Modeling Practices and Their Ability to Assess Tax/Expenditure Economic Impacts

Paper prepared for:

The AUBER Conference, New Orleans, October 2003

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Introduction

State legislatures, motivated by the desire to measure the "actual cost" of new tax legislation, are increasingly concerned about the indirect consequences of different kinds of taxes on firm and taxpayer behaviorial responses, on state/regional growth, and on the tax base itself. The authors conducted a review of the literature and reviewed several models that have been used for tax assessment.

We begin with definitions of commonly used terms, such as "dynamic" and "dynamic scoring," followed by a review of regional economic theory and the effect of a state's fiscal policies on behaviors of households and businesses. Desirable properties of models are then identified, followed by a description of three basic modeling approaches or types.

Five models (IMPLAN, TRAIN/Dynamic TRAIN, STAMP, DRAM, and REMI) are reviewed.

The report concludes with an assessment of the usefulness of these models to appraise behavioral responses as an aid to evaluating proposed tax legislation.

Tax/Expenditure Effects on Economic Behaviors

Before discussing types of models and before critiquing specific models, it is important to understand the types of tax/expenditure/government/economic interactions that have been discussed in the literature. Short and long run effects of taxes and expenditures on households and business firms are discussed. This list serves as a background for understanding the extent to which the academic literature has made its way into the economic models that we will be reviewing.

Short-run Effects of Taxes on Households

Disposable Income Effects

Short-run effects of taxes on households and produces are the tax impacts most commonly discussed both in the literature and in the press. The most commonly discussed impact of taxes is that they reduce peoples' disposable incomes and, therefore, have a negative impact on the economy. The contention is that, if we cut taxes, thereby giving money back to consumers, that this will stimulate the economy. This simplistic view of tax policy fails to recognize the differences between federal and state taxation, as well as the benefits of government spending.

In examining the effects of taxes on households, particularly the effect of income taxes on households, it is important to also consider state-federal tax interactions. If a state cuts or eliminates it's income tax, then the state taxpayers can no longer deduct their state taxes from their federal taxes and the result is higher federal taxes paid by state residents and more money into the federal coffers. Tax experts understand this, but remarkably, many models do not take this extremely important interaction into account. Sometimes models focus on far less important economic 'impacts' of the tax change and forget this important interaction, thereby seriously misstating the effects of such a proposed tax change.

Price Effects

Not all taxes directly affect disposable income. A majority of taxes do not affect disposable income directly (i.e., the taxpayer does not have to make a direct payment to government); rather, the tax affects the prices of certain commodities. For example, sales taxes are not paid directly to the government. Therefore by definition, sales taxes do not reduce "disposable" income. Sales taxes are designed as a pass through, which is why they are added to the sales price of an item. Most tax experts argue that by adding the sales tax to the price of the item at the time of sales, it makes the tax 'visible,' and this is a desirable feature of a tax. Taxpayers are supposed to understand their tax structure and taxes should not be hidden.

Of course, luxury taxes (taxes on beer, wine, liquor and tobacco products) are imposed, in part, *because* they affect the price of a good. Frequently luxury taxes are called 'sin' taxes and are often established because a) there is hope the tax will reduce the usage of the luxury item (e.g., to reduce the rate of teenage smoking), b) there are social costs associated with the consumption of these items so the tax is to help cover the cost (e.g., increased health care costs associated with alcoholism and smoking) or c) the taxes are good at raising revenues because you can raise the rates to a rather high level without people changing their behavior (i.e., there is an inelastic demand for these items because the taxpayers are unlikely to stop smoking or drinking, even if they have to pay higher taxes on tobacco or alcohol).

Because sales and luxury taxes affect the price of taxable items, it is somewhat harder to determine ahead of time how much a change in those tax rates will affect revenues. This is because people can avoid the tax by not buying taxable items or switching their purchases from taxable items to non-taxable items. People can avoid the luxury tax by reducing or quitting the use of tobacco and spirits. Alternatively, they can cross state or national boundaries (including Indian Reservations) where these taxes might be lower. For sales taxes, people can shift their expenditure patterns from taxable to non-taxable items or buy them from non-taxable sources (the Internet). In Arizona, most 'goods' are taxable and most 'services' are not taxable. So, instead of buying a lawnmower and lots of garden tools (which are taxable), a homeowner may decide to buy gardening 'services' (which are not taxable). They may reduce the number of times they eat out at restaurants (taxable) and buy more food to eat at home (not taxable). They may buy a nicer house (transaction is not taxable, although the non-labor portion of a new house at the time of construction is taxable under 'contracting') and stay home more rather than eating out, going to movies or visiting local attractions (which are taxable). We understand that these examples are extreme, that the shifts from taxable to non-taxable consumption items are much more subtle than this. However, the relative price effect of taxable vs. non-taxable items has been long recognized in public finance textbooks and relative price effects have also been incorporated in some models. (Charney and Taylor, 1986).

Unfortunately, the fact that certain types of taxes enter the economy through prices is not incorporated into many models. Some models cannot incorporate them this way because 'prices' aren't in the model framework; other models simply ignore this important price issue and subtract a first-estimate of sales and use tax revenues from disposable income. This approach is absolutely wrong because a) you cannot determine how much revenues will be collected with a sales or use tax (so you don't know how much to subtract) without understanding the price effects and b) as a result, the impact will always be overstated.

Work-Leisure Decision

Taxes that impact a worker's income (wage rate) can affect a worker's work-leisure decision. This is one of several supply side issues that received substantial attention during the Reagan administration. During that time, supply-siders argued that if we cut taxes, we would get more work 'effort' and therefore actually raise revenues. (Longer-run supply side issues will be discussed below.) Most economists believe that the decision between work and leisure is often very limited. For example, the vast majorities of workers work a fixed number of hours per week (typically 40) and can't work more or less when they choose. Another large segment of society are 'salaried' and may vary their workweek, but whose pay doesn't vary week by week. Also, there is the possible income-effect of an income tax cut. Individuals may actually choose to work less (buy more leisure) when there is an income tax because leisure is usually considered a normal good (i.e., people buy more of it when incomes rise).

The work-leisure relationship, although recognized in the literature, does not appear in many models. It can't appear in models that don't contain prices (see the discussion on input-output models, below). Also, it usually doesn't appear in econometric models because those estimated equations usually represent the derived demand for labor, rather than the supply. The supply of labor is indirectly affected in many models, as relative wages (sometimes after-tax) affect net-migration. But this is not directly estimating the effect of the work-leisure decision.

Distributional Effects of Taxes

Finally, different taxes can affect households differently, usually depending on their incomes. A strong belief that poor people spend a higher percentage of their incomes on food is why food is exempt from the sales tax in many states. Similarly, a belief that senior citizens pay a higher portion of their incomes on medicines is a major reason for exempting medicines from the sales tax. The income tax obviously affects households of differing incomes differently, but so do property taxes, luxury taxes and all other taxes, depending on the mix of expenditures of each income class. By affecting different income classes differently, taxes may have an impact that differs from what an aggregated analysis may suggest. For example, if the state income tax liability of all income groups is increased, low-income individuals may actually end up paying a higher proportion than was intended because they can't itemize (and therefore deduct state taxes) on their federal income tax.

Short-Run Effects of Taxes on Firms

Taxes can affect a firm's variable costs (unemployment insurance), fixed costs (property tax, personal property tax), or profitability (corporate income tax). All types of taxes on businesses affect costs to producers. The size of that effect depends on the market structure and on the nature of the production functions of businesses in the region. The market structures determine the extent to which business can pass taxes forward onto the consumer, backward onto labor, or is borne by the business owners (or stockholders). If the product market is perfectly competitive, then the business cannot pass the taxes onto the consumer, but they can pass a portion of the tax forward to the consumer in a monopolistic market. The production function determines whether the tax will increase or decrease the demand for labor in the short run. If the production function allows substitutability between labor and capital, then a tax on capital may increase the demand for labor in the short run. In this case, businesses can substitute labor for capital so the higher (after-tax) price of capital can cause an increase in the demand for the relatively lower priced labor. Alternatively, if production does not allow substitution between capital and labor, so that capital and labor are complements, then a tax on capital will raise overall costs of production, prices will rise, quantity demanded will fall, and less labor will be hired. Attempting to assess the market structure and the nature of the production functions in a region's economy is extraordinary difficult. Usually a market structure is *assumed* in a model framework.

Short-run Effect of Expenditures on Households

Government Spending Impact

All too often the expenditure side of government spending is ignored. This certainly isn't true when federal government spending affects a state's economy. For example, there is not a person in Arizona who would argue that national defense spending has no impact on Arizona's economy. On the contrary, most people would say that Arizona's economy is closely tied to national defense spending and that cuts in national defense spending have serious consequences on our manufacturing sectors. Why then is it that most people view state and local government spending as a drain on the local economy (i.e., they assume this money has zero economic impact)? Typically, the argument is as follows: if we cut taxes, we can give the money back to consumers and they will spend it and generate economic impacts. What happened to the government side of spending?

The reality is, government employees spend money in the same way as non-government worker consumers do. Some government spending is in the form of transfer payments (safety net payments to individuals), which puts money in the hands of yet another group of 'consumers.' In addition, government hires private companies to provide goods and services, e.g., construction companies, day care providers, and they pay workers who, in turn, consume.

There is a body of empirical evidence in the literature that this expenditure side is extremely important, especially when assessing short-run economic impacts. The fact is, that in the short-run, tax cuts accompanied by expenditure cuts may have a positive or negative economic impacts on a region, depending on which government expenditures are cut. For example, in Waters, et al (1997), they found using IMPLAN (discussed below) that the short-run economic impact of a tax cut in Oregon was negative because the corresponding cut in government expenditures resulted a net reduction in state economic activity. The simple reason for this is that there is a smaller 'leakage' out of the state from a dollar spent by government than a dollar spent by taxpayers. Out of every dollar most taxpayers receive, a portion goes to pay a mortgage (which frequently leaves the state), a portion pays for insurance (which frequently leaves the state), for utilities (some of which may leave the state), a portion makes local purchases (of which the retail margin is retained, but the rest leaves the state because the goods aren't produced in-state), … Relatively little of consumer spending is retained locally as earnings that are available for spending in the second round of spending. When government spends, a relatively higher portion goes directly to wages (teachers, health and welfare workers, correction officers, etc.), directly to households (transfer payments), or to locally provided goods and services (construction, daycare). Because a higher portion of government spending is retained locally as earnings in the first round, the economic impact of government spending can be larger than the economic impact of the tax cut, in the short run Helms (1985), Charney (1983a)

Public Goods as Consumer Goods

Some public goods/services directly improve public welfare. For example, state and local parks provide direct utility to persons living in Arizona. Reduced crime rates reduce the need and the cost of insurance.

Quality fire provision can reduce costs to homeowners. Quality education can reduce future crime rates, if young people obtain necessary skills for a job.

Public services can also have intrinsic value to individuals. The feeling of 'safety' has an intrinsic value beyond the reduced costs associated with reduced crime. Some people even derive 'utility' or satisfaction from the knowledge that there is a safety net for low-income people, kids are getting educated, and so forth.

Short-run Effects of Expenditures on Firms

Like households, firms can derive direct cost reductions from public services. A quality transportation system has been found to impact firm location both within a metropolitan area as well as between metro areas. Low crime rates, good fire protection, quality transportation, and adequate sewer/water facilities all impact on firm costs. In addition, an educated labor force reduces training costs of new employees.

Long-run Effects of Taxes on Households

In addition to the short-run impacts of taxes and expenditures on households, there are also long-run effects of taxes on households. Tax differentials among regions/states have sometimes been found to influence migration patterns of households. Usually tax differentials are entered into a migration equation via a relative real disposable (after-tax) wage variable. Some population groups are particularly attracted to low-tax regions, especially when the low tax region also has a favorable climate, e.g., the elderly. This locational effect of relative (or differential) tax rates has been found in the migration literature, but is rarely incorporated into regional models.

Long-run effects of Taxes on Firms

'Who pays' business taxes has been a subject of debate over the years, but most economists believe that these taxes end up falling on the owners of capital (i.e., business owners and stock holders). In fact, a result emanating from theoretical general equilibrium models is that business taxes fall on *all* owners of capital, even owners of capital that isn't taxed. The reason is that capital 'flows' from one use to another. If you tax one type of capital, then the rate of return on that capital is reduced and capital will 'flow' into another sector of the economy, thereby equalizing the rates of return of the taxed and non-taxed capital. Similarly, capital can 'flow' out of a high-tax region into a low-tax region, thereby equalizing after-tax rates of return on capital across regions.

These 'flows' of capital out of high-tax areas can affect private capital formation within a region.

Long-run Effects of Expenditures on Households

Just as differential tax rates can affect the migration of households, so can differences in quality of other types of public goods and services. Quality education, for example, is found in inter-regional and/or inter-state migration studies to be an attraction variable. Commute time is sometimes used in migration studies, indicating a good transportation system (or a smaller city). These public sector variables are frequently entered as regional amenities, along with climate and other quality of life measures. Frequently the amenity side of public services is neglected when tax differentials are examined.

Probably the most important long-run effect of government expenditures on an economy is through education. Human capital formation (education) is usually a public investment (K-12, public universities) because of the 'spillovers' to the general population. That is, education does not just benefit the person receiving the education. Rather, society as a whole benefits because of higher productivity, new ideas and new knowledge generated at universities, reduced crime rates associated with educated kids, fewer people requiring welfare because they have the skills to support themselves, and so forth. Education is to human capital formation as investment is to physical capital formation. There are two ways to increase productivity in an economy (and therefore real wages). The first is to increase human capital investment through education, so that individuals are more productive. The second is to give humans better/more capital equipment, which is related to physical capital investment.

Long-run Effects of Expenditures on Firms

In addition to the effect of tax differentials on capital flows, public service differentials can also impact location decisions of firms. The public services that directly benefit firms in the short-run (see above discussion of short-run impacts of expenditures on firms) can also affect location decisions of firms. It should be noted that 'quality of life' variables are the number one reason cited by high tech companies regarding firm site and location choices. Quality education is almost always one of those 'quality of life' measures. High tech firms are particularly interested in quality education because the employees of high tech firms are well educated and they place a high value on education for their families. In addition, high-tech employees sometimes want to continue their education at local universities. Quality universities are also linked with high-tech locations because of research connections and company spin-offs from university research activity. Partridge (1993) provides a brief literature review and estimates the tax and expenditure impacts on the growth of high tech firms across states and concludes that "tax and expenditure policies are jointly significant and can possibly be varied to attract HT firms. Increasing education and other expenditures beneficial to HT firms while reducing highway expenditures, appears to increase HT employment but at the expense of reducing other industries' employment. Regardless, the distribution of employment will likely shift to higher paying jobs (p.300)."

Regarding expenditures and taxes, there is a body of literature that states that (a) if taxes alone are considered in a study they are usually found to be insignificant in determining relative growth rates of a region (sometimes they are found to be weakly negative; sometimes weakly positive), and (b) when both taxes and expenditures are considered, taxes are negative but expenditures in certain categories are positive, so high tax areas can grow faster, depending on what government allocates spending toward. See Waters, et al. (1997), Helms (1985), Mofidi and Stone (1990), Charney (1983b).

Also, public infrastructure (stock of public capital, as opposed to current service levels) can impact on a firm's production and locational decision. Public infrastructure is equivalent to public investment in such categories as roads, airports, ports, schools, etc. (Dalenberg, Partridge and Rickman (1998).

Effects of Tax/Expenditures on Other Issues

Taxes and expenditures can also affect different households differently. These are the income distributional effects of the tax structure. Rarely are distributional impacts analyzed in the context of regional model. Waters, et. al. (1997) is an exception, which found that the property tax initiative in Oregon substantially favored high-income households.

Finally, consider the effect of taxes and expenditures on intergovernmental relations. There are interactions between federal tax collections and state/local expenditures because of pass-throughs (health and welfare subsidies), grants of various sorts, and federal highway and defense expenditures within a region. These are usually specified exogenously in regional models; however, for a very large state (such as California), there are clearly interactions between federal tax collections and regional economic activity. Further, there is the direct interaction between state income tax liabilities and federal income tax deductions.

There are also federal to state and state to local mandates that affect intergovernmental relations. Some services are mandated by one level of government, but the services have to be provided by a lower level of government. Unfunded mandates by higher levels of government can affect the tax rates of lower levels of governments. Sometimes lower levels of government are caught in a tax/revenue squeeze between service costs that are mandated and tax limitations imposed by higher levels of governments.

Several studies focus on the impact of property tax limitations on tax revenues and shifts in responsibilities between state and local government (Matsusaka 1995).

Finally is the issue of retaliation and state-to-state interactions. Sometimes states competitively adjust their tax/expenditure pattern in order to create a comparative locational advantage. However, it has to be recognized that all estimated economic and revenue impacts associated those state policies revolve around the assumption that none of the surrounding states will retaliate. When retaliation of other states is considered, dynamic feedbacks would be substantially reduced or nullified (Appendix to Berck, et. al., 1996).

Terminology

Econometrics. This word is used several times prior to the actual discussion of econometric models, so we want to define it here. Econometrics is the development and application of statistical methods to economic problems. Econometrics is a sub-field of economics, in which researchers not only apply statistical methods, but also actually develop new methods that have particular applications to the study of economics. An econometrically estimated equation is a relationship that is estimated using statistical methods.

Elasticity. This is a commonly used word in economics and it refers to the percent change response of one economic variable to a percent change in another economic variable. There will be many discussions of elasticities in this report. For example, taxes change prices, which in turn affect the level of sales of the taxable items. In order to assess how much those sales change, we need the elasticity of sales with respect to price. That is, it is necessary to know the percent change in sales associated with an X% change in the price.

Exogenous vs. endogenous. Exogenous variables are determined outside a model's framework and endogenous variables are determined within the framework of the model. For example, taxable sales are clearly affected by changes in things like tax rates (through prices), by changes in interest rates (as they impact on car sales), or by changes in household incomes. Variables like tax rates are usually specified as exogenous variables. In this case, they can be policy instruments in a model. 1 Similarly, in a regional model, interest rates are usually exogenous because they are usually determined in national financial markets. However, interest rates are important endogenous variables in national models. In state or regional models, both taxable sales and income would be endogenous.

Long-run vs. short-run. In common usage, the terms long-run and short-run bring to mind *time* periods. People talk about our short-run and long-run career plans. People talk about short-run forecasts that are typically for 5 years or fewer. People talk about long-run forecasts that tend to be 10 years or more.

However, in discussions of model design and economic theory, the terms long-run and short-run have little to do with a specific length of time. Rather, the terms short-run and long-run have very specific, but sometimes, different meanings.

In microeconomic theory, by definition, the short-run is the timeframe in which the stock of capital cannot be changed; long-run is the timeframe in which the stock of capital can be changed. For example, in the short-run, producers can determine how intensively they use the capital they own (for example, add on another shift of labor), or, they can let some (or all) capital equipment to sit idle when demand for their product is down. But in the short-run, they cannot change the level of capital stock (i.e., they cannot invest in new capital, divest of capital). In the long run, producers can make whatever adjustments they want to make to their plant and equipment stock. They can double the size of their production or go out of business.

The terms short-run and long-run also refer to consumer behavior in economic theory. In the short-run, consumers cannot change their 'capital stock,' either. In the short-run, when the price of gasoline goes up, consumers can choose to walk or take the bus, work at home more often, car pool, or make fewer shopping trips. They cannot sell their big gas-guzzling car and buy a small fuel-efficient model in the short-run. By definition, this is a long-run decision. Frequently we see discussions of short- and long-run price elasticities (responses), typically when discussing energy (gasoline, electricity, natural gas) and other utility (water) demand. The short-run is what we can do today, in response to a change in the prices of these goods; the long-run is when we can buy/sell a car, replace furnaces, build a pond, or fill in a pool.

[1] Note that we have known of some models in which the tax rate is endogenous. In these models the interest is in determining how the tax rate would have to adjust to some policy change. For example, how much would a tax rate have to change in order to offset some other loss in revenues? This is an uncommon way to enter tax rates into models, however.

In the literature associated with Computable General Equilibrium (CGE) models (discussed below), long-run refers to the mobility of capital and labor. If the long-run version used in the CGE literature only included the mobility of capital, it would be consistent with basic micro theory; however, also including the mobility of labor into their 'long-run' discussions is a logical divergence.

Static vs. dynamic. In some discussions of the impact of taxes, the words, 'static' and 'dynamic,' are sometimes associated with the concepts of 'no tax feedback' and 'tax feedback,' rather than referring, in a very specific sense, to 'static' and 'dynamic' models. We will use the word 'feedback' to generically describe multiple-round tax/expenditure impacts that occur as tax effects iterate through an economic system. Tax and revenue 'feedbacks' can occur in both 'static' and 'dynamic' models.

For example, the simplest assessment of the adding 1 percent to an existing 4 percent sales tax would result in an initial 25 percent increase in revenue. In some usage, any assessment of the tax impact beyond this has taken on the phrase 'dynamic' impact or 'dynamic scoring.' In other settings, the 'static' analysis would also include applying a price elasticity (a measure of the response of demand to the change in price caused by the tax change) to determine the new demand for the taxable good, but all *additional* analysis would be referred to as 'dynamic' (Haas and Knittel, 1997).

In modeling discussions, the distinction between 'static' and 'dynamic' do not refer to whether or not there are tax/revenue/economic feedbacks built into the model, but rather to whether the model is set up to solve without regard to time or whether the model is *inter-temporal* in design. For example, within a 'static' model, a sales tax increase can increase the price of a taxable goods or services, reduce the demand for those items (the price effect), shift the demand to non-taxable items (the substitution effect), cause employment in taxable sectors to fall, possibly cause employment in the non-taxable sectors to increase (at least in the first round of iterations), induce changes in total employment and total income and, therefore, cause changes in other revenue sources as the income changes iterate through the system. Models can have numerous types of tax/expenditure/economic interactions in its specifications and still be 'static.'

The word 'dynamic' in modeling literature has a very specific meaning that relates to *inter-temporal* issues. Similarly, the phrase 'dynamic scoring' means more than the assessment of tax-related economic feedbacks. The words 'dynamic' and 'dynamic scoring,' as coined by several economic researchers, refer to how taxes or other policies established today can affect tomorrow's growth.

In the following paragraphs, we quote heavily from Bruce and Turnovsky (1999, p.1) in defining 'dynamic scoring' because we believe they make it very clear.

"It has long been recognized that a reduction in the tax rate applied to an economic activity leads to an increase in the taxed activity, thereby offsetting, at least in part, the direct loss in tax revenues resulting from the lower rate.[2] In fact it is even possible that the induced increase in the tax base can dominate, leading to an overall rise in revenue collections. This possibility was popularized by Laffer, who argued that cuts in income tax rates would result in higher tax revenues because of increases in the labor supply, entrepreneurial activity, and the reduced use of tax shelters. Although Laffer's prediction may conceivably hold for very high income tax payers, most analysts agree that income tax cuts do not generate higher revenues from taxing earnings because the elasticity [response] of the labor supply to the after-tax wage is too small."

"Nevertheless, the proposition that high tax rates depress economic activity to the detriment of revenue collection remains a cornerstone of supply-side tax policy and is often raised in policy debates. Recently, a variant of the argument that a cut in income tax rates can improve the revenue situation of the government has gained currency. Whereas the original argument was static, in that it requires a cut in tax rates in a given period to generate a sufficient increase in the tax base of that same period, the new argument is explicitly dynamic, in that it focuses on the effect of a tax cut on the growth rate in the economy and hence on the growth rate of the overall tax base. Higher growth rates resulting from a lower tax rate may lead to higher tax revenues in the future, raising the possibility that a reduction in the current tax rate may nevertheless increase the present discounted value of all future tax revenues. [According to this argument], this is

[2] "Recognition of this can be traced back to Adam Smith."

possible even if the impact on the current tax base is small so that current revenue declines. Taking into account induced changes in the growth rate is sometimes described by budget officials as dynamic scoring."[3]

We believe this definition of 'dynamic' is that most used in the economic literature; however, its use to refer to indirect and unintended consequences of taxes is still common. Thus in this report, we will distinguish between 'static,' as occurring in one period of unspecified length, and 'dynamic,' as having inter-period, or inter-temporal effects built into models. 'Dynamic' models deal with how today's taxes and expenditures affect future household and producer decisions and the future economic growth of a country or region. The complex nature of the inter-temporal decisions makes true dynamic modeling extremely difficult. There will be more discussion of the complexities involving the modeling of the decisions of households and producers in a dynamic setting under the discussion of CGE models.

[3] It should be noted that after developing a dynamic theoretical general equilibrium growth model, one of Bruce and Turnovsky's (1999) key conclusions was that: "A … reduction in the income tax rate is unlikely to improve the long-run fiscal balance. A necessary condition for it to do so is that the inter-temporal elasticity of substitution exceed unity, a value not supported by empirical evidence (p.13)." This is in stark contrast to Ireland (1994) who concludes that a reduction in the marginal rate "… can be the key to both vigorous rates of real growth and long-run government budget balance in the U.S. economy today" (p.570) [as referenced in Agell and Persson (2001)]. Agell and Persson (2001) attempt to show, using a growth model, that Ireland's conclusions are theoretically possible (in contrast to Bruce and Turnovsky), but that they could only apply to countries with extraordinarily high tax rates, such as Sweden and perhaps Finland and Denmark (in contrast to Ireland).

Types of Models

In this section, different types of models are described. This general discussion will be useful as a background and reference when specific models are discussed below

Input-Output Models

Input-output (IO) models were pioneered by Wassily W. Leontief in the early 1950s, however it has been noted that early antecedents of input-output models date back to the 18th century in the writings of Francoise Quesnay (Isard, 1960). Input-output models were extremely useful to the central planners of communist regimes and have become the staple for impact analyses throughout the world.

In a market economy such as the United States, households maximize their utility (well-being) by making decisions about how much to spend and what to buy, subject to their budgets. In turn, their 'budgets' are determined by their market skills and how much they choose to work (the work vs. leisure decision). Similarly, in market economies, the decisions of "What to produce?" "How much to produce?" "How to produce?" and "Where to produce?" are left in the hands of the producers. Acting in their own self-interest (Adam Smith's *Invisible Hand*), producers make these decisions in an attempt to maximize their profits, with the result that production decisions are 'efficient,' i.e., costs are minimized.

In the planned economy of pre-World War Germany, the former Soviet Union, and other communistic governments, central planners determined how/what/where to produce and what items and how much consumers 'needed.' They also decided what government would provide and consume. The planners decided how many shoes to produce, what colors to produce them in, the styles, and the sizes. In addition, they decided how many trucks to build and how many tires those trucks would require each year. In short, the central planners attempted to answer all the 'production' and 'consumption' decisions for every good and service in the economy. One of the difficulties central planners had was attempting to estimate the amount of inputs needed to produce each item, given that those inputs, in turn, had to be produced somewhere in the economy. For example, to produce shoes, the planners had to make sure sufficient leather, thread, and sewing machines were produced. In turn, to produce sewing machines, they needed steel for the housing of the machines and motors; motors, in turn required steel and other metals; and steel production, in turn, needed equipment made of steel, and iron ore and coke. Because steel is needed to produce steel, motors, sewing machines and many other items, the central planners had to determine how much total steel was needed to satisfy all the needs of the economy, both at the final consumer goods stage (e.g., automobiles), at the final government stage (e.g., tanks), and at the intermediate production stage (e.g., sewing machines needed to make leather goods, and motors needed to produce the sewing machines).

Central planners found the IO framework extremely useful. The early versions of IO models began with large square matrices known as the inter-industry 'flow' matrix. Each row represented a producing industry and each column represented a purchasing industry. One of the producing industries is 'households' and one of the purchasing industries is 'households'. This is because households supply their labor as a factor of production and they purchase goods and services from all the other industries. Quite often an industry purchases substantial amounts from itself. Agriculture, for example, produces seed for other farmers to use, produces feed for animals, as well as producing food for direct consumption by households. Similarly, steel uses steel in producing steel. Also, many industries sell to each other. Agriculture sells to food-related manufacturers and steel sells to many different types of manufacturers. These interrelationships are represented in a square input-output flow table. The sum across all the columns represents the total gross output for each industry and the sum across all rows represents the amount of each industry used as inputs. This 'flow' table was then mathematically manipulated in a way that, for a vector of final demands, the input-output model could compute the total amount of output required for each industry, including the amounts needed as inputs. Thus, central planners could determine how many tanks, automobiles, shoes, etc., were required and the input-output framework could tell them how much steel to produce, how many sewing machines to produce, how much leather to produce, etc., in order to meet those final demands. Despite the usefulness of the input-output framework for this type of ‘planning,’ it was only a tool and was certainly not sufficient of a tool to overcome the numerous inadequacies of centrally planned economies. Without pricing mechanisms for both factors of production and final goods, there were persistent shortages and planners made amazingly inefficient production decisions.

Today’s input-output models are very similar in structure to those developed in the 1950s, although many enhancements have been made. They are rarely used for centrally planned economies anymore; rather they have been adapted for use as an extremely important tool for impact analysis – at both the national level and at the regional level.

They were originally developed for use at the national level. Their development for impact analysis of regional economies, such as groups of states, states, counties, or metropolitan areas, came much later. The primary reason for the lag in the development of regional IO models (or any regional models, for that matter) has to do with the availability of regional data. IO models are based on accounting relationships that are more related to national economies than to regional economies. Even at the national level, data requirements are enormous. For example, to build a national input-output model, it is necessary to know:

1) Sales by all industries (including households) to all other industries domestically
2) Imports from outside the nation, by industry
3) Exports, by industry
4) Consumption patterns of households
5) Consumption pattern of governments (what they buy from what industries)

This data is difficult to obtain, even at the national level, even though many of these categories are part of the basic accounting identity for output: Y(national income, or output) = C(consumption)+I(Investment)+G(government)+E(exports)-M(imports). Imports and exports, by industry, are relatively easy to obtain at the national level because of the monitoring of flows of goods, services, and money into and out of the U.S. Similarly, the federal government collects consumption patterns of households using consumer expenditure surveys. However, the actual industry ‘flow’ matrix is not traditionally collected. Economic censuses, for example, do a good job of estimating total output (sales) for each detailed industry. In addition, the economic census may record for certain industries some of their major purchases, such as labor and possibly raw materials. However, the actual flow matrix is not directly derivable from traditional economic censuses. Several times over the last five decades, the Bureau of Labor Statistics (BLS) has estimated flow matrices for the United States. The number of industry classifications reported in these flow matrices differ over time, but typically include about 500 detailed sectors of the U.S. economy.

Regional IO Models

If the type of data needed for national IO models is difficult to obtain, then the data needed for regional IO models are even more difficult to get. The most difficult part of the required data to obtain for regions (sub-national areas) is imports and exports. Because the U.S. is a single country and there are strong restrictions on regions or states establishing boundaries that could interfere with interstate commerce, there is simply no data on the flows of goods and services, by industry, among the 50 states. Hawaii and Alaska may have somewhat better data on imports and exports than the contiguous 48 states because of their remoteness and the necessity of trans-Pacific or trans-Canada shipments.

In the 1970s, regional flow tables and estimates of imports and exports were obtained for regions through long interviews and questionnaires administered to industries (and sometimes consumers) within a particular region. This was an extremely costly approach to building regional input-output models that paralleled the work of the BLS at the national level. Although some regional IO models were built in this manner, developing ‘survey-based’ IO models was simply too costly a process for most states, counties or metropolitan areas to undertake. Also, as Treyz (1993) points out, there may be a great deal of error associated with estimating those flow tables, even with the survey method. Even a modest-sized 50 x 50 table requires 2,500 interindustry coefficients that must be estimated from surveys.

Then some creative academics developed ways of estimating regional flow tables and estimates of commodity flows in and out of the region (imports and exports), i.e., they found ways of estimating a regional 'flow' matrix. The first thing they did was to adapt the national flow tables to regional flow tables by converting the flow tables to a technological table. This technological table is basically the inter-industry flow table converted to a *per dollar basis*. Then, if the region is very similar to the nation, the technological table is applicable to the region. If there are differences in the composition of industries at the regional level from the national level, then the method is to weight each four-digit industry coefficient by its relative importance in the particular industry. Essentially the methodology is to utilize the national technological coefficients (the purchasing relationships among industries) obtained from the national model, although sometimes modifications are made when regions differ substantially from the nation.

Estimation of imports and exports were more difficult. Early on, they used 'location quotients' as indicators of the amount of an industry that is exported or imported. Location quotients identify industries that represent proportionally larger (or smaller) share of the regional economy than the same industry represents of the national economy. Thus, an industry with a 'location quotient' greater than 1 is an industry that has a higher share of the regional economy than the same industry does at the national level; thus the amount of the quotient over 1 represents 'exports' from the region. Similarly, a quotient less than 1 implies that the regional economy produces less of that industry's output than the national figures would imply is needed, so that industry represents an 'input' to the region. Location quotients are very useful descriptive statistics for a region; however, they proved not to be the best method for regional modeling. They tended to underestimate imports and exports because of the problem of 'cross hauling.'

A good example of this is the aspirin example. If a town happens to have a plant that produces aspirin, the location quotient shows that aspirin is an export product for that town, which is true. However, using the location quotient to determine flows in and out of the region results in the implicit assumption that a) every person in that town uses aspirin as their pain killer and b) that every person uses that brand of aspirin. In fact, because economic data are not disaggregated to the 'aspirin' level (instead the data is at a much higher level of aggregation, such as 'pharmaceutical production'), the location quotient assumption is that the only pharmaceuticals used in that town are produced there.

Thus, the location quotient method of determining imports implies that every person in the town uses only the medicine produced at that plant. Once an estimate of how much medicine each person consumes on average (from U.S. data), the remainder is assumed 'exported.' Location quotients made no allowance for people using a wide variety of pharmaceuticals available from throughout the U.S. and the world; that is, they made no allowances for shipments of those pharmaceuticals to be made out of the region and shipments of other pharmaceuticals to be made into the region (i.e., cross hauling was implicitly not permitted).

They solved this problem by estimating Regional Purchasing Coefficients (RPCs). Regional purchase coefficients are estimated for each product and are the proportion of locally consumed product that is supplied locally. Thus, an RPC for pharmaceuticals for the above town would represent the proportion of the total amount of pharmaceuticals consumed in that town that is manufactured by that aspirin facility. This is a concept very different than the location quotient concept because it is related to consumer behavior, rather than simply production behavior. RPCs are defined as:

$$RPC_i = LS_i/D_i = (Q_i \times PS_i)/D_i$$

WHERE

LSi = local supply of the good or service i by the region to itself

Qi = the corresponding total supply in the region in thousands of dollars

PSi = the proportion of output i shipped to destinations within the region

Di = demand in thousands of dollars for good or service i.

Although this is the definition of RPCs, they don't have all right hand side variables for all regions. Therefore, they estimate an equation that relates known RPCs across industries and across regions (on the left-hand side of the equation) to a variety of other data (on the right-hand side of the equation), such as the size of the region, the weight/value ratio of the product, demand variables, industry specific variables and regional specific variables. The only good observations available on flow data is the 1977 Census of Transportation, which contained transportation of goods to as little as 25 miles from point of origin. Once this equation is estimated, the right hand side variables are used to estimate left-hand side RPCs for any region and for any year. Because RPCs are based on transportation data, they are usually not used for non-goods, e.g., health care, personal services, business services. There, location quotients or some enhanced version of location quotients are still used.

IO Models for Impact Assessment

The way that IO models work for impact analysis is that, by changing the final demand for an industry (or group of industries), the input-output framework computes the change in inputs (including labor from households) required for that new final demand. If a proposed new manufacturer is moving into state, the new employment, new wages and/or new output can be entered into an input-output model. Then the model will compute the economic 'impacts' associated with that new firm. That firm will buy inputs within the state in a manner similar to other firms within the same industry in the state. Also, the new firm will pay its workers and those workers will go out and spend their money in the state and generate yet more impacts. The following terminology is associated with IO models.

Direct effects. These are typically what is entered into an IO model and represent the first change in the model. In the above example, the direct effects of the new manufacturer are the new jobs, the new wages, and the new output associated with the new firm.

Indirect effects. These are the effects caused by the inter-industry purchases that are represented by the inter-industry 'flow' matrix described above. When that new manufacturer moves into a state, it is expected to purchase some of its inputs locally. The types of inputs purchased locally and the amount of inputs purchased locally is assumed to be the same as other firms within the same industry grouping. Then the industries that sell to the new manufacturer (known as technically-linked firms) increase their employment, output, and wages.

Induced effects. Employee spending causes induced economic impacts. The employees of the new manufacturing facility and the employees of the technically-linked firms that sell to the manufacturer all spend their money locally. As the new money is spent, additional impacts are generated throughout the economy, although most of the impacts are concentrated in the trade and service industries.

Different 'multipliers' are defined using these different effects.

Type I multipliers = (Direct effects + Indirect effects)/(Direct effects).

Type II multipliers = (Direct effects + Indirect effects + Induced effects)/(Direct effects).

Type I multipliers capture only the inter-industry linkage portion of an IO model. The Type II multipliers capture both the inter-industry impacts and the impacts of the change in consumption due to the change in income in both the direct and technically linked industries.

Using an IO model is generally simple. The model can be used to compute either Type I or Type II multipliers for every sector in the IO framework. It can also be used to assess the impact of an event such as the new firm coming into a community. When the characteristics of the new firm are entered into the IO model, it will generate the total new jobs, total new income, and total new output in the community. These impacts can also be reported by sector, so the user can see which sectors are impacted.

Input-output models have enjoyed widespread use throughout the country over the years. They have been used for all sorts of impact analysis. In addition to the basic framework described above, some enhancements have been made to some models. For example, some input-output models are interregional models in that changes in final demand in one region can affect production in another region. Usually these interregional models are one-directional; that is, a change in activity in Region 1 can affect Region 2 and visa versa, but there is no feedback mechanism, i.e., Region 1 can affect Region 2, but those resulting changes in Region 2 cannot feed back into Region 1.

The level of detail (and therefore, the number of sectors) contained in any IO model varies. It varies according to modeler decisions and also by the size of the region being examined. Generally speaking, the smaller the region (economically speaking), the fewer the number of sectors. This is because as the region size gets smaller, the quality of the data diminishes, data disclosure problems arise and it becomes harder to develop quality data for smaller regions.

Other enhancements include disaggregating government into more than one sector. Rather than government being represented as one 'producer,' it is sometimes represented as several. For example, a model might separate state and local government, or it might separate public education from other government services.

Some models have included several different household income groups into the model so that distributive impacts can be assessed.

Advantages of Input-Output Models

1. IO models are very useful for impact analysis. They are designed to estimate the economy-wide impacts of a change in final demand in any given sector or group of sectors.

2. Input-output models are often quite detailed, containing 500 or more sectors, or categories, of economic activity.

3. With the advancement of computers, large input-output models can be run on most personal computers.

4. They have become quite accessible now, with private firms providing both the data and required software at a very reasonable cost.

5. They are easy to use, requiring only a modest amount of training to run the software and models.

6. Input-output models provide a complete accounting of all monetary flows into, out of, and throughout an economy. Some I-O models include a complete accounting of payments to regional household income, by income group, thus enabling an examination of distribution issues.

7. They are tools that enable the user to quickly conduct certain types of impact analysis. They are particularly useful for assessing the economic impacts of changes in final demands, such as a new firm or an event, such as hosting the World Series.

Disadvantages of Input-Output Models

1. The data is cross-section in nature, so it represents a snapshot in time and is, therefore, not useful for forecasting.

2. IO models are designed to assess the economy-wide effects of a change in final demand. Only changes in final demand can be entered into the model, thus for many impact studies, considerable work must be completed prior to using the model. For example, it is not always immediately clear how a particular tax is going to affect final demand.

3. Input-output models assume perfectly elastic factors of production. This means that there are no supply constraints. If, for example, a model user wanted to assess the impact of a huge manufacturer moving its facilities to a region, the user could input the new number of employees (or

output) into the I-O model and it would provide an estimate of the "impact." The problem is that there may not be enough skilled (or unskilled) workers in a region to accommodate another large manufacturer. If additional factors of production are needed, the I-O model assumes they will be available. Not only will factors always be available, there will be no change in the prices of those factors, either (i.e., wages cannot be 'bid' up in response to the higher demand for labor). Note that when factors of production are assumed to be perfectly elastic (always available, perfectly mobile), the model is usually considered to be a long-run model.

4. Input-output models assume fixed-prices, so price effects must be analyzed outside the model, prior to inputting data into the I-O framework. Thus, tax rate changes that affect prices (e.g., property, sales, gasoline and luxury taxes) cannot be assessed directly with the model. Rather, the tax would have to be converted into a change in final demand prior to inputting into the model. Similarly, if energy prices were to soar as they did in California, the changes in both consumer demand and producer demand for energy would have to be determined outside the model framework. Once the price effects of demand for energy were determined for consumers and for each industry, then those changes in demand would be input into the IO framework for determination of the economic impact.

Computable General Equilibrium (CGE) Models

History

The concept of general equilibrium is generally attributable to Walras (1834-1910), although in his lifetime his work went largely unnoticed (Schumpeter, 1954). General equilibrium is a set of relationships (made mathematically rigorous in the 1920s and 1930s) that determine all prices of goods and services and the returns (wages and rents on capital) on factors of production by clearing markets. Theoretical (mathematical) general equilibrium models have been used to analyze a host of economic questions over the past 60 years or more. These theoretical models have many parameters (constants) in them. These parameters determine the size and the magnitude of the changes being examined in the theoretical models. (We give an example of what we mean by 'parameters' below, in the discussion of theoretical underpinnings.) Although some of the parameters were given reasonable ranges of values (often obtained from the empirical literature) in order to assess the signs of the economic effects being examined, the parameters are usually not assigned specific 'values' in theoretical general equilibrium models.

About 30 years ago, Computable General Equilibrium (CGE) models started to become popular, at least for national economies. CGE models differ from theoretical general equilibrium models in that the parameters are given *numeric values*. (Later we will discuss how these numeric values are determined.) Early CGE models were an attempt to simulate the national economy using the mathematical framework of general equilibrium theoretical models. CGE models consist of a set of theoretical equations designed to determine the economic behavior of a) consumers, b) producers, c) government, d) the rest of the world and to model 1) corporate financial decisions, 2) household financial decisions and 3) government financial decisions.[4] Doing a thorough job modeling any one of these is a major modeling feat.

Theoretical Underpinnings

CGE models begin as theoretical general equilibrium models. Each economic relationship in the economy is represented by an equation. Each equation has to be specified by the model builder. That is, the model builder has to determine which variables enter into each economic relationship/equation (e.g., how many inputs enter into the production functions) and the model builder has to decide on what each equation will look like (i.e., functional form). The model builder has to decide which, if any, government-economic interactions are incorporated into the CGE model. In addition, the model builder has to decide what type of

[4] List is from the Peirier and Shoven, 1988, review paper.

CGE model to develop (long-run vs. short-run, static vs. dynamic). There will be more discussion about these latter issues later in this section of the report.

Unlike an IO model, in which factors of production are utilized in fixed-proportions and prices of inputs don't matter, CGE models have a full-blown theoretical foundation in which everything 'adjusts' to prices. A CGE model may assume that each producing sector is characterized by a Cobb-Douglas production function and that each producing sector uses three inputs: labor, capital and 'other':

(1) $Q = \alpha L^{\beta} K^{\gamma} I^{\delta}$,

where Q=output, L=labor input, K=capital input, I=other inputs, and α, β, γ, and δ are parameters that are determined through 'calibration' (see the discussion under parameterization, below), and $\beta+\gamma+\delta=1$.[5]

Each sector's profit equation is given by:

(2) $P = p\,(Q) - wL - rK - iI$,

Where P is profit, p is the price of the good produced in this sector, Q is output, w is the wage rate of labor used in this sector, r is the rate of return on capital (or rent), i is the rate of return on other inputs.

This profit equation just says that profit is the firm's revenue (price times quantity) minus all its costs. Firms maximize profit, P, by choosing how much it produces, Q, how much labor to use, L, how much capital to use, K, and how much other inputs to use, I. The price of the good, p, is determined within the CGE framework (endogenously), as the price where total supply of this good equates with the total demand for this good. Similarly, the wage rate for each type of labor, w, is determined as the total demand for that type of labor equals the total supply of that type of labor. Similarly, the rate of return on capital is determined by the intersection of the supply of and the demand for capital.

In turn, those endogenously determined prices (p, w, r, I) iterate with the level of production Q and levels of inputs (L, K, I), until an 'equilibrium' is reached. Thus, the prices of the final products, all input prices, output, the amount of inputs L, K and I used in this (and all sectors) are determined endogenously in the CGE model.[6]

Similar theoretical models are used for consumers, where consumers maximize their 'utility,' or well being, by purchasing different items, subject to their household budget constraint.

Sometimes consumption and production are specified with what is known as the Armington assumption, derived from international trade. With the Armington assumption in production, all inputs other than capital and labor (I), are lumped together as a composite 'input.' And while a composite price may affect how much of that composite 'input' is used, the mix of those inputs (including intermediate production goods) is held constant and is typically determined by an IO table. Similarly, the Armington assumption means that consumers are only allowed to choose between 'imports' and 'locally-produced' goods. Once that choice is made, then the mix of consumer spending across industry categories is dictated by a fixed consumption mix, again derived from an IO-based social accounting matrix (e.g., IMPLAN). This assumption simplifies the CGE model structure but limits substitutability among factors to between capital, labor and the composite index. This assumption is sometimes referred to as 'nested' production/consumption functions.

It should be noted that the process is sometimes reversed. Sometimes a Cobb-Douglas consumption function is applied first to determine the mix of expenditures among various categories (cars, food, etc.), then the Armington assumption is applied, which treats imports as imperfect substitutes for domestically produced goods.[7]

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[5] Note that this functional form is the simplest functional form used in economics. There are many other, more complicated functions used for both production and consumption. There are also what are called 'flexible functional forms,' which allows not only parameters to be estimated, but also the functional form itself.

[6] This is in stark contrast to the IO model in which production in each sector is given by $Q = aL + bK + cI$. This is what is known as a fixed-proportion production function, where inputs are always utilized in the same proportion and where prices don't matter.

[7] This is the case in the model for California, DRAM.

When the CGE model simulates, it determines all the prices for goods and services, all the measures of output, all input prices, and so forth, and all those values depend on the values of the parameters, α, β, γ, δ in the production functions (and the consumption functions and a variety of other functions) and on the functional form of the production functions, consumption functions, etc.

CGE modelers must specify the type of production and consumption functions, the inputs that are permitted to enter into the production function, and the consumer goods permitted to enter into the consumption functions. Note also that CGE modelers have to specify the type of market structure in each and every market in the economy. For example, are all product markets perfectly competitive?

This discussion so far has dealt with national CGE models. Regional CGE models are even more difficult to specify because of the issue of inter-regional flows. Not only are regional CGE models burdened with data-related difficulties associated with interregional flows of goods, the theoretical structure of regional CGE models is also burdened by the inter-regional flows of factors of production (labor and capital, in particular). The specification, or assumption, of the interregional mobility of labor and capital is often critical in determining the simulation results of CGE models. These assumptions of interregional mobility are referred to as 'closure rules.'

Closure rules (assumptions, implicit and explicit)

CGE models generally use extreme closure rules. When capital and labor are perfectly mobile, then the model is viewed as 'long-run;' when capital and labor are perfectly immobile, then the model is viewed as 'short-run.'[8] It's unclear which or if either of these extremes is appropriate in predicting economic responses, yet the size of those responses is critically dependent on these closure rules.

Rickman and Treyz (1993) compare the two extreme closure rules, as they apply to the mobility of labor, and REMI (a model, discussed below) closures that are developed econometrically. In the REMI closure, a migration equation is estimated econometrically, which also provides for estimating the speed of the labor supply response. They found that the econometrically determined labor supply responses outperformed both of the extremes that are so commonly used in "pure" CGE models.

Size of Model

CGE models tend to be smaller than most non-survey IO models. Of the 28 regional CGE models reviewed by Partridge and Rickman (1988), the number of producing sectors in each model ranged between 1 and 28 (1 had 28, 1 had 24, 1 had 20, 1 had 15, 2 had 14, 3 had 13, and the rest had 10 or fewer). CGE models tend to be small, at least by IO model standards.

Paucity of Regional CGE models

Of the 27 models reviewed by Partridge and Rickman (1998), 14 of them were multi-regional, modeling at least two regions at once. These are usually multi-regional national models (e.g., a 3-region model of the U.S., 4 region model of the U.S. and Canada, 2-region model of Malaysia, 2 were 2-region models of Canada, 2 were 6-region models of Canada, a 6-region model of Canada with the U.S. added, a 6-region

[8] It is interesting to note that in the CGE literature, the focus on 'short-run' and 'long-run' seems to evolve more around the mobility of labor assumption than the mobility of capital assumption, which is somewhat contradictory to the traditional economic definition of long-run and short-run.

model of Australia, a model of the rural-urban regions of the U.S., a Scotland vs. rest of the UK model, etc.). The number of CGE models appearing in the literature for states were very few:[9]

*California, 28 production sectors, Berck et al. (1996)
California, 14 production sectors, Despotakis and Fisher (1988)
San Joaquin Valley, 14 production sectors, Berck, Robinson, and Goldman (1991)
New York State, 6 production sectors, Hertel (1985) and Hertel and Mount (1985)
California, 24 production sectors, Hoffman, Robinson, and Subramanian (1966)
*California, 10 production sectors, Kimbell and Harrison (1984)
Oklahoma, 9 production sectors, Koh, Schreiner and Shin (1993)
Virginia and rest of the U.S., 5 production sectors, Kraybill, Johnson, and Orden (1992)
Pennsylvania, unknown # of production sectors, Li and Rose (1985)
Plains-Rocky Mountain and rest of the U.S., 7 production sectors, Rickman (1992)
Oregon, 2 production sectors, Waters, Holland, and Weber (1997)

Paucity of CGE modeling papers dealing with Tax/Revenue issues

Of these 11 papers that deal with regional CGE models (state or sub-US regions), only two specifically focus on fiscal analysis (indicated by asterisks). The Berck, et al. (1996) report is related to California's existing DRAM model, which is reviewed in a later section. This model was in response to California's 1994 law requiring that all revenue/fiscal impacts beginning in 1997 include 'dynamic impacts.'

Government interactions with Tax/Fiscal Impacts

According to Partridge and Rickman (1998), most CGE regional models lump regional government together with the federal government, thus making all government expenditures exogenous to the region. There are exceptions to this, however. They cite some studies in which regional government is specified as a producing sector that demands inputs. However, they also note that even these studies typically assume that expenditures on goods and services by regional government are fixed or are proportional to consumer income. As such, the level of taxation does not affect the pattern of final demand expenditures in the region. That is, tax rates can double or be reduced to zero, but there is no consequential effect on government spending.

According to Partridge and Rickman, two exceptions are studies by Waters, Holland and Weber (1997) and Berck, et al. Waters, Holland Weber (1997) "link regional non-school expenditures to tax revenues not allocated to schools, but they do not specify regional government as a separate producing sector with input demands (Partridge and Rickman, 1998)." Berck, et al (1996), "lump state tax revenues into three funds which are linked to six categories of expenditure flows."

Thus, these two studies consider the distortionary side of taxes on household and firm behavior and the expenditure side of revenues. However, they and most other regional CGE models usually ignore the locational effects of government expenditures. The one exception to this is DRAM, a model reviewed below. DRAM incorporates relative taxes into its migration equation and its investment equation. REMI, a hybrid model, also incorporates taxes into its capital and migration flow equations. To our knowledge, no fiscal CGE models deal with the productivity effects of government expenditures.

There have been academic studies that examine specific parts of the government-economic interactions discussed above. For example, Deepak, West and Spreen (2001) examine investment in human capital and public infrastructure in a hypothetical regional CGE model (not calibrated for any particular region), Pecorino

[9] Not all of these papers were specifically reviewed by the current authors, although full references for these papers are included at the end of the report. They are listed because they are state CGE models.

(1995), and Capolupo (2000) examine human capital investment, growth and taxation issues. Other CGE models have examined education productivity issues for under-developed countries (e.g., Matovu, 2000).

Data Requirements

Data requirements for CGE models are enormous, requiring the same type of data as IO models (i.e., interregional flow data, inter-industry purchasing data, inter-institutional flow data, consumption patterns) and much more. While both IO and CGE models utilize a social accounting matrix that accounts for all flows within an economy, some CGE models have the added complication of needing prices for every good, every service, every production input (e.g., producer equipment), and wages in every sector. Although the inclusion of prices significantly improves CGE models' ability to adapt to exogenous changes in the economy, such as tax rate changes, it also substantially increases the data requirements for building a CGE model.

Date requirements are one reason, we believe, that CGE models tend to be substantially smaller than IO models and some econometric models. Note that some CGE models use purchased social accounting matrices from commercially available IO models (for example, IMPLAN, described below) as primary databases (see Partridge and Rickman, 1998, for discussion and Waters, Holland and Weber, 1997, for an example). The IO social accounting matrix is then aggregated to conform to the dimensions of the CGE model and combined with price (and other necessary) data to develop the one-period of data required to 'calibrate' the parameters in a CGE model.

Because much of the data for regional (and national, for that matter) CGE models are not regularly collected by traditional data agencies, e.g., Bureau of Labor Statistics, Bureau of the Census, Bureau of Economic Analysis, it has to be 'created' or estimated in some way. We went into a little detail of what that entails in the IO framework. It is only worse for CGE models.

Parameterization

Parameterization refers to assigning values to all the parameters specified within the CGE framework. All of the α, β, γ, and δs in each of the production functions must have numeric values assigned to them. This is also true for IO models, but it is usually assumed that the general production process for a product is the same for a particular region as it is for the nation; so regional IO models use technical coefficients from the national models, aggregated to suit the regional economy.

One reason Cobb-Douglas functions are popular in CGE frameworks is that the parameters β, γ, and δ can be estimated directly from IO 'flow' matrices. That is, if profit is maximized in a Cobb-Douglas production function, $\beta = wL$, $\gamma = rK$, $\delta = iI$, where wL is the share of expenditure going to labor, rK is the sharing going to capital, and iI is the share going to other inputs. These shares are obtained for CGE models by aggregating IO flow matrices. Other functional forms can require substantially more information.

Parameters are assigned values in different ways in a CGE model. Borrowing parameters from IO matrices is common. Sometimes certain elasticities (the β, γ, and δs in the above production function or their counterparts in consumption functions) are obtained from elsewhere in the empirical literature. The problem with this is that if those elasticities taken from partial-equilibrium studies, then certain 'dynamic' effects may already be included in those estimates. For example, if a price elasticity was estimated using time series tax base data for Arizona, the estimated elasticity could already include certain types of 'dynamic' effects, so those elasticities would be inconsistent with the CGE framework, which is supposed to start with 'true' elasticities (e.g., actual consumer response to a price) and then compute the dynamic effects. Another problem with this is that there are often contradictory estimates of key elasticities in the literature.

However the parameters are selected, the CGE model is ultimately 'calibrated' using a single year of data. This involves a) simulating the model twice, first maximizing some value (e.g., total state personal income, then minimizing that value, b) 'fixing' or 'setting' a parameter. Steps a) and b) are repeated until the maximum and minimum values of the solutions are identical, given some level of tolerance, e.g., 0.00001. Thus, they sequentially 'fix' parameters until they find the set of parameters that best fit the single-year of data. "Considerable debate exists in the national CGE modeling literature … regarding the appropriateness of calibrating CGE models to a benchmark year data set. (Partridge and Rickman, 1998, p.228)." It is argued that reliance on one-year's worth of data is 'under-identified.' This means that there is too little data to assign values to too many parameters, making the resulting calibrations unreliable.

Some have suggested system-wide econometric estimation of a CGE model. This solution is extremely impractical, however, because it would require developing time-series data for each of the variables in the model, which increases the data requirements many fold. In econometric estimation, you need more data observations than the number of 'parameters' you are estimating. The difference between data observations and the number of parameters is called 'degrees of freedom.' You can increase the degrees of freedom by incorporating restrictions among the parameters to be estimated (e.g., $\beta+\gamma+\delta=1$), but even with within-equation restrictions and across-equation restrictions on coefficients, it would be extremely expensive to collect sufficient data to do a system-wide econometric estimation of a CGE model. These problems are difficult at the national level; they are much worse at the regional level, where regional data on price and quantity are even scarcer.

As noted by Partridge and Rickman (1998), there is a real lack of understanding of how sensitive CGE simulation results are to the selection/calibration of the parameters in the model. They strongly argue for more research on this point. West and Deepak (2001) take the challenge and demonstrate clearly that the simulation results in their model regarding tax policy and human capital investment (Deepak, West and Spreen, 2001) are dependent on "(1) linkage of the regional economy to the external economy via income retentions (imports vs. the consumption of locally produced goods), (2) specifications of public/private-sector interaction, and (3) labor market closure assumptions."

Dynamic

In a static model, households maximize their 'utility,' or welfare by choosing between leisure and work, by making consumption choices within their budget (which in turn is affected by how much they work), and can shift from taxable to non-taxable items, etc. In contrast, 'dynamic' deals with inter-temporal issues, which are much more complex than simply incorporating time into a model. In a *dynamic* model of household behavior, consumers maximize their lifelong utility, subject to a lifetime inter-temporal budget constraint that equalizes the *present value* of consumer income and expenditure. In the dynamic model, consumers choose between consumption today and consumption over their entire lifetimes. Consumers invest today so they may consume at some point into the future. Households may choose to invest today so they can make bequests to their children in the future.

While 'dynamic' consumer theory tends to be well established, 'dynamic' production theory is much less so. As a result, most models that say they are 'dynamic' do not include dynamic production specifications in their models. "One reason that production-side dynamics has been more slowly adopted than consumption dynamics is the dearth of accepted theories concerning the dynamic behavior of firms. …[D]ynamic production and investment behavior are induced by the existence of capital adjustment costs, [which are] designed to capture both the incomplete mobility of capital across industries and the installation costs of capital (i.e., the costs of adjusting capital toward its optimal level). … With a dynamic formulation induced by adjustment costs, real investment decisions are forward looking, and investment is endogenously and optimally determined by firms. (Pereira and Shoven, 1988, p.416.)."

A true dynamic model is one that incorporates these much more complex 'behavioral' specifications than simply creating a series of 'static' models. Very few 'true' 'dynamic' models exist because 1) they are extremely difficult to specify, 2) there is not a consensus in the economic theory regarding what those specifications should look like, and 3) as complexities of the models increase, so do the difficulties associated with parameterization.

In a dynamic setting, the CGE model must now be calibrated to a 'growth path,' usually an assumed growth path, not just one year of data. The problem with this is that since a balanced growth path is not likely in reality, then the validity of such a model for dynamic policy analysis comes into question. Sometimes a time path is established by doing a sequencing of equilibria. In the first 'period,' the market clearing equilibrium is calculated, given existing supplies of capital and labor. Then supplies of capital and labor are updated using external, sometimes econometric equations, and a new market equilibrium is calculated. "The sequence of equilibria gives a time path of the economy. Yet, the timing of factor augmentation is often arbitrarily set, and equilibrium is assumed to occur in each period, rather than being empirically established (Partridge and Rickman, 1998)."

Advantages of CGE models

1. Like IO models, they take into account all flows in the economy.
2. The specifications are extremely flexible, so that the model builder can include any production function, any 'closure rules,' or any government-economic interaction.
3. They incorporate price effects into the models, which is important in assessing tax impacts, although the 'nested' consumption function limits the ability of price impacts to play a role.
4. They can provide interesting insights to the workings of an economy.
5. They can compute the economic feedbacks of tax and revenue changes on a regional economy.
6. CGE models incorporate many aspects of economic theory.

Disadvantages of CGE models

1. They are not useful for forecasting. They are calibrated at one point in time, the base year.
2. While they can provide an estimate of the economic impact of a revenue change, there is usually no time context associated with that impact. Most are not monthly, quarterly, or annual, as we are used to seeing in the forecasting context.
3. The models tend to be much more aggregated (fewer sectors), when compared to IO models.
4. Assumptions (explicit and implicit) and which government tax/expenditure feedbacks are incorporated into the model can determine the outcomes of fiscal impact simulations. Examples of assumptions include the closure rules discussed above.
5. Some parameters are typically determined by assumption.
6. Calibration can be done for any base year, but the resulting parameters may not be 'truth.'
7. Calibration is merely assigning values that fit the data. This is very different from the use of econometric statistical methods that have a whole assortment of statistical tests that can be used to test the validity of each variable in an equation and the validity of each equation in a model. No such statistical tests exist for numbers determined by 'calibration.'
8. Because much of the data required for CGE models are not available from traditional sources, e.g., Bureau of Labor Statistics, Bureau of the Census, Bureau of Economic Analysis, much of the data is 'created' or estimated in some fashion.
9. The results of CGE models are sensitive to a) the structure, specification of the model, b) to the calibration of the parameters, c) to the specification of the 'closure rules,' and d) to the base-year selected for calibration and the quality of the data 'created' for that base year.
10. They can be difficult to use, depending on which software is used to 'calibrate' the model and which software is used to simulate the model.

11. They can be extremely expensive to build or purchase.
12. While theoretically sound and perhaps an advancement in regional economic analysis, it is not clear how accurate they are quantitatively.
13. There is no consensus among economists as to which assumptions to build into CGE models, e.g., closure rules regarding factor mobility.

Econometric Models

Econometric models, like IO and CGE models, are collections of equations designed to represent economic relationships within an economy. This set of equations can be highly simultaneous, like CGE models, in that the values of many different economic measures are determined endogenously and contemporaneously. One important difference between econometric models, on the one hand, and IO models and CGE models on the other, has to do with the type of data used, and the statistical methods used to estimate parameters. These and other issues will be discussed in more detail below.

History

Econometric models were initially built for national economies. Early econometric models followed the traditional formula for national income: Y(income) = C(consumption) + I(investment) + G(government) + E(exports) - M(imports). One or many equations were estimated for each of these categories and added up to provide national forecasts and provide a framework to examine changes in national forecasts by changing various exogenous variables. At the national level, data is available for each category in this basic relationship.

Early regional econometric models attempted to follow this structure (Lawrence Klein, 1969), but as discussed before, data for several of these categories don't exist at the regional level. As a result, most regional econometric models focused more on modeling variables that were measured well and of interest to users of regional data, such as employment, unemployment rate, regional income, etc. To a large extent, the design of regional econometric methods apply regional economic theory to available secondary data, e.g., data from the Bureau of Labor Statistics, the Bureau of the Census, the Bureau of Economic Analysis. Regional data from these agencies are based on special surveys, sample interviews, etc. and are considered reliable sources for regional data. While heavy reliance on available data sources can be labeled as a criticism of econometric models, so can the extreme data constructions (making up what's needed) of IO and CGE models.

Theoretical Underpinnings

The economic theory underlying regional econometric models is similar to that used to build CGE models. For example, a number of econometric models have attempted to use time series data to directly estimate the production functions given by equation (1) in the CGE section. Unfortunately, output measures are often not available on a time series basis. Note that output, as formulated in equation (1) is for actual physical output (e.g., numbers of shoes, numbers of computer components, etc.). Thus, actual output measure is rarely available. Output, by sector, is sometimes estimated by deflating sales, by sector, using an appropriate price index. The problem is that sales for many sectors are only available for economic census years (years ending in 2 and 7), so developing time series from this data may be difficult. Tax base information, e.g., retail taxable sales categories, makes useful 'output' measures; however there are usually very few of these series available. Some econometric modelers approximated 'output' by sharing down national output (sales) measures to create state-level or regional data between census years (Kendrick and Jaycox, 1965). Sometimes County Business Patterns are helpful in filling in the gaps. Some econometric modelers were uneasy about estimating equations designed to explain 'output' when those output measures were, themselves, constructed.

Consider the Cobb-Douglas production function in the section on CGE models. In that example, the producer maximizes profits (P) by selecting Q, K, and L. Under competitive assumptions, the producer cannot select the price (p) for his goods. If a little calculus is applied, the result is a 'derived demand' for labor that looks like:

(3) $L = \alpha Q^{\beta_1} w^{\beta_2} r^{\beta_3} i^{\beta_3}$

In other words, the derived demand for labor is a 'multiplicative' function of output (Q), and all the input prices, w, r, and i. When there are only two inputs, say labor and capital, the resulting 'derived demand' equation is simpler:

(4) $L = \alpha Q^{\beta_1} (w/r)^{\beta_2}$

That is, when there are only two inputs, the 'derived demand' for labor includes output (Q) and the *relative price* of labor and capital (w/r). Note that the level of capital doesn't appear in the 'derived demand' equations for labor.

Although there are statistical methods that can estimate the parameters (α, β_1, and β_2) in non-linear equations, such as this one for labor demand, there is a straightforward way to make equations of this form linear. If we take the logarithm of both sides of equation (4), it becomes:

(5) $\ln L = \ln\alpha + \beta_1 \ln Q + \beta_2 \ln(w/r)$

The advantage of this version of the labor demand equation is that it is now linear and a simple statistical method, Ordinary Least Squares (OLS) can be used to estimate the three parameters. An econometric model is made up of a whole set of estimated equations similar to (4) and a set of identities summing up components to get important totals (e.g., the sum of the components of personal income, such as labor income, proprietors income, etc.). Each equation represents an important relationship in the economic system of the region.

The econometric model builder typically doesn't have reliable regional time series data for capital (K), rates of return on capital (rents, r) and reliable time series data for output (Q) exist only some of the time. However, time series data for regional labor demand (L), i.e., employment, and regional wage rates (w) are available. Data on prices (p) for some sectors are available and usually some producer price indices exist that can be used for other input prices (i). Because of the availability of data, this derived demand equation for labor is usually estimated, rather than attempting to model output directly (Bolton, 1985). When output (sales) measures aren't available at all, modelers substitute determinants of the demand (e.g., real regional income, or population and real per capital real regional income) for the product/factor as proxies for 'output.'

Regional wages are assumed to change generally with national wage rates. After all, some labor markets compete nationally (e.g., professors, engineers) and all regions share the minimum wage. However, the wage rate differs region by region from the national average, thus the wage equations also include variables designed to capture differences between the regional labor market and the national labor market, e.g., relative job opportunity growth or relative unemployment as indicators of market tightness, etc.

National Models

Most regional econometric models are attached to a national model. The reason for this is that most regional models are designed for forecasting so it is imperative to have forecasts of interest rates, the national business cycle, etc. Note that by linking a regional model to a national model does not mean that the regional forecasts will exactly follow the pattern of the U.S. In fact, the goal of a regional econometric forecasting model is to make use of differences in industry structure, wage structure, population composition, etc., to assure that the regional forecast represents the region, not the nation. At times, regional econometric forecasting models have been criticized because of the need to utilize national forecasts, because if the national forecasts are off, so are the regional model forecasts. This is only partly true. The regional modeler usually has *choices* regarding which national forecasts to use (pessimistic vs. optimistic), so there is the ability on the part of the regional modeler to ‘control’ the national forecasts. But more importantly, the error in regional forecasts associated with errors of the national model forecasts (known as exogenous variable error) is relatively small. The largest source of error in regional econometric models is associated with instability of the estimated coefficients from one estimation period to the next (Charney and Taylor, 1984).

Econometric Models Designed for Impact Analysis

So far, we have discussed econometric models primarily from a forecasting perspective. However, it must be noted that econometric models can be designed and built for impact analysis, as well. Econometric models can be large (over 1,000 equations) or small. They can be designed for one region or they can be multiregional. If they are multiregional, they may incorporate interregional linkages (Charney and Taylor, 1986). They can have IO models embedded in their structure (e.g., DRI-WEFA’s national level), they can have supply-side characteristics (such as capital and investment), they almost always include migration equations, they can have detailed government sectors, and they can be designed for revenue feedback impact analysis. There is no reason why an econometric model can’t be designed to account for all flows into and out of a region.

There are important trade-offs that usually have to be made between econometric models designed for forecasting and those designed for impact analysis. The most sophisticated econometric model designed for forecasting may not yield reliable impact estimates. In addition, the complexities in an impact model may make it extremely difficult and expensive to update often, which is necessary for a forecasting model (i.e., it is important to have an accurate ‘start point’). Forecasting models tend to be smaller than models designed for impact analysis and they tend to be short-run, demand-determined models designed to capture the business cycle.

From a modeling viewpoint, there are econometric models that are useful for impact analysis, but it is unlikely there will ever be CGE or IO models that are useful for forecasting. Econometric models can do both, depending on the design. There is little difference between a detailed econometric model designed for impact analysis and a CGE model in which every parameter is estimated econometrically.

After reviewing both CGE and econometric models, we believe the econometric framework may be the more useful because of the ease with which dynamic effects can be incorporated and the resulting time-path of impacts that is created. Also, there are econometric software programs that incorporate database management, estimation, model simulation, and impact analysis into one framework, e.g., AREMOS.

Dynamics

Almost all econometric models are ‘dynamic’ in some sense. Inter-temporal effects are incorporated into econometric models by using lagged variables on the right-hand side of equations. These lagged variables are used when a) economic theory dictates, b) when there are structural reasons (e.g., the lag between tax liability accruing and when taxes are paid), or c) when lags are absolutely necessary to make the equation represent the history of the data. These lags create time-dependent, dynamic responses. If lags are over utilized in regional forecasting models, the model forecasts become unresponsive to exogenous changes, such as fluctuations in the national business cycle.

Government-Private Sector Interactions

It is clear from equation (5), that prices play an extremely important role in most econometric models. In fact, the estimation of the price effect of a tax change is most easily handled in an econometric framework. In the example above concerning cigarette consumption, a time series on cigarette consumption (or tax revenues from cigarettes and knowledge of the historical changes in the tax rates), an econometric equation can be devised that computes the price response of consumers to a change in the cigarette tax. If the modeler has good price data on whatever is being modeled, then price responses can usually be estimated.

Unfortunately, statistical methods can sometimes result in an estimated price response of zero. This can occur because the price series doesn't adequately match the consumption data (e.g., the modeler wants to estimate an equation for food prepared at home, but the only price variable available is for all food consumption). Alternatively, a zero price response can occur because prices (inclusive of taxes) haven't fluctuated sufficiently over time to capture a price effect. This occurred back in the mid-70s when the US was suddenly faced with an oil embargo. Economists all over the country were attempting to estimate fuel demand equations and the corresponding behavioral response associated with the dramatic increase in prices. The problem was that prices had historically been so stable, that the demand equation for fuel usually ended up with a price response of zero. Today there is little problem in estimating a price response associated with fuel, because fuel prices have fluctuated often over the time-period that would be used for estimation. Sometimes, states will borrow price elasticities from the literature (Haas and Knittel, 1998), but they are not always readily available and must be estimated.

Government expenditures are usually not incorporated into econometric forecasting models, although they have been incorporated into models designed for impact analysis (Charney and Taylor, 1986). The model built by Charney and Taylor also incorporated revenue sharing formulas and modeled state and federal income taxes as interacting through mutual deductions. Locational effects of taxes on public taxes and/or growth are sometimes (but rarely) incorporated into econometric frameworks (Friedlaender, Treyz and Tresch, 1975, was a major exception and predecessor to REMI, discussed below). Public infrastructure and investment in human capital have not been incorporated into econometric models, to our knowledge.

Data Requirements

Data requirements for econometric models designed for forecasting are generally less than for IO and CGE models; however, econometric models designed for impact analysis can be as large, complex, and as data demanding as any other type of model.

Parameterization

A major advantage, in our view, that econometric models have over CGE models is the way the parameters are estimated. As discussed above, most CGE models assign values to the parameters through a 'calibration' process. The calibration method step searches through values of parameters until it 'fits' the data. Recall that there is only one period's worth of data and it is not difficult to 'fit' one period of data. This process has been criticized because, in statistical lingo, it is under-identified. That is, there is not sufficient information to be sure the estimated parameters are correct. There are no formal statistical tests that can be used to determine whether the calibrated values are accurate. In addition, when a CGE model is updated with a new base year, there is no guarantee that the new calibrated values will closely approximate the values from the previous base year. Thus, the calibrated parameters in CGE models can be very unstable between base years.

Econometric models use widely accepted statistical regression methods. Because they use time-series data, there are many observations (typically 20-30 in an annual estimation, 80-120 in a quarterly estimation) available for estimating parameters. Thus, while stability of estimated coefficients is of a concern in econometric models (Charney and Taylor, 1986), it is a relatively small problem when compared to CGE calibration.

A major advantage of using time-series data and statistical regression methods is that each equation can be evaluated using those statistics, e.g., how well does the equation fit the time series, how much of the variation in the time-series data is explained by the model, is the model statistically 'significant?' In addition, each variable in an equation can be evaluated for its contribution to the equation, e.g., does a particular right-hand side variable help explain the variation of the left-hand side variable, does the size of the estimated coefficient on that variable (the behavioral response) make sense and is it consistent with economic theory?

Advantages of Econometric Models

1. Extremely useful for forecasting because the model is estimated using time-series data.
2. Parameters in the models are estimated using formal statistical methods, which permit evaluation of the statistical significance of each variable in an equation and of the statistical significance of each equation. Computed standard errors measure how well each equation fits observed data.
3. Can be useful for tax impact analysis, but its usefulness depends on how many IO relationships and tax policy variables are incorporated into the model.
4. Almost all econometric models are 'dynamic' in the sense that changes today affect all the other economic terms in the future.
5. Because there is a time-dimension in econometric models, they can be used to predict changes over time on an annual, quarterly, or even monthly basis.
6. Labor supply is usually determined with a net migration equation, thus avoiding either of the extreme assumptions of no mobility or instantaneous and complete mobility of labor that exists in many CGE models.
7. Time paths of economic impacts can be computed easily with an econometric model.
8. They are usually short-run, demand-driven, designed to predict the business cycle.

Disadvantages of Econometric Models

1. Structure usually does not fully account for all flows within a regional economy, as does an IO and CGE model.
2. More econometric models are designed for forecasting, rather than impact analysis, although literally any structure can be incorporated into an econometric model framework.
3. Forecasting models have to be run in conjunction with a national model to obtain values for many of the exogenous variables in the model. Note that CGE models also assume some things are exogenous to the model, e.g., national interest rates. Most CGE models don't need a forecast of those variables because there is no time dimension.
4. Forecasting econometric models are usually short-term, demand-driven models designed to predict the business cycle.
5. Care must be taken to assure stable coefficients when models are re-estimated, but this problem is probably less than the problems of recalibrating a CGE model to a new base year.

Concluding Remarks Regarding Types of Models

This has been a general discussion of the three major model types that are available for impact analysis. There are some overlaps among different types of models, depending on model design. Some econometric models have CGE characteristics, while others are specified on more of an ad hoc basis. Some econometric models have IO models embedded in the framework, such as the national DRI-WEFA forecasting model. Some CGE models are parameterized by borrowing econometrically estimated relations from the economic literature, while others make heavy use of IO industrial 'flow' matrix from IO models to establish expenditure shares on goods and services and/or the use of intermediate goods in production functions.

Specific Models

IMPLAN (IMpact analysis for PLANning)

The IMPLAN system performs regional input-output analysis. The system has been in existence since 1979 and is now available for microcomputers.

The IMPLAN system can be thought of as consisting of two parts: IMPLAN Pro and IMPLAN data sets. IMPLAN Pro is the software that creates and runs the regional IO models and is purchased separately from the data sets. IMPLAN data sets are available for purchase for each state (which also includes all the counties within that state) or, for very small regions, any grouping of zip codes the user specifies. A set of U.S. data files accompanies the state (and other) data sets. Once installed, the user can ask IMPLAN Pro software to 'build' an IO model using a selected data set (e.g., the whole state or a specific county). Then the user can use the same software to conduct impact analysis with that model or create a set of standard reports, such as IMPLAN multipliers, by sector, for the region.

The following is a direct quote of its capabilities: "At each state of the model building process, reports can be generated which contain information about your model's market structure and industry interrelationships. Once you have generated a regional I/O model, you can perform impact analysis with that model. New industries can be introduced for "shock" value to the regional economy, industries can be removed to see the impact on regional employment and income, and reports can be generated to show the consequences of various other economic changes. With Micro IMPLAN's [MI] impact analysis capabilities, you can create multiple scenarios for each model to simulate many possibilities. Micro IMPLAN includes its own file management utilities so that you can manipulate the many types of files that are created by MI, plus manage the input data files and data files directories.

For most large regions (state and large metropolitan areas), the IMPLAN model will have 528 sectors. There are 27 sectors related to agriculture, 20 related to mining and energy extraction, 7 related to construction (including highways and street and government facilities) and repair, 385 manufacturing sectors, 8 transportation sectors, 5 communication and utility sectors, 9 wholesale and retail sectors, 7 sectors dealing with finance, insurance and real estate, 20 service sectors (including hotels and lodging places, a couple of business services, automobile services such as leasing), 7 amusement type services (bowling alleys, motion picture theaters,…), 4 medical service categories, 1 sector for legal services, 5 sectors for education at different levels and job training and child day care services, 3 sectors for social services, residential care and other nonprofit organizations, 3 sectors for business, labor, civic and religious organizations, 4 sectors for professional services, such as architectural engineering, accounting, management and research services, 3 state and local government enterprise sectors (for example, state and local utilities), 5 federal government categories, 2 state and local government categories, some miscellaneous categories, such as scrap, used and second hand goods, and domestic services.

IMPLAN databases would include all 528 sectors for all states and large counties. However, for smaller counties the numbers of available sectors diminishes with the economic size of the region. This is because regional data is extremely difficult to obtain and for very small regions, sectors have to be grouped because of concerns over confidentiality of data for sectors with just one or a few firms.

In addition to computing the Type I and Type II multipliers described in the general IO discussion, IMPLAN also computes a 'Type III' multiplier. The term Type III was originally introduced by Mierynk (1967), in which he argued that consumers do not spend *an additional dollar* in the same say they spend all their other dollars. Rather, the consumption pattern of the *marginal*, or incremental, income associated with a better job, for example, would be different than their *average* consumption pattern. Although they reference Miernyk, his concept is not what is used in IMPLAN Type III multipliers. Rather, IMPLAN's Type III multiplier takes total jobs from the Type I multiplier (Direct + Indirect jobs) and then multiplies these jobs by a constant factor to get the induced jobs. Thus the ratio of Type III employment divided by Type I employment is always a constant. The consequence of this is that the induced impact (the impact that is supposed to represent the spending of employees) of a shock to the economy is completely unrelated to the wages in the directly impacted sector. Thus, the estimated Type III induced impacts of an increase of 100 engineers would be the same as the induced impacts of 100 new telemarketing employees, despite the fact that engineers earn 3-4 times that of a telemarketing employee. This of course assumes that the indirect effects of engineers and telemarketers are similar (Charney and Leones, 1997). We recommend ignoring IMPLAN's Type III multipliers and using their Type II.

Similar to most other IO models, IMPLAN RPCs are derived from 1977 Multiregional Input-Output Accounts, which is based on the 1977 Census of Transportation (Alward and Despotakis, 1988).

SAM (Social Accounting Matrix) Framework

In addition to the basic IO framework described in the IO modeling section above, IMPLAN has an extended framework, known as the SAM framework. The SAM framework is a natural outgrowth of input/output accounting, extending the market-based transactions accounting to non-market financial flows. Mainly, the SAM framework introduces inter-institutional transfers into the traditional IO framework. Inter-institutional transfers capture payments of taxes by individuals and businesses, transfers of government funds to people and businesses and transfer of funds from people to people.

The SAM extension eliminates "two shortcomings of the IO accounting structure, inconsistent classification between household income and consumption and the lack of correction from 'place of work' to 'place of residence' (Alward and Lindall, 1996)." Also, they point out that the Type II multiplier limits the induced component of the multiplier model to household spending only. Arguments can be made, they say, that other institutions should be included in the induced component, such as parts or all of government operations. Expanding the multiplier definitions to accommodate these institutions as desired would result in the derivation of any of several Type n multipliers depending on which institutions are included. Thus, the SAM formulation solves the problems described above, but the SAM multipliers do not include all those inter-institutional transfers. In addition, they describe the SAM multiplier as "brain-dead" because it lacks "an appealing attribute for examining changes in the size distribution of income (Alward and Lindall, 1996)." "Only with the addition of transition sub-matrices to link sectoral factor incomes to institutions could the deficiency be overcome (Alward and Lindall, 1996)." We take this to mean that the SAM multipliers are missing important linkages between households (and household income) and the institutions in the social accounting matrix.

We also used IMPLAN to build a traditional IO model and a SAM IO model and ran the multipliers. The SAM multipliers were consistently smaller than the Type II multipliers from the traditional model. At first this didn't make sense because, if the flows through the institutions were counted, our expectations were that the SAM multipliers would be somewhat higher. On further inspection, we believe that the SAM multipliers are smaller than the Type II models because some money is siphoned off from households to institutions, but not all institution flows enter back into the system.

IMPLAN can be used to produce Tax Impact Reports from the Social Accounts from SAM. A major problem with their tax reports for use in tax impact assessment is that of aggregation. In SAM, no matter what tax is increased (sales, income, luxury, etc), the estimated business taxes for all these taxes would have the same distribution as in the base-year data base. Thus, no matter what tax is changed, IMPLAN distributes X% of it to the sales tax, Y% to the income tax, Z% to the motor vehicle tax, and so forth, where X%, Y% and Z% are the shares from the year the model was calibrated. Similarly, if the IMPLAN SAM structure were used to assess a change in tourism, for example, the estimated revenue impacts would again be distributed according to base-year data, even though tourism would impact the hotel/motel tax, the restaurant and bar portion of the sales tax, etc. (Olson, 1999). Thus, we believe the Tax Impact Reports generated from IMPLAN have little or no use in conducting tax impacts.

IMPLAN models can be used for tax analysis but with some difficulty. First, a tax change would have to be converted to a change in final demand, by sector. There is a way to enter a reduction in all consumer spending, which automatically reduces all sectors proportionally to the pattern of consumption. In fact, IMPLAN has seven household sectors, so an impact analysis of an income tax change could be undertaken. For a change in the sales tax, final demand in each taxable sector would have to be adjusted by some dollar amount. That dollar amount would have to have tax price effects already computed and the dollar amounts would have to be distributed across all sectors in a proportional fashion. Then the dynamic economic effects could be observed. Once this is complete, the economic impacts would have to be converted back somehow into revenues (using some average revenue/sales ratios), to get the revenue dynamic feedbacks.

TRAIN and Dynamic TRAIN (Tax Revenue Analysis in Nebraska)

TRAIN is a CGE model that is based on microeconomic theory. It is custom built specifically for Nebraska. The Legislative Council of the State of Nebraska contracted with the University of Nebraska to build the model. Thus, it is not commercially available.[10]

TRAIN has 1,300 equations representing 26 industrial sectors, 2 factor (capital and labor) sectors, an investment sector, 9 household sectors, 33 government sectors and a rest of the world sectors. As a custom built model, its tax structure is specifically designed to represent the Nebraska tax system. We presumed that with 33 government sectors, that tax rates themselves could be manipulated, rather than having to enter a tax-dollar change. This would be an important advantage for a custom built model when compared to an 'off the shelf' model. Even in TRAIN, however, the tax structure has been substantially simplified. For example, the model builders do not incorporate all the details of the income tax structure, with exemptions, deductions, etc.; rather, they determine taxes on new incomes by assuming that "new incomes in households are taxed at effective marginal rates." It is not at all clear from the write-up that we have for TRAIN that the price effects associated with tax changes (described earlier in this report) would automatically be dealt with. In their simulations, they enter all tax policy changes as dollar amounts, rather than changes in tax rates.

TRAIN builders describe TRAIN as a 'long-run' model "in the sense that changes or shocks to the system of equations are assumed to take "5 or 6 years" to work completely through the model. In fact, there is no time-dimension in TRAIN or most other CGE models. The model builders actually have no idea how long it takes for shocks to work through the system, although they recognize that it does not occur instantaneously. Impacts are determined by comparing the initial equilibrium state of the economy with the final equilibrium state. In CGE vocabulary, this is a 'static' model, despite the fact that it computes a wide variety of tax/revenue impacts and measures the tax-economic interactions in the economy. Because they describe it as "long-run," then we presume that labor and capital are mobile, although precise descriptions of the model were not available for review.

It is interesting to note that the model builders/authors of TRAIN do not recommend using TRAIN for impacts associated to specific firms; rather, they recommend using IMPLAN. We are not sure why they would state this as a TRAIN limitation, but we conjecture it is because 26 industrial sectors is too aggregated to represent an individual firm, whereas IMPLAN has 528 sectors in their state-wide models.

Another major advantage of a custom built model, like TRAIN, is that every parameter and every equation within the model can be modified. Complexities can be added when required and models can be adapted over time, as needs change, as the tax structure changes, etc. Of course, a major disadvantage of a custom built model is that all data must be updated by the users or contracted out. There are huge economies of scale to data updating and maintenance of databases; thus the maintenance costs of custom built CGE models are expected to be higher than that for 'off the shelf' models.

[10] This discussion borrows heavily from a well-written short description of the model obtained from the Legislative Council of the State of Nebraska.

From the write-up of TRAIN, it is not clear whether any of the public-private sector interactions are in the model, other than the short-run effects of taxes on households and firms. We do not believe they are.

Dynamic TRAIN

Recognizing the need for year-by-year impacts, the model builders of TRAIN took on the task of building a dynamic version of TRAIN. Note that not all 'dynamic' models can produce a time path of impact, but Dynamic TRAIN was designed to do this.

It assumes a 'myopic' expectation about future events in the sense that when households/producers make decisions, i.e., they do not take future events into account. In other words, Dynamic TRAIN is designed to produce a time path of impact, but it is not truly dynamic in the sense described above under CGE models. Rather, the equilibria in any sequence are connected to each other through capital accumulation, labor migration, and population changes. Dynamic TRAIN first simulates the current period, then, based on this simulation, adjusts the capital stock, the labor force and population, and then simulates again. Thus, the model builders have taken the static version of TRAIN and sequences TRAIN equilibrium through time via connecting relationships that determine capital and population (labor force) flows. The capital, population and labor force flows contain a lagged response, thus creating the time paths of adjustment.

The introduction of a tax change sets off a series of changes in the first period, requiring market quantities and prices to adjust. In this initial simulation, the economy instantaneously reaches a new equilibrium. In this new equilibrium, many variables are different than they were before the introduction of the tax change, e.g., wages, employment, etc. The model then takes some of these new values and uses them to generate population, labor force, and capital flows. The new levels of population, labor force and capital stock are re-entered into the model, setting off another round of adjustments. The combination of the population and capital flows and the new simulation of the model, determine the equilibrium at the end of the 2^{nd} period. This process continues for as many years as they need, up to 20.

They do not link savings with investment, which is appropriate in a regional context. Nebraska savings does not have to equal Nebraska investment as it does in a national CGE model.

Like most regional CGE models, only labor and capital vary with price. Instead, the only choice is between current consumption and future consumption (saving). Then current consumption is allocated in a fixed-bundle fashion across 27 categories of consumption. Similarly, when industry demand is changed, the industry can adjust labor, capital, and a bundle of 27 other intermediate goods. Like consumption, this bundle is always utilized in fixed proportions. These are 'nested' production and consumption functions.

An important difference between developing static vs. dynamic CGE models is that the latter requires the incorporation of a steady-state growth path. The steady-state path in dynamic TRAIN assumes a natural growth of n, where $n=(1+g)(1+h)-1$. This natural growth rate is the product of the g, the natural growth rate in the labor force (due to young people entering the labor force), and h, the growth rate in output per worker (productivity). This assumption creates the 'base-line' used in this dynamic CGE model. On a steady-state path, all relative prices remain constant. When a new tax or a new tax policy is introduced, the steady-state path is changed, and the model moves the economy on a transition path until a new steady state path is reached. The difference between the original steady-state growth path and the new steady-state growth path is a measure of the 'impact.'

Advantages of TRAIN

1. As a custom built model, it explicitly represents Nebraska's tax system.
2. As a custom built model, all data, all parameters and every equation can be changed and modified, as needed.
3. It represents all flows entering and leaving an economy.

4. It computes the economic impact of a tax change on the Nebraska economy, holding expenditures and public services constant.

Disadvantages of TRAIN

1. Data bases must be maintained by model users (or users must contract out database maintenance). Costs of data maintenance for custom-built models tend to be higher than for 'off the shelf' models because there are no economies of scale.

2. It is a 'long-run' model, but the impact has no time path. It can only compare the initial equilibrium state of the economy with the final equilibrium state.

3. They do not take into account any of the public-private interactions discussed in an earlier section, except the short-run tax impact on households and producers and the long-run impact on capital formation.

4. To the best of our understanding, the model does not examine the expenditure side of tax changes.

5. To the best of our understanding, the model does not incorporate initial price impacts associated with a change in sales or luxury taxes, thus those impacts would have to be computed outside the framework of the model.

Advantages of Dynamic TRAIN over TRAIN

1. It produces a time path for the impact. The model we reviewed starts in 2000-2001 and analyzes impacts for 20 years.

Disadvantage of Dynamic Train

1. Assumes a new equilibrium each "period," which is unlikely to occur.

STAMP (State Tax Analysis Modeling Program

Characterization of the Model

We reviewed this model as described in "Modeling Tax Policy in Arizona Using Arizona-STAMP (Beacon Hill Institute, 2000)." The discussion of STAMP includes describing the optimizing behavior of households and firms, so the theoretical underpinnings, we believe, is a small general equilibrium theoretical model. Because the authors state they are interested only in three variables (jobs, wage rate, and the capital stock), they repeatedly substitute the maximizing equilibrium values of variables back into the model, sequentially reducing the equations until, ultimately, they end up with three 'reduced form' equations, which are estimated econometrically.

Thus STAMP is a three-equation econometric model with general equilibrium underpinnings. The three equations estimate jobs,[11] the wage rate, and the capital stock. Each of the three variables are estimated in natural logs as functions of the following variables: a) the year, b) the U.S. unemployment rate, c) the natural log of the cost of capital, d) non-wage labor costs as a percent of the wage, e) the natural log of government

[11] The authors of the STAMP document say that 'jobs' used In their analysis are greater than 'employment' because of multiple job holders; however, we are unsure of the data source of this variable.

transfer payments, f) the state tax rate on labor income, g) the federal tax rate on labor income, h) the effective sales tax rate, and i) the working-age population.

Each equation is estimated using a pooled time-series cross-section data set, for the time period 1970-1997 (28 years of data) across seven sectors in the economy. The seven sectors of the economy used in estimation are: 1) agriculture, forestry, and fisheries, 2) construction, 3) finance, insurance and real estate, 4) manufacturing, 5) services, 6) transportation and public utilities, and 7) wholesale and retail trade.

Econometric results of the three estimated equations are very mixed, but it is hard to fully evaluate the equations. The wage equation did not fit the data well at all, indicated by the fact that not a single variable in the equation was significant. The capital stock equation contained three (out of seven) significant variables and the jobs equation had four (out of seven) significant variables.

Problems with the STAMP Approach and Specific Estimation Issues

We believe the major problem with the STAMP approach is the estimation of the 'reduced form' equations used in the model rather than estimation of the entire structural model. By estimating reduced form equations, individual pieces of the underlying structural model cannot be observed, nor can the coefficients of the structural model be evaluated. Thus, the model does little to further our understanding of Arizona's tax system.

The authors do not report the goodness of fit (F-statistics or R^2) for the estimated equations, so it is impossible to determine if any of the equations are statistically significant. It may be that the model fits the Arizona data so poorly that any discussion or interpretation of the results may be rendered statistically inconsequential. However, they do not present the necessary statistical information to determine this.

The equations are estimated using pooled time-series cross-section data across the seven economic sectors described above. The result of this pooling is that the equation coefficients are estimated for each of the seven sectors. There should be major differences among the seven sectors, which should have significant consequences on the magnitudes of the estimated coefficients. For example, a capital-intensive sector is expected to react differently to a high cost of capital than a labor-intensive sector, but in this model sectoral differences in responses to the variables contained in the model are impossible because of the use of pooled time-series cross-section data. They undoubtedly pooled the data this way because they only had 28 annual observations with eight (counting the unreported constant term) variables, which could make it difficult to get significance on any coefficient.

Public finance theory and most CGE models recognize that it is *relative* tax rates (Arizona tax rates *relative* to the rest of the country) that can impact capital stock and labor flows, not levels. Thus, the specification of state tax rates as *levels* is puzzling.

The estimated equations raise the important problem of *causality*. Arizona experienced substantial growth throughout the 1980s and 1990s. During this same period (especially through the 1990's), there were substantial tax cuts in both corporate and individual income taxes. A basic premise of econometric analysis is that the causality in an equation must unambiguously go from the right-hand side variables to the left-hand side variables. In Arizona, it is not clear whether growth and Arizona's tax structure generated additional revenues, thereby making it easier for the legislature to cut taxes or whether those tax cuts stimulated growth. A much more sophisticated statistical analysis is required to determine which way the causality actually goes, but the authors made no attempt to evaluate the causality issue.

Usually, the theoretical derivation determines which variables enter an equation and whether variables are entered as logarithms or levels. In the present case, the theoretical model has 'working age population' entered as a logarithm, but as a level in the estimated equation. Similarly, the theoretical model calls for a U.S. production index; instead the U.S. unemployment rate is used, a measure that does not at all reflect U.S. production. The model includes 'year' as a right-hand side variable, which is not in the theoretical equation. This variable acts as a trend in the estimated variables, which should not be there if the equation were adequately specified. We believe that several different data series were tried and the equations that best fit their *a priori* beliefs were reported in the model.

Note that the state sales tax rate was found to be statistically insignificant in all three equations, which means it is incorrect to assign any meaning to the estimated coefficients. Recognizing this, the authors did not report the effects of cutting the state sales tax rate. Nor did they report changes in the wage rate or capital stock for their simulations of cuts in state individual and corporate income taxes. To us it does not make sense that the state sales tax rate has an implied zero impact, but that the corporate income tax and the individual income tax generate dynamic consequences.

Data

The tax variables in the model are extremely aggregated and are only approximations of actual Arizona tax rates, so interpretation is unclear. To compute the sales tax rate, they divide sales tax collections by total consumption, that is, they don't distinguish between taxable and non-taxable goods.

Much of their work was in estimating the capital stock and the price of capital variables used in the models. It is always worrisome to see variables constructed by sharing down from the nation, then used as left-hand side variables in a time-series equation designed to explain those shared-down variables. The question always arises: Does this process result in estimation of a true relationship or is it data fitting of an artificially constructed dataset?

Problems with the STAMP report

The authors make a specious comparison of a 1% cut in corporate tax rates and a 1% cut in individual rates, but their implied conclusions are not supported by the analysis.

Advantages of STAMP

1. It is a simple model.

Disadvantages of STAMP

1. The estimated equations may or may not be statistically significant (and therefore may or may not be useful).

2. The STAMP model is not useful for forecasting. All the complicated cost of capital variables on the right-hand side would have to be constructed for the future in order to forecast the left-hand side variables.

3. Its use is very limited for impact analysis. The tax rates are artificially constructed, so it will be extremely difficult to accurately represent a change in Arizona's tax structure with a change in STAMP's tax variables.

4. The estimated equations rely heavily on constructed data for key variables, so it is not clear whether the estimated relationships are data fitting or are actual relationships.

5. It does not consider the expenditure side of government services nor any of the government-private sector interactions discussed earlier in the report.

6. Equation specifications raise the question of the direction of causality in the estimated equations, but the authors did not test for this problem.

REMI (REGIONAL ECONOMIC MODELS, INC

History of REMI

The creator of REMI is George Treyz and some elements of the REMI model (e.g., the relative attractiveness of regions) dates back to a well-known econometric model of Massachusetts (Friedlaender, Treyz, and Tresch, 1975). Later, Treyz was involved in the development of the RPC methodology that is widely used in IO models (Stevens, Treyz, Ehrlich and Bower, 1983. Then, Treyz received a grant, which permitted him to develop a model *structure* that could be designed and applied to *any* region. The idea was to specify many parameters to be the same across regions, e.g., consumer response to a change in price, but to allow each regional model to be unique because regions differ in terms of industry mix, comparative advantages, and so forth. The basic model structure is described in Treyz (1993). However, there have been advancements since 1993 in software, usability, and, very recently, methodology. Their most recent advancement is the development of New Economic Geography Models (a prototype of this model is described in Fan, Treyz and Treyz, 2000).

Characterization of REMI

REMI is self-described as a structural long-term dynamic macroeconomic model. In this context, *long-term* means that the model makes no attempt to capture the short-term volatility of the business cycle. One can imagine a picture of the ups and downs of a business cycle and a long-run model would be a much straighter curve that runs approximately through the midpoints of the up-cycles and down-cycles. Thus, we do not believe REMI is useful for revenue forecasting, particularly where revenues have to be predicted in short time periods (e.g., quarterly or, preferably, a monthly).

It is *macroeconomic* in that they begin with the Y=C+I+G+E-M framework of a national model.

It is *dynamic* in that there are inter-temporal effects; thus, 'exogenous shocks' to the model do not result in instantaneous impacts, as occurs in an IO model or a static CGE model. It is *structural*, in that the modelers have attempted to build in as much regional economics as possible. As a result, the model contains the important features of a CGE model, contains an embedded IO model, and estimates many of the other parameters in the model econometrically. Thus, it is truly a hybrid model that combines all three of the basic models described above.

It is similar to a CGE model in that producers produce, consumers consume, factor prices and prices of goods and services are market clearing (i.e., where the supply of goods equal the demand of goods, where the supply of labor equals the demand for labor, and so forth). Housing, housing prices, land absorption, land prices, etc., are determined endogenously within the model. It is also similar to a CGE model in that factors of production move between regions, but the flows occur using an empirically-determined time adjustment process, rather than instantaneously as in a static CGE model or in an indeterminable amount of time as in some dynamic CGE models. (The equations for net migration and for 'relative production costs' are discussed below).

It is similar to an IO model in that IO inter-industry linkages are embedded in the model. As with an IO model, when the output of one industry (the direct effect) changes, the output of industries that sell to that firm change (the indirect effects), and the incomes of workers in both direct industry and the technically-linked firms are spent locally, creating additional impacts (the induced effect). However, REMI differs from an IO model because the REMI model contains prices that are determined endogenously and allows factor prices (e.g., wages) to be bid up or down in response to other changes in the model. For example, if a new firm locates in the state, the demand for labor increases, wages are bid up, but higher wages draw more people into the state, thereby reducing wages. Whether wages end up higher or lower depends on a) the type of industry that locates here, b) the wage rate of the industry that locates here, c) the type of labor it demands (high or low skill), d) the rapidity of the migration response to the higher wage, and e) the productivity of the population and new migrants. These types of responses are CGE in nature; however, because of the time-responses in the model, the new equilibrium doesn't occur instantaneously; rather, it is empirically estimated.

REMI is certainly a kin of econometric models because its non-IO relationships are estimated econometrically. A major difference between most regional models and the REMI models is that REMI equations are usually estimated using panel data, that is, pooled time-series, cross-section data. The advantage for REMI using panel data is that estimated relationships can be used for all 3000 counties and, in an add-up fashion, for all 50 states. The right-hand side variables in these equations would be different for different counties, resulting in different *estimates* across regions, although the equation (the underlying structural relationship) is the same.

The way REMI and an econometric modeler would estimate an equation for the demand for new cars varies significantly. An econometric modeler would collect time-series data on new car sales in the region for, say, 20 years (or 80 quarters, if data is available) and estimate an equation with new car sales on the left side. Right-hand side variables might include: household income (perhaps per capita household real disposable income), a variable designed to capture the price of new cars relative to other goods and services, perhaps a variable designed to characterize the current stock of cars because cars are durable goods (e.g., how many people already bought new cars?), and the cost of borrowing since most people finance cars rather than pay cash (i.e., an interest rate). This equation can be complicated or simple, wrought with economic theory or ad hoc, within the boundary that the equation has to, at least reasonably, 'fit' the time series data.

REMI may use the identical specification, but estimate it across 3000 counties and across 20 years of data. Thus REMI would estimate this equation with 60,000 observations and the resulting equation is used for all 3000 counties. This has a disadvantage in that the resulting equation may not 'fit' the data perfectly for every one of the 3000 counties. However, the process has resulted in a very stable relationship that reasonably reflects consumer behavior throughout the country with regards to new car demand (i.e., it is a *structural* model). Note that this method does not result in the same estimate of new car sales (or even the same estimate of per capita new car sales) for each county because the right-hand side variables are different for each county. Some counties are very poor (low per capita incomes), so their new car sales would be lower than in high-income counties. One region may tax automobile sales differently than another, resulting in different prices and different estimates of car sales and, using this example, households in one region may have already purchased a lot of new cars so they are less likely to purchase new cars than a region that, for whatever reason, still has a high percentage of old cars.[12]

Net Migration and Industry Location

Four components of net-migrants are modeled: international migrants, retired migrants, former military personnel and their dependents reentering the civilian population, and economic migrants. All but economic migrants are exogenous to the economic sector of the model. International migrants are modeled as share of national international migration, using historical patterns. Retired military personnel and their families are linked to the size of the military in each region and the size of the population in each region. Retired migrants respond to non-economic factors, such as differential regional amenity levels, and rates of migration for retires by age cohorts for both males and females are computed.

Economic migration responds to both economic and amenity factors. Specifically, migration is a function of relative expected income (expected income in the region relative to expected income elsewhere) and relative amenities (amenities in the region vs. amenities elsewhere). Although the amenity variable is specified as a regional dummy variable in the REMI estimated equation, amenities can be changed in simulation, e.g., shorter commute times associated with road construction. Expected relative income is linked to relative employment opportunity (relative job growth), relative wage rate (relative wage rate for the

[12] Note that the 'new car sales' equation used in this discussion is merely an example. The actual new car sales equation in REMI may be substantially different.

same industry), and relative wage rate mix (relative numbers of industries that pay high vs. low wages). The relative employment opportunity, relative wage rate and relative wage rate mix enter the migration equation as a polynomial distributed lag; that is, the model explicitly recognizes that migration is not an instantaneous response to changes in job opportunities or wage rates.

Businesses, particularly businesses that sell to a national market, either expand or contract in a region, depending on that region's production costs relative to the rest of the country. REMI contains 'relative production cost' equations for different industries. This equation, representing relative average cost for an industry (average cost of production in the region divided by the average cost of production in the US) is specified using relative nominal wages (nominal wages in the region relative to the US), relative factor productivity (productivity of factors in the region relative to the US), relative prices of factor (capital and labor) inputs, and relative prices of material inputs (region relative to the US). The relative cost of capital calculates the implicit rental cost of capital, including structures, equipment, and inventory. Note that this concept of capital refers to 'physical' capital, not 'money available for investment,' as used in the world of finance. REMI assumes that capital funds are available everywhere but that the cost of capital varies among regions according to cost of production (for example, construction costs vary across regions), and taxes. Explicit in the relative cost of capital measures are numerous tax measures: federal and local corporate profits tax rates, local and national investment tax credits, federal and local depreciation deductions on equipment, federal and local interest deductions on equipment, federal and local equipment lifetime measures (for depreciation calculations), and a parallel set of taxes and tax concepts for structures. All these tax measures are available as policy instruments in REMI. These relative costs of capital enter as one of several costs in the 'relative production cost' equation. It is this equation that either draws industries to a region or, in the case of relative high production costs, sends industries to a different region.

Data Requirements

REMI has huge data requirements. It requires the type of cross-section data used in CGE models, but on a time-series basis. It uses a variety of sharing methods and estimation methods to develop the required data, just as CGE modelers have to do.

REMI, as originally developed by Treyz and others, estimated interregional flows using the RPC method, described in the IO Model section. Recall that this methodology utilized the commodity flow data obtained from the 1977 Census of Transportation and similar data did not appear in the 1997 Census of Transportation, which led REMI to develop the new "economic geography" approach.[13]

REMI's Government-Private Sector Interactions

Tax policy can be analyzed within the REMI framework. A variety of tax policy variables are in the model, which can be 'shocked' to observe the economic impact in a dynamic setting. A tax increase/reduction of, say, $100 million individual income tax can be entered directly into the model. However, corporate profits taxes must be entered by increasing/reducing the average tax rate, which may take a little calculation prior to entering the tax rate change in the model. This same dollar vs. rate input requirement occurs for other tax categories as well.

REMI also models government expenditures and government employment, but they are estimated proportional to population. An economic increase in population and inflation automatically increase government expenditures and employment. There is no balanced budget restriction in REMI. Thus to conduct 'dynamic scoring' where both the changes in taxes and government expenditures are equal requires the user to conduct several simulations to bring the change in tax revenue equal to the change in

[13] Note that REMI's New Economic Geography Model structure does not require RPCs. The paper by Fan, Treyz and Treyz, 2000, describe a prototype of these models, but it is hard to relate what is in the paper to know how the new models work. For example, the prototype has instantaneous speeds of adjustment in land and capital markets, all labor is identical (homogenous), there is no government activity, no capital formation process, etc. We are sure that these will be entirely different by the time the prototype is made operational in REMI modeling systems.

government expenditures. For example, if $100 million in the income tax were cut, one would think that one could also cut $100 million in expenditures, but that begs the question of dynamic scoring. In particular, the $100 million income tax cut will not reduce government expenditures by $100 million because of the dynamic feedbacks in the model. Thus the user would have to a) simulate the $100 million tax cut and then, b) put the resulting change in expenditures into the model and simulate again. Since action a) stimulates the economy and b) depresses the economy, it is unlikely that the revenue change and the government expenditure change will be equal. Then b) has to be changed again and again in an iterative fashion until the reduction in revenues created by a) is closely matched by the reduction of government expenditures. We believe that it should take only a few simulations of different government expenditures levels to get revenues and government expenditures to approximately match. It should be noted that there are several expenditure categories in REMI and they would all have to be changed in the iterative process.

While REMI automatically includes state-federal interactions on the tax side (i.e., state taxes are deductions from federal taxes), it does not include state-federal interactions on the revenue side. In particular, if certain types of state government expenditures are cut, then the state may lose $1 or $4 or $6 or even $20 of federal dollars in a match. REMI (and most models) assume all federal dollars come in the form of block grants, which is not true, particularly with regards to health and welfare spending. REMI can be used to handle federal:state matching dollars, but it significantly complicates the iterative process necessary to equate state expenditures and revenues.

REMI does not handle tax changes that affect price changes very well. Changes in tax rates that affect prices must have a price impact determined prior to entering most models. For example, suppose the tax on cigarettes is increased enough to cause the price of cigarettes (including taxes) to double. We know that some smokers will quit smoking due to the price increase. That price effect is not computed within REMI. Rather, a price elasticity should be applied to cigarette smoking (pretend it is -0.2), so that when cigarette price increases 100%, cigarette consumption falls by 20%. This has to be converted to a dollar figure drop in cigarette consumption and inputted into REMI as a reduced demand in whatever economic sector cigarettes are in. The revenue impact associated with the cigarette tax is then the sum of the reduction in total revenues associated with the economic impacts of fewer people buying cigarettes (derived from REMI from this simulation), *plus* the cigarette tax revenues computed by applying the new tax rates to the new (lower) level of cigarette consumption.

REMI handles locational effects of taxes well. As described above, REMI incorporates relative taxes into the relative real disposable wages for the migration equation and the 'relative production cost' variable for business attraction and growth.

REMI does not directly incorporate investment in human capital or public infrastructure into the impact of taxes and expenditures, but they can be manipulated within the framework. For example, productivity is a variable than can be manipulated if additional training programs or educational services are contemplated. Of course, secondary documentation (e.g., academic literature) would have to be used to determine how much productivity should be changed for a given public spending program. The change would also have to be entered with an appropriate lag, e.g., a change in K-12 would have to be entered as very small (negligible) in the early years, growing as the students receive the full benefits of the program. Similarly, public expenditures that affect the costs of doing business in Arizona, e.g., highways, public safety, can be entered as non-pecuniary (no money exchanges hands) benefits in the 'attractiveness' measure of the region.

The REMI model incorporates intergovernmental flows of money, e.g., state to local transfers; however, population drives the flows, not by the specific formulas that determine sub-state shares of revenues.

Dynamic

REMI and Dynamic TRAIN are the only models reviewed that produce a time-path of the revenue and economic impacts. IO models and most CGE models provide a measure of the 'impact,' but provide no information regarding how those impacts occur over time.

Ease of Use

We observed demonstrations of the REMI model and it appears simple to use. Entering an exogenous shock to the model takes under a minute and the model takes less than a minute to load the data change and simulate. However, trying to maintain a balanced budget and allowing federal dollars to adjust according to appropriate federal:state matches may require substantial work on the part of the user.

Because of the complexity of the model, it would be necessary for a potential user to attend the 3-day, we believe free, training session offered by REMI. This session would be extremely valuable in understanding what has to be changed in the model to get correct impacts. The following example describes a REMI simulation discussed in the afternoon session of our REMI demonstration.

Suppose that local (city) taxes are reduced because the city no longer intends to collect trash. As a result, households have to contract with a private trash collector to do the job the city had previously done. Theoretically, city dwellers should be indifferent between the city collecting trash or them having to pay for trash pick-up, but how would this simple example be entered into the model? Four variables have to be exogenously shocked to simulate the appropriate response: 1) taxes fall by, say, $100 per household so disposable income increases by $100 times the number of impacted households, 2) government employment is reduced by the number of displaced trash collectors, 3) demand for private trash collection increases by $100 times the number of impacted households, and 4) a government-provided benefit has been discontinued so that $100 in non-pecuniary benefits has to be subtracted from the relative attractiveness variable in the net migration equation.

Another example discussed during the REMI demonstration was how to simulate improvements in the highway system that results in a decrease in the time it takes to commute to work for Arizonans. A highway tax may have to be increased to pay for such an improvement, government spending would have to be increased to pay for the improvements, and the economic value of the reduced commute time has to be entered into the relative attraction variable as a non-pecuniary benefit.

We already discussed the fact that tax revenues are not directly linked to government expenditures so that several simulations may have to be done in order to get an approximate match. However, not linking them has an advantage, as well, because if, for example, money were put into the Budget Stabilization Fund, then tax revenues would not match exactly. Similarly, if tax dollars were spent on paying down past debt, then there would be no immediate government spending impacts. Then when government expenditures are simulated, rather than matching revenues, they would differ by amounts paid into the rainy day fund and/or paid on past debt.

REMI is also capable of assessing targeted tax credits (e.g., investment tax credits), by industry, but it must be done carefully. First, the tax credits must be converted to reductions in the cost of production before entering the model.

Thus, while it is physically easy to enter changes into the REMI model, conceptualization of the problem must be carefully done to get impact numbers that reflect the complexity of the issue being studied.

Other Comments

Because of the ease of use and the extreme flexibility built into the REMI framework, we had hoped that REMI could accept additional equations or an additional set of equations within the endogenous block of the model. That is, we thought it would be interesting to replace some of the relatively simple revenue specifications in the model with equations specifically designed around a specific state's tax laws. However, this cannot be done.

Because the model also has state and local taxes in the model (eighteen of each of the following categories: state revenue, local revenue, state expenditure, local expenditure), REMI can be used for 'dynamic scoring.'

Advantages of REMI

1. REMI is extremely useful for impact analysis, containing 6,000 policy variables that can be manipulated.
2. REMI is a hybrid model that captures the advantages of IO, CGE, and econometric models.
3. REMI captures the inter-industry linkages of an IO model, without the restrictive implicit assumptions that supply is perfectly elastic.
4. REMI captures the general equilibrium concepts of a CGE model, but permit adjustments in factors of production to occur over time, as occurs in the real world, rather than instantaneously.
5. REMI estimates its non-IO relationships using econometric methods, thus variables in the equations have been tested for their 'importance' and the equations themselves have been tested to determine the strength of the estimated relationship using a wide variety of acceptable methods.
6. Like IO and CGE models, it provides for a complete accounting of all flows within a region.
7. It includes a wide variety of taxes within its impact framework.
8. The impact of budget (government spending) cuts/increases can be assessed, in addition to tax cuts/increases.
9. The locational effects of tax cuts/tax increases are incorporated into the model via the 'relative attractiveness' specification included in the net migration and relative production cost measure.
10. Because REMI contains numerous components of state and local tax revenues, the model is extremely useful for dynamic scoring. Specifically, for a decrease in a tax, it would estimate the amount of revenues generated from that tax and other taxes associated with any stimulus created by the tax cut.
11. It has some interesting features. For example, it is possible to turn off specific equations. In addition, it is possible to turn off certain linkages so that the results are similar to other models. For example, when all the dynamics are turned off, it produces results similar to an IO model.

Disadvantages of REMI

1. REMI is not useful for short-term economic or revenue forecasting. It is not designed to capture the relationship between business cycles and tax revenues. Further, it is particularly not useful for revenue forecasting, where revenues have to be predicted for very short time periods, e.g., quarterly or, preferably monthly.
2. REMI is considerably more expensive than IMPLAN to purchase and its maintenance fees are costly as well. However, if a branch of state government purchase REMI, secondary licenses are available for other state agencies at reduced rates.
3. REMI requires more training than IMPLAN. However, REMI provides free 3-day training sessions while IMPLAN charges for their training.
4. Because of the complexity of the model, each analysis requires very careful conceptualization prior to running the simulation.
5. Taxes and government expenditures are not directly linked in the model. Therefore, if a 'balanced budget' tax impact is to be simulated, the user will have to do several simulations to get the dynamic impact of a tax change to 'match up' with the resulting level of more (or less) government spending.

6. Additional equations cannot be added onto the REMI framework within the endogenous block of the model.

7. A problem associated with REMI and all off-the-shelf models is that it is not specifically designed for any specific state's tax structure. For example, the property tax rate in REMI is an average rate that applies to all property. Thus, it cannot account for differences between residential and business assessment: sales ratio, such as occurs in Arizona. Although we believe that this problem can be circumvented by entering the property tax as an increase or decrease in production costs, this example shows the complications that can occur in attempting to adapt an off-the-shelf model to a specific state's tax/revenue structure.

DRAM (Dynamic Revenue Analysis Model)

DRAM was custom-built for the state of California. In 1994, California enacted a bill that required the Department of Finance to perform 'dynamic' revenue analysis for proposed legislation having a revenue impact of ten million dollars or more. The Department of Finance contracted with researchers at the University of California at Berkeley (Berck, Golan and Dabalen, 1996) to select a model type and design the model. They chose the Computable General Equilibrium (CGE) model form and the referenced report outlines that model.

In DRAM, the economy is divided into 75 total sectors, including 28 industrial sectors, two factor sectors (labor and capital), seven household sectors (income groups), one investment sector, 36 government sectors (7 federal, 21 state, and 8 local), and one sector that represents the rest of the world. There are over 1,100 non-identity equations in the model.

As with other CGE models, there are two major types of agents: households and producers. Households sell factors of production (labor) to producers and buy consumer goods and services from producers. Producers buy (rent) capital from other producers, and labor from households. Equilibrium occurs when the wages paid to labor adjust to equilibrate the amount of labor supplied by households with the amount of labor demanded by producers. Similarly, the price of capital (rent) adjusts until the demand and supply of capital adjust. Governments tax both producers and households and provide goods and services.

DRAM treats all non-California as 'rest of the world.' Thus flows of goods and services, intermediate goods, labor and capital are the same, whether they are from the rest of the U.S. or from non-U.S. sources.

Government expenditures are linked to government revenues, and funding formulas, such as those for K-12 local funding, formula-based health and welfare transfers to households, etc., are included in the model. However, DRAM does not adjust federal intergovernmental revenues with changes in state expenditures.

Although government produces goods and services, these goods and services do not enter either the utility function for consumers or the production function for firms. DRAM does not consider the impacts on productivity of either education or public infrastructure.

Although DRAM links California individual income taxes with the Federal personal income tax through the deductibility of state and local taxes, they do not make the same link between the California corporate tax with the Federal Corporate Income tax.

Theoretical Underpinnings

DRAM assumes competitive behavior in all private sectors and that involuntary unemployment is a constant. The latter is common among all CGE models and is indicate of a long-run structure.

In DRAM, there are two factors of production: labor and all other factors are aggregated into "capital."

Household demand for goods and services uses a Cobb-Douglas consumption function. Household savings is the residual of after-tax income less consumption.

Production function: they use a Constant Elasticity of Substitution (CES)14 functional form, which allows substitution between labor and capital. However, there is no substitution between capital and labor, on the one hand, and other inputs (e.g., intermediate inputs), on the other. Other intermediate inputs are combined in fixed-shares, as in an IO model. This is sometimes called a nested-CES production function.

Labor and capital don't always have to move in order to equalize factor prices (wages and capital rents), as long as products can move. This gets into the whole issue of international trade. In DRAM, first total household expenditure is allocated between the types of goods in the model. Using a Cobb-Douglas consumption function, a share of total expenditure is set aside for food, pharmaceuticals, cars, electronics, etc. Then, expenditures for each good is apportioned between imports and domestic goods using an Armington innovation in which goods from external sources are not viewed as perfect substitutes for domestic goods. Key assumptions in this section are the setting of the elasticities (responses) of imports and exports to relative price differences between California and the 'rest-or-the-world.' All import elasticities are set at 1.5 and all export elasticities are set at 1.65, "except for less traded goods such as services, which are set at 0.5 and 0.65." These elasticities seem extraordinarily high given the literature reviewed and reported in the DRAM document.

Investment is modeled using Engle's investment equation for Massachusetts, in which Massachusetts' investment is a function of U.S. investment and the rate of after-tax rate of return in Massachusetts compared to the rest of the U.S. They use Engle's estimates for Massachusetts for California, assuming that the elasticity of investment with respect to rate of return for California is 1.5. Thus when the ratio of California's rate of return relative to that of the U.S. increases by 1%, then California investment increases by 1.5%.

In terms of labor supply and taxation, their literature review indicated that the labor supply response to a change in wages was basically zero for most working males; however, there was a small positive labor supply response for married women with a tax cut. Low-income individuals are likely to reduce their labor supply in response to a tax cut. Elasticities (response measures) reflecting these responses are incorporated into the model.

Migration in DRAM is a simple adjustment function for the number of each of the seven household types. It is assumed that wages will adjust back to pre-shock levels in six years, as is sometimes found in the literature. Thus migration adjusts upward as per-household after-tax wages rise and adjust downward as the participation rate (unemployment risk) of that household group falls. Out- and in-migration are estimated separately. The migration responsiveness parameters chosen for upper-income households are set high (very responsive) for responses to after-tax incomes, but zero (no response) to the participation rates (the unemployment risk). Low-income households have a low response to relative after-tax incomes, but a high response to the unemployment risk. Households in between are assigned intermediate values.

California state government revenue and taxation receive the most attention while federal and local governments are held primarily exogenous to the model. DRAM does explicitly account for the deductibility of state and local taxes from individual federal taxable income, but not for the deductibility of these taxes from corporate federal taxable income.

[14] The CES production function is a more general functional form than the Cobb-Douglas. Implicit in the latter formulation is that the elasticity of substitution between capital and labor is one. The CES allows the elasticity of substitution to differ from one, but still be a constant, thus the name.

Data

Working in 1995 and 1996, the model developers wanted to have up-to-date data for California. So they started with IMPLAN's 528 sector data bases. In 1995/1996, IMPLAN's databases would only have been updated to 1993 or 1994, so the researchers combined the IMPLAN data with more current estimates from the Department of Finance's (DOF) econometric model to arrive at an approximation of the 1995/96 expected economic conditions.

Estimation of investment figures for California requires numerous assumptions. Investment is the addition of goods that augment the capital stock. They estimate this by first assuming the economy is in equilibrium, then use "IMPLAN's estimates of payments to capital, make some adjustments, to get gross investment values by destination of investment. They combine these estimates with an industry share matrix calculated from the most current (1982) BEA matrix of capital purchases by source and destination for the U.S. Combining the industry share matrix with the gross investment value of estimates by destination yields a matrix of investment demand, by source.

Calibration

They do not empirically directly estimate relationships in the model. Rather, they borrow econometrically estimated relationships and elasticity measures (e.g., price elasticities, cross price elasticities, import and export elasticities for both California and the 'rest-of-world,' etc.). When there are conflicting elasticities among the estimates reported in academic articles, they make judgment calls as to which sets to use. Often they select rounded numbers near the estimates reported in academic articles.

Results of Simulations and Sensitivity Analysis of DRAM

The corporate profits tax showed an 18 percent dynamic feedback. However, the authors of the report note that between 1/6th and 1/3rd of this is an overstatement because although in reality California profits taxes are deducted from Federal corporate taxes (as is the personal income tax). Thus, the corporate profits tax should have been stated as 12 to 15 percent.

Individual income tax has a 1.003 percent dynamic feedback, mainly because state individual income taxes are deducted from the Federal individual income taxes.

The sales and use tax has a 7.673 percent dynamic feedback. It should be noted, however, that this relatively large dynamic feedback is due, we believe, to the relatively high trade elasticities assumed in the model and the fact that California taxes intermediate goods (goods that are incorporated into final products, e.g., flour used to make tortillas) as well as final goods (the tortillas). Most states do not tax intermediate goods.

The sensitivity analysis conducted for DRAM show that the model shows fairly consistent results when assumptions regarding migration, investment and labor supply responses were altered. However, when the trade elasticities (response of trade to relative California/rest of world prices) were altered, the impacts changed dramatically. When the trade elasticities were set at 0.5 to 1.5 times their original levels, the estimated dynamic feedbacks changed dramatically. The dynamic feedback effect of a change in the corporate tax ranged from 8.44% to 23.84%, the personal income tax from -3.29% to 3.30%, and the sales and use tax from 5.21% to 9.05%, depending on the trade responses assumed in the model. This sensitivity of DRAM to changes in the trade elasticities should raise alarms because a) trade flows are difficult to estimate in the first place for regions, 2) the trade elasticities appeared to be set too high in DRAM to start with, given the literature cited by DRAM modelers.

Other DRAM simulations showed that when Federal support of welfare is made proportional to California's support of these programs (as opposed to the original version in which federal welfare was given to California as a block grants), the size of the dynamic feedback was reduced about 2% for all three simulations of taxes. When the balanced budget restriction is removed, the dynamic revenue impacts become bigger because the expenditure side is missing.

Advantages of DRAM

1. DRAM is designed to estimate the economic impacts of households and firms associated with tax changes.
2. DRAM considers the expenditure side of government, although non-formula local and federal funds do not change when there is a tax policy change at the state level. Formula driven changes are allowed to occur.
3. DRAM is custom-built, so that every number, every parameter, every assumption can be changed by the user, if additional information becomes available.
4. DRAM borrows many of its key relationships, key responsive measures from existing literature. These estimates would generally be of high quality since they appear in peer-reviewed journals and publications.
5. Another advantage of adopting literature-based elasticities, is that fewer parameters have to be 'calibrated.' Recall that calibration involves selecting parameters, one at a time, which exactly reproduces the base-year data. Because the number of parameters to be 'fixed' is usually very large in CGE models compared to the amount of data available, this process can assign values to parameters that are either unstable (change with new base year) or are incorrect. DRAM, by using published elasticities minimizes the calibration problem by reducing the number of parameters that have to be calibrated.

Disadvantages of DRAM

1. DRAM, like other CGE models is not a forecasting model. DRAM is calibrated to reproduce a single base year, 1995/96.
2. DRAM does not consider the impact of government expenditures on productivity or pubic infrastructure.
3. DRAM is difficult to run. It is custom-built using GAMS, so is more difficult to use than commercially built models.
4. DRAM, like all models, is a simplification of an economy, requiring multitudes of assumptions. In DRAM certain assumptions, namely the trade responses assumed in the model, dramatically change the results of the model.
5. DRAM is a California vs. rest-of-the-world model, in which the rest of the U.S. is treated the same as non-U.S. countries. Some of the international trade theories don't seem to apply as well to flows within the U.S. as to flows between the U.S. and the rest of the world.

Conclusions

Several important issues have been raised in this report, but it is important to review the important ones and relate them to the specific models we reviewed.

1. We believe that the price effect on consumption (or production) of a tax change is one of the most important 'behavioral' responses. This price effect occurs, for example, when people purchase less of an item when the tax rate goes up. Price effects are not explicitly dealt with in any IO based model, such as IMPLAN, in which prices do not appear. They are typically not in an off-the-shelf model, such as REMI. When asked about whether REMI would automatically compute the reduced consumption of cigarettes associated with a luxury tax increase, the answer was that the price effect on consumption would have to be computed prior to entering data into the model. Custom-built models, like DRAM, TRAIN and Dynamic TRAIN should automatically compute this effect. However, in the simulations of Dynamic TRAIN, first-step tax calculations (e.g., $X M) were entered to simulate the impact of a sales tax, i.e., they didn't consider the initial price effect. In contrast, the DRAM simulation of the sales tax altered the tax rate, which would then, we believe apply the price elasticity to taxable sales

In some cases, price effects can represent the largest component of a revenue impact and feedback analysis. The State of Michigan considered incorporating dynamic estimation into revenue estimates, but they currently do not. Although Michigan's Treasury "recognizes that dynamic effects indeed exist, it does not incorporate dynamic effects because the estimates are very difficult to quantify with any degree of accuracy. This is attributable to a lack of reliable state-level data (e.g., import-export data), problems in modeling interstate factor mobility and the sensitivity of estimates to elasticities used in the models. Other mitigating factors include budget and staff constraints." However, "…all fiscal impact estimates incorporate behavioral responses of taxpayers, consumers and/or firms. Taxpayer response can be modeled using estimated [price] elasticities. For example, when Michigan tripled the cigarette tax, Treasury assumed that consumption would decline approximately 20 percent in response to the higher price. While both long- and short-run [price] elasticities exist, treasury uses only short-run elasticities because they measure immediate responses are generally easier to quantify and verify (Haas and Knittel, 1997)."

Thus Michigan estimates behavioral responses through the use of price elasticities (the price effect discussed above), but they do not incorporate 'dynamic' estimation. Haas and Knittel use a 'taxpayer response' example (cigarette consumption), which is straightforward if an appropriate price elasticity can be found or estimated. However, they do not discuss exactly how they incorporate behavioral responses of firms. It's possible they utilize the expenditure 'share' data from IO models, so that when an input price changes, the corresponding amount of input changes. More investigation is required on this point.

In summary, to our knowledge, only the custom-built DRAM model automatically computes the price effects associated with a tax change.

2. It is critical that time-paths of impacts be computed. Decision-makers need to understand not only the magnitude of dynamic feedbacks of a tax policy change, but when those feedbacks occur. It is important to understand that tax policy involves trading off higher/lower levels of public services (health and welfare, investment in human capital, and public infrastructure) for the promise of economic contraction/expansion in the future. Without knowing when the expansion/contraction occurs, it's impossible to make the trade-off decision. The decision to cut/increase taxes may be different if the economic impacts occur this year compared to 15 years from now.

Time-path of impact is critical for the Bruce and Turnovsky definition of 'dynamic' scoring. Recall that their definition requires comparing the *present value of the revenue stream* with a tax policy change with the *present value of the revenue stream* without a tax policy change. Note that this definition requires revenue 'streams,' i.e., time-paths. The use of present value recognizes that a dollar spent today is worth more than a dollar spent next year or five years out. When an individual is deciding to put money in, say, a certificate of deposit for one year, they make that decision based on the interest rate paid. An individual may decide they will purchase a CD if the interest rate is 5 percent or above, but they will keep the money as cash for possible spending today if the interest rate is under 5 percent. If this person purchases a CD and the interest rate is exactly 5 percent, then it means that $105 next year has the same value to this person as $100 today. The 5 percent is their 'discount' rate. In economic theory, society has a 'discount' rate, too, and understanding the timing of the impacts is the only way to make tradeoff decisions between higher (lower) public service levels today and an economic contraction (expansion) at some point in the future.

Only two models reviewed compute a time-path for revenues: REMI and Dynamic TRAIN. However, Dynamic TRAIN uses econometrically-determined adjustment processes only for migration and investment. All other adjustments are assumed to fully occur within the "period" used to estimate migration and investment equations.

3. One thing seems to be clear from the literature. Estimating the positive (negative) impacts of a tax decrease (increase) will be overstated if a) government expenditures are not permitted to change with the change in tax and b) the interactions between regional taxes and federal taxes are not accounted for. IMPLAN can be used to compute expenditure economic impacts either by distributing government expenditures across final demand sectors or utilizing IMPLAN's built-in final demand vectors for state and/or local government, but as already discussed, it is difficult to convert the resulting economic impacts to revenue impacts for use in computing 'dynamic' feedbacks. REMI is capable of doing this, although several iterations will be required to get the revenue impacts associated with a tax policy change to match the new expenditure levels, because changing the expenditure levels also creates an economic impact. Note that IMPLAN doesn't require iterating to get revenue change to match expenditure change simply because IMPLAN's impacts are linear. That is, a representative $1M expenditure impact from IMPLAN can be proportioned up or down to match a revenue change associated with a tax policy change. In contrast, REMI, DRAM, TRAIN and Dynamic TRAIN are non-linear. DRAM links expenditures to revenue impacts, so DRAM automatically considers the expenditure side, but to our knowledge, TRAIN and Dynamic TRAIN do not. STAMP is not useful for this.

Only DRAM, REMI and possibly IMPLAN can incorporate the short-run effects of government spending into account. DRAM does it automatically, but REMI and IMPLAN would have to have the model user establish a balanced budget. This is relatively simple to do in IMPLAN because it is linear, but IMPLAN lacks many of the other tax/expenditure public/private sector interactions described in the beginning of this report. REMI incorporates many of the tax/expenditure interactions described earlier, but fully accounting for them in the REMI framework can require substantial effort.

4. We cannot recommend any state or government entity building a custom-built CGE model at this time, particularly for use in revenue 'feedback' analysis. We completely agree with the conclusions of Partridge and Rickman (1998) in their CGE survey article: "Regional CGE models have provided unique insights into the workings of regional economies and on the possible effects of regional policies. To this end, regional CGE models represent a significant advancement in regional economic analysis. However, it is not yet clear how accurate regional CGE models are quantitatively, particularly in comparison to other types of regional models. Issues of functional form, elasticity specification, closure rules, sensitivity analysis, market structure, and dynamics need to be explored more. Regional CGE models need to be examined whether they better explain patterns in the data than other regional models. Also, CGE modelers need to carefully identify why their findings differ from those produced by other types of regional models. In many of the articles surveyed, it was difficult determining what the authors did, making interpretation of their results problematic. Only through these types of efforts can regional CGE models be demonstrated to provide more accurate insights and predictions. Finally, the regional modeler should be cautioned to weigh the costs of correctly constructing and verifying a CGE model against the expected marginal benefits (p.239)."

Of particular concern to us is that results from these models are strongly dependent on the assumptions built into the model. We believe that until there is more development of CGE models and a literature consensus starts forming about the issues outlined by Partridge and Rickman, that the benefits of such a model in estimating revenue feedbacks are substantially out-weighed by the costs.

In addition, in the few studies that compare simulations using different models, the results are not widely different. The Waters, etc. al. (1997) article examines the impact of a property tax limitation in Oregon using three different models: IMPLAN, a CGE model with one set of closure rules, and a CGE model with a different set of closure rules. Although the resulting behavioral impacts are different (some even have opposite signs), there is only a one-half percent difference between the highest and the lowest of the three revenue impacts. Again, the marginal benefits of a state contracting to build an expensive custom-built CGE model appear to be small.

References

Agell, Jonas and Mats Persson 2001. "On the Analytics of the Dynamic Laffer Curve." *Journal of Monetary Economics* 48:2 (October): 397-414.

Alward, Gregory S. and Scott Lindall 1996. "Deriving SAM Multiplier Models Using IMPLAN," paper available on IMPLAN's website: < http://www.implan.com >.

Berck, P., E. Golan and B. Smith with J. Barnhart and A. Dabalen. 1996. "Dynamic Revenue Analysis for California," a report for the California Department of Finance, Sacramento, CA (summer).

Berck, P., S. Robinson, and G. Goldman, eds. 1991. "The use of computable general equilibrium models to assess water policies." In *The economics and management of water and drainage in agriculture*. Norwell, MA: Kluwer Academic Publishing.

Bolton, Roger 1985. "Regional Econometric Models." *Journal of Regional Science*. 25, 4 (November): 495-520.

Bruce, Neil, Stephen J. Turnovsky 1999. "Budget balance, welfare, and the growth rate: "dynamic scoring" of the long-run government budget." *Journal of Money, Credit and Banking* 31:2 (May), 162-88.

Capolupo, Rose 2000. *Output taxation, human capital and growth*. Manchester School 68, 2 (March): 166-83.

Charney, Alberta H. 1983a. "Impacts of State Tax Changes in Arizona: A Simulation. *Arizona Review* 31:1, 3-12.

Charney, Alberta H. 1983b. "Intraurban Manufacturing Location Decisions and Local Tax Differentials," *Journal of Urban Economics* 14, 184-205.

Charney, Alberta and Carol Taylor. 1984. "Decomposition of Ex Ante State Model Forecasting Errors." *Journal of Regional Science* 24, 229-248.

Charney, Alberta and Carol Taylor 1986. "Integrated State-Substate Econometric Modeling: Design and Utilization for Long-run Economic Analysis." Chapter 3, *Regional Econometric Modeling*, M. Ray Perryman and James R. Schmidt (eds.), Kluwer-Nijhoff Publishing, Boston.

Charney, Alberta H. and Julie Leones 1997. "IMPLAN's Induced Effects Identified Through Multiplier Decomposition," *Journal of Regional Science* 37:3, 503:517.

Dalenbert, Douglas R., Mark D. Partridge and Dan S. Rickman. 1998. "Public Infrastructure: Pork or Jobs Creator?" *Public Finance Review* 26:1, 29-52.

Despotakis, K.A., and A.C. Fisher. 1988. "Energy in a regional economy: A computable general equilibrium model for California." *Journal of Environmental Economics and Management* 15: 313-50.

Haas, Mark P. and Knittel, Matthew J. "Revenue Forecasting in Michigan." *Proceedings, 90th Annual Conference on Taxation,* Minutes of the Annual Meeting of the National Tax Association, November 1997, published Washington, DC 1998.

Helms, L. Jay. 1985. "The Effect of State and Local Taxes on Economic Growth, A Time Series-Cross Section Approach," *Review of Economics and Statistics*, 67 (November), 574-582.

Hertel, T.W. 1985. "Partial vs. general equilibrium analysis and choice of functional form: Implications for policy modeling." *Journal of Policy Modeling* 7: 281-303.

Hertel, T.W., and T.D. Mount. 1985. "The pricing of natural resources in a regional economy. Land Economics." 61: 229-43.

Hoffman, S., S. Robinson, and S. Subramanian. 1996. "The role of defense cuts in the California recession: Computable general equilibrium models and interstate factor mobility." *Journal of Regional Science* 36: 571-95.

Ireland, P.N., 1994. "Supply-side economics and endogenous growth." *Journal of Monetary Economics* 33, 559-571.

Isard, Walter, 1960. *Methods of Regional Analysis: an Introduction to Regional Science*. The M.I.T. Press, Cambridge, Massachusetts.

Kendrick, J.W. and C.M. Jaycox. 1965. "The Concept and Estimation of Gross State Product." *Southern Economic Journal* 32, 153-168.

Kimbell, L.J., and G.W. Harrison 1984. "General equilibrium analysis of regional fiscal incentive." In *Applied general equilibrium analysis*, eds. H. Scarf and J. Shoven. New York: Cambridge University Press.

Klein, Lawrence. 1969. "The specification of regional econometric models," *Papers, Regional Science Association*. 23: 105-115.

Koh, Y.K., D.F. Schreiner, and H. Shin. 1993. "Comparisons of regional fixed price and general equilibrium models." *Regional Science Perspectives* 23: 33-80.

Kraybill, D.S., T.G. Johnson, and D. Orden. 1992. "Macroeconomic imbalances: A multiregional general equilibrium analysis." *American Journal of Agricultural Economics* 74: 726-36.

Li, P., and A. Rose. 1995. "Global warming policy and the Pennsylvania economy: A computable general equilibrium analysis." *Economic Systems Research* 7: 151-71.

Matovu, John M. 2000. "Composition of Government Expenditure, Human Capital Accumulation and Welfare." International Monetary Fund Working Paper: WP/00/15 (February).

Matsusaka, J. 1995. "Fiscal Effects of the Voter Initiative Evidence from the Last 30 Years." *Journal of Political Economy* 103(3):587-623.

Miernyk, William H. 1967. *Impact of the Space Program on a Local Economy, An Input Output Analysis*. Morgantown, West Virginia, West Virginia University.

Minnesota IMPLAN Group, Inc. 1999. *IMPLAN Professional, Version 2.0, Social Accounting and Impact Analysis Software, User's Guide, Analysis Guide, Data Guide*, April.

Minnesota IMPLAN Group, Inc. "IMPLAN Regional Purchase Coefficients (RPCs)," document on IMPLAN website http://www.implan.com.

Mofidi, Alaeddin and Joe A. Stone. 1990. "Do State and Local Taxes Affect Economic Growth," *Review of Economics and Statistics* 72:4 (November), 686-91.

Olson, Douglas C. 1999. "Using Social Accounts to Estimate Tax Impacts," document on IMPLAN website < http://www.implan.com >

Olson, Doug, Scott Lindall, and Wilbur Maki. 1993. *Micro IMPLAN User's Guide, Version 91-F*, Minnesota IMPLAN Group, January.

Partridge, Mark. 1993. "High-Tech Employment and State Economic Development Policies." *Review of Regional Studies* 23, 287-306.

Partridge, Mark D. and Dan S. Rickman. 1998. "Regional Computable General Equilibrium Modeling: A Survey and Critical Appraisal." *International Regional Science Review* 21, 3: 205-248.

Pecorino, Paul 1995. "Tax rates and tax revenues in a model of growth through human capital accumulation." *Journal of Monetary Economics* 36, 3 (December): 527-39.

Pereira, Alfredo M. and John B. Shoven. 1988. "Survey of Dynamic Computational General Equilibrium Models for Tax Policy Evaluation." *Journal of Policy Modeling* 10, 3: 401-36.

Rickman, D.S. 1992. "Estimating the impacts of regional business assistance programs: Alternative closures in a computable general equilibrium model." *Papers in Regional Science* 71: 421-35.

Schumpeter, Joseph A. 1954. *History of Economic Analysis*, Elizabeth Boody Schumpeter (ed.), Oxford University Press, New York, New York.

Stevens, B.H., G.I. Treyz, D.J. Ehrlich, and J.R. Bower. 1983. "A New Technique for the Construction of Non-Survey Regional Input-Output Models." *International Regional Science Review* 8(3):271-286.

Treyz, George I. *Regional Economic Modeling: A Systematic Approach to Economic Forecasting and Policy Analysis*, Kluwer Academic Publishers, Boston, Massachusetts, 1993.

Tuerck, David G., In-Mee Baek, and Johathan Haughton. 2000. "Modeling Tax Policy in Arizona Using Arizona-STAMP," a study prepared for the Heritage Foundation by the Beacon Hill Institute is at Suffolk University & Ashburton Place, Boston (September).

U.S. Department of Commerce, County Business Patterns.

Waters, E., D.W. Holland, and B.A. Weber. 1997. "Economic impacts of a property tax limitation: A computable general equilibrium analysis of Oregon's Measure 5." *Land Economics* 73: 72-89.

West, Carol T. and M.S.Deepak 2001. "Policy Sensitivity in Dynamic Optimization Models: A Study Remembering William Alonso's Regional Modeling Perspectives." *International Regional Science Review* 24, 3 (July): 302-327.