A BRIEF REVIEW OF ALTERNATIVE APPROACHES TO INTER-SECTORAL POLICY ANALYSIS AND FORECASTING

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Policy changes create winners and losers. Correctly identifying those winners and losers is an important part of any policy analysis. In economic policy analysis, a variety of approaches are used to assess the effects of different policies on different industries. INFORUM has recently been involved in two attempts to establish the strengths and weaknesses of different modeling approaches in assessing policy problems. In early November 1996, INFORUM was asked by Resources for the Future to be on a panel discussing alternative modeling strategies used to analyze the economic effects of proposals to limit greenhouse gas emissions. In February 1997, one of our users presented their work -- which included a version of LIFT -- to the Joint Committee on Taxation at a symposium discussing the feasibility of modeling the macroeconomic consequences of tax policy (dynamic scoring). Both of these sessions were remarkable for the diversity of models presented, the diversity of results described, and the diversity of opinions held by modelers about other groups' models.

These sessions have underscored the need for a careful, and somewhat dispassionate, comparison of different modeling approaches. This paper attempts to address that need. In it, we will try to outline what we think are the key differences between other modeling approaches and our own. Although we won't comment on other specific models, we'll try to illustrate our general opinions about other well-known model types and provide references so you can investigate these model types yourself. At the end, we'll compare some of these models' characteristics with an eye on choosing the appropriate tool for the given situation.

We'll limit ourselves to types of models that try to explain or account for all parts of the overall economy. These must have sectoral detail, but they must also present aggregate phenomena -- GDP, total employment, inflation, -- in addition to their sectoral data. This means that we are excluding detailed, single-industry models, like an energy model, that do not generate forecasts or perform simulations for other industries or for the economy as a whole. Such models may use aggregate data as exogenous variables, but do not generally attempt to explain how the aggregate data are formed. Our discussion centers around three broad model types, which we name AGE (applied general equilibrium models), Macro-IO (macroeconomic model linked to an IO model), and IM (interindustry macro model).

Before we discuss any of these types, we'll briefly review the basic input-output (IO) model. We will use the terms and small data set described in the first section as we describe the other model types. And, by the end of the paper, it should be clear that while all of these types make use of I-O relationships, they have all gone quite far beyond a "standard" I-O model.

An Input-Output Calculator

The concept of input-output is quite simple, but also quite ingenious. Wassily Leontief received the 1973 Nobel Memorial Prize from the Bank of Sweden for his pioneering work in the area. There are several good, comprehensive discussions of basic input-output techniques and concepts, including Miller and Blair (1985) and Almon (1996). The discussion here gives only a flavor of the analysis, and glosses over many of the more technical details of the approach.

The root of an IO model is the input-output transactions table, which shows the amounts of inputs used by an industry to produce its output during a given time period (usually a year). The table generally measures inputs in terms of dollars, not physical units like barrels, or tons, or hours. For example, to produce its output, the automobile industry spends so many dollars on steel, plastic, glass, bolts, nuts, computers, and a host of other items and services. These items themselves are typically the outputs of other industries. The auto industry's "recipe" of inputs demanded from all other industries to generate its output can be arranged as a column of numbers. These columns can be constructed for each industry, and placed together in a matrix. Each column of the IO matrix shows what a particular industry needed from all other industries to produce its output in the measurement year. Each row shows the composition of demanders for each industry's output, i.e., who buys the industry's output. The input-output flow matrix captures the interindustry flows for a given time period, usually a year. When each entry in the column is divided by the industry output for which it is used as an input, we get a set of coefficients. The coefficient form of the interindustry flow matrix is often called the A matrix, or the *direct requirements matrix*. Table 1 shows a small IO table based on the 1987 IO study done by the Bureau of Economic Analysis. This is the most recently published official IO table for the US.

Looking across the row of an input-output flow table, the output for any industry can be divided into two uses: (1) the amount needed to satisfy the demands for other industries to make their own output (intermediate demand), and (2) the amount used to satisfy final demands (like consumer purchases, government purchases, inventories, exports, and investment). In Table 1, manufacturing buys $101 billion from agriculture as an intermediate use, while consumers buy $23.2 billion as a final use. A fundamental equation of IO separates output into intermediate and final demand, making use of matrix multiplication to describe intermediate use. The matrix equation is:

$$q = Aq + f \quad (1)$$

where q is a column vector of industry outputs, A is the direct requirements matrix, and f is a column vector of final demand for each industry. The matrix equation shows the interdependence of industries, and is really just a set of simultaneous equations. An explicit mathematical solution to the simultaneous equations shown above is the following:

$$q = (I-A)^{-1}f \quad (2)$$

where I is an identity matrix. The $(I-A)^{-1}$ matrix is often called the *total requirements matrix*. If you were to increase the second element in the f vector -- mining -- by one unit (a billion dollars of coal, perhaps), the resulting vector of q would probably show increased outputs for almost all industries. Although we have increased final demand only for mining, in order to produce an extra billion dollars of coal, you need more output from all of the industries that produce its inputs to coal mining. These input-producing industries in turn demand output from all other industries, according to their direct requirements recipe. At least some industries will use coal as an input in their production (consider the electricity industry, classified in Table 1 as a service industry). This will lead to even greater demands for coal production, again raising demand for coal mining's inputs. In a single matrix calculation, the $(I-A)^{-1}$ gives you the total requirements -- from all industries, and accounting for all simultaneity -- for producing any combination of final demand.

A less well-known, but equally useful equation can be developed to account for industry prices. Rather than asking to who buys the output, we can ask what it costs to produce a unit of output. To produce a unit of output of the automobile industry, you make payments to all of your intermediate suppliers. You do this according to the direct requirements recipe. However, you must also pay for the labor to assemble all of these inputs, the value of the machines used up (depreciated) in the production process, the taxes the government imposes, the interest charges for borrowed funds, etc. When you sell your output, if there is any income left, you earn a profit, which can also be counted as a "cost" of doing business. Thus, by definition of profit, the sum of all of your costs exactly equals the value of your production.

Looking down a column of the IO table, total costs per unit of output (price) can be split into two pieces: (1) intermediate cost, and (2) final costs or value-added. For example, from the direct requirements table in Table 2, to produce a dollar's worth of agriculture, agriculture paid 13.5 cents for manufactured goods (intermediate cost), and 9.4 cents in labor costs (value-added). Total intermediate costs per unit of output can be represented as a weighted sum of all input industry prices, where the weights are the A matrix coefficients in that column. Final costs are the sum of labor, taxes, capital income. In matrix form, this gives us equation (3):

$$p = pA + v \tag{3}$$

where p is a row vector of prices, A is the direct requirements coefficients matrix and v is a row vector of value-added per unit of output. Again, this is nothing more than a set of simultaneous equations written in compact matrix form. The mathematical solution to these equations is:

$$p = v(I-A)^{-1} \tag{4}$$

The intuition behind the equation is straight-forward. An increase in the wage bill per unit of output in agriculture -- the first element in the v vector -- leads to price increases almost everywhere, rather than just in agriculture. This happens because almost all sectors are linked through the input-output structure. The linkages are best seen in Table 2, which shows the coefficient form of the A matrix, as well as the total requirements matrix.

So far, this discussion has been aimed at accounting. Simply writing down the accounting framework and putting data into it is a considerable trick, and was especially noteworthy the first time it was done. The accounting and mathematics are true, and must hold in the year for which the accounting is done. To emphasize, the equations hold in the base year without reference to the underlying production functions or utility functions of consumers.

The IO framework and equations can be thought of as a simple model of the economy that captures the way in which economic sectors interact, both in terms of the flow of goods and services and in terms of the prices. Many IO models are as simple as equation (2). That is, they consist of an IO table and a set of final demands. The tables used have great detail, at least a few hundred sectors.

Now, equation (2) can give us arithmetically correct answers to a host of questions. One example is: "What happens to the output of all industries if the government increased purchases of agricultural goods by $1 billion?" The changes in industry output are shown in Table 3, which by inspection, shows that the experiment (by its construction) simply replicates the first column of the total requirements matrix. To support the $1 billion in government purchases of agricultural goods, the agricultural sector has to produce about $1.5 billion. Somewhat surprisingly, service sector output has to rise by $460 million, about half as much as the original government stimulus.

Likewise, equation (4) can give us the price effect of placing an indirect tax equal to 1 percent of agricultural output (also shown in Table 3). In this case, the indirect tax raises prices by 1.5 percent in the agriculture sector, but much less in other sectors. Equations (2) and (4) can work in reverse, too. For example, we could use (2) to solve for the f vector consistent with any arbitrary vector of industry output.

From Calculation to Economics

The key question for policy analysis and forecasting is whether the calculations done above bear any resemblance to what the US economy would generate in response to the exogenous changes. The usefulness of the calculation depends on the answers to several questions that we would expect an analyst to be able to answer before we might accept the results of the simple IO calculation.

First, shouldn't it matter whether or not the economy is at full employment? If the economy were at full employment (all factors, including labor and capital), how did we manage to coax the extra output out of it? Wouldn't prices and wages go up? And if they did, how would this affect the composition of final demand? Wouldn't changing prices also have an impact on the A matrix coefficients themselves?

Second, what should we make of the extra value-added generated by the increase in government spending? Of course, since we have arbitrarily raised final demand by $1 billion, we have automatically increased factor payments by $1 billion. (A useful idea to keep in your head is that the sum of all final demands must equal the sum of all value-added payments, which incidentally, equals GDP.) Where does this income go? Because income accrues mostly to labor, shouldn't we account for the extra consumption this income generates? And won't this cause another round of spending? Of course these questions are exactly about the Keynesian multiplier, with the added complication that we have several possible goods on which to spend the extra income.

Finally, does it matter how the government increased spending in the first place? For example, if the government increases spending by $1 billion, does it matter whether the increase was financed through spending reductions elsewhere, tax increases, or deficit financing? Each of those alternatives seems to suggest a slightly different composition of final demand, with correspondingly different projected changes in output.

To the extent that $1 billion is small -- and it is, even for agriculture -- we may be able to safely assume that a general answer to the barrage of questions will suffice: all of the effects alluded to are small, except maybe the Keynesian effect in the short-run. If that's true, the simple IO calculation gives a reasonably good approximation to how the economy would really respond to the changes.

Analytically, this might be the appropriate general answer. But while we might be able to answer these questions clearly for $1 billion, it's difficult to know in general when these effects are small enough to ignore. One way to look at the three modeling approaches outlined here is to see them as different ways to attempt to resolve these questions by explicitly expanding the model. They attempt, in some sense, to generalize the static IO calculations.

The simple IO model is an exceptionally data-intensive tool. But using the table, along with some assumptions, you can go quite far in analyzing an economic problem. Little theory is needed to get the model to go; indeed, it is largely agnostic on theoretical questions. Realistically, the solutions are probably most appropriate in the nearby neighborhood of the original data creation, that is, it is probably best used to analyze small changes.

However, even the simple analyses done above for illustrative purposes have revealed some significant weaknesses. The first problem in using the simple IO approach is coming up with how the final demand and value-added vectors change, both in response to policy and over time in response to factors like demographics and general economic growth. The simple IO model is silent on this issue, and assumes values for the vectors come from somewhere. In reality, we know that whatever process generates changes to final demand also probably changes the composition of value-added. The simple IO model is a "real production" model, and is silent on a whole host of important issues such as how interest rates are formed and how exchange rates are formed.

It is also essentially timeless. Although we can shock the final demand column (or one of the final demand pieces), the model doesn't tell us how long it takes, in real time, to reach the new solution. In some instances, you might assume that the new solution was reached almost immediately, as might be the case if you were investigating the effects of ordering, say, a single additional fighter jet for the Defense Department. But for larger changes, it's hard to believe that the new solution wouldn't take some time to achieve. Along with this problem, we also don't know the path by which the new solution is reached, which may have enormous practical considerations for policymakers.

Despite these limitations, the simple IO model captures an essential feature of the economy: the inter-relatedness of production. Perhaps the best way to use a simple IO model is as an economic sketch-pad, providing a vehicle through which you can, by making explicit assumptions, investigate the effects of a wide variety of policies.

Applied General Equilibrium Models (AGE)

Applied general equilibrium models -- also called computable general equilibrium models (CGE) -- have recently become popular tools for policy analysis, especially in the areas of tax policy and international trade policy. There is an extensive literature on AGE models. This summary draws heavily on two articles by Kehoe and Kehoe (1994a,b), and Kehoe (1996). Other useful sources include Dervis, deMelo, and Robinson (1982) and Shoven and Whalley (1984).

Applied general equilibrium models come in two flavors: static and dynamic. The static AGE is a generalization of the simple IO model. In a static AGE, explicit assumptions are made about the forms of consumer utility functions, producer's production functions, the relative preferences for foreign and domestic goods, and how markets work. Conceptually, a dynamic AGE adds the machinery of a single-sector growth model to each of its sectors, along with functions that incorporate inter-temporal decision making. In other words, in dynamic AGE models, investment spending by sector turns into capital, which increases the productive capacity of the sector. The dynamic AGE can incorporate assumptions about how consumers choose their optimal consumption spending path over time, and how quickly producers and consumers move to their new equilibrium.

AGE models rely heavily on neoclassical general equilibrium theory and the implications of equilibrium conditions. This minimizes the data requirements almost to the level of the static IO model. Usually you need only data for a single year to get the model to run. The process through which the data and the theoretical specifications are used to determine the model's parameters is called *calibration*. Calibration can be exceptionally easy if you stick to Cobb-Douglas production and utility functions. For example, a feature of the Cobb-Douglas function is that the factor payment shares of output are constant, and, these shares are the only needed parameters in the function. Thus, you can calibrate the production function for a sector to the year in which you have data simply by calculating the factor payment shares of total value-added for the sector and using these as your parameter values. A similar process holds for utility functions, in which a Cobb-Douglas form implies that the share accounted for by each good of disposable income is constant.[2] Of course, different utility and production functions are used often in practice. The corresponding calibration exercise becomes somewhat more complicated mathematically, but not conceptually.

Once the model is calibrated, it is ready to run comparative statics exercises, in much the same way that we performed the static IO calculations above. In contrast to the static IO approach, the static AGE model functionally integrates all markets and often explicitly assumes that all factors, especially labor, are fully employed. These differences allow AGE models to address the three groups of questions raised in the discussion of simple IO calculations. When full employment is assumed, for example, then the increase in government spending on agriculture leads to greater agricultural output, but higher prices in both goods and factor markets, since markets must clear and prices are endogenous. The higher prices reduce real spending on all goods, with the greatest reductions coming in those sectors with the highest price elasticities. Income is fully endogenous in the model, and, if care has been taken to include a financial sector, all aspects of possible government financing options are covered.

The AGE approach has a considerable number of appealing features. First, it depends explicitly on neoclassical general equilibrium theory. Once you have specified the underlying structure of the economy, markets are allowed to operate to determine prices, wages, and amounts demanded and supplied in factor and product markets. This conforms with the way that many economists think about the market economy, and so, in some sense, is more "elegant" than the static IO model. The explicit assumptions about behavior -- you can have deviations from perfect competition if you are ready to write down the mathematical form of market participant interaction -- is appealing in situations where modelers have some idea of how participants actually operate. It is, of course, also useful when the question itself concerns the effects of changing market structure. It is reasonably easy to incorporate deviations from full-employment in the model; you simply need to write down in a mathematical function how labor responds to the real wage, and calibrate that function along with the rest of the model.

The relatively modest data requirement also carries some benefit, especially by keeping the time spent on the care and feeding of the database to a minimum. The basis for most AGE models is a social accounting matrix (SAM). The SAM itself is a method for presenting a snapshot of the circular flow of income and products in an economy with more than one producing sector.[3] One part of a SAM is the IO transactions matrix shown in Table 1. The SAM however, also includes information on flows from producing activities to factors of production and final demand, and then from factors back to activities. SAMs also typically include some disaggregation of consumer spending by interesting types, like showing transactions of low-income households separately from transactions of high-income households. Adelman and Robinson (1986) show how a SAM can be converted into a set of multipliers that can be used in a way very similar to the static IO calculation shown in Table 3.

AGE models can be built fairly cheaply and easily, and can be quite powerful in situations where there is little data available. There is a large literature of applying AGE models to developing countries, where data, especially time series data of some length, are sparse. The ability to specify simple functional forms and use the sparse data to help give policymakers insight to economic problems in a consistent modeling framework is a major contribution of the approach.

The appealing features, however, carry some costs. To get the model to go, you need to have explicit, numerical representations of production functions and utility functions. Unfortunately, we don't actually observe these functions, nor do we typically have data, like survey data, that suggest the appropriate form. Instead, we have data on outcomes from the actual economy, which can be consistent with almost any combination of production functions, utility functions, and market behavior. In many situations, model results depend crucially on the forms chosen. Static AGEs, like the static IO calculation above, tell us nothing about the time path to the new equilibrium. Dynamic AGEs might, but in practice relatively simple cost-of-adjustment functions are assumed, so the path and adjustment speeds are artifacts.

There is also something troubling about calibrating the chosen functional forms to a given year using equilibrium conditions as if they were appropriate for that year. To be blunt, suppose the base year chosen was not in equilibrium. Then the whole calibration exercise is somewhat pointless, since we are imposing conditions on the data that were not already there. Calibration for a number of years is not an impossibility, but essentially gives you a different model for each year of the calibration. Which year do you choose as the "right" base for your policy change? The last? Or a year whose other characteristics (unemployment rate, interest rate, inflation rate) are closest to the current year? There have been some attempts to estimate statistically the parameters of an AGE model, but this is not the general approach for turning the theoretical GE specifications into an AGE.[4]

Although it is not necessary that AGE models leave out a monetary sector, in practice, most do. This is probably because the initial builders of AGE models were themselves mostly interested in microeconomic issues, like tax incidence issues or trade policy. Of the four AGE models used in the JCT study of dynamic scoring, none included an endogenous monetary sector, that is, none accounted for Federal Reserve policy influences on interest rates or the economy. This was true despite the fact that the group was convened specifically to "model the macroeconomic consequences of tax policy."

Even with these limitations, AGE models are popular in policy analysis. They operate like many economists believe the economy does. They are reasonably cheap to implement. And they provide explicit statements about consumer welfare, which, if the results are to be believed, considerably simplifies policy choices.

Macroeconomic Models Linked to I-O Tables

A macroeconomic model is a collection of equations -- with parameters estimated using regression -- that relate economic aggregates to one another. Useful macro models may consist of several hundred equations, or they can be as small as 3-to-4 equations. Good introductions to macro models can be found in Almon (1996), Taylor (1993). A useful work that surveys very modern approaches to macro modeling can be found in Brayton (1997).

Most macro models themselves have little, if any, meaningful sectoral detail. Many separate agriculture from the rest of the economy, and many have equations for a few broad types of consumer goods or investment goods. However, whatever sectoral detail there is does not usually have meaningful economic content for other parts of the model. For example, there may be a regression equation that predicts consumer car-buying behavior, but, changes in auto production do not lead directly to increases in employment in the automobile industry or identifiable changes in labor demand specific to car production. Rather, increases in auto purchases tend to raise aggregate demand, which tends to raise aggregate employment. A similar problem occurs on the price side, where there is usually a single price level equation, that usually takes account only of a few sectoral supply-shock variables, like food and energy prices. Oil prices may appear as an independent variable in many different regression equations, but in general, little care is taken to ensure that value-added, labor-demand, or other variables change consistently as a result of oil price changes.

It is somewhat unfair to criticize macro models for leaving out sectoral detail and ignoring sectoral consistency, since they were not designed to answer sectoral issues. Instead, macro models are generally built to capture the interaction of interest rates, inflation, real activity and employment. They were originally designed to allow policymakers to understand the effects on aggregate economic activity of changes in fiscal and monetary policy. A key issue for these models is the determination of total employment. They are generally used in short-to-intermediate term analysis (anything from 1 quarter to 5-10 years). Much attention has been devoted to studying the role of expectations and the paths by which the economy responds to shocks. In contrast to AGE models, an enormous amount of effort has been expended in modeling the financial sector effects on the real economy, and in the dynamic adjustment paths of the economy to shocks.

These models are rooted in the data, usually national income and product account data (NIPA), augmented by time series of financial and employment data. Regression equations are typically estimated that attempt to capture the movements in the data. Goodness-of-fit of the regressions is a prime objective, and theory is generally used to provide a list of variables that should enter each regression equation, rather than to suggest a particular functional form. The equations themselves are not often derived from any model of optimizing behavior. There are some models in which optimizing behavior is used in the consumption function and in the one or two investment functions, but most other equations have no “theory” attached to them, beyond common sense. These models tend to use higher frequency data -- either quarterly or monthly -- than AGE, static IO, or IM models. This is mostly done to capture the paths by which the aggregate economy adjusts to shocks.

Traditional structural macro models are currently viewed with some derision. This is perhaps because they have been used so extensively over the last 30 years, and have had a chance to make forecasts and analyses which have subsequently been proven wrong. The models went significantly off-track in the early 1970s when stagflation emerged as a phenomenon. These misses were partially blamed on the use of backward-looking expectations. Lucas (1976) made a more fundamental criticism of macro models. He showed -- theoretically -- that because the estimated equations were reduced forms based on observed outcomes, the parameters were functions of the average embedded policy regime. He pointed out that this means that the regression equation parameters should change with the policy proposals made. The Lucas Critique was a telling blow to macroeconomic modeling because it suggested that policy analyses with the models were conceptually flawed. Proper policy analysis would have to begin from the underlying utility and production functions, which even if not stable, were at least independent of policy changes.

The steady confrontation of these models with new data and sharp theoretical criticism improved the macro models. Under the pressures of competitive markets themselves, macro modelers continued to try to show that their models were useful forecasting tools, carefully kept track of their forecasting records, and changed their models when they needed to. The current generation of macro models has addressed the two major concerns.

Most macro models now have “good” long-run properties. That is, most operate -- for better or for worse -- like neoclassical growth models in the long run. In fact, of the three “macro” models used in the JCT study, all characterized themselves as neoclassical growth models in the long run. This essentially means that, while demand changes like monetary and fiscal policies can effect the level of output in the short-to-intermediate term, in the long term, supply forces -- available labor and capital and technology -- will determine the level of output. As a corollary, in most macro models, inflation is neutral in the long-run.

Second, many models now either have “empirical” expectations, or “rational” expectations, in which the agents in the model use the model to generate their own expectations. Brayton et.al. (1996) discusses the development of solutions to the expectation issue in some detail. In addition, macro modelers have mounted a spirited counter-attack on the Lucas Critique, arguing that most policy proposals are incremental, and therefore the “regime change” effects would be small.

Macro Models and Sectoral Analysis

Despite their recent improvements, macro models have not moved in the direction of adding more sectoral detail, meaning they need some help if they are to provide useful sectoral policy analysis and forecasts. One way these models try to forecast sectoral information is by estimating time series regression equations relating sectoral variables to the endogenous aggregates in the model. This approach is described in Adams (1986).

Another way that macro models have been used to address sectoral questions is to use the macro results to “drive” a simple IO model. A simple, static IO model requires some exogenous means of developing the final demand vector. The “two-model” approach uses the macro model to generate the final demand totals, then controls the IO final demand vectors to move like the total. For example, the macro model’s prediction for growth in total consumer spending would provide the growth rate for each of the consumer spending categories in the IO model. A more sophisticated version would allow the relative industry shares to vary with the available aggregates, while maintaining the constraint that the predicted shares themselves always sum to unity. Then the final demand vectors are used in conjunction with an IO table to produce forecasts/simulations of output changes.

This appears to be a reasonably good, approximate approach to arriving at industry results while at the same time accounting for the interaction of fiscal and monetary policies and outcomes. Using the sectoral regression approach requires time series data for the sectoral data. The mixed Macro-IO approach, often called the “top-down” approach, requires less data and estimation work, since, once the macro model is available, only a single year’s IO table is necessary to generate results.

However, the top-down method does have some limitations. Many of these were laid out in Almon (1986). The chief difficulty is that of internal consistency. Unless the predicted output and implied value-added changes are allowed to affect the macro model, the combined predictions from the Macro-IO approach will be consistent only by accident. Whether or not the consistency problem is large depends on two factors: (1) what type of shock or policy change, and (2) the time frame of the analysis.

Consider how a Macro-IO model will analyze a rise in interest rates. A standard macro model would probably predict lower construction spending, followed in importance by reductions in consumer spending, and investment spending. If there is a link between interest rates and exchange rates, the model would predict a decline in exports and rise in imports. Because it is likely that there would be IO final demand components that correspond with each of these categories, the predicted output effects would probably be about right -- industries like lumber milling, concrete production, agriculture (sensitive to the exchange rate through international trade), and manufacturing in general would be most affected. Over the short-run, this analysis is probably quite a good prediction of the industry effects of monetary tightening. Thus, as a first approximation, it would appear that if the expected change is macro in nature, the Macro-IO approach will do quite well, especially in the short run.

But even if the shock is macro in nature, the correspondence of the predictions of a Macro-IO approach and what actually happens in the economy could begin to diverge in the longer run. Consider which kinds of industries are affected most by monetary tightening: manufacturing, export, and import-competing. These industries also happen to be high labor-productivity industries. Thus, over time, the overall rate of productivity growth would likely slow as activity shifted away from these sectors. Unless the macro productivity equation incorporates industry effects, it will predict productivity growth that is too high for the implied change in the structure of the economy. The difference between average economy-wide productivity implied by the mix of activity and that predicted by a regression equation that ignores this effect will widen over time. Similar differences will be arising in other variables, like prices and wages.

A more fundamental problem arises when a Macro-IO model is asked to simulate a shock that is concentrated in a particular sector, like an agricultural price shock. There the macro model will be faced with, what is in all likelihood, a small shock for one of the aggregate pieces of the overall economy. It will predict small movements in GDP, employment, interest rates, and inflation. Then it will distribute these small effects to all industries, using the final demand vectors from the IO model. Thus, it will spread these effects to all industries, rather than concentrating these effects in agriculture and its major input-supplying and output-using industries.

Despite these limitations, the Macro-IO approach has much to recommend it. Macro models are readily available, they have known track records, and, have in some sense, passed a market test for use. If the greatest source of variability for the study is the macro relationships, then for the short and intermediate term, they can probably provide useful industry forecasts and policy analysis.

Interindustry-Macro Models (IM)

IM models have a lineage that is almost as long as the macro models. The empirical implementation of these models has generally evolved along with the available computing resources. Almon et al (1974) is a good source for the early background of IM models. A more recent survey that covers the structure of the current INFORUM implementation of an IM model for the US can be found in McCarthy (1991). A short appendix describing the current version of the US IM model maintained by INFORUM (LIFT) appears at the end of this paper. IM models are not just built by INFORUM. Klein (1986) gives an example of a model he calls a "Keynes-Leontief" model that appears to be an IM.

The general idea of an IM model is to use econometric equations to predict the behavior of each sector of each real final demand category at a detailed level. Then the detailed predictions are used along with the IO A matrix to generate output. To be concrete, using the detail from Table 1, an IM model would estimate 20 separate equations for final demand (5 final demand types, with 4 sectors each). The projections from these estimated equations would, in turn, be summed by industry, then passed through the total requirements matrix to project industry output, using equation (2). In contrast, the macro model would estimate 5 equations (one for each type of final demand) and then "share" the projections from these equations out to the specific industries.

The IM approach to projecting prices is similar to that used for projecting final demand. Equations are estimated for each of the value-added components for each industry, which are then turned into a forecast of prices using equation (4) above. Thus, income and prices are directly related and are consistent. Relative price terms are included as independent variables in the regression equations for final demand, which creates a simultaneity between final demand and value-added. Conceptually, relative price effects can appear in equations to predict the evolution of the A-matrix coefficients, although, in the current implementation of the INFORUM IM model, the coefficients move with time trends rather than prices.

Most IM models have at least a rudimentary financial sector, that is, interest rates are endogenous, and usually related to some monetary policy variable. In the INFORUM LIFT model, the financial sector is fairly well-developed, and includes an exchange rate equation based on the well-known interest parity conditions.

The advantage of the IM approach over the Macro-IO approach for sectoral analysis is economic consistency. Sectoral developments drive the macro totals. These models are "bottom-up" models. GDP, total employment, and other aggregates are derived by adding up the sectoral predictions. This is in direct contrast to the Macro-IO approach, but it is more like the AGE approach. The major advantage of the IM approach over the AGE approach is that it uses as much data about the economy as the modeler can feed into it.

Because IM models are rooted in data, they provide information about the dynamic paths by which the economy adjusts to shocks. In addition to macro adjustment paths, predictions of time paths are naturally computed at the industry level. In point of fact, the macro dynamics are simply the result of the industry dynamics.

The major costs of the INFORUM type model are the enormous data base necessary to support the model and the time and energy it takes to maintain and improve the detailed regression equations. Because parts of the model are so tightly linked, an equation for a small sector that inadvertently strays off into uncharted territory can carry the whole model with it. While this can happen with any model that uses regression-based parameters, the problem is magnified in IM models due to the sheer volume of equations to estimate and test. In practice, the volume of equations has raised some interesting issues relating to the stability of estimated parameters and the usability of sectoral equations for forecasting aggregate behavior. For example, while we have found it is possible to have a reasonably stable regression equation to predict aggregate profits, it has proven devilishly difficult to estimate functions that simultaneously capture the behavior of profits at the industry level and, when added up, give a reasonable view of profits in the aggregate.

In a very real sense, IM models are generalizations of macro models (we actually prefer to think of macro models as special cases: single-sector IM models). The approach combines econometric modeling and IO concepts to provide an integrated view of all industries in the economy. The approach is decidedly empirical, and strongly based on annual time-series data. It shares with macro models a heavy reliance on econometric equations using observed economic outcomes. However, because it is a bottom-up modeling approach, it shares with AGE the idea that macroeconomic aggregates should be derived from industry detail through simple addition.[5]

Which Model is Best?

Economists involved in some aspect of policy analysis and forecasting almost always ask a difficult question: “Which model type is best?” This question is usually asked before a study begins, at the time when managers are trying to allocate funds to an effort that will eventually support some policy or forecasting work. The managers know that the choice of the model will be scrutinized, and also will have to be justified to higher-ups. They would like a simple answer to a simple question. In this environment, groups try very hard to differentiate their model, and, of course, are often happy to characterize other approaches in a less than favorable way.

Discussions among the modelers are very interesting, and depending on who is debating, very entertaining. Debates generally revolve around very fundamental issues. Proponents of AGE often argue that the regression-based approach of Macro-IO and INFORUM is based on a fallacy that the future -- or a simulated policy change -- will look pretty much like the past -- or like the average of policy changes in the past. Lucas Critique arguments are routinely employed, implying that the estimated regression coefficients are not stable with respect to the relevant changes. Even if stable, AGE modelers point out the difficulty of extracting the “true” economic signal from noisy, aggregated, and highly serially correlated time-series data with regression equations. They bemoan the lack of strong consistent microeconomic underpinnings in the models.

Naturally, Macro-IO and IM modelers reply in kind. They argue that utility and production functions are chosen more for their analytical tractability than for their correspondence with reality. They point out that the reliance on a single-year’s worth of data as representative of how the economy will work is questionable. They look askance at the idea that the economy ever was in a measurable “equilibrium” that would enable good calibration. They express incredulity that any meaningful macro analysis can be carried out assuming the economy is always at full employment and without reference to the tendencies of the central bank.

But then new alliances form in the discussion. AGE and INFORUM modelers usually criticize Macro-IO models because industry results tend not to affect the overall outcomes in their analyses. The characteristics of different industries, and thus the resulting differences in projected outcomes, are not allowed to influence the overall economy. Not only does this not conform to our observation about how the economy works, but as pointed out above, the approach can provide misleading industry results in the long term or in cases where the shocks are sector-specific.

In truth, there is no “best” model. Models are either more or less appropriate for the intended study, and some models may be just the right tool to use for one part of a study, but exactly the wrong tool to use in another. As should be clear from the preceding discussion, different modeling approaches lead to models with different characteristics. The best model for any use is that model whose characteristics are strongest in the areas that are most important to the analysis.

Having been involved in several of these discussions, and thus, having some data on which to extrapolate, we predict that individual modelers themselves will not likely reach consensus about the “best” model. The reason may have more to do with individual modelers’ tastes, rather than from objective analysis. But pity the poor manager with a limited budget who must still make a decision about which model to use for his work. Taste arguments will not make him very comfortable. He is still searching for the bottom line. Our best advice would be to use them all. We admit that’s unlikely. Our next best alternative is to outline some model characteristics and show the various types’ strengths and weaknesses. Our manager can use this list to help her decide what’s right for the particular situation. The list of characteristics is preliminary and somewhat speculative. We hope the list will generate discussion about desirable characteristics, and we know it will probably generate disagreement. That discussion can only be beneficial to the modeling and policy-analysis community.

We provide two lists, one that concentrates on characteristics important to model builders and another that focuses on model users. Then we rank each model type allocating a total of 6 points to the characteristic. The “best” model for each characteristic gets a 3, the next, a 2, and the worst, a 1. Ties are used liberally. Summary scores for the lists are shown in tables 4 and 5.

To use the tables effectively, you need only provide your weighting scheme for the characteristics to arrive at the right model choice for the particular task.

For multi-sector model builders, the characteristics are: (1) Adheres to standard, neoclassical general equilibrium theory, (2) Incorporates “known” economic data , and (3) Minimizes maintenance and care costs. For model users, the characteristics are: (1) Easy to understand and use, (2) Has a good track record, and (3) Provides policy-relevant output. In the next several sections, we’ll discuss each of these qualities and assign scores. The summary results are shown in Tables 4 and 5.

Adheres to Standard Neoclassical Theory

For better or for worse, the reigning paradigm for intersectoral analysis in economics is general equilibrium modeling in the Walras-Arrow-Debreu sense. AGE models generally aim to have strong theoretical underpinnings. They typically begin by specifying the exact form of the underlying consumer utility functions and producers’ production functions. Then the assumption of equilibrium is used to generate the parameters that are consistent with observed data. These models strongly adhere to the dominant theme of modern general equilibrium work, that agents optimize continuously and inter-temporally, that competitive product and factor markets that reach equilibrium quickly is the norm, and that full employment is automatically generated. This seems to stem from the belief that the actual economy is a general equilibrium system with these characteristics, about which the observed data provide only a faulty, partial picture. For these modelers, the world is tidy, as are the models. The data are messy, mainly because economic statisticians can’t measure what the theory needs to become truly operational.

In contrast, both Macro-IO and IM models only partially incorporate the current dominant paradigm. Although model-builders may adhere to the optimizing-agent paradigm for some parts of their models -- like in the development of consumer spending equations -- it is not used generally. Instead, theory is used as a guide for selecting variables to be used in regression equations, but does not provide a recommendation for functional forms, elasticities, etc. This “eclectic” view of theory may be because it is impossible to implement the full paradigm with data, or because Macro-IO and IM modelers simply do not put as much faith in the dominant paradigm. For whatever reason, the ordering for this characteristic is AGE(3), followed by IM (2) and Macro-IO (1). The IM type gets a slight edge over the Macro-IO because it at least allows sectoral outcomes to determine aggregate outcomes, rather than the other way around.

Incorporates Known Economic Data

Even though theory is important, for applied work, at least some data needs to be used. Macro-IO and IM models generally aim to have a strong correspondence to the available data. The emphasis is on the models matching and accounting for past data movements. This emphasis derives from the underlying belief that a model incorporating as much information from the past as possible will have a better chance at predicting the future or accurately projecting the effects of a policy change than a model that incorporates less information. This belief is nearly the reverse of the AGE modelers.

It is worth commenting that AGE modelers would like to use more data, but are often suspicious that the available data is the proper kind of data. They would prefer direct observation on utility and production functions. Their use of large micro data sets is an attempt to bring in more information. However, in general, economic data are observations on outcomes of decisions, not observations directly on the decision-making machinery per se. IM and Macro-IO modelers do not seem to mind modeling outcomes, often in their wilder moments, doubting that there is any stable decision-making machinery in the first place.[6] The ordering for this characteristic is IM (3), Macro-IO (2), and AGE (1). The IM models get a slight edge over the Macro-IO because they use a much richer data set for their estimations.

Minimizes Maintenance and Care Costs

In general, model builders like to erect a structure that generates answers, not that simply houses a data set. As a result, modelers have a love-hate relationship with data (I love it! It gives me numerical answers. I hate it. It's messy and takes time away from analysis!) The data requirements for building a proper IM model far exceed the requirements of the other model types. In the US, the problem is made worse by the fact that the IO accounts and the NIPA do not agree for any year and there is no official series on real industry output.[7] Thus, some data manipulation has to occur before any analysis can be done. Because of the data inconsistency, even AGE models need to perform some reconciliation analysis before calibration begins. However, as noted above, a static AGE needs only one year of data. An IM model would need several years, with corresponding increases in the time for care and feeding of the database.

Assuming that Macro-IO models incorporate only one year's worth of industry data, they typically require more data than the AGE model, but far less than the IM model. However, recent advances in data dissemination -- Internet links, etc -- make the maintenance of even the complete US NIPA a relatively painless task. Thus, while Macro-IO models require more data than a static AGE, the extra cost is quite small. It's important to note that for some purposes, even a static AGE can require enormous amounts of information too. The AGE models used in the JCT dynamic scoring study had considerable detail about households and the distribution of income and taxes. Nonetheless, the typical data requirements for a general model are quite modest .

There is more to the maintenance and care of a model than its database, even in a world where regression packages can do almost any reasonably sized estimation faster than the average human can take a sip of coffee. With so many equations to monitor, re-estimate and fine-tune, the IM models are also quite costly. Macro-IO models have this problem to a lesser extent. AGE models generally substitute theory for data. Thus the scores for least costly to maintain and build are AGE (3), Macro-IO (2), IM (1).

Easy to Implement Policy or Other Exogenous Changes

This category is not about the software or machine requirements. While these are extremely important, they are not inherent characteristics of the model types. This characteristic is aimed at how easily a user can implement a policy change in the model and get out an understandable story about the policy change. In general, the more detailed a model, the greater the number of policy possibilities are open to the user, and the greater the probability that any individual policy can be implemented directly. For example, an increase in the cigarette tax could likely be implemented more easily in an IM or AGE with enough sectoral detail, than in a Macro-IO model. While the IM or AGE would generate the aggregate results as a natural part of letting the model run, in the Macro-IO approach, "off-line" guesses at the aggregate effects would have to be incorporated in the macro model. Then the sectoral effects would be estimated.

However, the very richness of the AGE and IM models can be overwhelming to the user initially. The learning curve for the both the AGE and IM models can be quite steep. AGE models may be somewhat easier to understand as economic models, simply because they largely conform to graduate microeconomics training, and intersectoral policy analysis is generally done by microeconomists. At the same time, large, empirically-based models have been criticized because they turn into "black boxes," whose results cannot generally be easily explained. In truth, this appears to be mostly an issue of the training and taste of the user. While any particular group could probably figure out what their tastes are, there is no clear "best" for all users. In advance, each of the model types gets a 2 for this characteristic, but any specific group would probably have clear preferences for one type over another.

Track Record

A user would like to feel that the model he is working with has been able to explain the behavior of the economy in the past or has offered important insights on other policy questions. A good track record makes it relatively easy to justify the choice of the particular model of a general type. Some evidence of track record is simply to be found in the uses to which the models have been put. Since all of these model types have been engaged in serious policy work for several years, all have a track record. Another indicator of track record could be the number of professional journal articles using the model as a basis. Here too, the models are on relatively equal footing, although the macro part of Macro-IO has recently fallen severely out of favor at about the same time the AGE models have gone through their growth spurt. IM models trail both in that regard.

However, Macro-IO and IM models have been actively engaged in forecasting for almost three decades. This gives an indication of track record that the AGE models generally do not have. A key question often asked by policymakers is: "How well has your model done in forecasting the last few years?" This is usually a more polite form of the real question: "Why should we believe you?" AGE modelers answer by reiterating that their theoretical base is valid. Macro-IO and IM models generally respond with a study about their average errors over some forecasting horizon. Our experience is that the second kind of reply is usually better received and actually conveys information to the policymaker. Score 2.5 for the Macro-IO and IM, and 1 for the AGE for this characteristic.

Policy-relevant Output

All of these models provide lists of winners and losers at some level of detail. AGE models can provide true welfare results, in terms of indexes of utility. IM and Macro-IO focus on directly measurable variables, rather than utility. In the main, this would seem to argue that the models are about equal in their policy-relevant output. However, AGE models, even the dynamic form, have little to offer in the way of guidance of how the economy responds over time to shocks or policy changes. IM and Macro-IO models explicitly turn out predictions of the economy's dynamic response to policy changes. IM models, in which the outcomes are modeled directly at the sectoral level, have dynamic responses that are based directly on the sectoral data. Because policymakers are often just as interested in the path to equilibrium as they are in the ultimate equilibrium point, and because the sectoral dynamic paths are available for the IM model, the IM approach gets a high score.

Another important area of policy relevance is the extent to which important real-world interactions are modeled in each approach. Most AGE models do not have a meaningful financial sector, nor do they account for international capital flows (none of the four AGEs used in the JCT study had these features). These features are, however, strongly present in the Macro-IO and IM models, simply by virtue of the attention paid to the macroeconomic side of the modeling exercise. It is sometimes argued that policy evaluation of, say, a tax change, should be done in isolation of monetary policy possibilities, since to include a monetary policy change is really evaluating two policies. While this is true as a logical proposition, the model should be able to at least account for different possible monetary policies, even if it does not choose one as likely. In addition, it is useful information for the policymaker to know that the benefits or harms of his policy change can be mitigated or magnified by monetary policy. With these considerations in mind, the scoring for this characteristic is IM (3), Macro-IO (2), and AGE (1).

Conclusion

By necessity and by historical accident, there are few "pure" forms for these models. Almost any model has some features from more than one of the ideal types. For example, there are macro models that have some sectoral detail, which, at least in a limited way, is allowed to affect the generation of the macroeconomic totals. By the same token, although the INFORUM approach emphasizes the calculation of aggregates from outcomes of individual sectors, there are some instances in the applied models in which a single macro equation determines the aggregate, while "share" type equations distribute the aggregate to individual sectors. Theory is very strong in some macro model equations, and there are some AGE models that use ad-hoc approaches for some sectors. There have even been instances in which static AGE models have been driven by small macro models. The point of this paper has been to lay out the broad outlines of these competing modeling strategies, with an eye toward developing a framework by which users can choose intelligently among them.

Table 3: Results of Simple I-O Calculations

	Effect on industry output of $1 billion increase in agriculture final demand, billions of $	Effect on industry prices of 1 percent increase in value-added per unit of output in agriculture, %
Agriculture	1.47	1.47
Mining	0.02	0.01
Structures	0.02	0.04
Manufacturing	0.37	0.10
Services	0.46	0.01

Table 4: Rankings of Model Characteristics for Builders

	AGE	Macro-IO	IM
Standard micro theory	3.0	1.0	2.0
Data	1.0	2.0	3.0
Maintenance	3.0	2.0	1.0
Total	7.0	5.0	6.0

Table 5: Rankings of Model Characteristics for Users

	AGE	Macro-IO	IM
Ease of Use	2.0	2.0	2.0
Track record	1.0	2.5	2.5
Policy-relevance	1.0	2.0	3.0
Total	4.0	6.5	7.5

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Endnotes

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[1] This paper has benefited from a number of discussions with several people. Among those who have had a hand in shaping this piece are Clopper Almon, Margaret McCarthy, Douglas Meade, and Douglas Nyhus of INFORUM. John Phelps, of the Office of the Actuary of the Health Care Financing Administration also made several helpful comments. Lorraine Monaco made contributed useful observations. Amy Moxey and Jessica Flores carefully read for clarity and suggested several changes. Remaining mistakes are my own.

[2] Kehoe and Kehoe (1993a) provides a clear example of calibration.

[3] Hanson and Robinson (19) provide a clear example of constructing a SAM, and show how a SAM can be constructed using US data for 1982.

[4] Jorgenson (1984) is the standard citation for an AGE built with parameter estimation rather than calibration.

[5] In practice, the recent revision of the US NIPA, which has included a move to using chain-weighted aggregates, has meant that the aggregation of sectoral projections to NIPA totals is no longer quite straightforward. Nominal projections at the sectoral level can, of course, be simply added up to give correct nominal totals. "Real" sectoral data no longer sums to the "real" aggregate published by NIPA. Modelers working extensively with sectoral data in the US are still grappling with the implications of this change for their modeling work.

[6] In a very real sense, the AGE modelers are followers of Decartes, while the Macro-IO and IM modelers are followers of Bacon or Hume. If that is a fair characterization, it's no wonder discussions among these groups are so much fun.

[7] See McCarthy (1997) for a thorough discussion of data requirements of an IM model in the US context.

A Quick Overview of LIFT

INFORUM's Interindustry-Macro Model of the U.S. Economy

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Appendix

A Schematic Overview of LIFT: INFORUM's Interindustry-Macro Model of the U.S.

LIFT is a macro-interindustry model of the U.S. economy that forecasts:

- o Output, employment, prices, and interindustry sales information for 85 producing sectors
- o Factor costs (value-added) for 51 industries, including labor compensation, profits, depreciation, and net interest payments.
- o All standard macro aggregates, including GDP, interest rates, inflation rates, the overall unemployment rate, etc

.

- o Through the year 2050.

The model's design incorporates macro-industry relationships:

- o Macroeconomic aggregates are generally sums of industry forecasts.
- o Achieves industrial consistency through its input-output structure.
- o Accounts for relationships among producing sectors to forecast output, employment, and prices.

Product output is the sum of final use and intermediate use.

- o Final use is the sum of consumer spending, investment, government, export, import and inventory demand.
- o Intermediate use is derived from an input-output table that tracks purchases by each sector from all other sectors. Example: an increase in auto production leads to increases in the output of steel, plastics, and business services.
- o The model uses the basic input-output equation to determine output:

$$q = Aq + f$$

  where q is a column vector of outputs, A is the technology matrix, and f is a column vector of final demands.

- o Technology matrix shows how much of each product is needed to produce another product.
- o Interindustry structure changes over time. Time-series of A-matrices are derived from a 1982 matrix.
- o Matrix coefficients are forecasted with time trend equations to capture technology changes, and trends are applied across rows.

Final demand equations are estimated econometrically at detailed levels.

- o There are equations for Consumer spending (80 types), Equipment investment spending (57 industries), Construction (31 types), Exports and imports (85 products each).

- o Equations depend on sectoral and macroeconomic variables. Example: business investment spending by the motor vehicles industry depends on motor vehicles output (sectoral demand), interest rates, and tax rates (macro factors).

- o Most estimated equations are based on econometric analysis of time-series data from about 1955 through 1993 (macro equations have later ending dates).

- o "Bridge" matrices translate consumer spending by category, equipment investment by industry, and structures purchases by type of structure into goods and services defined in terms of producing sectors. Example: the equipment-by-industry bridge translates investment by agriculture into farm machinery, trucks, computers, etc.

Output forecasts are combined with industry-level equations for productivity and average hours per job forecasts to derive jobs required by industry.

- o Productivity forecasts by industry depend business cycle effects and time trends.

- o Hours by industry forecasts rely on time trends and movements in the unemployment rate.

Prices for any product are the weighted sum of unit costs.

- o Costs include the cost of intermediate goods and direct factor costs (labor compensation, indirect taxes, capital income, i.e. value-added).

- o Labor compensation is divided into wages and salaries and employer contributions for pensions, for health insurance, for social insurance, and for other benefits.

- o 8 components of capital income are modeled separately: corporate profits, proprietor income, net interest payments, capital consumption allowances.

- o Intermediate costs are calculated using the input-output structure. Example: an increase in profits in the steel industry raises steel prices (all else constant), raising costs for auto makers, and, in turn, raises prices in autos and all other products using steel.

- o Prices by industry are calculated using the dual of the input-output equation:

$$p = pA + v$$

where p is a row vector of prices, A is the technology matrix, and v is a row vector of value-added per unit of output.

- Equations for labor compensation, profits, etc. (value-added) are estimated at the 51 industry level and depend both on sector specific and macroeconomic factors. Example: Equations to predict corporate profits by industry depend on real output growth (sectoral demand), and the GNP gap (economy-wide excess demand).

Standard accounting turns industry income flows into macro aggregates like personal income, etc.

Extensive government accounting tracks social insurance programs, etc. at both the federal and state and local level.

- Model distinguishes social insurance fund deficits from operating deficits. Extensive transfer payment detail and tax detail, at federal and state and local level.

LIFT Product Side

Component	Sectors	Influences
Output by product sector	85	q = Aq + f
Personal Consumption by NIPA expenditure category	80	Disposable income Size distribution of income Change in disposable income Interest rates, Relative prices Age structure of population Other demographic variables
Equipment Investment by investing industry	55	Change in product outputs Change in relative prices of user cost of capital, labor, and energy Stock of equipment by industry
Construction by type	31	Output, Income, or Expenditure Interest rates, Stocks, Demographics
Inventory Change by product sector	85	Product output, Inventory stocks Interest rates and inflation
Imports by product sector	85	Domestic demand by product Domestic/foreign product prices Exchange rates
Exports by product sector	85	Foreign demand by product Foreign/domestic product prices Exchange rates
Labor Productivity by product sector	85	Output cycles by sector Time trends
Length of Work Week by product sector	85	Change in output, Unemployment rate Labor force participation
Employment	85	Labor productivity, output, work year
Consumption, Equipment, **& Construction by product**	85	Final demands by category are bridged to producing sectors
Government Purchases by product sector	85	Exogenous

LIFT Price-Income Side

Component	Sectors	Influences
Prices by product sector	85	$p = pA + v$
Value added by product sector	85	Value added by industry distributed to products based on product-to-industry bridge
Value added by industry:		
Labor Compensation	51	Hourly compensation * hours
Aggregate wage (hourly compensation)	1	Labor productivity Excess money growth GNP Gap Price shocks (oil,agric)
Relative wages industry/aggregate	51	Unemployment, inflation Labor force participation
Return to capital by industry	51	Corporate profits + Proprietor income + Net interest + Depreciation allowances + Inventory value adjustment + Business transfer payments
Rental income for 1 industry	1	Average share of nominal GNP Inflation Transitory nominal GNP
Indirect business taxes total of all industries	1	Lagged IBT as share of GNP Growth in real GNP
by industry	51	Share of total IBT Exogenous
Government subsidies (largely Agricultural subsidies)	51	Exogenous

LIFT Return to Capital by Industry

Component	Sectors	Influences
Corporate Profits by industry	51	Mark-up over labor costs Input costs Demand (output, unemployment, interest rates)
Proprietor Income "large" industries	9	Mark-up over labor costs Capital stock to output Demand
all other proprietor income by industry	42	Change in labor compensation (three-year average)
Net Interest Payments total domestic payments	1	Current AAA-bond rate Smoothed average rate Business debt
by industry	50	Share of total domestic payments
Rest of World payments	1	Change in net factor income
Capital Consumption Allowances Corporate and Noncorporate totals determined by same specification, but with different equations	51	Depreciation of equipment Depreciation of structures
Inventory Valuation Adjustment Corporate & Noncorporate determined by same specification, but with different equations	1	Inflation
by industry	51	Share of total IVA
Business Transfer Payments total	1	Share of nominal GNP Lagged real interest rate Unemployment rate
by industry	51	Share of total Business Transfers

LIFT Macroeconomic and "Other" Variables

Component	Influences
Population	Exogenous: INFORUM DPM
Labor Force	Exogenous: INFORUM DPM
Tax policy	Exogenous: 1986 Tax Law, 1993 changes
Monetary policy	Exogenous: INFORUM (M2 or monetary base. St. Louis)
Government expenditures	
Purchases	Exogenous: INFORUM assumptions
Transfer payments	Exogenous: INFORUM assumptions
Old age	constant in real terms per recipient
Medicare	constant fraction of health spending
Unemployment	constant in real terms per recipient
Other	nominal level assumed
Interest payments	Endogenous: depends on Debt and Interest rates
Price of crude oil	Exogenous: INFORUM assumption
Savings rate	GNP Gap
	3-month Treasury bill rate
	Consumer installment debt ratio
Interest rates	
3-month Treasury bill	Inflation
	Real monetary base, St. Louis
	GNP Gap
	Credit demand (including Federal deficit)
10-year Treasury note	3-month Treasury bill rate
	Inflation
	Credit demand (including Federal deficit)
Commercial paper	3-month Treasury bill rate
Mortgage rate	10-year Treasury note rate
Aaa bond rate	10-year Treasury note rate
	Profits + Depreciation as share of GNP
Bridge tables:	
Intermediate coefficients	Across-the-row trends
Construction materials	Across-the-row trends
Personal consumption	Trends
Equipment investment	Investment cycle, Trends

LIFT Matrix Listing by Seller

An Example for Motor Vehicles and Parts
Sales of the motor vehicle and parts sector to other producing sectors a nd to final demand.
Millions of 1977 Dollars

SELLER: 43 Motor vehicles and parts

BUYER:	1990	1995	2000	2005	2010	Avg Annual Growth, % 1990-2000	Avg Annual Growth, % 2000-2010
SALES TO INTERMEDIATE							
43 Motor vehicles	26659.2	32870.5	35910.5	41057.8	46755.9	2.98	2.64
67 Automobile repairs	8278.9	9199.4	10189.5	11413.0	12626.8	2.08	2.14
SUM: INTERMEDIATE	37334.7	44652.3	48939.7	55620.2	62859.9	2.71	2.50
SALES TO EQUIPMENT INVESTMENT							
1 Agriculture(1)	644.2	630.8	622.0	625.3	633.3	-0.35	0.18
4 Construction (8)	2207.3	2416.7	2919.2	3325.4	3827.7	2.80	2.71
5 Food, tobacco (9)	756.0	806.4	882.4	980.9	1090.8	1.55	2.12
9 Paper (13)	707.2	689.0	743.0	807.4	886.6	0.49	1.77
44 Trucking, oth transport	5002.2	3937.9	4279.0	4733.6	5218.1	-1.56	1.98
46 Electric utilities (56)	651.2	1126.2	1174.5	1235.3	1304.5	5.90	1.05
47 Gas,water & sanitation (	1032.1	1151.1	1299.8	1469.1	1667.9	2.31	2.49
48 Wholesale & retail trade	20762.9	25722.6	28316.4	31946.4	36064.9	3.10	2.42
49 Finance & insurance (62)	2017.7	2146.2	2347.3	2656.0	3057.6	1.51	2.64
51 Hotels; repairs exc.auto	929.5	1124.4	1208.5	1318.6	1449.0	2.62	1.81
52 Business services (66)	1717.3	2063.0	2297.8	2638.2	3042.1	2.91	2.81
53 Auto repair & rental (67	5268.8	5743.2	6409.8	7250.5	8157.3	1.96	2.41
55 Medicine, educ, npo (69)	1993.6	2377.0	2591.1	2944.1	3390.1	2.62	2.69
SUM: EQUIPMENT INVESTMENT	48820.1	55447.7	61066.5	68512.2	77187.4	2.24	2.34
SALES TO CONSTRUCTION							
SUM: CONSTRUCTION	124.7	144.0	159.7	175.7	187.1	2.47	1.58
SALES TO PERSONAL CONSUMPTION							
1 New cars	43528.3	39507.1	43554.3	51387.2	59118.2	0.01	3.06
3 New & used trucks	17404.6	20543.8	21603.1	24064.2	26471.5	2.16	2.03
5 Auto accessories & part	957.4	1050.3	1114.0	1194.1	1272.9	1.51	1.33
SUM: PERSONAL CONSUMPTION	61890.4	61101.2	66271.4	76645.5	86862.6	0.68	2.71
SALES TO OTHER FINAL DEMAND							
DEFENSE	1129.1	889.7	880.0	933.6	955.0	-2.49	0.82
S&L EDUCATION	866.2	903.0	986.6	1089.3	1209.7	1.30	2.04
S&L OTHER	1883.4	2123.9	2234.2	2339.6	2434.2	1.71	0.86
EXPORTS	15088.0	21997.6	25909.9	33960.7	43198.0	5.41	5.11
IMPORTS	-49643.0	-54477.8	-59788.9	-70089.4	-80768.0	1.86	3.01
INVENTORY CHANGE	-4200.0	1571.4	1000.0	1000.0	1000.0	0.00	0.00
SUM: OTHER FINAL DEMAND	-34507.7	-26566.4	-28350.4	-30334.6	-31534.3	-1.97	1.06
SUM: FD STATISTICAL DISCREPANCY	3038.7	9112.1	9112.1	9112.1	9112.1	10.98	0.00
OUTPUT: Motor Vehicles	116701.0	143891.0	157199.0	179731.1	204674.9	2.98	2.64

LIFT Matrix Listing by Buyer

Example for Motor Vehicles and Parts
Purchases by motor vehicle and parts from other producing sectors.
Millions of 1977 Dollars

BUYER: 43 Motor vehicles and parts

SELLER:		1990	1995	2000	2005	2010	Average annual growth, % 1990-2000	2000-2010
				INTERMEDIATE PURCHASES				
12	Apparel, household text	2168.3	2673.5	2920.8	3339.4	3802.9	2.98	2.64
16	Other chemicals	1304.6	1640.1	1816.2	2097.4	2404.4	3.31	2.81
19	Rubber products	2933.0	3560.8	3831.3	4330.0	4892.6	2.67	2.45
20	Plastic products	2912.1	3811.4	4380.2	5193.5	6055.1	4.08	3.24
24	Stone, clay, glass	1002.3	1246.4	1372.6	1578.7	1804.9	3.14	2.74
25	Ferrous metals	5740.1	6250.7	6089.7	6328.8	6726.0	0.59	0.99
27	Other nonferrous metals	1600.1	1977.7	2165.8	2480.8	2828.5	3.03	2.67
28	Metal products	10051.4	12558.8	13883.2	16012.7	18341.1	3.23	2.78
29	Engines and turbines	1906.9	2351.2	2568.6	2936.8	3344.4	2.98	2.64
32	Metalworking machinery	645.4	795.7	869.3	993.9	1131.9	2.98	2.64
34	Misc non-electrical mac	2556.0	3263.5	3681.5	4308.9	4982.5	3.65	3.03
37	Service industry machin	2499.2	3154.1	3497.7	4043.6	4638.5	3.36	2.82
38	Communic eq, electronic	583.6	785.1	922.0	1109.3	1305.1	4.57	3.47
41	Misc electrical eq	2012.4	2526.6	2790.5	3216.4	3682.5	3.27	2.77
42	Tv sets,radios,phonogra	645.4	795.7	869.3	993.9	1131.9	2.98	2.64
43	Motor vehicles	26659.2	32870.5	35910.5	41057.8	46755.9	2.98	2.64
49	Railroads	711.8	821.2	844.7	920.7	1014.3	1.71	1.83
50	Trucking, hwy pass tran	1423.2	1822.5	2049.4	2393.1	2763.2	3.65	2.99
56	Electric utilities	837.4	1017.9	1090.4	1222.0	1363.4	2.64	2.23
59	Wholesale trade	12628.9	16416.8	18731.0	22098.4	25683.4	3.94	3.16
66	Business services	2832.0	3740.7	4355.3	5210.1	6108.0	4.30	3.38
67	Automobile repairs	1538.8	1979.7	2253.4	2654.0	3081.3	3.81	3.13
71	Non competitive imports	631.4	778.5	850.4	972.3	1107.3	2.98	2.64
SUM:	INTERMEDIATE	91731.5	114280.1	126028.7	145097.5	165982.6	3.18	2.75
OUTPUT:	Motor vehicles	116701.0	143891.0	157199.0	179731.1	204674.9	2.98	2.64