

ANALYTICAL FORECASTING OF
AGGREGATE ECONOMIC ACTIVITY

by

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INTRODUCTION

Men have often pondered the dream of discovering the outcome of some future event before the actual event occurs. A moment's reflection reveals how wealthy and powerful an individual could become if he alone knew in advance such things as the stock market quotations, the outcome of an athletic contest, or the consequences of some political action. Unfortunately, however, a reliable method of forecasting or predicting day by day phenomena has not been discovered. Yet everyone, from business executive to bureaucrat, professional man to housewife, must base decisions on uncertainties of future events.

Consequently, everyone welcomes any portents, signs, or any sort of "scientific" assistance to aid in making sound decisions concerning these future events. Whenever and wherever planning is required, therefore, some effort must be made to forecast or predict the future.

A forecast or prediction, then, is simply a statement concerning the condition of an event or situation that will occur in the future. In economics, these statements are quantitative in nature and can be represented by one or more numbers (i.e., consumer expenditures for some country in a given year.). If future economic activity were known with certainty, a forecast would be trivial. Decisions could be made and plans formulated without the risk of loss. However, one of the most pervasive characteristics of economic decision making is the existence of imperfect knowledge of the future. Nothing is more common or more certain in a private enterprise economy than the recurrence

and inevitability of change. Therefore, an organized system of forecasting must be developed with the ultimate objective to predict with a reasonable amount of accuracy and certainty the fluctuations of future economic activity.

The essence of all economic forecasting, no matter how specialized, lies in the ability to predict how the major segments of the economy behave, and ultimately on predicting movements of total aggregate economic activity. Thus, in order to facilitate the comprehension of this task, this paper will be primarily concerned with forecasting the aggregate level of economic activity.¹

CHAPTER I

TECHNIQUES OF ECONOMIC FORECASTING

The techniques available for formulating economic forecasts may be classified into three broad categories: the naive methods, the barometric methods, and the analytical methods.

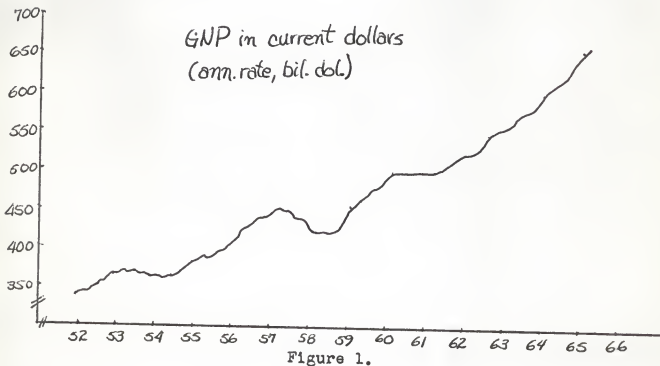
The Naive Methods

The naive methods are unsophisticated and unscientific projections. They include...random methods, guesses, straight line or mathematical trend projections, autocorrelations and harmonic analysis. Typically, they are distinguished from other forecasting methods in that they are essentially mechanical and not closely integrated with relevant economic theory and statistical data.²

¹Perhaps the most comprehensive measure of aggregate economic activity, and the measure that will be used in this paper, is the gross national product--the total value of all final goods and services produced during a given year.

²Charles F. Roos, "Survey of Economic Forecasting Techniques," Econometrica, (October, 1955), p. 363.

One of the most objective methods of "naive" forecasting is time series analysis. A time series is merely a sequence of data observed successively in time--either monthly, quarterly, yearly, or according to any other temporal measure. Thus, in forecasting aggregate economic activity, the value of the GNP is observed at different intervals of time and the results are plotted as in Figure 1. (GNP being the dependent variable and "time" the independent variable.)



The series of GNP data may be regarded as being composed of four distinct elements: seasonal fluctuations during a single year as a result of weather or social traditions (i.e., Christmas, Easter, etc.); cyclical variations of a few years due to economic recessions and recoveries; random movements due to many small causes, as well as larger shocks, such as wars and sudden political changes; and secular trends which project the long-run growth of the series.

The simplest type of naive forecast, then, would be a projection of the series along the prevailing trend line. Needless to say, the series does not advance in any particular smooth fashion. There is, in fact, sufficient random motion in the differences between successive observations to make short term forecasting along the trend line a rather uncertain and hazardous matter.

Another method of naive forecasting is the opinion polling or sample survey technique. This method is primarily concerned with forecasting or discovering some particular aspect of economic activity.

The procedure is quite simple. The forecaster sends a questionnaire to a large number of organizations or economic units (those units that are involved in whatever the forecaster is attempting to predict) asking them about their past activities and their planned or anticipated activities for the coming year. When the information is received, it is organized and classified. On the basis of this information, then, a forecast is made.

One such sampling study is the survey of consumers' finance and buying plans by the Survey Research Center of the University of Michigan.³ Operating under the assumption that most consumer purchases of appliances, houses, cars, etc., are "preceded by deliberation, discussion, and even shopping around,"⁴ the task, then, is to select relevant questions (that is, questions that will reveal consumer intentions), to randomly collect interviews

³See, for example, George Katona, The Mass Consumption Society, (New York: The McGraw-Hill Book Company, 1964).

⁴Ibid, p. 83.

based on these questions and to transform this information into coded numerical values. After extensive empirical studies involving much experimentation, the Survey Research Center constructed an Index of Consumer Sentiment based on six such questions: two concerning personal finances, two on the general economic outlook, and two on market conditions.⁵ This index anticipated the level of expenditures on consumer durables by six to nine months.

A related sample survey technique is also used by the McGraw-Hill Publishing Company and the Department of Commerce to reveal the intentions of businessmen to invest in plant and equipment. Their results are published periodically in Business Week and the Survey of Current Business, respectively.

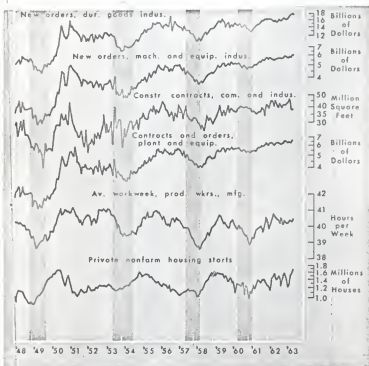
The basic problems involved in trying to forecast economic activity with the naive methods is quite simple. Not only is the level of economic activity constantly changing, but the future is unlike the past. Simple trends and selective sampling by themselves do not provide the foundation for making reliable forecasts of aggregate economic activity. The forces that make for change in this aggregate activity are many and complex. They are not always easy to discover and measure and they occur in many sorts of amalgamations. Thus, mere projections of the past--the "next year will be the same as this year" philosophy--can never be a perfect guide to the future and there will always remain many elements of uncertainty. Therefore, other methods (perhaps

⁵Ibid, p. 77.

utilizing the information and insights provided by the naive methods) must be developed.

The Barometric Methods

The dark grey stretches show periods of business contraction. The stretches between show business expansion. The series displayed are a sample of the "leading" indicators of business recession and recovery discovered by the National Bureau of Economic Research. In general, the series decline some time before over-all contractions and rise before expansions.



Source: Business Cycle Developments, Bureau of the Census, June, 1963.

Figure 2.

The barometric approach to forecasting economic activity was initially pioneered by Wesley C. Mitchell and Arthur F. Burns and is currently directed by Geoffrey H. Moore at the National Bureau of Economic Research. The essence of this method lies in the search for a statistical series of economic indicators that will reliably turn up and turn down, before the peaks and troughs in

the level of aggregate economic activity. A series of indicators are selected and classified into three groups according to their typical time sequence in the business cycle; a leading group, a coinciding group, and a lagging group, as in Figure 2, page 6.

Thus, when the leading group of indicators begins a downward movement, a decline in the level of aggregate economic activity can be predicted, and when the leading group again begins to rise, a recovery can be expected. For example, such things as business failures, industrial common stock prices, new orders of durable goods, building contracts, and average hours worked per week in manufacturing tend to lead the level of aggregate economic activity; unemployment, corporate profits, industrial production, and wholesale prices are roughly coincident with the level of aggregate economic activity; and personal income, sales by retail stores, consumer installment debt, the bank rate on business loans, and manufacturers' inventories tend to lag the aggregate level of economic activity.⁶ The indicators thus act as barometers of economic change.

The barometric method also has many weaknesses. None of the leading indicators is perfectly regular in its anticipation of turning points and therefore can not be mechanically interpreted. Furthermore, it is difficult to distinguish brief, erratic movements in the indicators from movements which have fundamental cyclical significance. On occasion, for example, the majority of leaders have shifted up or down, even though there was no funda-

⁶Alvin H. Hansen, Business Cycles and National Income, (New York: W. W. Norton and Company, Inc., 1954), pp. 588-589.

mental change in the level of aggregate economic activity. Moreover, the duration of the leads varies widely from one turning point to the next so that there is no way of pinpointing in advance the precise timing of the turning points. That is, no two cycles behave exactly alike. The "average" cycle, with respect to duration and amplitude, never occurs. Finally, even when the leading indicators do give accurate and recognizable signals of a coming turn, they provide no measure of the magnitude of the coming change--either in the overall level of economic activity or in any of its parts. Because of these limitations, the barometric methods can also be counted on to provide only supplementary evidence of a forthcoming change in economic activity. At best, they provide only a partial analysis of economic trends. Other analytical information not reflected in the indicators must therefore be considered.

In other words, both the naive and barometric methods present some potentially valuable techniques of forecasting and yield some relevant insights into a forthcoming change in the level of economic activity. However, the basic need is not just a collection of available data and a specialization in technique, but rather a synthesis of these data into a significant framework of analysis. The forecaster must be able to draw from various sources of information and to utilize the valid elements of each different technique. But most important, he must be able to put these data together into a meaningful composite.

The Analytical Methods

The most informative process of synthesizing data into a meaningful forecast is achieved by the use of an analytical technique--formulated within the framework of the national income accounts and making use of the relationships among the variables suggested by economic theory. By combining the relevant variables into what appears to be the best mathematical arrangement, the forecaster is able to make predictions on the basis of established relationships. This "best mathematical arrangement" is a system of equations that seems best to describe the past set of relationships according to economic theory and statistical analysis.⁷

The analytical technique thus attempts to isolate the various influences of important sectors affecting the aggregate level of economic activity at a given time (as suggested by the theory of income determination) and subsequently integrate these influences into an econometric model to predict an overall change into the future.

The use of econometric models as a forecasting technique is a relatively new idea. The exact origin of the concept of aggregate econometric models is difficult to determine. Certainly the development of mathematical economics and general equilibrium and the concept that economic phenomena could be represented by a system of simultaneous equations expounded by Walras⁸ and his

⁷Milton H. Spencer, Colin G. Clark, and Peter W. Hoguet, Business and Economic Forecasting, (Homewood, Illinois: Richard D. Irwin, Inc., 1961), p. 16.

⁸See, Leon Walras, Elements of Pure Economics, Translated by William Jaffee (London: George Allan and Unwin, 1874).

followers in the late 19th Century provided a stimulus for later thinking.⁹ It was not until the early 1930's, however, that economists turned their attention to the measurement of and the determination of national income, employment, and prices, and the way goods and money flow among the different sectors of the economy. At this time, statisticians like Simon Kuznets¹⁰ began to develop annual estimates of national income. As the depression of the 1930's continued and development of macro-economic theories accelerated, the estimates by the National Bureau of Economic Research were expanded.

In 1933, Ragnar Frisch, a Norwegian mathematical economist, pointed out the possibilities of constructing an econometric model to explain the business cycle.¹¹ R. A. Fisher¹² contributed to the development of the statistical theory of estimation, and J. M. Keynes contributed the essential theoretical economic background in the General Theory.¹³

Finally, in 1939, J. Tinbergen published, under the auspices of the League of Nations, a two volume classic study of business fluctuations.¹⁴ The second of these volumes represented an

⁹Valfredo Pareto and the Lausanne School.

¹⁰Simon Kuznets, Seasonal Variations in Industry and Trade, (New York: National Bureau of Economic Research, 1933).

¹¹Ragnar Frisch, "Propagation and Impulse Problems in Dynamic Economics," Essays in Honor of Gustav Cassel, (London: George Allan and Unwin, 1933), pp. 171-205.

¹²R. A. Fisher, Statistical Methods For Research Workers, (London: Oliver and Boyd, 1925).

¹³J. M. Keynes, The General Theory of Employment, Interest, and Money, (New York: Harcourt, Brace, 1936).

¹⁴J. Tinbergen, Statistical Testing of Business Cycle Theories: I. A Method and its Application to Investment Activity, II. Business Cycles in the United States of America, (Geneva: League of Nations, 1939).

econometric study of business fluctuations in the United States from 1919 to 1932.¹⁵

Although the basic principles of model construction remain largely as Tinbergen expressed them, great strides have been made in improving the forecasting ability of economic models. These advances have come about as a result of the improved estimates of national income data made available by the Department of Commerce, the improved statistical estimation methods,¹⁶ and a greater understanding of macro-economic theory. Much of the recent work in macro-econometric model construction is associated with the names of Lawrence Klein,¹⁷ A. S. Goldberger,¹⁸ Daniel B. Suits,¹⁹ Carl Christ,²⁰ Colin Clark,²¹ and Irwin Friend.²²

¹⁵Robert A. Gordon, Business Fluctuations, (New York: Harper and Brothers, 1961), p. 394.

¹⁶T. C. Koopmans, (ed.), Statistical Inference in Dynamic Economic Models, Cowles Commission Monograph, No. 10, (New York: John Wiley and Sons, Inc., 1950), and W. C. Hood and T. C. Koopmans, (eds.), Studies in Econometric Method, Cowles Commission Monograph, No. 14, (New York: John Wiley and Sons, Inc., 1953).

¹⁷L. R. Klein and A. S. Goldberger, An Econometric Model of the United States 1929-1952, (Amsterdam: North-Holland, 1955) and L. R. Klein, "A Postwar Quarterly Model: Description and Applications", Models of Income Determination, (Princeton: Princeton University Press, 1964).

¹⁸A. S. Goldberger, Impact Multipliers and Dynamic Properties of the Klein-Goldberger Model, (Amsterdam: North-Holland, 1959).

¹⁹Daniel B. Suits, "Forecasting and Analysis with an Econometric Model", American Economic Review, LII, March, 1962, pp. 104-132.

²⁰C. F. Christ, "A Test of an Econometric Model for the United States, 1921-1947", Conference on Business Cycles, (New York: National Bureau of Economic Research, 1951).

²¹C. Clark, "A System of Equations Explaining the U.S. Trade Cycle 1921-1941", Econometrica, XVII, 1949, pp. 93-124.

²²Irwin Friend and Robert C. Jones, "Short-Run Forecasting Models Incorporating Anticipatory Data", Models of Income Determination, (Princeton: Princeton University Press, 1964).

CHAPTER II

ANALYTICAL MODEL CONSTRUCTION

The construction of an econometric model that is an adequate and reliable method of forecasting the level of economic activity is a sophisticated and rigorous task and is, therefore, beyond the scope of this paper. However, with only a simple understanding of economic theory and the methods of model construction, even a novice econometrician can use a constructed model for policy problems and economic forecasting. Therefore, before an actual model is presented, the essential economic elements of model construction and income determination will be discussed.

The construction of an econometric model involves:

...an interweaving of economic theory, statistical techniques, and empirical investigation. Hypotheses are drawn from many fields of economic theory and fitted together to form a self-contained system of simultaneous relationships. A priori information and preliminary empirical observations are employed in this formulation phase. Formal methods of statistical inference are applied to the body of observed data in the estimation stage. The result is a model which characterizes quantitatively the structure of the economic system.²³

The best model, of course, would provide a thorough representation of the economic system. Unfortunately, however, a complete representation of a large economic system would involve literally millions of equations--certainly an unmanageable number for each economic unit. Therefore, the theorist must be selective. From the complex of interrelated events, some are selected and others neglected. The economic system is simplified and condensed. For

²³Goldberger, op. cit., p. 1.

example, millions of individual households become a single "household sector", thousands of products become a single item of expenditure. Thus, an econometric model is not necessarily an exact description of the way the economic process really works. It is an abstraction and representation of the economic process--as a model airplane is a representation of a real airplane--that provides an analytical method for studying and forecasting the "real" economic system.

The Equations

From the viewpoint of the econometric model, economic life is explainable by a set of simultaneous mathematical equations. These equations express the relationships among a number of economic variables. The model is constructed for the ultimate purpose of solving the equations simultaneously, and thereby obtaining the values of the unknown variables that are contained in the equations. The values of these variables, once obtained, constitute the forecast.²⁴

The mathematical equations of the model are called structural equations in that they show the basic structure of the economy. The "size" or number of structural equations in the model vary--depending on the degree of aggregation (the number of variables that are to be explained by the model). The number of equations, of course, must be equal to the number of unknown

²⁴Michael J. Brennan, Jr., Preface to Econometrics, (Cincinnati: Southwestern Publishing Company, 1960), pp. 9-12. (Most of the material presented in this section is taken from this source.)

variables. Four different kinds of structural equations may be used in a model: a) identities or definitional equations, which are true by definition, such as savings equals investment, b) institutional rules, such as those describing the reserve requirements of the banking system, c) technological transformation equations, such as those describing the way output varies with inputs, and d) behavior equations representing the way consumers or producers react to given stimuli, such as the consumption function which illustrates how consumers respond to changes in income.²⁵ Thus, the model is a complete system made up of structural equations.

The Variables

The structural equations of the econometric model state the relationships between the variables that are to be examined. In economic problems, however, it is unavoidable that some factors be taken as given for the purpose of analysis. It is almost impossible to take into account and explain all of the factors that influence the variable or variables being studied. It is the recognition of this fact that has led economists to classify economic variables as endogenous and exogenous.²⁶ Endogenous variables are those that are explained by the model. They both determine other variables in the model and are, in turn, determined by other variables. Exogenous variables, on the other hand, are not explained by the model but are determined by forces outside

²⁵Gordon, op. cit., p. 389.

²⁶Brennan, op. cit., p. 204.

the model. They are assumed to be known and are taken as given. They are predetermined variables.

Now, utilizing what economic theory suggests, a system of equations is constructed to represent this theory. Then, if the model is in proper statistical form, the equations are fitted by some statistical method to the actual observed data to determine the values of the parameters in the chosen equations. After the parameters are determined, the model is tested by applying the equations to known data. If the equations fit these data well, and if the sampling errors involved are relatively small, then, the model can be thought to represent the behavior of the "real" economy for that particular time.

A Simplified Econometric Model

Suppose the following equations were found to represent and to fit data of an economic system for a specified period of time.²⁷

$$(1) \quad Y_t = C_t + I_t + G_t$$

$$(2) \quad C_t = a + b Y_t$$

$$(3) \quad I_t = c + d (Y_{t-1} - Y_{t-2})$$

The first equation is a definitional equation which says that the gross product or income (Y) in a given time period (t) is equal to the sum of consumer spending (C_t), investment spending (I_t),

²⁷There are, of course, no exact relationships in economic theory. In view of this fact, therefore, a random disturbance term is generally included in every behavioral equation. To facilitate the mechanics of this example, however, this random term is ignored.

and government spending (G_t). The second equation says that consumer spending in time period (t) is a linear function of gross income in t , with the parameters a and b simply being constants describing the precise nature of the linear relationship. The third equation says that investment in time period (t) is a linear function of an increase or decrease in gross income from time period $t-2$ to time period $t-1$. Now since Y_{t-1} and Y_{t-2} are known data in time period (t), once the parameters c and d are estimated by statistical methods, an estimate for I_t can readily be obtained from equation (3). Assume G_t in equation (1) is an exogenous variable, derived from various governmental budgets or some other means (perhaps some naive method). Therefore, in the first two equations (assuming estimates for the parameters a and b have also been made), only Y_t and G_t are unknown. Thus, having only two equations and two unknowns, they can be solved simultaneously for the values C_t and Y_t .

Forecasting Future Economic Activity

In order to make further forecasts, estimates could be made for I_{t+1} by viewing the third equation as $I_{t+1} = c + d (Y_t - Y_{t-1})$. Then by viewing the first and second equations as $Y_{t+1} = C_{t+1} + I_{t+1} + G_{t+1}$ and $C_{t+1} = a + b Y_{t+1}$ the values of C_{t+1} and Y_{t+1} could be obtained with little effort. Likewise, the values of C_{t+2}, \dots, C_{t+m} , I_{t+2}, \dots, I_{t+m} , and Y_{t+2}, \dots, Y_{t+m} could also be obtained.

There is, however, an alternative way to describe the same economic system. A set of equations may be derived by reducing

the structural equations so that all of the endogenous variables are on the left side of the equations and only exogenous or predetermined variables are on the right side. That is, the system of equations is reduced so that there is an explicit dependence of each endogenous variable on the predetermined or "known" variables. Such a system is appropriately called the "reduced form". Consider again the simple set of structural equations: (1), (2), and (3) above.

Since I_t and G_t are assumed to be known in time period (t), the model is reduced to a system of two equations. By transferring all unknowns to the left side, and representing the right sides by P_1 and P_2 respectively, the equations thus become:

$$Y_t - C_t = I_t + G_t = P_1$$

$$C_t - bY_t = a = P_2$$

Now, solving this system for Y_t and C_t in terms of P_1 and P_2 gives:

$$Y_t = \frac{P_1}{(1-b)} + \frac{P_2}{(1-b)}$$

$$C_t = \left(\frac{b}{1-b}\right) P_1 + \left(\frac{1}{1-b}\right) P_2$$

Again, forecasts can repeatedly be made by substituting in the values for the predetermined variables P_1 and P_2 .

Both the structural and the reduced form systems of equations serve a useful purpose. The structural equations are most informative when the primary interest is in the connections and interdependencies of the sectors of the economic system. The reduced form, however, is more suitable for forecasting. Given the values

of the exogenous variables, it is possible to immediately determine the values of the endogenous variables. With the reduced form, it is possible to observe the effect of changes of the exogenous variables on the endogenous variables. Furthermore, it may be statistically impossible to find the parameters of the structural equations by direct application of statistical methods. In such cases, indirect methods may be applied to find the parameters of the reduced form equations and then working backward, the structural parameters may be obtained.²⁸

Obviously, if forecasting were merely this simple mechanical operation involving only a minimum number of variables and relationships, everything would be easy and there would be little risk involved. Unfortunately, however, it is not this simple. In order to illustrate and examine some of the problems associated with forecasting economic activity with an econometric model, therefore, an actual model will be presented.

CHAPTER III

AN ANALYTICAL FORECASTING MODEL

Although a sizable number of forecasting models have been constructed in the last decade, the task of selecting one of these models to present in this paper is most difficult. A number of major problems are encountered.

The first problem, of course, was the level of aggregation of the model. The model selected must be small enough (there must be a limited number of structural equations and endogenous variables)

²⁸That is, if the model is "just identified".

to facilitate the computational task of testing the model. Mere size, therefore, eliminated several of the most popular models. (Klein-Goldberger - 20 equations, Klein - 29 equations, Suits - 32 equations, etc.)

Terminology presented another problem. Each model is self-contained with its own separate variables and system of relationships. There is no unique system of equations and unknowns. Each author includes in his model those equations and variables which he considers the most appropriate. Unfortunately, there is no universally accepted definition of each variable. Each author may have a different name for the same variable or they may have a common name for different variables. In many cases, the author failed to indicate his own particular definition of a variable. Furthermore, some failed to include the source of the statistical data.

The data problem is also fundamental. The forecasting equations are fitted by some statistical method to a sequence of data (or a given set of observations) usually indexed to a certain level of prices. However, over a period of years, data are revised and corrected. Perhaps a different technique of defining or calculating the data has been developed. Perhaps a different price level index is used. Thus, the "given" or "known" data are by no means constant and change with each new method of calculation. In other words, even the given set of observations does not remain truly "fixed".

The model that has been selected hopefully minimizes each of these shortcomings and will allow "reasonable" forecasts to be made.

One attempt to develop a statistical system of the U.S. economy for forecasting GNP was a model presented by Irwin Friend and Robert C. Jones to the Conference on Models of Income Determination held in February, 1962.²⁹ Their objective was to determine a reliable model for forecasting short-term (periods up to about one year ahead) fluctuations in GNP. They started with the assumption:

...that a highly multiequational and multivariate econometric model is not likely...to give as satisfactory results for short-term forecasting as a simple model. There seem to be little evidence that otherwise important niceties, such as production functions, demand-for-labor equations, disaggregated consumption functions, or perhaps even distributive share and financial variables, added significantly to the short-term prediction of GNP and its major components.³⁰

Thus, the "supply of output accommodates itself to demand for output".

The Friend-Jones model consists of four structural equations and an identity. These four equations, explaining consumption, residential construction, plant and equipment expenditures, and inventory investment, represent the most powerful among those factors contributing to the explanation of GNP on the demand side.

Utilizing the above variables, three separate forecasting models were presented--a quarterly,³¹ semi-annual,³² and annual model³³ fitted to changes in GNP and its major components. The semi-annual model was found to give better results than either the quarterly or annual models. Perhaps this was because it represented an averaging out of random disturbances associated with the

²⁹Friend and Jones, op. cit., pp.

³⁰Ibid, p. 279.

³¹Ibid, p. 293.

³²Ibid, p. 299.

³³Ibid, p. 302.

quarterly data (including errors of observations) and a lessening of serial correlation among the variables. The annual model did not provide an adequate number of observations to make significant forecasts. In any event, the semi-annual model will be presented.

The Model

The sample data for explaining semi-annual changes in the total GNP and its major components include the observations from the second half of 1951 through the end of 1960 (18 observations). The data were obtained from semi-annual estimates by the U. S. Department of Commerce published monthly in the Survey of Current Business. The regression coefficients have been estimated by a two stage least squares procedure.

List of Variables

*HS = housing starts

*G' = government expenditures plus net exports

H = residential construction

PE = plant and equipment expenditures

I = inventory investment

C = consumption expenditures

Y = gross national product

*PE^o = plant and equipment anticipations

(* denotes a predetermined variable)

Unless otherwise indicated, all variables are seasonally adjusted at annual rates in billions of 1954 dollars except for HS, which is in hundreds of thousands of units.

The variables were arranged into the following structural equations to represent the economic system for the specified time period:

Consumption Equation: 1) $\Delta C = a_{11} + a_{12} \Delta \tilde{Y} + a_{13} C_{-1}$

Investment Equations: 2) $\Delta H = a_{21} + a_{22} \Delta HS_{-\frac{1}{2}} +$
 $a_{23} (\Delta \tilde{Y} - \Delta Y_{-1}) - a_{24} PE^e$

3) $\Delta PE = -a_{31} + a_{32} \Delta PE^e +$
 $a_{33} (\Delta \tilde{Y} + \Delta Y_{-1})$

4) $\Delta I = a_{41} + a_{42} (\Delta \tilde{Y} + \Delta Y_{-1})$
 $- a_{43} I_{-1} + a_{44} \Delta PE^e$

Identity: 5) $Y = \Delta C + \Delta H + \Delta PE + \Delta I + \Delta G'$

The symbol, Δ , represents the semi-annual change in each variable and the a_{ij} 's represent the coefficients to be estimated. The $\Delta \tilde{Y}$ variable indicates that computed values of GNP (computed from the reduced form equation for ΔY) was used instead of actual values. Thus, the reduced form for ΔY obtained by solving the structural equations is:

$$= b_{11} + b_{12} \Delta G' + b_{13} \Delta PE^e + b_{14} \Delta Y_{-1} + b_{15} \Delta HS_{-\frac{1}{2}} - b_{16} I_{-1}$$

Estimated Equations

The best set of structural equations derived for explaining semi-annual changes (that is, changes in the variables rather than with their actual levels) in the total and major components of GNP over the period from the 1951 to 1960 were:

- 1) $\Delta C = 1.95 + .38 \Delta \hat{Y} + .14C_{-1} \quad \bar{R}^2 = 0.77$
(.71) (.05) (.12)
- 2) $\Delta H = .28 + 1.06 \Delta HS_{-\frac{1}{2}} + .037(\Delta \hat{Y} - \Delta Y_{-1}) - .16PE^e \quad \bar{R}^2 = 0.76$
(.15) (.22) (.012) (.09)
- 3) $\Delta PE = -.81 + .57 \Delta PE^e + .072 (\Delta \hat{Y} + \Delta Y_{-1}) \quad \bar{R}^2 = 0.64$
(.39) (.26) (.032)
- 4) $\Delta I = .77 + .12(\Delta \hat{Y} + \Delta Y_{-1}) - .94I_{-1} + 1.21 \Delta PE^e \quad \bar{R}^2 = 0.44$
(1.18) (.09) (.27) (.83)
- 5) $\Delta Y = \Delta C + \Delta H + \Delta PE + \Delta I + \Delta G'$

In the above equations, the numbers in parentheses under each coefficient are estimated standard errors. Changes with the subscript -1 (i.e., $t-1$) are measured from $t-2$. The reduced form for ΔY which was used to obtain the structural relations presented above is:

$$\Delta Y = 6.53 + 1.96 \Delta G' + 5.27 \Delta PE^e + .50 \Delta Y_{-1} + 2.0 \Delta HS_{-\frac{1}{2}} - 3.35 I_{-1} \quad \bar{R}^2 = 0.80$$

(1.36) (.45) (.83) (.21) (1.90) (.67)

The structural equations are generally straightforward. Each represents a simple demand equation for consumption expenditures and the three major components of investment-residential construction, plant and equipment expenditures, and inventory investment. These equations are the obvious result of a highly simplified theory of income determination. "All the signs of the regression coefficients are in accordance with what theory would suggest, and given the standard errors, even the size of the coefficients are not too unreasonable."³⁴

³⁴Ibid, p. 300.

The most basic shortcoming of the model is the assumption that government expenditures and net exports are known. Each forecast is thus conditional upon the levels of this variable. Another deficiency of the model is the lack of any tax variables and relationships. Certainly the impact of major adjustments in the tax rates will have substantial effects on the level of economic activity. Thus, one large sector of economic activity, government, is treated exogenously.

Applications

The forecasts made from the structural equations are presented in Table 1, page 25. The first three forecasts (1st and 2nd half of 1961 and 1st half of 1962) were made by Friend and Jones. Computed rather than actual values were substituted for the exogenous variables in these relationships. The remaining forecasts were made by the author. In these forecasts, actual values rather than computed values were substituted for the exogenous variables. Also, the residential construction equation gave such "poor" results, that it was treated as an exogenous variable.

As a whole the forecasts obtained from this system of equations seem to be quite mediocre. The most obvious explanation would be the defects in the data. The equations were fitted to the official national accounts data before the substantial revision in July, 1962, and subsequent later revisions. Thus, perhaps a major portion of the discrepancies between the forecast and actual data may reflect the revision of the basic data rather than

Table 1

Comparison of Predicted and Actual Changes in GNP,
Semi-Annual, 1961-62. (billions of 1954 dollars)

| | C | | H | | PE | | I | | G |
|---------------|---------|------|------|-----|--------------------|------|---------|------|--------------------|
| | A | P | A | P | A | P | A | P | A |
| 1st half 1961 | 1.4 | 2.5 | -1.0 | 1.0 | -1.8 | -1.6 | -1.0 | -4.2 | |
| 2nd half 1961 | 8.0 | 8.9 | 2.3 | 1.7 | 1.7 | 1.0 | 5.0 | 4.8 | 1.0 |
| 1st half 1962 | 7.1 | 10.3 | -0.2 | 0.2 | 1.4 | 2.3 | 0.3 | 2.3 | 3.7 |
| 2nd half 1962 | 5.3 | 5.1 | 1.3 | | 1.8 | 7.6 | -3.7 | .6 | 1.2 |
| 1st half 1963 | 5.6 | 7.4 | .4 | | -.6 | 0.1 | 3.2 | .2 | 2.8 |
| 2nd half 1963 | 4.7 | 7.0 | .6 | | 3.1 | 2.7 | 0.7 | 3.3 | 1.1 |
| 1st half 1964 | 12.0 | 7.4 | .3 | | 2.4 | 2.2 | -2.1 | 1.8 | 2.3 |
| 2nd half 1964 | 9.1 | 7.6 | -1.5 | | 3.7 | 3.0 | 0.9 | 5.2 | 0.1 |
| 1st half 1965 | 11.1 | 9.2 | .6 | | 1.5 | 2.9 | 2.2 | 2.2 | -0.8 |
| 2nd half 1965 | | 8.7 | | | 3.9 ^{est} | | | 3.8 | 2.1 ^{est} |
| | r = .52 | | | | r = .90 | | r = .54 | | |

Y = GNP

| | A | P |
|---------------|------|--|
| 1st half 1961 | 0.2 | 0.3 |
| 2nd half 1961 | 18.0 | 17.5 |
| 1st half 1962 | 12.9 | 18.8 |
| 2nd half 1962 | 5.6 | 9.8 |
| 1st half 1963 | 12.4 | 10.9 |
| 2nd half 1963 | 11.3 | 14.7 |
| 1st half 1964 | 12.4 | 13.9 |
| 2nd half 1964 | 10.4 | 14.4 |
| 1st half 1965 | 15.8 | 14.1 |
| 2nd half 1965 | | 17.2 (estimated from the reduced form) |

r = .86

A = actual change
 P = predicted change
 r = a simple correlation coefficient

pure forecasting deficiencies of the model. Certainly adjusted equations would have given better results. Also, certain other "exogenous" factors, such as the recent tax reductions or the current military build-up, would be known to the forecaster attempting to make short-run forecasts, and could be incorporated in the model.

CHAPTER IV

CONCLUSION - THE LIMITATIONS OF ANALYTICAL FORECASTING

The central problem in constructing an econometric model to forecast economic activity concerns how many and which variables to include in the model. The principal requirement is that the model be as complete as possible. But what size is that? The variables must represent all of the important forces affecting the economy in sufficient detail to contain knowledge of all independent movements or unusual developments in each sector. In this respect, the degree of aggregation is important. To some, the more variables that are included (the more detailed the model) the more precise and accurate the forecast becomes. Thus, models with as many as 150 equations are constructed. Actually, mere quantity has no direct correlation with accuracy. After a certain degree of dis-aggregation, further dis-aggregation of variables tends to confuse and conceal rather than enlighten. For example, in the forecasting model presented on Page 25, all consumer expenditures were aggregated into one variable. In a more detailed model, consumption expenditures might be broken down into

durable goods, non-durable goods, and services. Even a single commodity, like automobiles, might be represented. But further dis-aggregation into more variables may only lead to more computations without really improving the forecastibility of the model.

Each forecaster, no doubt, has his own version of what characteristics constitute "the best" representation of the "real" economic system. Table 1 summarizes the important individual characteristics of three pioneering models, those of Tinbergen,³⁵ Klein,³⁶ and Klein-Goldberger.³⁷

Problems also arise in finding the functions which correctly express the relationships between the variables. There are few (if any) invariant functions in economic behavior. Consequently, there will always remain unexplained factors in even the most carefully fitted equations. Therefore, a residual term--a random variable--is included in each equation to bridge the gap between the exact relationships of economic theory and the relationships of the "real" world. There are a number of ways of rationalizing the insertion of this term. First, in explaining human behavior the list of relevant factors may be extended ad infinitum. Many of the factors, however, will not be quantifiable, and even if they are, it is usually not possible to obtain data on them all. Therefore, the disturbance term represents the net effect of all omitted variables. Secondly, there is a basic and unpredictable element of randomness in human behavior which can be adequately

³⁵Tinbergen, op. cit.

³⁶L. R. Klein, Economic Fluctuations in the United States, 1921-1941, (New York: 1950).

³⁷Klein-Goldberger, op. cit.

TABLE 2: A COMPARISON OF THREE AGGREGATE MODELS³⁸

I. TINBERGEN: (Years: 1919-32) Stochastic Equations, Definitions,
Total Equations: 42 6 = 48

Endogenous Variables: 4 consumption variables (2 farm, 2 non-farm), 4 investment components, 5 output components, 11 price variables, 13 stocks (2 real, 11 financial).

Main Exogenous Variables: Exports and imports, building costs, required reserves, 5 financial stocks, 3 financial flows, agricultural supply.

Dynamic Features: Lags up to 4 years, cumulated profits, cumulated investment.

II. KLEIN: (Years: 1922-41) Stochastic Equations, Definitions,
Total Equations: 12 3 = 15

Endogenous Variables: Consumption, 4 net investment components, private output, disposable income, wage income, price level, interest rate, rent level, capital stock, 2 money stock, % vacant housing.

Main Exogenous Variables: Governmental expenditures, taxes plus corporate saving, excise taxes, capital goods, prices, excess reserves.

Dynamic Features: Lags of 1 and 2 years, cumulated investment.

III. KLEIN-GOLDBERGER: (Years: 1929-1950, not including 1942-43)

Stochastic Equations, Definitions,
Total Equations: 14 5 = 19

Endogenous Variables: Consumption, gross investment, depreciation, imports, corporate saving, private employees, national income and 4 components, price level, wage level, 2 interest rates, capital stock, 2 liquid assets components, corporate surplus.

Main Exogenous Variables: Governmental expenditures, 4 components of direct taxes, indirect taxes, import prices, excess reserves, 5 population and labor force variables, weekly hours.

Dynamic Features: Lags of 1,2,3, and 5 years, cumulated investment, and corporate savings.

³⁸Carl F. Christ, "Aggregate Econometric Models", The American Economic Review, June 1956, p. 390.

characterized only by the inclusion of a random term. Third, it may be possible that there really is an exact relationship among the variables, but the observations obtained were not exact measurements of these variables. The disturbance term, therefore, affects these errors of observations.³⁹

Finally, it must be realized that many of the factors that affect economic conditions in the "real" world are not subject to a systematic or mathematical treatment. In a world of social beings, anything can happen at any time. For example, a change in the political administration can result in a change in fiscal ideology and with it a change in the distribution of income. Such things as international disturbances, wars, and rapid changes in technology can hardly be built into a system of equations.

In short, solid facts, sophisticated statistical techniques, and sound theoretical analysis are not enough. Good judgment is one of the prime requisites for a good forecast. And with this good judgment, analytical forecasting will continue to contribute with increasing effectiveness to policy-making and economic forecasting as well as to the basic understanding of the functioning of the economic system.

³⁹J. Johnston, Econometric Methods, (New York: McGraw-Hill Book Company, Inc., 1963), pp. 6-7.

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ANALYTICAL FORECASTING OF AGGREGATE ECONOMIC ACTIVITY

by

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One of the most pervasive characteristics of economic decision making is the existence of imperfect knowledge of the future. Nothing is more common or more certain in a private enterprise economy than the recurrence and inevitability of change. It is the recognition of this fact that has prompted economists to devote time and effort to the task of attempting to obtain reliable forecasts of aggregate economic activity.

The techniques available for formulating economic forecasts may be classified into three broad categories: the naive methods, the barometric methods, and the analytical methods.

The naive methods are essentially mechanical trend projections (such as a time series) which are separated from economic theory. These methods are quite useful in providing forecasts of certain sectors of the economic system. However, mere projections of the past--the "next year will be the same as this year" philosophy--can never provide an adequate foundation for forecasting aggregate economic activity.

The barometric methods attempt to discover a statistical series of economic indicators that act as barometers of economic change. These methods also yield some relevant insights into a forthcoming change in the level of economic activity. Yet, like the naive methods, they provide only a partial analysis of economic trends.

The most informative process of synthesizing data (including relevant information obtained from the above methods) into a meaningful forecast is achieved by the use of an analytical technique--formulated within the framework of the national income accounts and

making use of the relationships among the variables suggested by economic theory. The analytical technique thus attempts to isolate the various influences of important sectors affecting the aggregate level of economic activity at a given time and subsequently integrate these influences into an econometric model to predict an overall change into the future.

From the viewpoint of the econometric model, economic life is explainable by a set of simultaneous structural equations that express the relationships among the endogenous and exogenous variables. The model is constructed for the purpose of solving the equations simultaneously to find the values of the unknown endogenous variables. The values of these variables, once obtained, constitute the forecast.

The task, then, is to construct an abstract econometric model that provides reliable forecasts of the aggregate level of economic activity. This, of course, is beyond the scope of this paper. However, in order to illustrate and examine some of the problems associated with forecasting economic activity with an econometric model, an actual economic model of the U.S. economy (the Friend-Jones model) is presented.

The objective of this model (the Friend-Jones model) was to determine a reliable model for forecasting short-term (periods up to one year) fluctuations in Gross National Product. The model consisted of four structural equations (explaining consumption, residential construction, plant and equipment expenditures, and inventory investment) and an identity.

The model was fitted by a two stage least squares procedure to semi-annual changes in the variables based on observations from the second half of 1951 through the end of 1960. Semi-annual forecasts were made by the author for the first half of 1961 to the second half of 1965 and the results compared with the actual values.

When forecasting economic activity with an econometric model, one must always be mindful of its limitations. There are, of course, many factors that affect economic conditions that are not subject to a systematic or mathematical treatment. In a world of social beings, anything can happen at any time. Such things as international disturbances, wars, and rapid changes in technology can hardly be built into a system of equations. Thus, solid facts, sophisticated statistical techniques, and sound theoretical analysis are not enough. Good judgment is one of the prime requisites for a good forecast.