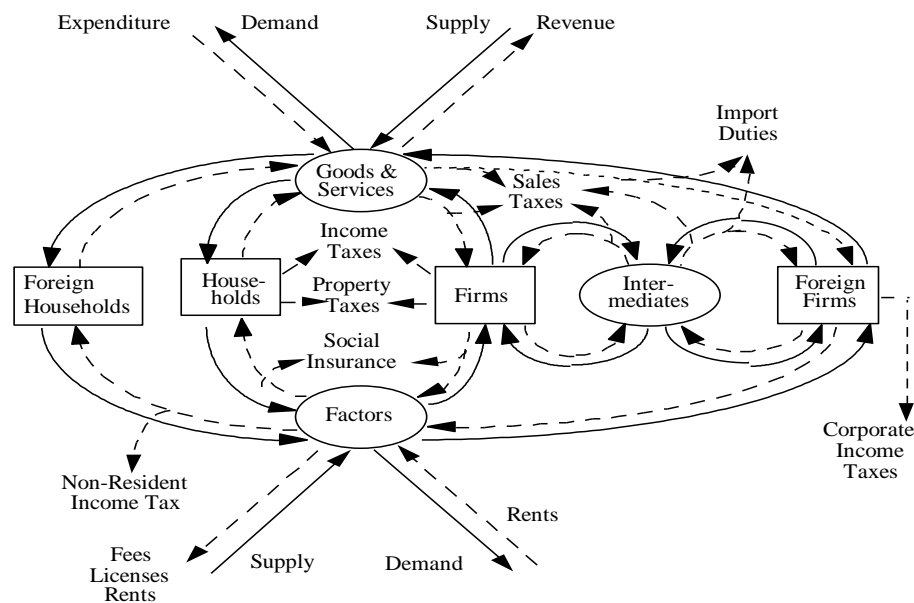
Source: Mirowski (1982)

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 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; 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 revenues) 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 that 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) for California, the economists who developed the model used the diagram shown in Figure 2.

Figure 2. The Complete Circular Flow Diagram for DRAM



Source: Berck, Golan, and Smith (1996)

Dynamic models are generally comprised of 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, i.e., 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. In addition, 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 particular good or service.

State level dynamic models are largely “supply side” models and are based on economic theories that are heavily concerned with the supply of labor and capital and their subsequent influence on the level of production or income in an economy. One of the key assumptions 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 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 where 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 box on the following 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 (e.g., 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 economy-wide shifts can then be translated into estimates of the impact on state (and local) governmental revenues.

The model described by Figure 2 shows the effect of taxes on different parts of the economy,⁷ but as noted in the empirical literature, the economy is also influenced by changes in variables such as government expenditures and related benefits such as 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 entirely 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 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.⁸

“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.

⁷ For detailed descriptions of the interacting effects that ripple through the economy see Berck, Golan and Smith (1996) or Charney and Vest (2003).

⁸ 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.

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).⁹ All of these are models that policymakers can use to try to predict how various policy or economic changes might affect the regional or national economy.

Input-Output Models

An input-output 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 is 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, are 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 rise 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 with respect to industry inter-relationships. Some contain 500 or more sectors of the economy and thousands of metrics that describe inter-linkages 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.¹⁰

⁹ For an excellent in depth technical discussion of these models, see Charney and Vest (2003).

¹⁰ Exogenous changes are those that come from outside of 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.

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 economy-wide long-term effects such as a tax reform or tax change (Charney and Vest 2003).

Computable General Equilibrium Models

A Computable General Equilibrium (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 inter-relationships 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 upon the prices for 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 model, which had only 28 industry sectors, still required a set of around 1,100 equations that had to be solved to reach the new equilibrium (Berck, Golan and Smith, 1996, 10).¹¹

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 a particular external shock, such as a tax change, on prices, as well as on household and firm behavior, changes 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.

Some other important considerations related to CGE models include the following:

CGE models may differ from one another in their assumptions and behaviors modeled. Thus, for example, some CGE models might assume that the goods in one state are perfectly substitutable

¹¹ Note that DRAM also included other sectors such as governmental sectors, households, etc.

for the same good in another state. Some models may assume labor is perfectly mobile while others assume complete immobility of labor.¹²

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 (Berck, Golan and Smith 1996, Oregon Legislative Revenue Office and Oregon State University 2001). Population migration for instance is likely to be dependent on differentials in housing costs across states (Tannenwald, Sure, and Johnson 2011), but these differentials were not included in either the Oregon or the California model specifications, both only included after tax income and employment opportunities in their migration equations.¹³

CGE models also are 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 parameters of the model's equations using base year economic conditions in order to produce an initial equilibrium that matches the actual, observed equilibrium. Notably, different parameters 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 Gross Domestic Product (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 timeframe when equilibrium will be reached. Typically, the assumption is that it would take five or six years to reach a new equilibrium (Charney and Vest 2003). 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 parameter values.

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 particularly notable for econometrically estimating labor flow and industry location (Charney and Vest 2003). Like standard IO models, REMI has inter-industry linkages and can determine direct, indirect, and

¹² The assumptions around the mobility of labor and capital are often referred to as closure rules in U.S. regional models (Charney and Vest 2003).

¹³ REMI has updated its migration equations to reflect new real estate pricing and homeowner lock-in due to declining home values.

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.

The REMI model looks somewhat like a CGE model 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 (Charney and Vest 2003).

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 where equilibrium has been reached (Charney and Vest 2003). Because REMI uses some econometrically derived equations for key parts of their model, REMI also does not assume that all input and output markets necessarily clear at the end of the time period analyzed.

REMI versus 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 where sophisticated CGE models, such as DRAM in California, only included 28 (Berck, Golan, Smith 1996). 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 of the critiques of REMI, such as difficulties modeling tax changes that affect the price of goods (see Charney and Vest 2003, 38), 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, parameters must be calculated manually before being entered into REMI, and the operator often has to understand the economic theories behind these parameters and the basic intuitions behind REMI in order to enter the parameters correctly and then appropriately interpret the results.

Experience from the States

OVERVIEW

A review of the literature, other state surveys, as well as the responses to a Federation of Tax Administrators (FTA) listserv request suggests that at least 21 states have experimented with dynamic scoring of tax proposals (Hepner and Reed 2003, Charney and Vest 2010b, Colorado Legislative Council Staff 2004, Bean, Wortley, and Haas 1997, Arizona Joint Legislative Budget Committee Staff 2006, Institute on Taxation and Economic Policy 2014). The majority used or are using REMI for their analyses.¹⁴ Three states are notable for developing complete CGE models for tax analysis: California, Oregon and Nebraska. All of these models are largely grounded in the California Dynamic Revenue Analysis Model (DRAM). Additionally, the Beacon Hill Institute at Suffolk University has developed the State Tax Analysis Modeling Program (STAMP). According to the Institute, STAMP has been used since 1994 and has been applied to tax policy in at least 24 states (Beacon Hill Institute at Suffolk University).¹⁵

Several states’ legislative staff have published memos reviewing other state experiences with dynamic scoring of tax policy,¹⁶ and the conclusions from these memos are as follows:

- 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

States Experimenting with Dynamic Scoring (Model Used)

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

¹⁴ This list is not necessarily comprehensive. In some of the states listed, the FTA listserv responses suggest that all institutional memory of the use of dynamic scoring has been lost. Additionally, 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 Mikesell (2012).

¹⁵ For an interesting exchange about the validity of the STAMP model and by extension CGE models more generally, see the Beacon Hill Institute at Suffolk University (2010, 2014), Charney (2010a, b), and Institute on Taxation and Economic Policy (2014). The STAMP model as well as other CGE models are widely associated with advocacy for pro-growth/limited government policies and are often developed at the behest of policymakers who want to see pro-growth results from tax reductions or tax reform.

¹⁶ Scoring is a term that refers to estimating the revenue effect of some tax policy.

\$15,000 in annual fees. They also estimated that a customized CGE model costs approximately \$300,000 to develop for a state (Colorado Legislative Council Staff 2004). Mikesell (2012) estimates that these models cost at least around \$200,000 to develop.

- Policymakers are often disappointed in the results, particularly as it relates to 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 (Arizona Joint Legislative Budget Committee Staff 2006, Francis 2007); Arkansas, Louisiana and Texas staff also noted policymaker disappointment in the size of the effects (Colorado Legislative Council Staff 2004, Hamilton 2015).¹⁷
- 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 (Mikesell 2012), and in California, economists recommended a similar threshold before applying dynamic scoring (Berck, Golan, and Smith 1996, Colorado Legislative Council Staff 2004).

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 is available, we attempt to present comparable numbers such as the dynamic effects on state revenues and changes in employment, personal income, and investment; however, in a number of 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.

STATE CASE STUDIES

California: Dynamic Revenue Analysis Model (DRAM)

In 1994, California adopted legislation that required dynamic scoring for all tax proposals whose static revenue impact was greater than \$10 million annually. California chose to build its own CGE model, referred to as the Dynamic Revenue Analysis Model (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 (Vasche 2006). One of the problems faced 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

¹⁷ 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.

decisions” (Arizona Joint Legislative Budget Committee Staff 2006). Because the design of DRAM is particularly well documented and formed the foundation for most of the other CGE models currently in use, 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 (Berck, Golan, and Smith 1996). 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, 15 accounted 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, 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 revenues 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 state 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 governmental spending rather than the productivity gains that might be associated with certain expenditure flows, such as gains associated with a more educated population or better transportation infrastructure (Berck, et al. 1996).

On the private sector side, the model then worked much as described in Section 3, 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 consumers in California 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 due to out-migration and a preference for leisure, pre-tax 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 quantity of labor supplied was equal to 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 (Berck, Golan, and Smith 1996). 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 (Vasche 2006, Charney and Vest 2003).

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.¹⁸ 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, i.e., 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 revenues 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.)¹⁹

Table 1A. California DRAM Model of Dynamic Effects of a \$1 Billion Increase in Each Tax Type (2000 Model Estimates)

	CHANGE IN INDIVIDUAL INCOME TAX	CHANGE IN SALES AND USE TAX	CHANGE IN BANK AND CORPORATION TAX
Size of Static Increase (\$millions)	\$1,000	\$1,000	\$1,000
Revenue Feedback (\$millions)	-\$40	-\$120	-\$180
% of Static Estimate	-4%	-12%	-18%
Employment Change (persons)	-18,000	- 10,000	-11,000
Business Investment Change (\$millions)	-\$83	-\$109	-\$479

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

Source: Vasche (2006)

Table 1B. California DRAM Model of Dynamic Effects of a \$1 Billion Decrease in Each Tax Type (1996 Model Estimates)

¹⁸ According to the California Department of Finance, the California general fund revenues were \$46.3 billion in 1996, so a \$1 billion tax change would be 2 percent when the model was first run; general fund revenues were \$71.9 billion in 2000, so a \$1 billion tax change would be around 1.4 percent.

¹⁹ Berck, Golan, Smith (1996) report the dynamic effects from a rate decreases, while Vasche (2006) reports the equivalent rate increases. We use the Vasche (2006) estimates which 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.

	CHANGE IN INDIVIDUAL INCOME TAX	CHANGE IN SALES AND USE TAX	CHANGE IN BANK AND CORPORATION TAX
Size of Static Increase (\$million)	\$1,000	\$1,000	\$1,000
Revenue Feedback (\$millions)	\$10	\$77	\$184
% of Static Estimate	1%	7.7%	18%
Employment Change (persons)	18,000	10,000	12,000
Employment Growth (% change)	0.14%	0.08%	0.10%
Personal Income (\$millions)	-\$738	\$107	\$1,600
Personal Income (% change)	-0.10%	0.01%	0.21%
Wages (% change)	-0.21%	-0.038%	0.028%
Return on Capital (% change)	0.01%	0.02%	-0.40%
Gross Investment Change (\$millions)	\$6	\$16	\$147
Gross Investment (% change)	0.009%	0.023%	0.217%

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

Source: Berck, Golan and Smith (1996)

To raise \$1 billion (static revenue estimate) through the personal income tax required an increase of 4 percent 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 due to 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 due to the dynamic adjustments (\$40 million would be “lost”) (Vasche 2006). Importantly, because income taxes are deductible from federal taxes, this mutes some of the effect of a state-level tax change. Additionally, higher income groups hold a portion of their earnings outside the state, which can reduce the dynamic effects (Berck, Golan, and Smith 1996).

To generate a \$1 billion (static revenue estimate) increase in sales tax would require raising the sales tax 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 (Vasche 2006). As the sales tax rose, consumers might forego purchases of some discretionary goods or substitute away from goods that were taxed, which now cost more due to 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 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 (Berck, Golan, and Smith 1996).

Finally, to generate a \$1 billion (static revenue estimate) increase in corporate income tax would require raising the corporate tax 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

(Vasche 2006). 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 (Berck, Golan, and Smith 1996).

Oregon: Oregon Tax Incidence Model (OTIM)

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 also to look at how the tax burden would be distributed across different income levels. The Oregon Tax Incidence Model (OTIM) was based on the California 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 decrease across different tax types (Oregon Legislative Revenue Office and Oregon State University 2001). 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.²⁰ As with DRAM, OTIM required an expenditure side offset to a tax cut or increase.

Oregon modeled a proportional change in income tax liability, thus 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 revenues would largely affect the state general fund, which would only recoup \$3.2 million of the loss—the other gains would go to other funds in the state 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 pre-tax wages and/or personal income to decline slightly but will have a greater effect on employment than the other tax changes.

Table 2. Oregon OTIM Model of Dynamic Effects of a \$100 Million Decrease in Each Tax Type

²⁰ This amount is based on the National Association of State Budget Officers reported final FY 2001 expenditures for Oregon in the FY 2002 State Expenditure Report. The number adds state general funds to state other funds and does not include federal funds or bond financed expenditures (National Association of State Budget Officers, 2002).

	CHANGE IN INDIVIDUAL INCOME TAX	CORPORATE INCOME TAX	BUSINESS PROPERTY TAX
Size of Static Decrease (\$millions)	-\$100	-\$100	-\$100
Revenue Feedback (\$millions) ⁽ⁱ⁾	\$9.65	\$15.84	\$10.98
State Revenue Portion (\$millions)	\$6.7	\$13.6	\$8.1
Local Revenue Portion (\$millions)	\$2.8	\$2.2	\$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)	0.0075%	0.03%	0.0095%
Investment (% change)	0.14%	0.53%	0.2%

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

(i) 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)

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 around an 11 percent revenue offset. Here, the loss in revenues would largely be absorbed by local governments, which would recoup \$3 million from dynamic effects (Oregon Legislative Revenue Office and Oregon State University 2001).

Nebraska: Tax Revenue Analysis in Nebraska (TRAIN)

In the late 1990s and early 2000s, Nebraska developed a CGE model 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 it is customized for Nebraska's economy. In its *2003 Tax Burden Study*, produced in 2007, TRAIN was modified to produce a household income incidence analysis along the lines of OTIM and also included an analysis of the incidence across industry sectors. The 2003 study and 2007 studies both consider the hypothetical impact of a \$10 million change in revenue collections from the income tax and from the sales and use tax (Nebraska Department of Revenue Research Services 2007, 2010). The most recent report, the *2010 Tax Burden Study* is presented here and assesses the impact of a \$100 million tax change. To give a sense of scale, Nebraska's state general fund

and other state fund expenditures in FY 2010 were \$6.9 billion,²¹ 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 (Nebraska Department of Revenue Research Services 2013). These are effects on state revenues only. The incidence analysis suggests that a cut in sales tax has progressive effects and income tax is somewhat regressive. The impact of the income tax changes are also more evenly distributed across industry sectors while the sales tax change heavily affects the retail business sector (Nebraska Department of Revenue Research Services 2013).

Table 3. Nebraska Train Model of Dynamic Effects of a \$100 Million Decrease in Each Tax Type

	CHANGE IN INDIVIDUAL INCOME TAX	SALES AND USE TAX
Size of Static Decrease (\$millions)	-\$100	-\$100
Revenue Feedback (\$millions)	\$6.4	\$20.6
% 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 (\$millions)	\$121.6	\$181.2
Investment (\$millions)	\$64.8	\$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)

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 a variety of tax reform proposals between 1993 and 1995, including raising the state's investment tax credit (Clayton-Matthews 1993). 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 using the argument that the fiscal impact would not be as large as the static forecast because of projected dynamic effects. Ultimately, overall revenues came in *below* the static revenue forecast in fiscal year 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 (Sullivan 2004, Moccia 1995).

²¹ Expenditures based on the National Association of State Budget Officers' FY 2011 State Expenditure Report final expenditure amounts reported for FY 2010 (National Association of State Budget Officers 2010).

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 (Clayton-Matthews 1993). These are hypothetical cuts of \$100 million by tax types. Importantly, they are not balanced estimates, i.e., 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 to the other states (12 percent in California and 21 percent in Nebraska), while the most significant dynamic effect 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.

Table 4. Massachusetts REMI Model Dynamic Effects of a \$100 Million Decrease in Each Tax Type

	CHANGE IN INDIVIDUAL INCOME TAX	CHANGE IN SALES AND USE TAX	CHANGE IN CORPORATE INCOME TAX
Size of Static Increase (\$millions)	-\$100	-\$100	-\$100
Revenue Feedback (\$millions)	+\$6.4	+\$4.9	+\$30.4
% of Static Estimate	6.4%	4.9%	30.4%
Employment Change (persons)	1,600	1,500	10,500
Personal Income (\$millions)	\$66.2	\$57.9	\$409.4
Investment (\$millions)	\$21.7	\$31	\$302.4

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)

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 legislature: a 21 percent reduction in the state personal income tax; a 0.5 percentage point reduction in the state sales tax; the elimination of the tangible personal property tax on machinery and equipment, inventory, and furniture and fixtures; the elimination of the corporate franchise tax; increases in the excise tax on tobacco and alcohol; and the creation of a broad-base, low-rate commercial activities tax. The REMI report concluded that the combined package of tax changes would generate a reduction in tax revenue of \$3.06 billion in FY 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 Ohio

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 (Honeck and Schiller 2005).²²

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 state capital-gains tax over the same time 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 with respect to state revenues, 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 FY 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 loss of \$21 million. (To put in context, New Mexico's FY 2004 general fund revenues were \$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, FY 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 some form of 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 (Francis 2007, New Mexico Legislative Finance Committee Staff 2004).

Notably, the tax changes were projected to prompt investment in the state but were not projected 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 (Berck, Golan, and Smith 1996). While it is not clear what exactly 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 a reduction in income tax may be shared by employees and employers would have the effect of reducing or slowing the growth of pre-tax wages, even as employees have more after-tax wage income (as shown in Table 5, personal income declines but

²² 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 (Honeck and Schiller 2005).

total disposable personal income increases). While not shown here, the New Mexico dynamic estimates projected a dynamic *decline* in income tax revenues relative to the static estimate, but also projected that this would be made up through increased economic activity and associated enhanced collections in the gross receipts tax and corporate income tax (New Mexico Legislative Finance Committee Staff 2004).

Table 5. New Mexico REMI Model of Tax Reform

	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Static Analysis (\$millions)	-\$21.8	-\$83	-\$167.2	-\$275.2	-\$360.3
Dynamic Analysis (\$millions)	-\$21	-\$80.8	-\$163	-\$268.7	-\$352.2
Difference	\$0.8	\$2.2	\$4.2	\$6.5	\$8.1
% 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	2.950
Employment: Government	-0.342	-0.932	-1.759	-2.641	-3.191
Personal Income (\$millions)	-\$1.5	-\$5.0	-\$9.0	-\$11.5	-\$9.5
Disposable Personal Income (\$millions)	\$30.0	\$84.0	\$165.5	\$260.0	\$332.0
Output (\$millions)	\$0.597	\$1.824	\$4.326	\$10.064	\$16.627

Source: New Mexico Legislative Finance Committee Staff (2004)

Kansas: STAMP

In 2012 and 2013, Kansas made a series of significant tax changes. Because the dynamic analysis pertains only to the 2012 changes (HB2117), 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 pass-through 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 revenues (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 HB2117 and the 2012 tax changes (Davidson, et al. 2012).

As shown in Table 6, STAMP estimated the dynamic effect from these tax changes modeling the tax cut on pass through income in two different ways. In their pass-through 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 pass-through model, where the tax cuts are largely a benefit to businesses, predicted less of an employment gain (33,430 over six years) than the standard model that assumed the benefits were largely influencing household choices via the income tax (41,690 over six years), but gross investment in the economy would be higher

in the standard model: \$307 million in the pass-through model versus \$85 million in the standard model (Davidson, et al. 2012).

Table 6. Kansas Legislative Research Department (KLRD) Estimates of Impact of 2012 HB2117 and STAMP Dynamic Revenue Estimates

	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	CUMULATIVE FY 2013- FY 2018
KLRD Final Revenue (pre-tax changes, \$millions) ⁽ⁱ⁾	\$6,394	\$6,231	\$6,466	\$6,708	\$6,980	\$7,259	\$40,038
KLRD Final Revenue (post-tax changes, \$millions)	\$6,163	\$5,428	\$5,642	\$5,854	\$6,087	\$6,325	\$35,499
KLRD Estimate of HB 2117 (2012 Tax Impact, \$millions)	(\$231)	(\$803)	(\$824)	(\$854)	(\$893)	(\$934)	(\$4,539)
% Decline from Original General Funds Budget	-4%	-13%	-13%	-13%	-13%	-13%	-11%
STAMP Dynamic Revenue (Pass-Through, \$millions)	\$18	\$87	\$93	\$101	\$111	\$123	\$533
STAMP Dynamic Revenue (Standard, \$millions)	\$27	\$108	\$110	\$115	\$122	\$130	\$612
% Dynamic Effect (Standard)	11.72%	13.47%	13.37%	13.43%	13.70%	13.87%	13.48%
% 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)

(i) These are calculated by authors and are derived by restoring the projected HB2117 static tax revenue declines to the post HB2117 baseline.

The STAMP model found large dynamic revenue effects in the range of 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 being 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 revenues (Davidson, et al. 2012) (see Table 6).

Deciding that the tax cuts were too large to sustain, the following year, the Kansas governor and legislature modified the tax reform proposals, which had the effect of reducing the near term impact on the state general fund from a \$5.5 billion impact from FY 2013 through FY 2019 to a \$5 billion impact, with some of the large effects pushed to the out years (Courtwright 2012, Henchman and Drenkard 2013, Kansas Legislative Research Department 2013). As of 2015, Kansas Legislative Research Department has projected revenues falling *below* previous estimates that were grounded in the static revenue estimate of the tax changes (Kansas Legislative Research Department 2014). 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 (Pew Center on the States and The Nelson A. Rockefeller Institute of Government 2011), which is to say that even very large dynamic effects fall within this range.

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 tradeoffs 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 (Bartik and Erickcek 2004, Charney 2010a).

A critique of all dynamic models is that the models 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 (Institute on Taxation and Economic Policy 2014, Berck, Golan, and Smith 1996).

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. Additionally, a tax change in one state can produce a reaction by another state. No current dynamic models account for such reaction effects, but such reactions to state policies are not uncommon and may have a significant impact on a state’s economy.

Conclusion: Pros and Cons of Dynamic Revenue Models

Dynamic modeling has some interesting applications to policy analysis and provides potentially useful information on the different ways that 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 much 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 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 tradeoffs.

Where dynamic modeling falls short, and what is apparently often disappointing to policymakers, is that dynamic revenue analysis has not proved to be a particularly appropriate tool for budgetary decision-making 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 sub-national 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 parameters, 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 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 to a state's general fund revenues (and even more minuscule when compared to 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 actually 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 then maintain the models.

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