THE UNIVERSITY OF MANITOBA

AN OUTLOOK MODEL OF CANADIAN AGRICULTURAL INPUTS AND OUTPUTS: AN INPUT-OUTPUT APPROACH

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

DEPARTMENT OF AGRICULTURAL ECONOMICS

AND FARM MANAGEMENT

WINNIPEG, MANITOBA

MAY 1980

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A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF SCIENCE

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ABSTRACT

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A. K. BANERJEE

Major Advisor: Dr. M. H. Yeh

The need for economic forecasting may not be over-emphasized. Accurate forecasts could be used in a number of economic activities - productions, consumption, investment and employment. Almost all forecasts are structural forecasts i.e. forecasts based upon the assumptions of the economic structure of the past. A significant change in the structure between the base and the future period will, therefore, distort a set of forecasts. For this reason, structural change is also of interest to economists.

With emphasis on agriculture and related sectors of the Canadian economy, the objectives of this study were to: (a) forecast gross output vectors for 35 industries; (b) examine changes in input structure of industries between 1961 and 1966, and 1966 and 1971; (c) examine structural change in the economy between 1961-1966 and 1966-1971 periods.

A rectangular input-output model was used for the analysis. The model is based upon a commodity-industry system where the number of commodities exceeds the number of industries. There were three compatible tables for the Canadian economy for the years 1961, 1966 and 1971.

The following were the main findings of the study:

1. Commodity multipliers showing the necessitated change in gross output due to a one dollar rise in final demand were calculated for the year 1971. The multipliers for the unprocessed agricultural commodities were, in general, lower than the various manufacturing sector commodities which, in turn, were lower than the processed agricultural commodities.

2. Gross output vectors were forecasted for the year 1980. The average yearly growth rates between 1961-1971 period were comparable to 1971-1980 period for similar groups of industries.

3. The change in input structure among industries between the two five-year periods: 1961-1966 and 1966-1971 were fairly similar indicating that 'new' inputs have not been introduced or the accounting practice for keeping record of inputs has not changed. As for changes within industries, pattern of input structure was different for the two same five-year periods.

4. Structural changes between 1961-1966 and 1966-1971 periods were examined by multiplying the 1961 and 1966 structural matrices with the final demand vectors of 1966 and 1971 respectively. These hypothetical gross outputs were indeed different from the actual values.

It was concluded that: (a) the processed agricultural commodities, in general, have higher multiplier effects than other commodities; (b) the average growth rate of gross outputs between 1971 and 1980, for similar groups of industries, will be comparable to those between 1961 and 1971; (c) change in input structure within industries were different between 1961-1966 and 1966-1971 periods; (d) structural change between the two five-year periods: 1961-1966 and 1966-1971 had taken place.

ACKNOWLEDGEMENT

I wish to thank Professor Martin H. Yeh under whose direction this thesis was written. Professor Yeh has been patient and helpful throughout this study.

This thesis could not have acquired its present shape without the valuable suggestions and constructive criticism of Professor Charles F. Framingham, Department of Agricultural Economics.

In the space available I can only thank Professor C. A. Nicolaou, Department of Economics. Professor Nicolaou has been most helpful and has made significant contribution during the early days of this thesis.

I also wish to thank Messers Neil Longmuir and Maurice Senkiw for their assistance in the computer work.

Thanks are also due to Agriculture Canada for financial support, and in particular, Dr. Ralph Lattimore who made the data available.

Mr. Mike Palme of Input-Output Division of Statistics Canada helped with numerous questions on the data structure.

I can only mention but cannot repay my debt to my wife Edith and daughter Mitzi who have stood beside me and shared with me all feelings as this thesis was written. An additional thank you to my wife for typing this thesis.

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CHAPTER I

INTRODUCTION

Justification for the study

In recent years, economists have often been asked to predict with confidence the future needs of the economic system. The accuracy of such forecasts depends, to a large extent, upon the depth of understanding one has of the structure and organization of the economy as well as its complex interrelationships. While the future does not necessarily mirror the past, and the accuracy of any forecast is often constrained by those events which may or may not occur, the importance of selecting those regularities of the past which the economist feels will repeat in the future cannot be overstated. As such, the selection of these apparent regularities cannot but be enhanced by a thorough knowledge of the system with which one is dealing. Assumptions and/or conditions in forecasting are often the points of criticism. This certainly is not to imply that a forecaster must be bogged down in a morass of detail in identifying those regularities of the past which will repeat in the future, or setting aside conditions that are far from reality. Conditional forecasts arise from the fact that economists, through judgements, predict or expect certain future events and, in turn, forecast particular activities in the near or distant future. The fact that forecasts cannot be made unconditionally, is not any reflection on the progress of economic science. A set of forecasts with strong statistical confidence may well be distorted through exogenous forces.

The actual amount of information required for forecasting will depend on the type of forecasts to be made and the forecasting tool which is to be employed. In this latter regard, there are various tools, each with its strengths and limitations. One of the simplest methods available is partial forecasting which involves extrapolation a time series mathematically or graphically. This may work satisfactorily if the time series has been observed and has been proven to follow past trends. A good example of where this technique might be employed is sales forecasting for a short run period because of consumption patterns. Since long-run forecasting requires more than rudimentary knowledge, this particular method may be ruled out for anything but a short time horizon.

Another forecasting technique that is widely used is the econometric model. Such a model usually consists of a set of equations that are believed to describe the interrelationships between a number of variables. The equations often describe the simultaneous relationships between variables and hence an econometric model is sometimes known as a simultaneous equation model. The simplest example of this type of a model would consist of one demand and one supply equation where quantity demanded and supplied are both endogenous in the system. Such models are usually stochastic in nature in that an error term is introduced to allow for any discrepancies between the forecasted and the realized value. It might be appropriate to mention that in addition to the task of forecasting, econometric models are sometimes put through static and dynamic multiplier analysis where the effects on endogenous variables, both in the short and long run, are captured due to changes in policy and other exogenous variables. However, like all other models, econometric models also suffer from their specific limitations. Three main limitations are stability of parameters, stability of relationships among endogenous and exogenous variables, and an accurate method to forecast exogenous variables which in turn determine forecasts for endogenous variables. One further consideration is that an econometric model may be viewed as a problem solving model, i.e. a model that will answer only specific questions. For example, if a model were designed to forecast the demand for wheat, it would not be able to forecast the output of steel which would be necessary to meet the requirements of the agricultural implements industry to produce the tractors that would be used to produce wheat. Thus it can be seen that an econometric model will not provide a consistent and compatible set of forecasts for an entire economy at a particular point in time. This is not to denigrate the value of the econometric model, but merely serves to establish its limitations.

It can be seen, then, that if one is interested in obtaining forecasts for all industries in an economy, a tool other than the econometric model will have to be employed. One technique which will provide such overall forecasts is input-output analysis. An input-output table describes the inputs and outputs i.e. the interdependence of all the industries in an economy at a particular point in time. A conventional input-output table as designed by Professor Leontief, is a square matrix in dollar values with a one-to-one correspondence of industries. That is, if the third row in this table represents the Agriculture industry, then the third column will represent the Agriculture industry as well. The third column will depict the values of various inputs absorbed by Agriculture for production of output, whereas the third row displays the value of Agricultural output purchased by the various industries in the economy. In all cases, the value of total industry inputs just equals the value of total industry outputs. In other words, the table is based upon a double-accounting framework. We will not be concerned here with the details of an input-output framework. There are numerous references [26,40] that may be cited in this regard. The criticism, as we departed from the discussion of econometric models, was that these models cannot provide a compatible set of forecasts for the entire economy. With reference to input-output analysis, the point that should be brought to light is that an input-output system can provide forecasts of the outputs which will be necessary to meet the demands that are expected to stem from every part of the economy. We turn now to Professor Leontief's comments on this.

> "The analytical methods that are used to transform raw economic data into the final product of specific market forecasts and other types of economic projections are well known to economist-technicians (whom I would like to distinguish from political economists or economist-politicians). The large-scale data processing operation, which only a few years ago would have made the realization of the entire project unwidely, if not impossible, can be performed today rapidly and cheaply.
>
> But an important caveat is needed here. By their very nature, consistent porjections of the demand for good and services produced and consumed in all the many different, but mutually interdependent, sectors of the national economy cannot be run off as so many cars on on assembly line. Despite the use of electronic computers, the entire operation should first be visualized and organized like a construction job; all the parts have to be fitted skillfully to each other all-though no two of them are alike." [22.9]

Thus far we discussed forecasting with particular emphasis on the needs for consistent and compatible set of forecasts for the economy as a whole. In this discussion, one very important point has been imlictly assumed - the structure of the economy. Whether we speak of a mathematical relationship between variables in case of partial forecasting, in an econometric model or in an input-output context, each situation assumes or depicts a particular set of economic structure. It is needless to mention, cognizance of an economic structure leads to an accurate set of forecasts. Examination of an economic structure provides one with a set of answers in terms of performance of a whole system. Information from a structural analysis could be of significant value if:

(a) governments intend to carry out better planning activities in the future

(b) certain industries wish to explore the various activities of related sectors

(c) research is necessary in a certain sector for its continous poor performance

(d) policy changes are to be implemented

(e) each sector needs to be analyzed relative to all other sectors in an economic system.

As we speak of past performance and wish to analyze it, the job will be easier if there was a point of reference for the purpose of comparison. In other words, if we had two economic structures, or two identical input-output matrices say, sufficiently removed in time from each other then we can analyze the interim period. Consider two input-output matrices, for the same economy for two different years, expressed in a common base year price level. Now if the identical input coefficients were considered, the coefficients, in all likelihood, will show some discrepancies. This leads to a violation of an assumption in a Leontief system which suggest that the combination of inputs, will remain fixed whatever the level of output. It may be argued that due to improper deflation of the matrices such statistical problems may well appear. This is true to some extent because unavailability of proper indices often means that each cell of an input row is often deflated by the index number of the delivering industry whatever the type of input. But the problem does not get resolved with this. As new products emerge, relative prices rise and substitution takes place, shifts from one production process recipe to another occur. To a great extent these structural shifts are unknown and, the turning points of a certain well-followed economic relationship is discovered only after they have occurred. It is needless to say, much of this centers around technological change. For the purpose of this study, no distinction or inquiry will be made for the various kinds of technological change. We will treat this change as structural change in general, and focus upon the ultimate impact due to this structural change. As for the ultimate impact, our interest lies on the gross output vector. More specifically, since indirect demand is an input demand to produce gross output, with fixed final demand as indirect requirements change so do gross output levels. As we proceed, different concepts and expositions of structural change will be considered in Chapter II. Input-output analysis may be employed for examining structural changes as we shall see in Chapter II.

This study is based upon a rectangular input-output system. The rectangular system is one of the family of input-output models associated with Professor Leontief. This is a commodity-industry system where the number of commodities exceed the number of industries, as opposed to the more familiar square inter-industry system. The usefulness of a rectangular system will be dealt with in Chapter III. In this study, there are, three compatible input-output tables of the Canadian economy for the years 1961, 1966 and 1971. These tables describe 35 industries and 134 commodities aggregated from 191 industries and 595 commodities respectively. The value of commodities may be viewed as inputs to industries or products of industries. There are 4 primary inputs respectively aggregated from 7 primary inputs. It should be pointed out that although the inputs and outputs of agricultural commodities and industries are represented at a relatively low level of aggregation, the picture of the non-agricultural sectors is rather a highly aggregated one. However, this does not cause any complications for it is the agricultural and related sectors that are emphasized in this study.

Objectives

The objective of this study is threefold. First is that of forecasting industry outputs for 1980 based upon the structural matrix of 1971. We cannot make use of a more recent structural matrix due to data unavailability. There are two forecasts, as we shall see - one is based upon projected final demand of 1980 based upon final demand of 1966 and 1971. The second is due to projected final demand of 1980 based upon final demand of 1961, 1966 and 1971.

The second objective is to explore the change in input structure both primary and intermediate over the years 1961 to 1966 and 1966 to 1971.

Third, we study the impact of the structural matrix of a different year upon industry outputs given an identical vector of final demand. More explicitly, we are concerned with the question that: would there be any changes in the industry output vector of 1966 if final demand of 1966 was to be delivered with the 1961 structural matrix? Similarly, a second question is concerned with the behaviour of industry outputs if final deliveries of 1971 were to be met with the structural matrix of 1966. Essentially then we are comparing a vector of industry outputs produced under two different economic systems sufficiently removed in time from each other. As time goes on, and input requirements change over time, a change will be captured in the output vector produced for the same bill of goods. It may be pointed out that the second and the third objective are interrelated for the third is a function of the second. Insofar as this study is concerned, the interest lies in capturing the ultimate effect of structural change between 1961 through 1966 and between 1966 through 1971 upon all industries. The particular cause of structural change in any particular industry or industries will not be examined.

<u>Organization of the study</u>

Having stated the objectives of this thesis, it remains to be indicated how the steps are taken to achieve them. Chapter II will deal with a detailed review of literature pertinent to this thesis. Chapter III will focus on the usefulness of a rectangular input-output system and will include a general output determination model of this particular type of system. The methodology based upon this general model is dealt with in Chapter IV, Chapter V briefly examines the data structure. Chapter VI includes a discussion of the results which were obtained. Finally, there are three appendicies. Appendix A displays all results. Appendix B contains the complete disaggregation of all commodities and industries used in the analysis. Appendix C includes the data base used in the study.

CHAPTER II

REVIEW OF LITERATURE

There exist a number of studies that have used input-output analysis to forecast gross output or intermediate demand or final demand. Input-output analysis has also been used to examine structural changes. This chapter reviews studies that are relevant to this thesis. Before proceeding to particular studies, discussion of a few points is warranted. After an extensive search, no study that uses a rectangular input-output scheme to forecast or to examine structural changes has been found. The review of studies presented are, therefore, limited to classical inter-industry Leontief models. While similarities in mathematical models between the studies reviewed and this particular study may not be found, the objectives remain similar. This limitation, it is hoped, will not be detrimental to the objective of this chapter. For the sake of clarity on notation, we will write $(I-A)^{-1}$ as the standard inverse of the unit minus the intermediate input coefficient matrix and refer to this as the 'inverse matrix' or 'the Leontief inverse' throughout this study. As for mathematical exposition, equations are borrowed directly from the respective study wherever necessary.

Review of Studies On Forecasting

With the above points in mind, we first refer to a study by Tilanus [37]. He performed forecasting experiments for the Dutch economy. Tilanus placed a great deal of emphasis on the statistical properties of the errors between the predicted and realized values. Our discussion will be specific to the forecasting experiments and, therefore, the reader is encouraged to refer to the study with regards to the statistical methods. The first aspect of the study was to predict intermediate demand after predicting final demand of the particular year. Two methods were introduced to calculate intermediate demand. Let us denote gross output vector, intermediate demand matrix and final demand vector by X, z and f respectively. Then,

$$z = \frac{z}{f} f, \text{ for year } t \tag{2.1}$$

It was assumed that $\frac{z}{f}$ would remain constant between year t the base year and, year t+k the year to be predicted. Therefore, for year t+k, intermediate demand will be proportional to final demand in relation to the base year t. Mathematically,

$$z_{t+k} = \left(\frac{z}{f}\right)_t f_{t+k} \tag{2.2}$$

In the second method, intermediate demand for year t+k was predicted with given final demand for year t+k. It is correct to write,

$$z_t = ((I-A_t)^{-1} - I)\ f_t \tag{2.3}$$

where z_t, A_t and f_t represent the intermediate demand vector, matrix for intermediate input coefficients and final demand vector respectively for year t. It was proposed that,

$$z_{t+k} = ((I-A_t)^{-1} - I)\ f_{t+k} \tag{2.4}$$

The basic difference between the two methods is that, in the first method it was assumed that the intermediate demand will be proportional to final demand for the year t+k as in year t.

In the second method, the base year inverse was assumed to remain stable between years t and t+k. It was concluded that the second method works out better as long as the inverse was not more than two years old. Input-output tables for the Netherlands were available for the years 1948 through 1957. The inverse matrix for each of these years was introduced in (2.4) to calculate intermediate demand for 1958 with estimated final demand of 1958. The first method is similar to the concept of GNP blow-up and is referred to as final demand blow-up. We will discuss the method of GNP blow-up later in this chapter. Tilanus' experiments were based upon input-output tables of dimension 35 x 35, however, only 27 sectors were projected because intermediate demand of the remaining 8 sectors were considered unimportant. A comparison between the errors computed from the final demand blow-up and input-output estimates suggests that the latter is a better choice.

The second problem dealt with the value prediction of primary demand: Imports, Wages (aggregated from Wages and Salaries, and Employer's social insurance fees) and Gross profits (aggregated from Depreciation allowances, Intermediate taxes, Subsidies, Net profits and Interest). Denote the flow from primary sector i into industry j by p_{ij} and this matrix by P, and the corresponding primary input coefficient by b_{ij} and this matrix by B then,

$$B = PX \qquad (2.5)$$

We know that,

$$z + f = X \qquad (2.6)$$

and,

$$X = (I-A)^{-1} f \qquad (2.7)$$

Substitution of (2.7) in (2.5) suggests that for the year t+k,

$$B_{t+k} = P_t \ (I-A_t)^{-1} \ f_{t+k} \qquad (2.8)$$

where matrices P_t and A_t suggest that primary and secondary input coefficients are for the base year t and, the final demand vector f_{t+k} is given for the year t+k. There is no specific mention of the predicted year by Tilanus. It should be noted that the final demand vector f_{t+k} will serve both for predicting primary and intermediate demand for the same year. In addition to the input-output scheme, a procedure of the blow-up type was employed as an alternative approach to predict primary demand for the same year. It was again assumed that the proportion of primary demand to final demand will remain constant for the year t+k as in year t, suggesting that:

$$P_{t+k} = \frac{P_t}{f_t} f_{t+k} \qquad (2.9)$$

a comparison between the input-output and the blow-up procedure again suggests the input-output method yields better estimates.

Thirdly, the primary demand vector was predicted given final expenditure. Thus far we have considered a single vector f for final demand. This vector sums across the columns of the each sub-sector of final demand. We can also speak of a final expenditure columns which is the sum over the rows for a particular column in the matrix of final demand. More clearly, if household consumption is a column in a final demand matrix then, the total final expenditure on household consumption is the sum over this column for all industries. Let the flow of the ith industry to the jth sector of destination in a final demand matrix be f_{ij}, the total final expenditure on the jth sector be g_j, c_{ij} the appropriate coefficient and C the corresponding matrix. Then,

$$C = c_{ij} = \frac{f_{ij}}{g_j} \qquad (2.10)$$

Substitution for the vector f from (2.10) in (2.8) gives,

$$B_{t+k} = P_t \ (I-A_t)^{-1} \ C_t \ g_{t+k} \qquad (2.11)$$

It should be clear that g_{t+k} denotes total estimated final expenditure for the year t+k. However, there is no specific mention of the methodology for predicting final expenditure and, this places a constraint on the discussion for predicting the vector g. Equation (2.11) projects the vector of primary demand with given final expenditure. A ratio was calculated by dividing the vector of primary demand obtained from the final expenditure prediction by the vector of primary demand obtained from the final demand prediction. This ratio was quite close to unity indicating that neither method is particularly superior. In each of these predictive experiments, Tilanus fails to mention the particular methodology employed in forecasting the primary or the final demand.

The last section dealt with forecasting volume prediction of intermediate demand given final demand. If we denote the secondary coefficient by a_{ij} then,

$$a_{ij} = \frac{z_{ij}}{X_j}$$

$$= \frac{q_{ij} p_i}{q_j p_j} \qquad (2.12)$$

where q_{ij} is the volume of flow from sector i to j, p_i is the unit price of input i, q_j is the total production in quantity terms of sector j and p_j is the unit price of sector j repectively. It should be perfectly clear that, the p's here are prices and not primary inputs discussed earlier. It was assumed that volume coefficients were constant for the base year t to the year t+k. In other words,

$$a_{ij}\ (t+k) = \frac{q_{ij}(t+k)\ p_i(t+k)}{q_i(t+k)\ p_j(t+k)} \qquad (2.13)$$

or,

$$a_{ij}\ (t+k) = \frac{q_{ij}\ p_i(t)}{q_j\ p_j(t)}\ \frac{p_i(t+k)}{p_j(t+k)}\ \frac{p_j(t)}{p_i(t)} \qquad (2.14)$$

where aij(t+k) is an intermediate input coefficient for year t+k. The ratio of prices were treated as diagonal matrices and denoted by a circumflex sign. By postmultiplying we write,

$$A_{t+k} = \hat{p}_t\ A_t\ \hat{p}_t^{-1} \qquad (2.15)$$

where A_{t+k} is a matrix of input coefficients for year t+k, a_t for year t and $\hat{p}_t$ is a diagonal matrix of price ratios p_i/p_j for year t. Again, it was assumed that $A_{t+k} = A_t$

Substitution of (2.15) in (2.4) gives

$$\begin{aligned} z_{t+k} &= ((I - \hat{p}_t\ A_t\ \hat{p}_t^{-1})^{-1} - I)\ f_{t+k} \\ &= ((\hat{p}_t\ \hat{p}_t^{-1} - \hat{p}_t\ A_t\ \hat{p}_t^{-1})^{-1} - \hat{p}_t\ \hat{p}_t^{-1})\ f_{t+k} \\ &= (\hat{p}_t\ (I - A_t)^{-1}\ \hat{p}_t^{-1} - \hat{p}_t\ \hat{p}_t^{-1})\ f_{t+k} \\ &= \hat{p}_t\ ((I - A_t)^{-1} - I)\ \hat{p}_t^{-1}\ f_{t+k} \qquad (2.16) \end{aligned}$$

where f_{t+k} is again the predicted final demand vector. Using equation (2.16), volume prediction for the year 1958 was made. Now the errors between the predicted and the realized value of intermediate demand were compared to the errors between the predicted and the realized volume of intermediate demand. Mean errors for volume predictions were larger than the value prediction. Tilanus suggests two reasons for this. First is that the value coefficients in constant prices are believed to be more stable than the volume coefficients. The second is that lack of data necessitated use of appropriate price indices for the diagonal matrices and this might have introduced some bias. Consider the input from Chemicals to Agriculture, this flow consists of fertilizer, pesticides and other typical chemicals used by the Agriculture sector. Unfortunately, the various components of such an input is almost never found in an input-output matrix. As for data availability, there exists a price index for the Chemicals industry, but not individual index for fertilizer or a particular chemical. Ideally for each volume flow q_{ij}, there should exist its own price index p_{ij}. In reality however, index number of the Chemical industry was needed to represent the prices of the products of this industry used as inputs by all other industries. On the other hand, insofar as the output is concerned, there is no particular difficulty in applying this treatment if homogeneity of output is assumed.

Before proceeding to the next study, we recall that one of the objectives in this thesis is to forecast gross output for 1980 after forecasting final demand for 1980. One common ground between Tilanus' study and this thesis could have been the similarity or difference in the methodology in forecasting final demand. As stated earlier, Tilanus does not describe the particular methodology employed in projecting final demand. We could, therefore, only summarize the described framwork.

Cornfield, Evans and Hoffenberg [8] attempted to estimate the impact of full employment upon the United States economy in 1950 based upon a 28 x 28 input-output matrix of 1939. The authors maintain:

"The present estimates are consequently neither fore-

> casts, a statement of present government intentions, nor a model of an ideal structure of government revenue and expenditure. They are best interpreted as an approximate picture of what might happen under full employment conditions in 1950 if there were no basic change in the scope of government activities from the prewar period, except those alterations which are an aftermath of the war itself." [8:173-74]

For the sake of similarity, the objective of forecasting in this thesis may also be viewed as an approximate picture of the Canadian industries in 1980 if the final demand between 1971 to 1980 grows at the same rate as it did between 1961 to 1971 or between 1966 to 1971. The ultimate objective of the study of Cornfield et al. was to obtain a statistical picture of output and employment in different industries under full employment conditions. The authors suggest that the main components that determine employment are: income - consumer, corporate and government; and demand - consumer, export, government, capital goods and gross output. Looking at it from another angle, demand determines employment. Therefore it is quite conceivable that while forecasting a statistical picture for the future, the main thrust may be placed on the demand analysis. The authors put forward two different estimates of final demand, namely, consumer demand and investment demand. The consumption model fixes the investment demand and the government demand and, augments the estimated consumer demand by the amount necessary to achieve full employment. The investment model, on the other hand, fixes the consumer demand and augments the investment demand by the amount necessary to achieve full employment. The assumption made on the consumption model was that an increase in the level of expenditure between 1939 (the base year) and 1950 will be relative to income, i.e. a point at which income and expenditure are equal. There were four assumptions made on the investment model side. First, between 1939 and 1950, construction activity would rise by two-thirds. Second, final demand for durable goods would rise by over fifty percent. Third, exports would rise by twenty percent. Finally, the inventory change was held constant. An important point is, with regards to these assumptions, made by the authors. The fact that consumer demand would rise relative to income reflects more of a structural change than those assumed in the investment demand model. The case in point is that, as consumer income rises so does expenditure, but perhaps up to a point lower than income. In addition, expenditure on certain goods rises more rapidly than others. A suggestion with regards to similar studies is that it may be helpful to study the spending habits of families of different income distribution. An example cited here by the authors is that between 1935 to 1936, families with income below $1,250, incurred deficits, but as income rose above that amount, saving rose quite rapidly. Savings were 10, 20 and in excess of 40 percent at incomes of $2,500; $5,000 and $20,000 respectively. On the investment model side, the key components are - durable goods, construction, inventories and exports. The thrust of this model is not on forecasting the output of durable goods, but rather on the prediction of level of employment which would be generated from maintenance of these goods.

The framework of the analysis follows certain guidelines. As mentioned before, since all findings stem from the nature of final demand in 1950, mostly judgement was used in recognizing the characteristics and the behaviour of the American people in 1950. Past performance i.e. buying habits, preferences etc. were used throughout