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A COMPARISON OF ECONOMETRIC MODELS

A STUDY

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LETTER OF TRANSMITTAL

JULY 25, 1978.

To the Members of the Joint Economic Committee:

Transmitted herewith for the use of the members of the Joint Economic Committee and other Members of Congress is a study entitled "A Comparison of Econometric Models." This paper is designed to assist in understanding the various econometric models commonly used in policy evaluation. It is not intended to criticize any of the models, but to explain their similarities and differences. Such an understanding should contribute to more careful and useful policy evaluation. The paper was prepared by Mr. L. Douglas Lee of the committee staff. The views expressed in the study are those of the author and do not necessarily reflect the views of the Joint Economic Committee, individual members thereof, or other members of the committee staff.

Sincerely,

RICHARD BOLLING,
Chairman, Joint Economic Committee.

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A COMPARISON OF ECONOMETRIC MODELS

By L. Douglas Lee

INTRODUCTION

In the process of decisionmaking, a policymaker sometimes will pose the following question: "If we adopt this particular policy, how will it affect the economy?" Analysts will often use an econometric model to answer this question. By changing the policy assumptions which are fed into the model, an analyst can explore the probable outcome of various policy options.

There are three large macroeconomic models of the U.S. economy which are commercially marketed and widely used by analysts in government and private industry. These models were developed by Chase Econometric Associates, Inc. (Chase), Data Resources, Inc. (DRI), and Wharton Econometric Forecasting Associates, Inc. (Wharton).

Each of these models is an attempt to describe the U.S. economy using a group of mathematical equations and statistical relationships. Not surprisingly, since there is disagreement among economists on the economic theory which underlies the models and disagreement among statisticians and econometricians on the best equations to capture the statistical relationships, the three models are quite different.

The following paper is divided into two sections. The first is a description of the model structures. It is an effort to translate the mathematical equations into words. It also points out the economic theory underlying the equations. The second part of the paper discusses some of the theoretical issues surrounding this particular approach to economic analysis. In recent years this approach has come under attack by some economists who argue that it is not justified on fundamental theoretical grounds.

THE ECONOMETRIC MODELS

Since the commercially available models undergo constant revision and updating, careful attention must be paid to the specific version being used. The version of the DRI model discussed in this paper is designated 77y. It was reestimated and revised in 1977 and is described in the collection of papers, "The Data Resources Model, 1977 Edition" (mimeo) edited by Otto Eckstein. The Chase model discussed is the version in effect in December 1977. Most of the equations in the Chase model were estimated in 1976 or 1977. The discussion which follows is based on a listing of those equations. The Wharton Mark IV quarterly econometric model was constructed in 1974. While various sections have been updated and changed, the model has not undergone a complete revision since that time. The equations in the version used in this paper were estimated in 1974–77, and the discussion comes from a listing of these equations.

A few general comments are in order before plunging into the model structures. First, one should note that these general equilibrium models have grown increasingly large and complex in recent years. For example, the models designed in the 1940's and early 1950's by Lawrence Klein contained 12 equations. By contrast, today's DRI model contains some 800 equations. Similarly, the Wharton model uses 669 equations while the Chase model contains about 455 equations.

Second, these models are best used in combination with the judgment of an economist. Whether the model is used for forecasting or for policy analysis its results are always subject to modification by the analyst if they appear "unreasonable." [1] This means that different analysts may derive different results from the same model if they alter the model's output to conform to their own judgment. Several evaluations of the accuracy of these judgmental forecasts have been published.[2]

Third, the models described in this paper are all quarterly models which are typically used for analyzing an 8–12 quarter time period. Other models using annual data or focusing on long-term analysis are not considered. This distinction is not especially important for Chase and DRI because their long-term projections are produced by merely extending the quarterly model. For Wharton, however, the annual model is different both in structure and in the level of aggregation.

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[1] The only nonjudgmental model of which this author is aware is the model developed by Ray Fair. For a more complete discussion of it see Ray C. Fair, *A Short-Run Forecasting Model of the United States Economy* (Lexington: D. C. Heath & Co., 1971).

[2] See, for example, the following series of articles by Stephen K. McNees: "How Accurate Are Economic Forecasts," *New England Economic Review* (Boston: Federal Reserve Bank of Boston, November/December 1974); "An Evaluation of Economic Forecasts," *New England Economic Review* (Boston: Federal Reserve Bank of Boston, November/December 1975); "The Forecasting Performance in the Early 1970's," *New England Economic Review* (Boston: Federal Reserve Bank of Boston, July/August 1976); "An Evaluation of Economic Forecasts: Extension and Update," *New England Economic Review* (Boston: Federal Reserve Bank of Boston, September/October 1976).

Fiscal Policy

The fiscal policy variables in the DRI model correspond closely to the broad divisions used in the National Income and Product Accounts. Exogenous variables are government purchases (divided into military and nonmilitary), grants-in-aid to State and local governments, foreign transfers, wage accruals less disbursements,[3] and subsidies. Endogenous spending variables are transfers to persons and net interest. All receipt categories are determined endogenously and are broken into the following broad categories: Personal tax and nontax payments, corporate tax accruals, indirect business taxes, and social insurance contributions.

A unique feature in the fiscal policy section of the DRI model is the option of specifying government purchases in either current dollar or constant dollar terms. When the analysis covers a longer time period, it is sometimes easier to estimate purchases in real terms.

The spending side of fiscal policy is much more disaggregated in the Chase model than in the DRI model. Although purchases are nominally endogenous (that is, determined within the model), the aggregate level is the summation of several exogenous components (that is, determined by some unspecified source outside the model): Purchases of durables, nondurables, services, structures, and Commodity Credit Corporation payments for surplus crops. Subsidies, wages, and grants-in-aid are also exogenous. Transfer payments are a summation of many individual components—veterans benefits, retirement and health benefits, foreign transfers, medical payments, aid to families with dependent children, business transfers, unemployment insurance—with all components except unemployment insurance being exogenous. Interest payments are endogenous. While the Chase model provides a high degree of disaggregation of the spending components, the fundamental structure is quite similar to that of DRI.

The level of most receipt categories is determined endogenously in the Chase model. It contains these components: Personal tax payments, corporate tax accruals, individual contributions for social insurance and employer contributions for social insurance. Federal indirect business taxes are exogenous.

Government spending in the Wharton model is handled in much the same manner as in the DRI model with roughly the same level of disaggregation. There are exogenous variables for defense and nondefense purchases, subsidies, wage accruals less disbursements, transfers other than unemployment compensation, and grants-in-aid. Unemployment compensation and net interest are determined by behavioral relations.

The tax side of the Wharton model contains a theoretically nice and unique feature. Personal income is divided into seven tax brackets with a separate equation used to generate the proportion of income taxed in each bracket. These proportions are then used, in addition to an income variable, in the Federal personal tax equation.

Although the Wharton model offers the possibility of changing personal income taxes in various tax categories, this option is very complicated to use. As a practical matter, policy analysts frequently

[3] This is a time-balancing item assumed to be zero throughout each forecast period.

do not have the detailed information necessary to fully use this feature of the model. Corporate, indirect business, and social insurance receipts are each generated by a behavioral relationship.

MONETARY POLICY

The monetary sector of the DRI model is an attempt to describe the many components of each financial market in terms of supplies and demands. There are equations to describe the behavior of households, businesses, financial institutions, State and local governments, and the Federal Government. The household and nonfinancial corporate sectors share a common structure with the demands for financial assets and liabilities and the stock of assets being modeled in sufficient detail to construct a complete balance sheet. From a policy perspective the major instruments are nonborrowed reserves, the Federal funds rate, deposit rate ceilings and legal reserve requirements. Money supply is determined endogenously. Interest rates are determined in each of the individual markets through a flow of funds approach. Inflation expectations are explicitly modeled and play a role in the determination of long-term rates.

Like the DRI model, the Chase model uses a flow-of-funds approach to the financial sector. It is, however, much more highly aggregated, using 20 behavioral equations as compared to 110 for DRI. The principal policy instrument is nonborrowed reserves less currency. While both models use a lag structure with past price levels to model expected inflation, these lag structures are quite different in both weight structure and the length of the lags.

The financial sector of the Wharton model most closely resembles the traditional Keynesian model. The major interest rate comes from a liquidity preference schedule, and currency demand depends on the level of transactions. Again the model is highly aggregated, containing 24 behavioral equations. Price expectations enter the utility and corporate bond rates through a distributed lag structure although short-term interest rates are the primary explanatory variables in the long-term rates. The Wharton model also contains another variable which some consider desirable—a proxy for wealth. Once again nonborrowed reserves are the primary policy instrument.

Interest rates are, of course, the major elements linking the IS and LM structures in the models. The DRI model contains the closest ties between the financial and real sectors since it tries to model the business and the household balance sheets, and the mortgage market. In the Wharton model the interest rate links are through the influence of user cost of capital on investment, and through the housing sector. The most important linking variable in the Chase model is an index of credit rationing which is a weighted average of the real money stock, real deposits in thrift institutions, and a loan to deposit ratio. It works largely through the housing sector but also affects other components of aggregate demand, notably the durable portions of consumption. The only direct effects of interest rates in the Chase model are in the equipment and nonresidential structures equations which depend partially upon the Aa bond yield.

Anyone familiar with the extreme or very unusual financial conditions which have often characterized the 1970's might question how these conditions have influenced the econometric models. More specifically, would a shifting money demand equation invalidate the results of this analysis? The answer is surely no. Model builders typically reestimate and, if necessary, respecify the equations frequently enough to capture and model any demand shifts. Second, as pointed out elsewhere, the analysis is valid only to the extent that the model accurately describes the economy. Only if the change in fiscal policy being simulated were so radical that it caused money demand to shift, would the analysis be affected. In this event, the interpretation of the econometric results would be heavily weighted by the analyst's judgment.

Foreign Sector

The foreign sector in the three models ranges from very small to practically nonexistent. The underlying problem in this area is the asymmetry between information available relating to exports and that available for imports. Export prices are largely determined domestically while import prices are determined abroad. Conversely, import demand functions can use a variety of domestic variables while there are few variables available for use in an export demand function.

The DRI model has the most disaggregated foreign sector of the three models examined here, although it is still small. The sector as a whole impacts the domestic economy through the balance on goods and services which relates by definition to the underlying end-use categories. Real merchandise exports are divided into six end-use categories while imports are divided into seven categories. Fuel imports are exogenous. There is a single equation for service exports and another for service imports. Import prices are determined primarily by a composite index of the wholesale prices of our major trading partners; export prices are related to domestic wholesale prices.

The Chase foreign sector consists of two equations—one to estimate exports of nonagricultural goods excluding petroleum and one to estimate imports of nonagricultural goods excluding petroleum. Other variables relating to the foreign sector, including import prices, are exogenous. The implicit price deflator for exports is related to domestic prices and the import deflator.

The foreign sector in the Wharton model is similar to DRI's. Endogenous imports are divided into four categories of goods and three categories of services. Most equations include a final demand variable, a terms of trade variable spread over a lengthy period by a polynomial distributed lag, and a dock strike dummy. The export sector is divided into three groups of goods and three groups of services. Generally they are related to a world trade index, a relative price term, and a strike dummy. Fuel imports are exogenous. Again export prices are related to domestic variables while import prices are exogenous.

Supply

Turning to the supply side of the models, equations for production in 75 industries form the heart of the DRI system. Production is the key determinate of investment and employment. The model begins by using an input-output matrix to produce a generated output series. Standard regression techniques are employed in comparing actual and generated output to model the implicit coefficient changes. Additional information is used to alter the coefficients if the 1967-based information is judged atypical or if structural changes have substantially altered interindustry relationships.

Industry employment is derived from a straightforward production function of the form

$$Q=\alpha L^{\beta}e^{(time)}$$

where Q is output, L is labor input growing at the rate β, and $e^{(time)}$ represents a time trend. This formulation produces a desired level of employment which corresponds to the production levels calculated earlier. Equations translating desired employment to actual employment capture any recognition delay. Military employment is exogenous and spending is the proxy for production in the civilian government employment equations. Total employment is not derived by summing the various industry employment levels. Instead, it comes from the relationship between the unemployment rate and the civilian labor force. The unemployment rate is derived using an Okun's law relationship and the labor force depends on population and participation rates. Unlike the other models which derive total man-hours from a production function then convert them into employment, in the DRI model man-hours are an uncalculated residual.

Investment is estimated using a neoclassical capital stock adjustment equation. It generally takes the form

$$I=F(K^{*}-K_{t-1})$$

where K^{*}, the target capital stock, comes from a Cobb-Douglas production function. In other words, investment is determined by the difference between the desired capital stock and the observed capital stock in the previous time period. To a large extent, aggregate investment is determined prior to production while industry-specific investment is determined directly by the rate of production and other factors. Aggregate production influences aggregate investment through capacity utilization rates and, less directly, through its impact on prices, profits, and the general level of economic activity. Financial variables, shortfalls in expected sales, and capacity utilization play less important roles.

The Chase model focuses on the macroeconomic approach to production. While there is no input-output matrix automatically solving for industry level production, Chase does have a 200 equation input-output model which can be linked to the macro model to produce a joint forecast. The macro model does contain a few equations to independently estimate certain components of special interest (i.e., manufacturing, metals, autos, construction, etc.).

Employment in the Chase model is derived from the usual Cobb-Douglas production function of the form

$$Q=\alpha L^{\beta}K^{\gamma}e^{(time)}.$$

The only difference between this production function and the one specified in the earlier description of the DRI model is the addition of a capital stock variable, K, growing at the rate γ.

Unlike the DRI model where productivity is estimated by a time trend, Chase has done some special analysis of the historical data and constructed a series which shows cyclical as well as secular movements. For forecasting purposes productivity is entered exogenously. Unemployment is a residual, calculated as the difference between labor force and the level of employment estimated for six sectors.

Normally one might expect production variables to be influential in the investment equations—certainly they play a major role in the DRI model. Chase argues that since investment is used as an independent variable in the production equations, a high degree of spurious correlation prevents the use of production variables in the investment equations. Instead, the independent variables represent rental cost of capital, an index of credit rationing, new orders, and consumption. As a result of this specification, changes in corporate taxes have a very large impact on investment.

Aggregate supply in the Wharton model is the sum of output originating in 12 industries. The 12 equations are designed to respond to demand changes, although there is substantial variation among them. For example, current consumption of food and beverages is the dominant factor in determining output originating in agriculture, forestry, and fisheries, but output originating in manufacturing durables is determined by consumption, fixed investment, government purchases, inventory stock, exports and imports, the unemployment rate, and an auto strike dummy.

Employment estimates have often been a problem in the Wharton model. Basically each industry's production function is solved twice—once for man-hours and once for employment. The conversion from man-hours to employment seems to cause problems, and as a result these equations are frequently changed. Note that the Wharton model uses only real variables in the determination of employment demands—wages and prices are not considered. Unemployment—the difference between the civilian labor force and employment—is a residual.

The investment equations in the Wharton model are an outgrowth of the same neoclassical theory which underlies the DRI model. The common explanatory variables used in these equations are level of output, the ratio of final product price to user cost, and capital stock. Business fixed investment is generated separately for each of nine sectors. Tax rates and depreciation enter through the user cost of capital variable. Separate equations divide the totals into various subgroups such as equipment and structures.

Income Determination

To this point, the discussion has focused on the fiscal and monetary aspects of the models and the IS–LM structure. Approaching these models through their method of income determination provides a different perspective and highlights some of their differences. One must remember that in these simultaneous models the income and product sides fully interact.

The income side of the national income accounts is divided as follows:

Gross National Product

Less:	Capital consumption allowance
Equals:	Net national product
Less:	Indirect business taxes
	Business transfer payments
	Statistical discrepancy
Equals:	National income
Less:	Corporate profits and inventory valuation adjustment
	Contributions for social insurance
Plus:	Government transfer payments to persons
	Interest
	Dividends
	Business transfer payments
Equals:	Personal income
Less:	Personal taxes
Equals:	Disposable personal income

The DRI model follows this table quite closely. GNP is an identity and personal income is derived as a residual. The large piece that comes from a behavioral equation is profits. Profits are modeled as a function of capacity utilization, final sales, the wholesale price index, and the ratio of compensation to output. The capital consumption allowance derivation follows the methodology used by the Bureau of Economic Analysis which depends upon the price deflator and the average life of business investment. The inventory valuation adjustment depends upon constant dollar inventories and the price level changes. Interest payments by consumers and the Government are simply a function of interest rates and the amount of debt. For corporations they are a function of interest rates and corporate credit outstanding. Dividends are largely a function of past dividends and after-tax profits. The important government-related variables are explained elsewhere.

Despite the fact that personal income is determined as a residual, some of its components are modeled explicitly. For example, wages and salaries are determined fundamentally by an equation for average hourly earnings. It depends heavily on the change in prices to adjust for inflation and contains the inverse of the unemployment rate as a measure of labor market tightness.

Tracing through the same table for the Chase model, one finds that the capital consumption allowance, rather than using the BEA methodology, is modeled as a function of several dummy variables and the implicit price deflator. The specification of the corporate profits equation is also quite different in detail but not necessarily different in theory. Chase models profits primarily as a function of investment, consumption expenditures, net exports, prices, change in unit labor costs, interest rates, and government purchases. The inventory valuation adjustment equation contains no real variables—only prices. Interest payments by consumers depend primarily upon changes in the 4–6 month commercial paper rate; government interest payments depend upon the Treasury bill rate and the government deficit. Dividends are a function of profits, capital consumption allowances and taxes. Personal income is an identity built of its various components. The wage equations depend heavily upon previous changes in the CPI and changes in the money supply, with the unemployment rate having little impact. Cyclical fluctuations are captured by including an industrial production index.

Turning to the Wharton model, one finds a sharp difference in wage determination. Here wage rates are determined by labor market tightness, lagged changes in the CPI and social insurance contributions. While this resembles the DRI specification, it is actually much closer to a pure Phillips curve relationship. Other components of the above table are determined along the lines discussed for the other models with this major exception: The capital consumption allowance is entered exogenously and corporate profits are a residual.

Prices

The final broad component of the models which cannot be ignored is price determination. Experience in recent years has stimulated new work aimed at improving the very poor performance observed in the 1973–75 period.

The DRI model includes 15 behavioral equations for wholesale prices with the farm products index entered exogenously. There are equations for the deflators in 19 categories of final demand and 3 components of the CPI. In general, unit labor costs are the driving force behind price increases. Wage and material costs enter with a lag structure designed to represent the stage of processing. Other variables include vendor performance, capacity utilization, and special factors.

The price sector in the Chase models is more disaggregated, but it follows the same basic approach. The components of the WPI are determined as functions of unit labor costs, capacity utilization, and other special factors. The components of the WPI along with demand factors and unit labor costs determine components of the CPI. Components of both the WPI and CPI are used to determine sector deflators. As mentioned earlier, both import prices and farm product prices are exogenous.

The price sector of the Wharton model begins with sector prices needed to deflate the output originating in the various industries. These are basically markup equations over unit labor costs. The mining deflator (which includes energy costs) is exogenous. Final demand prices are determined by 18 behavioral equations with the dependent variable expressed as the ratio of the price deflator to a weighted average of all sector prices. These weights are determined separately from an input-output matrix. Wholesale prices are built up by stage of processing.

THEORETICAL ISSUES

Having examined the structure of the models, let us turn to some of the more controversial issues surrounding this method of analysis. The first concerns the theoretical basis for using large-scale macroeconometric models and some of the criticism raised by "rational expectations" theorists, particularly Robert E. Lucas. The second concerns the limitations inherent in this approach to economic analysis.

The three econometric models described in this paper were constructed primarily for economic forecasting purposes. However, since government policy variables are exogenous inputs to the models, using the model to analyze the impact of alternative policies is a natural extension.[1] This use of models has been criticized by Robert E. Lucas and others.[2]

Lucas' criticisms can be summarized in his own words:

> I shall argue that the features which lead to success in short-term forecasting are unrelated to quantitative policy evaluation, that the major econometric models are [well] designed to perform the former task only, and the simulations using these models can, in principle, provide no useful information as to the actual consequences of alternative economic policies. These contentions will be based not on deviations between estimated and "true" structure prior to a policy change but on the deviations between the prior "true" structure and the "true" structure prevailing afterwards.[3]

To put it in more operational terms, Lucas is arguing that as policy changes, the parameters of the model equations will also change. Since econometric policy analysis, according to Lucas, assumes that these parameters are fixed, the simulation is bound to yield inaccurate results.

Lucas' criticisms have been challenged on several grounds. First, Robert Gordon has argued, while—

> The mechanical extrapolation of a model with fixed parameters cannot provide useful information on the effects of *all* policy changes, on the other hand the effects of *some* policy changes can be determined if parameter shifts are allowed and are either *(a)* estimated from the response of parameters to policy changes within the sample period or *(b)* are deduced from a priori theoretical consideration. * * * Thus, the practical importance of Lucas' critique varies for each specific case.[4]

Gordon is arguing that while Lucas' criticisms may be correct, the degree of such parameter shifts is sufficiently small that the analysis remains valid. It is quite possible that Lucas is theoretically cor-

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[1] For a discussion of the theory behind econometric model forecasting see Lawrence R. Klein, *An Essay on the Theory of Economic Prediction* (Chicago: Markham Publishing Co., 1968), and Herman O. Stekler, *Economic Forecasting* (New York: Praeger, 1970). For a discussion of current use of econometric models see Otto Eckstein, "Information Processing and Econometric Model Forecasting," paper presented to the Ottawa meeting of the North American Econometric Society, June 25, 1977. (Mimeographed.)

[2] Robert E. Lucas, Jr., "Econometric Policy Evaluation: A Critique," in *The Phillips Curve and Labor Markets*, eds. Karl Brunner and Allan H. Meltzer, vol. 1 of the Carnegie-Rochester Conferences on Public Policy, a supplementary series to the *Journal of Monetary Economics*, 1976. Other papers by rational expectations theorists can be found in *A Prescription for Monetary Policy: Proceedings From a Seminar Series*, Federal Reserve Bank of Minneapolis, December 1976.

[3] Lucas, "Econometric Policy Evaluation: A Critique," p. 20.

[4] Robert J. Gordon, "Can Econometric Policy Evaluations Be Salvaged?—A Comment," in *The Phillips Curve and Labor Markets*, eds. Karl Brunner and Allan H. Meltzer, vol. 1 of the Carnegie-Rochester Conferences on Public Policy, a supplementary series to the *Journal of Monetary Economics*, 1976, pp. 47 and 49.

rect yet the approach to policy analysis remains useful from an empirical perspective. The degree of parameter shift is important in determining its practical significance.

A second criticism of the Lucas-type model is that it assumes perfect wage and price flexibility and symmetrical behavior. As Gordon points out, in the real world "a firm has a single option in a boom, to attract more labor input by raising its wage offer, and two options in a recession, either to reduce the wage offer or to discharge employees." [5] If firms choose to lay off employees rather than lower wages, wages and therefore prices will be sticky downward. This situation is further aggravated by prices which are fixed by law (e.g., interest rate ceilings, regulated prices, minimum wages) and by timing inflexibilities introduced by contractual arrangements. In addition, the assumption that adjustments take place instantaneously is undoubtedly an exaggeration since time is required for the labor force to move from one market to another. The validity of this criticism is currently being debated within the economics profession. There are some who argue that Lucas' flexibility and timing assumptions are unnecessary and that relaxing these assumptions does not alter the conclusions.

In addition to the specific criticisms Gordon makes, the basic assumption of rational expectations can be questioned. In general terms, rational behavior means incorporating all available information into the formation of expectations about the future and acting upon those expectations. It is quite possible that this assumption may not be a good guide to individuals' actual behavior. Voluntary overwithholding of personal income taxes in 1972 is an example of behavior that seems to be nonrational. If individuals do not behave rationally they may still behave predictably and past actions may provide a good guide for making such predictions.[6]

I would raise two additional points. First, the "black box" approach to policy analysis is an inappropriate description of how these econometric models are (or at least should be) used. Lucas has argued that the reasons econometric models are successful in forecasting is that their managers adjust them for systematic bias in the residuals, frequently reestimate them, and ignore extreme values. In other words the combination of an econometric projection and an economist's good judgment and additional knowledge can produce a good forecast. This same combination is necessary to produce a good policy analysis. Further, Lucas' argument that models produce good forecasts but bad policy analysis is inconsistent with the fact that the models are typically used to generate several forecasts based on alternative policy assumptions.

For the most general types of policy change and for examining the resultant aggregate multipliers, the econometric models should work fairly well. However, for example, to analyze the impact of a temporary personal income tax cut, it would be necessary to examine the income concepts used in the consumption equations to see whether they accurately reflect current knowledge about the impact of such changes. Similarly, to analyze the impact of a government expenditure program designed to create jobs by directly hiring people, one

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[5] Ibid., p. 56.

[6] Another discussion of some of these issues is found in Preston Miller, Clarence Nelson, and Thomas Supel, "The Rational Expectations Challenge to Policy Activism," in *A Prescription for Monetary Policy: Proceedings From a Seminar Series*, Federal Reserve Bank of Minneapolis, December 1976, pp. 51–64.

could not simply increase the exogenous level of government expenditures. Among other things, one would need to examine the micro literature to answer questions such as how much of the expenditure will be offset by reductions in spending by other levels of government?; how much is a net addition to total government expenditure?; how much will be absorbed in administrative costs and how much will show up in wages of new workers?; will the program cause workers to move out of the private sector and into the public sector?; how rapidly can the funds be spent?; etc. To properly use an econometric model, the analyst must be willing to apply outside information to those areas where the structure of the model is inadequate for the particular purpose. As Eckstein has argued, the most difficult and time-consuming part of policy analysis is the preparation necessary to properly plan an econometric simulation.[7] He argues that "The model exercise turns out to be a harsh discipline for the policy analyst." [8] For this reason the combination of econometric simulations and the good judgment of a policy analyst can consistently produce better analysis than would be otherwise possible.

The second point is that econometric simulations are frequently used by policymakers to influence their decisions. This factor alone makes policy simulations important regardless of whether their results are in fact "true." If I look out in the morning and decide that it is going to rain, I will wear a raincoat and carry an umbrella. Whether it actually rains is unimportant—my belief has influenced my behavior. Similarly, when econometric policy analysis predicts that a certain consequence will result from a policy change, that prediction will influence the decision to change policy. Certainly econometric analysis is not the only factor influencing policy decisions, but judging from congressional use of econometric models, it has become increasingly important in recent years.[9]

It should also be noted that even if the rational expectations theorists are correct in their criticisms of the large scale macroeconomic models, the theory will only allow one to reject the conclusion that a policy change results in a change in the growth path of the economy. The theory cannot reject the conclusions that policy changes produced no significant change in economic growth.

Having accepted the proposition that econometric model simulations are a useful tool for policy analysis, one must always keep in mind the limitations of such analysis. The most important limitation has already been implied: in order for the simulation to accurately describe the impact of alternative policies, the models must accurately describe the economy. The availability of numerous models with different characteristics indicates a lack of agreement on the best description of the economy. Therefore, to be completely correct, one must realize that simulation results show how alternative policies would affect the model and, only to the extent that the model describes the economy, how they would affect the economy.

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[7] Otto Eckstein (ed.), *Parameters and Policies in the U.S. Economy* (Amsterdam: North Holland Publishing Co., 1976).

[8] Ibid., p. 5.

[9] When the Joint Economic Committee began using the DRI model in 1973, it was the first congressional user. Today the JEC has access to Chase, Wharton, and DRI. Other congressional users of some or all of these models include the Congressional Budget Office, the House and Senate Budget Committees, the Joint Committee on Internal Revenue Taxation, the General Accounting Office, the Library of Congress, the House Information Systems Group, and the House Agriculture Committee.

Another limitation on all analysis of this type deserves mention: When a dynamic economic system gives rise to oscillations, they will normally be damped. In attempting to explain why this is not always observed, Frisch showed that erratic shocks, or in this case the random errors associated with the model's equations, can become an independent source of cycles.[10] Nevertheless, one can observe that econometric models based on historical averages tend to produce cycles which are weaker than those actually experienced. This suggests that random errors are not a major source of cyclical fluctuation despite the theoretical possibility raised by Frisch's analysis.

[10] Ragnar Frisch, "Propagation Problems and Impulse Problems in Dynamic Economics," from *Economic Essays in Honor of Gustav Cassel*, 1933, reprinted in *Readings in Business Cycles*, selected by a committee of the American Economic Association (London: George Allen and Unwin, Ltd., 1966), pp. 155–185.

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