ON THE INPUT-OUTPUT ANALYSES AS TECHNIQUES OF PROJECTIONS AND PREDICTIONS[1]

By

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Input-output analyses may fall under one of the general classification of analyses. There are analyses designed to increase the understanding of the complexities and interdependence of the economy. They involve no forecast element, that is, they relate exclusively to the past or to the present. There are those types that include most mobilization analyses, conjoin a particular demand structure with a forecast of the processing structure appropriate to the situation. Such models facilitate a rational choice among possible alternatives by examining the logical consequences of each. The validity of such models depends on the analysts' ability to forecast the main features of the processing structure while their utility depends on the judgment and common sense exercised in portraying the hypothetical demand structure. Lastly, there are analyses using models in which both processing and demand structures are forecasts. The validity and usefulness of such forecast models depend on the degree to which the future structures are actually approximated. The problems of making a realistic forecast of the demand structure are difficult and the value of the model will chiefly depend on the success in this area.

However, the problem of forecasting the structure of demand is not peculiar to input-output forecast models. Similar

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1 Norton defines projections as conditional forecasts, or models of the future, or analyses of the implications of certain policy and structural assumptions and predictions as something expected to be realized.

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problems are encountered in connection with nearly any kind of forecast model (Evans and Hoffenberg, 1955).

Evans and Hoffenberg, 1955, further stated that any new tool of economic analyses should be examined in terms of whether or not it helps forecasting. Input-output methods receive an undue amount of attention in this respect. This paper intends to consider input-output analyses as devices for projections and predictions and also to consider briefly the lack of agreement on their role in forecasting. Finally, some areas of research, theoretical or applied, which might contribute to the establishment of the input-output techniques as predictive economic tools will be considered.

The Input-Output Model: Nature and Assumptions

In this section, the nature of the input-output analysis will be reviewed and the assumptions pertinent to the problem on hand will be considered.

Nature. Leontief was the first to apply a modified Walrasian general equilibrium system to a particular country in a particular period. He arrived at a system of equations which could be used to compute the relations among inputs, outputs and demands, using a simplified static general equilibrium system with linear production functions and fixed technical coefficients and empirically derived table of flows of goods.

The economy is considered as consisting a number of homogeneous producing industries or sector. These are engaged in trade with each other and with other sectors. The output of each sector is defined as the sum of the sales by the sector to all other sectors including sales for exports, to government, and to individuals. Intermediate or producing sectors are those sectors whose demand for a product arises out of their own decisions to produce goods. While autonomous sectors are those whose demand for goods arises partly for other reasons, such as political decisions or individual preferences. These represent the final demand or the final bill of goods. Government, foreign trade, and households are usually placed under this class, although various arrangements can be made for these sectors.

Individuals make households absorb inputs in order to produce the quantity and quality of labor service demanded by intermediate sectors. This implies that the household is an autonomous sector because of the independent nature of its decisions to absorb inputs. The flows between intermediate sectors consist of goods which still has to undergo some stage of processing in the usual input-output analysis. Goods ready for final consumption or consumption outside the system enter the final demand sectors. An input-output table is as follows:

Producing Sectors	Consuming Sectors 1	2	...	j	...	n	Final Demand	Total Output	
1	x_{11}	x_{12}	...	x_{1j}	...	x_{1n}	Y_1	X_1	
2	x_{21}	x_{22}	...	x_{2j}	...	x_{2n}	Y_2	X_2	
.	....								
i	x_{i1}	x_{i2}	...	x_{ij}	...	x_{in}	Y_i	X_i	(1)
.	....								
n	x_{n1}	x_{n2}	...	x_{nj}	...	x_{nn}	Y_n	X_n	

This array of data could be expressed as a set of simultaneous equations. With X_i, the total output of industry i and Y_i, the final demand for the product of industry i, the equation are

$$Y_1 = X_1 - x_{11} - \cdots - x_{1j} \cdots - x_{1n}$$

$$\cdots\cdots\cdots\cdots\cdots\cdots$$

$$Y_i = X_i - x_{i1} - \cdots - x_{ij} \cdots - x_{in}$$

$$\cdots\cdots\cdots\cdots\cdots\cdots$$

$$Y_n = X_n - x_{n1} - \cdots - x_{nj} \cdots - x_{nn}$$

where each equation may be interpreted as saying that the total output of each industry minus the sales to other industries is equal to the amount of the industry's product going to final demand. Final demand can origniate in households, in foreign trade, in government or in any other sector which is considered to be in the autonomous category.

A coefficient of production is defined to be the fraction which represents the share of output of industry j supplied by industry i in a given time interval, usually a year:

$$a_{ij} = x_{ij} / X_j \qquad i, j = 1, 2, \ldots, n$$

Substituting (3) in (2) we obtain the sets of equation:

$$Y_1 = X_1 - a_{11}X_1 - \cdots - a_{1j}X_j - \cdots - a_{1n}X_n$$

$$\cdots\cdots\cdots\cdots\cdots\cdots$$

$$Y_i = X_i - a_{i1}X_1 - \cdots - a_{ij}X_j - \cdots - a_{in}X_n$$

$$\cdots\cdots\cdots\cdots\cdots\cdots$$

$$Y_n = X_n - a_{n1}X_1 - \cdots - a_{nj}X_j - \cdots - a_{nn}X_n$$

which permits finding the goods bought by households and other autonomous sectors if total outputs and the coefficients of production are known.

Solving for the X_i's in Equation 4 in terms of the Y_j's the following system of equations is obtained:

$$X_1 = A_{11}Y_1 + \cdots + A_{j1}Y_j + \cdots + A_{n1}Y_n$$

$$\cdots\cdots\cdots\cdots\cdots\cdots$$

$$X_i = A_{1i}Y_1 + \cdots + A_{ji}Y_j + \cdots + A_{ni}Y_n$$

$$\cdots\cdots\cdots\cdots\cdots\cdots$$

$$X_n = A_{1n}Y_1 + \cdots + A_{jn}Y_j + \cdots + A_{nn}Y_n$$

where the coefficient A_{ji} indicates how much of the total input of industry i must rise if the final demand of industry j rises one dollar. The coefficient Aji reflects direct inputs from i to j and also the indirect inputs via intermediate industries as well (Eckstein, 1955).

A model can be completely self-contained, closed, if foreign trade, government and households are all consolidated to be industries. Households then consume various commodities and produce labor and entrepreneurial services. Foreign trade consumes exports and produces imports and the government supplies goods and services and buys part of each industry output. Under these conditions the final demands are all equal to zero. In contrast to the closed model is the open model in which some of the industries are exogeneous.

Assumptions. The economic tableau of interrelationships among the many industries resulting from an input-output analysis provides an analytical tool for prediction based on a number of simplications of economics relationships. Some of these simplifications (Balderston, 1955) are:

1. The technical coefficients for producing industries are assumed fixed which implies constant return to scale. In case of a single primary factor (labor) substitution among inputs may be neglected. However, with more than one exogenous factor the assumption of fixed coefficients is not strictly true.

2. The assumption of free competition implies average costs equal marginal costs (i.e. equal price).

3. Under the assumption of static equilibrium, the total output of any good in a period is equal to its consumption within that period. No storage activity is implied, that is, inventories are treated as part of the bill of goods, or counted as one of the industries within the system for which fixed coefficients hold true. This would tend to underestimate requirements in the upswing and overestimate them in the downswing of the business cycle.

4. The number of inputs equals the number of kinds of output.

5. All results are obtained for an arbitrary definition of industries in an aggregated model.

6. The determination of demand, supply and utility functions for the individual and the market are done under the assumption of equilibrium. With fixed coefficients the maximizing behavior of producers is neglected. While in the open model the maximizing behavior of consumers, if considered at all, is outside the system, and is relevant only to separate studies of the bill of goods.

7. Specifications of consumer demands for a full employment program, necessitates the search for information outside the model (if it is an open model) for estimating productivity, population, working force, working hours, government expenditures, tax structures, inventory changes, and so on.

8. A long run equilibrium is assumed for the static model which implies a first order approximation and will eventually be superseded by a dynamic model.

Projections and Predictions of Output and Employment

Leontief's projections. Leontief, 1944, indicated the possible place of the model in the analysis of problems of total output and employment. A ten aggregated-industry model was set up. It showed how the total outputs of each industry could be determined provided the final outputs of the economy's industrial structure were known. Since the labor input per unit output of the various industries can be derived from the table, like any other input, the total amount of employment can be calculated for any bill of goods (using System of Equation 5). In order to isolate the effects of independent changes in the demands of households on the outputs of the other parts of the economy, households are considered exogenous.

A backcast to 1929 provided a check for the stability and linearity of the technical relationships. Comparisons of the actual outputs of the ten aggregated industries with the figures obtained by applying the 1939 coefficients to the final demands of 1929 are given in Table 1.

As shown inTable 1, small differences between the actual outputs and their estimates would support the hypothesis that the 1939 technical coefficients are good estimators for the 1929 economic structure. Empirical verification cannot be completely conclusive due to the presence of offsetting errors. Such errors can be of two types:

1. non-linearity of the production function may offset changes in the technical coefficients, and

2. since only the total output of each industry are estimated, there is likely to be a certain amount of cancellation of errors in interindustry demands.

While only the total is indicated the overestimation of the others should not be overlooked.

Since the bill of goods is given, the total outputs have been divided into two components, one generated by the direct or final demands of the bill of goods, and the other by the indirect or interindustry demands. The precision of the estimates is very uneven (Table 1). The indirect demands for the basic material industries, agriculture, mineral industries, and fuel and power were estimated within 0.7%, 1.8% and 3.5% of the actual figures. On the other hand, railroad transportation was underestimated by 33.1%; industries not elsewhere classified (n.e.c.), a heterogeneous group, was overestimated by 20.8%, and metal fabricating by 17.9%. Explanation of the largest errors was attributed to technological changes. The 33% underestimation of the railroad transportation was due to the rise of the trucking industry. Trade restrictions were reflected on the underestimation of foreign trade demands. Aggregation as crude consolidation; such as grouping of chemicals, lumber, printing and constructions may also explain a large part of the error. The inapplicability of technical coefficients derived for the product mix of one year to another year is explained by the disproportionate changes in each of the components of the aggregated industries. Revisions of these coefficients and greater statistical resources are expected to reduce the errors.

An application by the Bureau of Labor Statistics (BLS)

A study designed to show the structure of the economy at full employment in 1950 was conducted by the Bureau of Labor Statistics using the input-output technique. The procedure is outlined in the block diagram shown in Figure 1.

This structural study of the BLS is the kind of use for which the input–output system is best suited. A set of basic assumptions about quantitative aspects of the economy which must remain exogeneous is included. A total labor force of 62.5 million and prewar working hours were assumed. Government activity was assumed to be at prewar levels with a balanced budget and prewar tax rates, which is much too low an estimate and introduces a departure from the assumptions that makes it difficult to check the endogenous aspects of the analysis. On the basis of certain assumptions about wage rates, both a level and a distribution of disposable income were forecast. The prewar relationship between incomes and expenditures on various income groups as derived in a budget study in 1941 was assumed part of the bill of goods. Construction was projected to be 90% higher than in 1939 and demand for producers durables was estimated on the basis of a 1941 survey. The ratios between imports and domestic outputs of various commodities were taken to be the same as before the war, but with an export surplus of two billion. The input-output model based on 1939 data was assumed to apply with some obvious adjustments to new technology and with estimated changes to the productivity of labor. The input-output system yielded the total output required of each industry and on the basis of the estimated productivity changes total employment in each industry could be forecast. On this basis it was estimated that there would be deficiency of demand for labor of 6.7 million men. Two different arbitrary changes in final demands were made designed to raise the total demand for labor to the full employment level. One of these estimates was based on an increase in the propensities to consume the other on higher levels of construction and investment in producers durables.

The projected values for the outputs of various industries differed from the actual figures by more than 30%, though others coincided very closely. International developments have precluded the return of a normalcy of an American economy which could have upset the estimates. Also, by retracing the development of the original model, it should be possible to estimate where the structural changes have been greatest and in what fields the assumptions of constant linear structure was adequate (Eckstein, 1955).

Projections and Predictions in Agriculture

The solutions of the increasing problems of the agricultural economy arising from their interrelations with other sectors of the national economy have not been studied very extensively. Very few studies have been made to describe and to predict these interrelationships. A simple descriptive tool which can be used is the input-output analysis. However, its usefulness as predictive method is not fully established. This device has not been used with emphasis on agriculture because it appears to be complicated and because of its limitations in projections away from a given point in time (Heady and Candler, 1958).

Schnittker, 1956, has studied the applications of input-output projections in agriculture. He considered the six agricultural regions of the United States. Further classification into primary and secondary agriculture was also studied. Primary agriculture is concerned with agricultural output derived from the culture of plant life, secondary agriculture refers to livestock production and storage activities. He commented regarding this application that economists and historians have in common that the fact that both look backward as part of their desire to see what lies ahead. Interindustry analysis is peculiarly historical in that it attempts to ascertain the relationships among sectors of the economy in some past period of time as an aid in estimating what the effects of future changes might be.

Simple projections based on a 10% change in the final bill of goods of Sector 13 are given in Table 2. It can be seen in this table that either increases or decreases in the demand for processed primary food products would have smaller effect but a larger relative effect on most primary agriculture sectors than on each industry sector. The absolute change required in the products of Sector 18 indicates in numerical terms the current situation with respect to the farmer's share of the consumer's dollar.

At best these results present the real world rather vaguely. Any increase in demand for food products is not likely to be due solely to an increase in population, leaving each part of the country a slightly enlarged model of today with respect to tastes and income as is implied by the assumption of proportional demand changes for all products. The practical need to aggregate products whose demand structures may change differentially, requires that the input-output model be interpreted in the context of its limitations. Supplementing the information in Table 2 with data on allocation of various farm commodities to various uses may result in the relaxation of the assumption of proportional increases in demand for all products.

The effects on the net output of all agricultural and industrial sectors of a 10% change in the final demand for products of Sector 15 are presented in Table 3. This change brought about a relatively large change in agricultural net outputs. But the changes induced by a 10% change in the final bill of Sector 15 are not as sizable as that of a corresponding change in Sector 13.

Added flexibility in projecting the effects of changes in final demand may be had by considering foreign trade and government as autonomous sectors. Changes in final demand besides changes in personal consumption may include changes in foreign demand, and government policy or program changes. The results of the change in the transaction matrix are given in Table 4.

Some of the possible causes which will limit the wide application of input-output as a predictive device in agriculture are as follows. The output of a single commodity may vary from 30 to 50% between years with only minor input variations. Total agricultural output may vary from 10 to 20% at the same time (Johnson, 1951). He calls 1947 an atypical year with respect to output, since aggregate agricultural production was relatively low in 1947.

Regional differences in value of production may result from shifts in physical production and/or shifts in relative regional prices.

Input-Output Analysis in Comparison with OtherTechniques of Projections and Predictions

Leontief's test. Leontief took as his problem the prediction of the total outputs of each industry in 1919 and in 1929, when the actual final bill of goods for each of those years is known. He compared the results of three methods using 1939 as a base year for each, with the actual outputs. These methods are input-output, the final demand blowup method and the method of GNP blowup. The final demand blowup method assumes that for each industry the ratio of total output to final demand is the same in every yeat as it was in the base year. Thus it predicts that for any industry the total output in a given year will be the final demand in that year times the total output in the base year divided by the final demand in the base year. The GNP blowup method ingnores the distribution of final demand and assumes that for each industry the ratio of its total output to GNP is the same in every year as in the base year. Thus for any industry it predicts the output in the base year divided by the GNP in the base year. For comparability, Leontief used the same must work perfectly in the base year and the fact of continuity in economic affairs insures that errors will be small for periods far away; given time enough, technology and relative prices can change the input-output ratio. In some cases, the 1931 or 1933 error is greater than 1929; this is probably due to the depression.

Except for a few industries (agriculture, motor vehicles, other transportation equipment, coal and coke, communications, and steam railways, representing together about 1/4 of the total output of the 25 indusries included) the errors for the years 1929 to 1935 are predominantly overestimated while those for 1937 are almost all underestimated. The total production in 19 of the 25 industries considered was overestimated for the period 1929 to 1935 on the basis of actual final demands in those years and the 1939 matrix. In other words, the degree of indirect use of the outputs of these 19 industries, i.e. their use as intermediate products must have been increasing over the period 1929 to 1939 (except 1937). This is expected in the case of the chemical industry and others whose products were being put to new and 13 industries in all three methods. The input-output method has a much smaller standard error for both 1919 and 1929 than the other two methods (Table 5).

Hoffenberg-BLS tests. Hoffenberg took as his problem the prediction of the total outputs of each industry in 1929, 1931, 1933, 1935 and 1937, when the actual bill of goods for each of these years is known. He compared input-output predictions and those of final demand blowup and GNP blowup (1939 as base year) with the actual total outputs. For his input-output predictions he used 38 x 38 1939 matrix, but since his actual total output figures for the odd years from 1929 through 1937 cover only 25 of the 38 industries, the analysis of his results here is confined to those 25 industries.

Hoffenberg's comparisons show that the input-output and final demand blowup predictions are approximately equal in quality neither being good enough to arouse enthusiasm, while the GNP blowup predictions are markedly worse (Tables 6 and 7).

The magnitudes of errors, in general, are the closer a year, is to the base year, the smaller they are, which is to be expected because both the input-output and the final demand blowup methods work perfectly in the base year. The errors for the years 1929 to 1935 are predominantly positive while those for 1937 are almost all negative. Since a positive error indicates a high prediction, the total production of the 19 industries included was overestimated for the 1929 to 1935 period. The degree of indirect use of of the output of these 19 industries have been increasing, which is to be expected since products of the industries involved are put to new and large scale use replacing other products. But it appears to be a characteristic of the greater part of the economy and suggests that on the whole production is becoming more indirect. Theoretically this might have been due to shift in the composition of final demand from industries having low indirect requirements to industries having high ones. However, there was practically no shift in the industrial composition of final demand between 1929 and 1939 (Christ, 1955).

Barnett's tests. Using an unweighted index (Table 8) Barnett's regression technique appears to be slightly superior to the input-output method. The final demand blowup yielded about the same results as input-output methods, while the GNP blowup results are inferior to the results obtained by other methods. The weighted index of errors (Table 9) shows that the Barnett's regression method is considerably superior to any of the others, the final demand blowup is slightly better than input-output which in turn is considerably better than the GNP blowups.

In the interpretation of these results the following should be taken into consideration.

1. Since the period of verification is part of the period to which Barnett fitted his regression, in effect, his estimates are interpolations. Due to the continuity of economic phenomena, the accuracy of the fit is even more overstated than it would be in an ordinary regression problem. The continuity of economic variables also increases the apparent fit of the input-output projections, since they must fit perfectly in 1939 there is some limit on the possible errors in earlier years. Since observations on only one point in time, and that at the end of the period, are used in the latter method, the goodness of fit is probably much more aggregated for the Barnett regression than for the input-output.

2. The 1939 table is admittedly highly inaccurate as well as unduly aggregated so that tests of the input-output technique based on it give a biasedly low estimate of its value. There is a large unallocated quantity of inputs and outputs, when applying the table to a given set of final demands, the derived demands are scattered more widely over the industries than they should be, which is a possible explanation for the failure of input-output to show the expected marked superiority to final demand blowups (Arrow and Hoffenberg, 1959).

Evaluations of the Worth of the Input-Output Analysis as Devices of Predictions and Projections

Evans' and Hoffenberg's point of view. The lack of agreement on the role of input-output methods in forecasting seems to have arisen because the term is sometimes used wihtout distinction in two rather different senses. There has been some disposition to treat all input-output analysis as if they were forecast. The majority are not forecasts in the full sense of the word, but rather conditional statements that are established as well as possible under the circumstances, the input-output approach is primarily a tool to help the analyst make conditional statements about the economy. It is a tool that may be used by forecasters as well, but it is not primarily an instrument of prophecy.

Forecasters have used and will continue to use many methods with varying proportions of objectives. Although subjective elements are not overlooked the tendency is to adopt methods in which the objective element is somewhat strengthened rather than resort to the use of empirical data and of varied mathematical complications. The principal alternative to input-output methods for forecasting purposes would probably be one or another form of regression analysis.

The fundamental difference between input-output analysis and regression analysis is as follows. Input-output approach is based throughout on an attempt to establish specific causal sequences. Errors in estimates are not to be considered to be the result of a stochastic process but rather the result of failure to identify accurately the parameters of the demand and processing systems. Regression in contrast while they imply the existence of a structure do not imply any direct structural connections between dependent and independent variables. The rationale of regression estimates may be presented in various ways, but it is significant that regardless of rationale, the full machinery of stochastic inference is brought into play.

Assume that there were more changes in the demand and/or processing structure which were within the range of available historical data. If only few estimates were required, economy in time and effort the regression methods should be used. Depending on the number of different estimates needed on the requirements for consistency among them, and on the extent of changes that it was felt might have occurred, a point might be reached where an input-output approach would be preferred.

If suppose that a major alteration in processing structure would occur, or that the pattern of demands in the future period would be radically different from the patterns found in the available historical data, the basic assumptions on which regression methods rest would be violated and they could be used if at all only with risk. Under these circumstances, an input-output approach to the problem would become almost mandatory if any solution were to be attempted at all.

Another feature of the input-output is if separate results obtained from an input-output analysis will normally be consistent with one another in the sense that they will represent possible outcomes for an economy that have technologically existed, or that the analyst has a reason or feeling could exist. This consistency is not usually a feature of regression estimates for a number of variables.

Christ's appraisal. In attempting to evaluate input-output one should apply the dependable old economic principle of considering the available alternatives. The problems for which input-output is called upon chiefly those of guiding the allocation of resources in wartime, and of guiding the economy so that it enjoys something like full employment and so that investment and resource needs are continuously foreseen.

The input-output technique is certainly better than no technique. A real general equilibrium system would be the best, barring cost, but that is not a realistic alternative. Linear programming would be better than input-ouput if relevant data were developed to the same degree, for it would have all the advantages of input-output plus the advantage of being able to deal automatically with substitution among inputs. The input-output analysis is the best technique now available for handling problems that require a picture of the production function of the entire economy, and that its results can serve as just approximations from which to start making corrections where special information permits or experience demands.

Christ also dealt considerably with sources of error of the input-output method.

Friedman's view. In judging the analytical validity of input-output analysis, only the accuracy of the conditional prediction should be taken into account, for errors in forecasting final demand cannot be attributed to defects of input-output analysis. The central feature of input-output analysis as a predictive device is that it assumed all coefficients of productions fixed, regardless of relative prices levels of output etc. It is obvious that these coefficients are not rigorously fixed that all sorts of variations are possible and do occur. The lack of descriptive realism of fixed coefficients of production is not an objection to input-output analysis. If it yielded good prediction would be a decided advantage for it would simplify the working of predictions by making it unnecessary to take changes in these coefficients into account. It is here where extensive interest in the input-output analysis lies.

Ritz's opinion. The problem of testing predictive models is one of testing the various predictive elements included in the mechanism. Various critics have strong doubts that input coefficients can be changed to fit more properly a given analytical situation. The criticism is generally made that substitution possibilities, changes in scale, technological innovations tend to render these coefficients invalid.

Writers at times seem to suggest that the necessity for revising coefficients for industry analysis is a disadvantage and a distinct drawback to the use of the system. At the same time, by indirection it seems that they believe that either methods of analysis can make allowances for these conditions in their parametric system. No method of analyses will take account of such effects, unless specific allowances are introduced in the apparatus. The input-output technique actually provides an advantage in this regard over other methods, since it readily permits the introduction of revised coefficients. Other methods often have no means of introducing such revisions in parameters, or the actual incorporation of them may be extensively difficult.

No method of solving problems by complete models, or even by partial systems, can really give positive answers to the question of how far one must go in anticipating the future. You put into a system what you feel most strongly belongs. If you have improved information, your answers improved the advantage of input-output techniques is that this improved information can be used simply, completely and with logical consistency.

On the question of time, once a basic year chart has been developed for a non-abnormal year and it has been refined to give the best possible chart that available funds can produce, it is a much simpler matter to bring other charts into up-to-date terms.

Norton's expectation. I look forward to the early adoption of the practice of making multiple projections based upon alternative policy preferences and sets of expectations. This procedure is customary with respect to population and labor forces projections. The advent of inter-industry techniques makes it practical and expedient to extend the practice to economic projections. Indeed, one of the contributions of interindustry analysis, in contrast with the more agggregate systems of GNP analysis, is that such alternative projections may now be given sufficient detail to be interesting. But something else may be involved. Interindustry analysis necessitates the manipulation of very complex structures. If it is to play as versatile and effective a role as GNP analysis in day-to-day decision-making, much work will have to be anticipated and kept in readiness. The preparation of multiple projections is one way of further precooking the material to hasten its application to more specific problems as they arise.

If among a set of multiple projections contains a stipulation of final demand and subsequently turns out to approximate actual deliveries, and this projection also anticipates approximately the achieved levels of industrial activity, then it is a good projection; a good projection system is one that can estimate actual activity levels and input schedules from actual deliveries with something approaching the same degree of approximation that the basic data used have to the reality they are intended to present.

Dorfman et al.'s conditions. Dorfman et al. stated that the usefulness of the input-output analysis, (specifically the simple Leontief system) as a predictive device rests upon two conditions, namely:

1. The degree to which each industry continues to expend its money to labor and other industries in the same fractions regardless of the changes going on (from year to year, place to place, etc.).

2. The degree to which a given physical pattern of consumption goods can be predictably connected into physical production because consumers prefer physical-consumption goods to dollars per se.

In general, this means that physical coefficient (a_{ij}'s) must be predictable or constant and not the percentage expenditure $\bar{a}_{ij}$'s above.

A recapitulation. In spite of the undue amount of attention given the input-output methods relative to their worth in forecasting, their prospects for projection and prediction is not dark. Critics agreed that the present appraisals and tests are not clearly conclusive as to establish their merits for economic analysis. Economic forecasters have their vicissitudes. Poor results from forecasting may not have shaken their interest in a method due to so many contemporary actions which must be conditioned by and based on expectations for the future.

The two points of disagreements are the assumptions of fixed coefficients and product mix. Proponents of the method recognize these difficulties. They, however, indicated that the input-output methods are more flexible than the other methods of forecasting. Where the full machinery of stochastic inference is violated, input-output methods are preferred over regression analysis. The superiority of the final demand blowup over the input-output methods is not well established. However, the indications are strong that input-output analyses are better than GNP blowup methods.

In general, the interest placed in input-output methods for forecast purposes seems to lead to more research. The problem of aggregation is the most difficult one for the economists because of the exteremely heterogeneous and highly aggregated industries. There might be some desirable properties of the model which may be responsible for these paradoxical results. It may also be possible to use other models to interpret input-output data. Alternative models for studying the role of aggregation should be considered. Such models should explicitly consider additive from non-additive factors as monopoly. It may be possible to incorporate certain proportionality or time series factors into the coefficients to achieve better technical relationships. While the variability of the results have been considered other properties of these results should be examined. In short, as Ritz put it any event, it seems reasonable that the economic world do not condemn an infant without giving it a fair chance to develop.

Summary and Conclusions

The applications of input-output analyses in projections and predictions have been discussed. They were also compared with the final demand blowup method, the GNP blowup method and regression methods. Evaluations by different writers of the merits of the input-output method for projective and predictive purposes were also presented. Critics agreed that the present tests and appraisals did not yield conclusive results. The method of final demand blowup and input-output techniques are almost the same as far as prediction is concerned. However, there are indications that the input-output techniques are better than the method of GNP blowup. With regards to to regression, it sums that when stochastic inferences are violated the input-output methods are more appropriate to used they are also flexible and more consistent under this condition.

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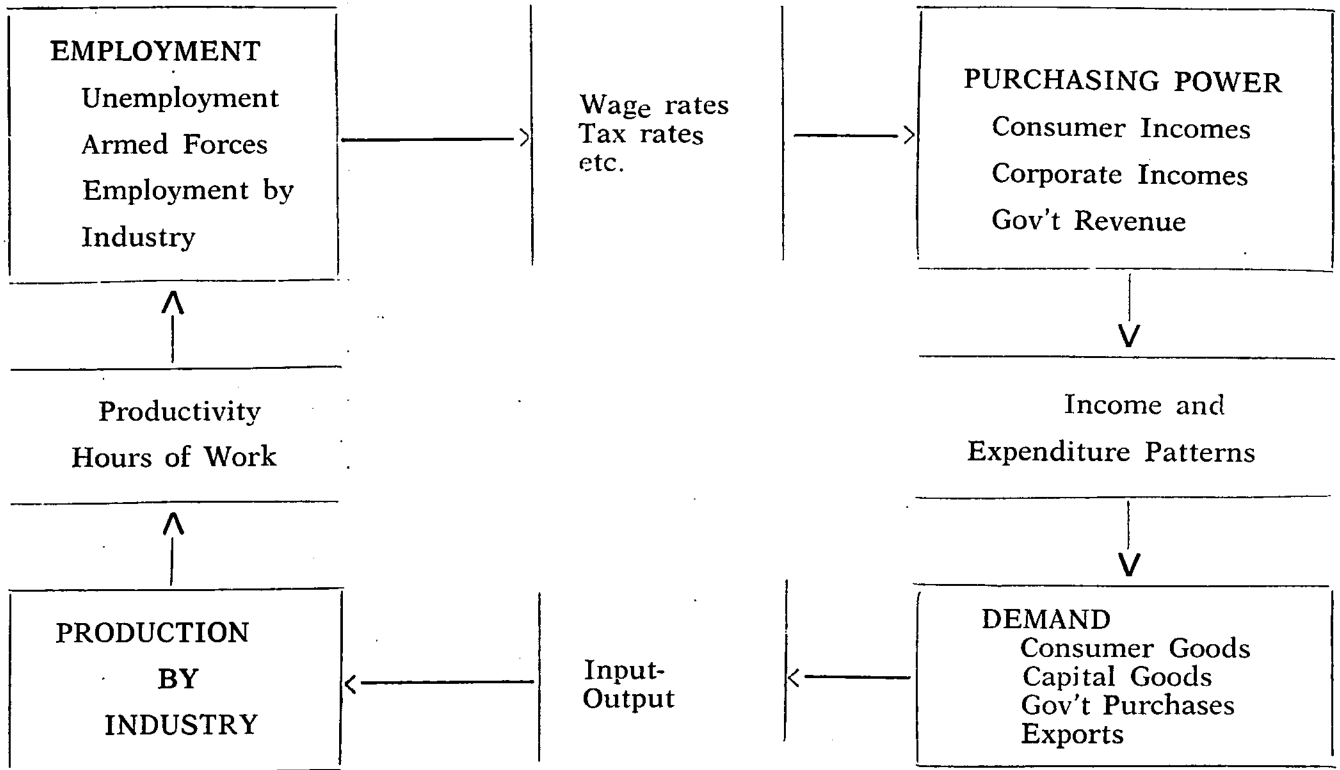
FIGURE I

PROCEDURE FOLLOWED BY THE BUREAU OF LABOR STATISTICS
IN SHOWING THE STRUCTURE OF THE ECONOMY
AT FULL EMPLOYMENT IN 1950.



Source; Eckstein

TABLE 1

COMPARISON OF THE ACTUAL INDIRECT DEMANDS FOR 1929 AND OF ESTIMATES BASED ON THE STRUCTURE OF 1939 (IN $1,000,000; 1939 PRICES)

	Industry	Bill of goods I	1929 output II	1929 output estimate III
1.	Agriculture	9,227	11,496	11,512
2.	Mineral industries	143	3,711	3,647
3.	Metal fabricating	5,029	15,909	13,964
4.	Fuel and power	3,998	8,822	8,992
5.	Textiles, leather and rubber	6,009	7,677	7,465
6.	Railroad transport	812	5,699	4,081
7.	Foreign trade	619	3,673	3,115
8.	Industries (n.e.c.) chems, resid, const, etc.)	9,555	19,003	20,972
9.	Government and other industries	23,346	48,836	52,563

	Actual indi- rect demand (II-I) IV	Estimated indi- rect demand (III-I V	Errors in esti- mating indirect demand (V-IV) VI	Errors as % of actual (VI-IV) VII
1.	2,269	2,285	+ 16	+ 0.7
2.	3,568	3,504	— 64	— 1.8
3.	10,880	8,935	— 1,945	— 17.9
4.	4,824	4,994	+ 170	+ 3.5
5.	1,668	1,456	— 212	— 12.7
6.	4,887	3,269	— 1,618	— 33.1
7.	3,054	2,496	— 558	— 18.3
8.	9,448	11,417	+ 1,969	+ 20.8
9.	25,490	29,217	+ 3,727	+ 14.6

SOURCE: Leontief.

TABLE 2

ABSOLUTE AND PERCENTAGE CHANGES (PLUS OR MINUS) IN THE NET OUTPUTS OF PRIMARY AGRICULTURE AND INDUSTRY SECTORS AS A RESULT OF A 10% CHANGE IN SECTOR 13 FINAL BILL OF GOODS

Sector	Absolute change in net output (in $1,000)	Percent of change in net output
Primary agriculture		
1	29,197	2.2
2	93,320	1.7
3	80,333	1.9
4	80,531	2.0
5	28,648	2.7
6	90,684	4.4
Industry		
14	112,028	0.8
15	71,466	0.4
16	126,413	0.4
17	61,228	0.9
18	620,844	0.3

SOURCE: Schnittker.

Industry Sector	Description
13	Industry processing the products of primary agriculture, chiefly for food use, but including livestock feeds
14	Industry processing the products of primary agriculture, chiefly for nonfood use
15	Industry processing the products of secondary agriculture
16	Industry providing machinery and machine services, fuel and oil to all sectors of the economy
17	Industry furnishing fertilizers, seeds, and other supplies to agriculture, as well as in any products to other sectors
18	Indusrty including services not elsewhere included

TABLE 3

ABSOLUTE AND PERCENTAGE CHANGES (PLUS OR MINUS) IN NET OUTPUTS OF AGRICULTURE AND INDUSTRY SECTORS AS A RESULT OF A 10% CHANGE IN THE SECTOR 15 FINAL BILL OF GOODS

Sector	Absolute change in net output (in $1,000)	Percent change in net output
Primary agriculture		
1	49,881	3.9
2	214,496	3.7
3	62,660	1.5
4	104,631	2.5
5	31,638	2.9
6	36,630	1.8
Secondary agriculture		
7	159,065	7.1
8	519,404	7.0
9	118,620	5.2
10	192,999	6.4
11	62,445	6.6
12	83,152	6.9
Industry		
13	161,485	0.8
14	40,948	0.3
16	139,853	0.5
17	57,136	0.9
18	577,522	0.3

SOURCE: Schnittker.

Note: See Table 2 for description of the industry sectors.

TABLE 4

ABSOLUTE AND PERCENTAGE CHANGES (PLUS OR MINUS) IN NET OUTPUTS OF AGRICULTURE AND INDUSTRY SECTORS AS A RESULT OF A 10% CHANGE IN SECTOR 15 FINAL BILL OF GOODS

Sector	Absolute change in net output (in $1,000)	Percent change in net output
Primary agriculture		
1	52,622	4.1
2	225,152	4.0
3	61,444	1.4
4	106,569	2.6
5	32,723	3.0
6	37,395	1.8
Secondary agriculutre		
7	169,390	7.6
8	552,983	7.5
9	126,161	5.5
10	205,569	6.9
11	66,409	7.0
12	88,507	7.4
Industry		
13	166,609	0.9
14	33,933	0.3
16	127,036	0.5
17	53,767	0.8
18	498,917	0.3

SOURCE: Schnittker.

Note: See Table 2 for description of the industry sectors.

TABLE 5

STANDARD ERRORS OF PREDICTION OF 13 INDUSTRIAL OUTPUTS IN 1919 AND 1929 FROM 1939 DATA (IN $1,000,000)

Method	1919	1929
Input-Output	380	237
Output of industry / GNP	1,363	1,744
Output of industry / Final demand of industry	2,021	1,539

SOURCE: Leontief.

TABLE 6

25-INDUSTRY AVERAGES OF PERCENTAGE ERRORS OF THREE METHODS OF PREDICTING INDUSTRY OUTPUTS, 1929 — 1937 (ODD YEARS)

Method	1929	1931	1933	1935	1937	Avg.
			Absolute averages			
Input-Output	18	17	13	7	5	12
Final Demand	19	24	14	8	5	14
GNP	23	26	35	10	10	21
			Algebraic averages			
Input-Output	7	11	6	0	— 4	5
Final Demand	14	20	5	1	— 4	7
GNP	1	20	24	1	— 8	8

SOURCE: Hoffenberg.

TABLE 7

INDUSTRY OUTPUTS AND PERCENTAGE ERRORS OF TWO METHODS OF PREDICTING INDUSTRY OUTPUTS, 1929-1937

	1939 output ($ bill)	Average percentage error Input-Output	Final Demand blowup
1. Agriculture	9.8	10	2
2. Food processing	13.2	15	15
3. Ferrous metals	2.5	10	15
4. Iron & steel fdry.	0.5	25	25
6. Agric. machinery	0.4	30	15
8. Motor vehicles	2.5	8	9
10. Trans. equip. n.e.c.	0.3	12	12
13. Mdsg. mach.	0.3	11	10
15. Nonferrous metals	1.5	9	9
16. Iron & steel prod.	2.2	7	20
17. Minerals nec.	2.1	8	9
18. Petroleum	4.7	7	12
19. Coal and coke	1.7	7	12
20. Elec. & mfd. gas	2.8	5	6
21. Communication	1.5	15	12
22. Chemicals	3.3	35	40
25. Paper	1.7	9	7
26. Printing	2.2	4	4
27. Textiles	3.1	10	10
28. Apparels	3.4	9	9
29. Leather	1.0	13	15
30. Rubber	0.9	15	30
31. Mfg. nec.	1.6	15	15
33 & 34. Misc. trans.	3.0	11	35
35. Steam railways	4.2	11	2

SOURCE: Hoffenberg.

NOTE: Approximate absolute average rounded to nearest multiple of 5 if over 15%.

TABLE 8

AVERAGE PERCENTAGE ERRORS OF ALTERNATIVE INDUSTRY OUTPUT PROJECTIONS, UNWEIGHTED, ODD YEARS, 1929-39

Year	Input-Output	Regression dev. from Barnett's Index	Final Demand blowup	GNP blowup
1929	18.6	6.4	18.0	21.9
1931	18.8	14.4	20.0	24.6
1933[a,b,c]	8.6	7.0	12.7	14.8
1935[b]	6.6	4.9	8.1	10.0
1937	5.4	8.4	5.0	9.4
1939	0	5.1	0	0

TABLE 9

AVERAGE ERROR OF ALTERNATIVE INDUSTRY OUTPUT PROJECTIONS, WEIGHTED, BY INDUSTRY SIZE IN 1939, ODD YEARS, 1929-39

Year	Input-Output	Regression dev. from Barnett's Index	Final Demand blowup	GNP blowup
1929	450	166	361	624
1931	372	188	260	477
1933[a,b,c]	248	150	377	381
1935[b]	184	135	175	238
1937	196	172	159	217
1939	0	98	0	0

SOURCE: Barnet.

a—excludes agricultural machniery
b—excludes transportation equipment
c—excludes all other manufacturing