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INPUT-OUTPUT TABLES AND ANALYSIS

(Memorandum by the Secretary-General)

I. Systems of national economic accounting

1. The now-familiar systems of national income accounts cannot claim to present a complete picture of a national economy. The accounts focus attention on certain aspects of production, consumption and investment, and on the incomes and expenditures associated with these different forms of activity. The development of accounts of this kind can be directly traced to earlier national income studies which had as their main objective the measurement of total national income from whatever point of view the available statistics allowed; and the systems of today are still basically oriented towards showing the level and distribution of national income and product. Although in practice a system of national accounts is often accompanied by related tables which provide additional detail or extend the coverage in new directions, these tables do not as a rule afford an essentially new perspective.

2. Input-output accounting, the subject of the present paper, does furnish a new view of the workings of an economy by emphasizing the structural interrelations among industries. Attention here is directed to the allocation of the output of each industry among the other industries and to the inputs into each industry from the others. The complete input-output table is thus a record of technological relations, but it is also more than that since sales and purchases

are recorded in value terms at annual rates, thereby reflecting levels of production. The technical relations of inputs to output apply specifically to a given year, but to the extent that these relationships can be expected to persist an analytical model is provided for use in a broad range of economic inquiries. The fact that the scale of production for the year in question is also involved permits linkage with the national income and product accounts, which show the value of all production in consolidated form and the income of the factors of production that constitute the primary inputs in productive activity.

3. For certain purposes a view of the network of financial relationships rather than - or in addition to - national production and productive relations is needed. Such a view is furnished by yet another form of accounts, the money flows or flow-of-funds statements. This type of accounting is at an earlier stage of development than the two forms described but the main emphasis is on showing the financial transactions (involving currency and deposits, credit, securities and the like) of the different parts of an economy and their relations to other transactions. The "parts" of the economy usually distinguished go beyond the broad sectors found in national income accounting - e.g. business, households, government, and the rest of the world - and follow institutional lines, with financial institutions distinguished from non-financial, corporations from unincorporated business, federal government from state and local government, etc. Sub-sectoring of a system of national accounts such as the United Nations system along these lines would provide one method of relating the flow of funds to the accounts, and through them, to input-output.^{1/}

4. A quite different vantage point is afforded by a national balance sheet, which shows the tangible and intangible assets of an economy and the resulting liabilities and equities. Sector and national balance sheets are thus related to flow-of-funds statements prepared in terms of the amounts of financial assets and liabilities rather than changes in them.

5. Since a national wealth statement may be regarded as the consolidated balance sheet of the sectors (the combined balance sheet is the national balance sheet),

^{1/} See "Progress Report on National Accounts and Associated Topics" (document E/CN.3/267) for an account of recent activities of the Statistical Office in regard to the development of flow-of-funds accounts.

there is also a connexion with the national income accounts, which show saving and investment and thus the increase in national net worth. No specific connexion with inter-industry accounting can be claimed until it has become possible to incorporate the requirements for capital goods in input-output studies. While activity in the field of national balance sheets and wealth, especially at the official level, has been small in recent years, an upsurge of interest in the coming years is possible. A major difficulty stems from the fact that because stocks rather than flows are involved, a uniform valuation basis must be applied to assets arising at widely different dates in the past if aggregation of values is to have economic meaning.

6. Of these various forms of national economic accounting, probably only two have in practice been pursued in integrated fashion by any significant number of countries: national income and input-output. In a number of European countries, for example, input-output tables have been brought within the framework of the national income accounts in such a way that conceptually and statistically reconciliation is possible. There is, indeed, no valid reason why a statement of input-output relationships cannot be regarded as an auxiliary statement to the national accounts. Nevertheless, the resources required for producing input-output tables are so considerable that on occasion the work involved has had to be wholly undertaken by groups other than those responsible for the work on national income. Where this has been the case some of the benefits of an integrated approach have had to be foregone.

7. Flow-of-funds statements are as a rule being developed apart from national income. They are still very much in experimental form, if only because the objectives and uses of such statements have not yet been generally agreed upon. The natural impulse to explore the relations with other forms of national economic accounting is, however, leading to attempts at formal integration with the national income accounts.

8. Indeed, there are already clear signs of a movement to bring together national income accounting, input-output tables, flow-of-funds statements and balance sheets into a comprehensive system.^{2/} Despite the special purposes each

^{2/} This point of view pervades the report of the U.S. National Accounts Review Committee. The report is printed in The National Economic Accounts of the United States, Hearings before the Joint Economic Committee, Eighty-fifth Congress, First Sessions, Washington, D.C., 1957.

form is designed to serve, there is no question that the imposition of uniform concepts, the incorporation of reconcilable data and the clarification of relationships would enhance the usefulness of all the accounts or statements and provide new insights into the functioning of the economic system. In this integration an elaborated form of the national income accounts seems destined to provide the unifying framework.

II. The rationale of input-output

9. The inter-industrial relationships within a country can be set out in a table or account which shows for each of the various industries into which the economy is divided both the sales to other industries and the purchases from them. Such a table of input-output relationships furnishes not only a statistical picture of industrial inter-dependence but also an empirical basis for analysis. Before considering the characteristics of an input-output table and the uses to which it may be put, it will be convenient to examine in a general way the basic assumptions underlying input-output analysis, since these have a direct bearing on the form and interpretation of the table.

10. To the extent that inter-industry transactions reflect technological relationships between inputs and output, the input-output ratios obtained in a particular year may be regarded, it is argued, as sufficiently stable, at least over short periods, to be useful for working out certain problems, such as changes in the pattern of production under altered conditions. An assumption to the effect that these technical coefficients are constant, however, would not seem to be equally plausible as regards all sectors engaging in economic activity. Specifically, it is difficult to maintain that for households, government and the foreign transactions of a country, purchases and sales are linked in the same manner as for processing industries dominated by technological relationships. (For instance, to regard households in input-output analysis like any other industry would amount to claiming that a simple production function related inputs to outputs, specified amounts of each consumer good (input) yielding a man-hour of labour (output). Although household purchases and labour, exports and imports, etc. are not unrelated, the relationships are of too complex a

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nature to be explained in this way.) For this reason, these sectors have generally been regarded as outside the system of functionally interrelated productive activities, or as autonomous, their purchases constituting the final demand and their output the primary input of the economy. In order to base the structural relationships of productive industries on current account flows (input ratios reflecting current and capital account flows would be inherently unstable), investment is also treated as autonomous.^{3/} Analytical applications using a model in which certain sectors are thus freed of structural constraints, are said to be based on an open model.^{4/}

11. Even for the processing industries which convert inputs into output, the relation of inputs to output still calls for careful study. The coefficients obtained by relating each of the inputs purchases by an industry on current account to the industry's total output reflect essentially technological conditions underlying production. More specifically, they reflect relationships corresponding to the industry's scale of production, given its stock of capital and technical organization. A more dynamic formulation would need to take account of changes in the stock of capital and in technology, the availability of imports on the scale required, limits to industrial capacity and other factors. So far, however, as present-day static models designed for the more limited purpose of tracing through shorter-term developments, their main shortcoming in analysis may be said to stem from the assumption of fixed input coefficients.

12. The inter-industry relations approach does not, strictly speaking, require the assumption that for output to increase by a certain proportion, each input must be increased strictly in the same proportion, and other functional relationships in better agreement with the facts can be utilized. For example, instead of using constant average input coefficients, a linear, curvilinear or

^{3/} For an example of an input-output table showing inter-industry transactions on both capital and current account, see Report on the Inter-Industry Study of the New Zealand Economy in 1952-53, Supplement to the February 1957 Monthly Abstract of Statistics, Wellington, 1957, page 15. In addition, input-output tables showing separately current account and capital flows are provided.

^{4/} Almost all analytical models are now of the open type. The pioneer attempts of Leontief at structural analysis of the US economy were based on a closed model. See W.W. Leontief, Structure of American Economy, 1919-1939, New York, 1951.

broken line relationship could be assumed to hold. The difficulty of establishing and justifying such relationships has, however, resulted in their being seldom used. The preparation of input-output tables for a series of years would be one way of establishing trends, marginal relationships, etc. in input-output ratios over time and thus anticipating coefficients for future years.^{5/} While the compilation of annual tables on a sufficiently detailed and firm basis to permit changes in coefficients to be interpreted in the light of structural, technological and other developments is not a possibility in most countries, it may still be quite feasible to investigate the changing cost structure of selected industries. As opposed to a time series approach to the problem, the variability in the input patterns of various firms in an industry could be studied for a particular census year and related to other characteristics of the firms (e.g. age, capital) with a view to discovering the evolving relationships.^{6/} Reference to the relevant data for other countries may also be useful for adjusting coefficients to reflect future trends, or even for establishing the coefficients initially, provided account is taken of differences in stage of development and other relevant factors. Much research remains to be done in this whole area.

13. The use of fixed coefficients in input-output analysis amounts to a rejection of marginal productivity theory, for the assumption of constant returns to scale implies that production will not be increased at all by the increased application of any one input. Furthermore, the use of fixed coefficients denies the possibility of the substitution of one input for another, that is to say, once the level of output is specified the bill of input requirements is uniquely determined. The assumption also implies that the

^{5/} Carrying this argument a step further, it is clear that it should be possible to replace the input-output model by a system of simultaneous stochastic equations utilizing time series for industry outputs and final demand and with functions of certain explanatory variables replacing the usual input coefficients so that input-output relations are not held fixed in the system. The data requirements of such a system, however, seem formidable indeed.

^{6/} Such an investigation for the canning industry in the United States is under way in the Harvard Economic Research Project.

composition of the output of an industry (or productive process) is uniquely determined by its inputs, a point related to that of input substitution. Whether the employment of input-output tables for prediction (based on fixed coefficients) is permissible depends, therefore, on whether realistic predictions are possible despite the fact that in the real world constant returns are not the rule, input substitution does take place in response to relative price changes, etc. The simple working hypothesis of proportionality, contrary to the facts as it is known to be, may still be good enough to yield satisfactory results, at least under circumstances that do not put it to too much strain. Opinions differ on the merits of the approach, and a clear consensus one way or the other has not emerged.

14. An input-output table of the kind described is, it should be noted, a perfectly valid statistical description of the relations involved based on empirical evidence. The input coefficients that can be derived from the flow data at actual levels are averages obtained by dividing each purchase by the using industry's total sales, and cannot be questioned on theoretical grounds. The difficulty arises, in other words, in trying to decide whether the data are more than a description of certain aspects of economic interdependence for a particular year, that is, whether the derived coefficients are sufficiently meaningful and stable to be useful for predicting output levels for industries in changed circumstances. The conceptual problems that arise in preparing an input-output table are thus related to the problem of producing an empirical model that will best serve the ends of analysis and predictions, and it is in this sense that criticism of the tables is profitable.

15. The main, although certainly not only, justification of input-output tables being their usefulness as an analytical tool, those responsible for compiling tables have been at pains to divide up the economy, to route inter-industry flows and in general to present a picture of inter-industry relations in such a way that the statistical model should be in the greatest possible harmony with the assumptions of input-output analysis. The discussion immediately following on the division of productive activity, it will be seen, illustrates this point, as does the discussion of routing conventions in a later section.

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III. The classification of productive activity

16. Several different divisions of production are possible in input-output studies, ranging from branches of industry composed of enterprises engaging in similar activity to individual products or processes, and including alternative classifications for the allocation of outputs as compared with inputs, a procedure leading to rectangular tables. An enterprise basis of industrial classification has the consequence that the great variety of outputs typical of certain branches would have to be treated as single flows. Given this lack of homogeneity in production, and therefore the possibilities for changes in the composition of output, the assumption of fixed input coefficients would be difficult to justify. Furthermore, since the same products may be produced by different branches of industry - that is, produced by enterprises classified in different branches - analysis could be complicated where interest centred on particular key products.

17. A better division of productive activity is into industries based on establishment units. This is in fact the system for industrial classification in force in many countries for census operations. Since, however, it is the principal product or group of products which determines the branch of economic activity to which an establishment as a unit is assigned, secondary or subsidiary products of establishments are included in industries outside whose scope they properly fall. Nevertheless, the fact that the establishment, where it differs from the firm, is a simpler unit of production means that it has a more homogeneous output and provides a more suitable unit of classification for input-output work. The designations "principal" and "secondary" are of course not independent of the industry divisions adopted; secondary products will in part become principal as the industry groupings become broader and encompass a wider range of commodities or activities. Broad classifications of establishment-based industries so as to minimize the amount of subsidiary production, or overlapping of output between divisions, are thus not a solution to the problem of homogeneity. Product homogeneity within branches can be improved, however, by transferring the secondary production of each branch to the industry producing similar products. Most input-output tables, as we shall see, are constructed along these lines.

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18. Still more satisfactory from many points of view would be the replacement of the establishment type of classification by a product classification. The latter is more suitable for certain branches of activity than for others (agriculture and mining are more easily dealt with in this fashion than, say, manufacturing). Grouping of commodities is usually carried out on the basis of their similarity from the user's point of view, but in cases where the input patterns for similar products are very different it may prove preferable to take similarity of inputs as the criterion. The commodity basis of classification is especially useful at the worksheet stage because of its detailed nature and also because the figures facilitate the making of allowances for changing coefficients. Commodities or commodity groups can be readily combined into branches of industry approximating an establishment-based industrial classification with secondary products removed. Aggregation into a manageable number of industries or principal product groups is of course necessary for a table to be analytically useful.^{7/} In a few instances rectangular tables have been compiled using industries for columns and a larger number of product classes for rows.^{8/} Since the commodity input requirements of industries are often known in greater detail than the distribution of sales to industries, such an arrangement may be highly efficient, especially if the various product groups can be related to the industry sectors so that a square matrix can also be derived.

IV. The input-output table: accounting and functional relationships

19. The general format of the usual open static model input-output table is fairly well standardized. The main body of the table shows inter-industry sales

^{7/} It may also be observed that the larger the number of industries, the greater the possibilities of technical substitution between products of different industries and therefore the less stable the coefficients derived from the table. In addition, of course, the need for a finer breakdown of final demand for projections is imposed.

^{8/} See, for example, The Structure and Growth of the Italian Economy, Mutual Security Agency, Rome, 1953.

and purchases of goods on current account, sales being recorded in the rows and purchases in the columns. This part of the table is square where the same classification of productive activity is applied to outputs and inputs, as is usually the case. This intermediate product flow matrix is followed by a border of columns to the right and of rows below which contain, respectively, sales constituting final demand (i.e. sales outside the "closed" system of activities characterized by fixed technological relations) and purchases from the autonomous or final demand sectors (factor costs of primary inputs, depreciation, imports, and indirect taxes and subsidies). The table is shown below in schematic form.^{9/}

	Industry						Final demand	Total output
	1	2	3	.	.	n		
Industry 1								
" 2								
" 3								
.								
.								
.								
" n								
Factor costs and other primary inputs								
Total input								

20. In theory, the entries in the table can be either in terms of physical quantities or monetary units. For the table to show physical quantities it would have to be set up in terms of homogeneous commodities, a formidable

^{9/} The principal diagonal of the intermediate product flow matrix may either be filled in or left blank. Where figures are shown they refer to intra-industry transactions, e.g. sales between establishments in the same industry if the establishment is the unit of classification. Total output may thus be gross or net of such transactions.

undertaking.^{10/} Furthermore, columns could not be summed without introducing price weights. Almost invariably, therefore, the flows are recorded in current value terms.^{11/}

21. In such an arrangement of data it is clear that the row total for any industry must equal the corresponding column total, since in each case receipts from sales (including the value of the stock change) equal total outlays on inputs purchased (including profits). It is also clear that the value of gross national product is implied in the array of data; this aggregate or one of its variants may be derived either by summing final expenditures and deducting imports, by summing total receipts of all industries reduced by the cost of intermediate products, or by summing factor costs, depreciation allowances, and net indirect taxes.

22. The "deconsolidation" of production accounts is the distinctive feature of the input-output table as compared with the national income accounts. Since the inter-industry flows of intermediate product corresponding to a particular level and pattern of final demand are revealed, the input-output table provides a basis for establishing, under specified assumptions, the structure of production corresponding to a different bill of final goods and services. Thus, suppose final demand for the output of some industry is raised. To meet this increase the industry's input requirements are enlarged, which necessitates a further increase in the industry's output to satisfy the derived demand of other industries. This, in turn, requires additional inputs into the industry in question, leading to still further requirements of the industry's output. And so on ad infinitum. The successive increments of intermediate output which the industry must supply converge, since the column sums of input coefficients are invariably less than unity (the primary inputs being considered exogenous variables), and the limit of the sum of these increments is the additional intermediate production implied by the new level of final demand. The consequences

^{10/} A table set up in terms of homogeneous products and showing values can be thought of as being in terms of quantities, the unit of quantity then being the amount that can be bought for one unit of money.

^{11/} A few countries have also prepared tables in terms of the prices of an earlier year rather than in current prices.

of changes in final demand for any number of industries simultaneously can be viewed in the same light. Clearly the final outcome depends on the input-output relationships that are used to compute additional requirements in each round.

23. A general mathematical solution is possible where the average input-output coefficients derived from the flow data for productive activities (by dividing each input acquired by an industry by the industry's total production) are assumed to be fixed. Thus, if X_i is the total annual production of industry i , X_{ij} the amount used by industry j , Y_i the amount available to satisfy final demand, and if there are n industries, then the fact that for each industry row, the total production equals intermediate product plus final product may be expressed by the equation

$$X_{i1} + X_{i2} + \dots + X_{in} + Y_i = X_i, \quad i = 1, 2, \dots, n.$$

Letting $X_{ij} / X_j = a_{ij}$, the average input coefficient, the equation becomes $a_{i1}X_1 + a_{i2}X_2 + \dots + a_{in}X_n + Y_i = X_i$, $i = 1, 2, \dots, n$. Since there are n equations and n unknowns, the system can be solved simultaneously to give the output of each industry, X_i , in terms of the specified n final demands. Using matrix notation and denoting by A the matrix of input coefficients with the elements a_{ij} , the solution becomes

$$AX + Y = X,$$

or

$$(I-A)X = Y,$$

and

$$X = (I-A)^{-1} Y,$$

where X and Y are vectors with components X_i and Y_i . Hence, if the matrix $(I-A)$ is inverted, the solution corresponding to any specified schedule of end-product deliveries can readily be obtained. The inverse matrix provides a set of coefficients representing the combined direct and indirect requirements of input per unit of final output, and the sum of the products of each of the elements in a particular row by the final sales of each industry yields the total requirements of the industry which the row represents.

24. As the number of multiplications involved in inverting an n -industry matrix is of the order n^3 , modern electronic computers would appear to be necessary for this task where the number of industries is large. With the

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inverted matrix available, solutions to problems will require from n to n^2 multiplications depending on whether attention is directed to one industry, several industries, or all. Since the indirect effects on production levels induced by a change in final demand form a converging series, the method of successive approximations can be used to provide solutions to specific problems. Convergence in most cases is rapid and more than four to six iterations are not normally required. A simple iterative solution involves about kn^2 multiplications, where k is the number of iterative stages; by comparison, direct non-iterative solutions to problems require $n^3/2$ multiplications for small matrices and $m^3/3$ for large ones.^{12/}

25. The advantages of a general solution involving inversion of the matrix as compared with the iterative method are not all on the side of the former. Granted that the availability of the inverse matrix is a great convenience where a considerable volume of inter-industry analysis is to be undertaken, the mechanical approach which it implies puts this method of problem-solving at a disadvantage. Once the inverse is calculated, changes in input-output relations can no longer be taken into account without completely scrapping the inversion. The method of successive approximations, because it starts every time with the table of input coefficients, can allow for new input-output relationships that have come to light since the original table was prepared, as well as for variable coefficients, capacity limitations which are seen to be approached or exceeded at some stage in the iterative process, and so on.

V. The routing of inter-industry flows

26. Input coefficients based on purchases and sales are but an approximation to technical coefficients relating inputs actually absorbed or used up in production to the value of the resulting product. Since changes in stocks of inputs are not explicitly considered where purchase and sales data are used in inter-industry investigations, whenever the inventory of some material input

^{12/} For a discussion of iterative solutions, see "Input-output Computations" by W. Duane Evans in The Structural Interdependence of the Economy, John Wiley and Sons, New York.

held by an industry is reduced (increased) in producing the year's output, the computed coefficient for that input in the industry will be too low (high) as compared with a "use" concept of input-output. Changes in stocks being a dynamic factor, the influence of input stock changes on input coefficients introduces an element of instability which in principle is best removed from the coefficients. A more satisfactory procedure would therefore be to adjust the entries in the inventory change column so that the figure corresponding to each row refers exclusively to the rise or fall in the stocks of products produced by the industry irrespective of where the stocks are held, and to adjust sales and purchases to a use basis. Such a procedure obviously carries the sectoring of productive activity further in the direction of a commodity or principal products basis of classification.

27. The practical difficulties of replacing actual purchases and sales by the amounts absorbed in production are such that in general it has not proved possible to do so.^{13/} The distorting effects of changes in input stock levels, however, may be reduced by using average figures for a number of years, a procedure that has been followed in one or two instances.^{14/} Another distorting element associated with stock changes generally arises from price fluctuation. In principle what is required is that the value of the physical change in the stocks of a commodity be valued at an average of prices ruling during the year. Again, for practical reasons this preferred procedure cannot be followed consistently and the change in book values is used instead.^{15/}

28. The problem posed by secondary production in any classification of productive activity (except on a commodity basis) has been referred to in

^{13/} The procedure has been followed in Canada and the United Kingdom. See The Inter-Industry Flow of Goods and Services, Canada, 1949, Dominion Bureau of Statistics, Ottawa, 1956, pp. 11-12, and National Income Statistics, Sources and Methods, Central Statistical Office, London, 1956, p. 53. In the U.S. certain adjustments made in this connexion are described in "The Interindustry Relations Study for 1947" by W. Duane Evans and Marvin Hoffenberg, The Review of Economics and Statistics, May 1952, pp. 118-119.

^{14/} e.g. in Norway.

^{15/} In the U.K., however, a "stock appreciation" figure for each industry is shown. Op. cit., p. 53. In a few cases inventory movements are revalued to a current year basis for a limited number of industries where the adjusting data are available. See, for example, Evans and Hoffenberg, Op. cit., p. 118.

passing. In the usual establishment-based industry classification, the heterogeneous character of the output of certain industries may make the assumption of stable coefficients implausible; furthermore, since information on the cost structure of industries very often relates to commodity inputs rather than vendor industries, utilization of source data is hampered.^{16/} One solution is to segregate subsidiary from primary production in each branch and to treat the subsidiary portion as if it were sold to the industries where the products concerned are primary. The distribution of sales for each industry will then include the industry's own production as well as its principal products which are produced elsewhere. This method, which is frequently followed, may improve the stability of some of the coefficients and facilitates the recording of data, but inasmuch as subsidiary production is still distributed in each row along with (total) production of the primary type, homogeneity is not attained. If, however, subsidiary production is treated as negative input into the producing industries and negative output of the industries in which it is primary, homogeneity of the rows will be attained, In analysis this alternative would have advantages when by-products are technically related to the main production.

29. Where for an industry the principal and secondary products are not technically related, the best solution may be simply to remove the secondary products and the corresponding inputs to the industry in which the products are main output. If the inputs are not directly ascertainable, the cost structure of the industry to which the products are transferred may be used if there is no reason to believe that the production techniques in the two industries are very different.

30. The recording of imports also poses difficulties. To begin with, all imports could be treated in a row in which the entries are the cost of imported supplies used by the various industries. This method has a number of disadvantages, however, Thus, as regards any product whose total supply is met partly by domestic production and partly by importation and for which variations in the proportions of supply are

^{16/} Specifically, it is difficult to determine how much of the requirements of a particular industry for a commodity is met by production in the industry where the commodity is a primary product and how much from the subsidiary production of other industries.

to be expected, it is clear that coefficients relating only domestically produced inputs of the product to the outputs of using industries will also be variable. From a statistical standpoint, the method has the drawback that it implies that the amount of each product supplied in part from abroad which is bought by industries can be broken down into its domestic and foreign components. Where it can be contended that practically all imports are non-competitive with domestic commodities (i.e. that they are not close substitutes for locally produced products), of course both these objections cease to apply.^{17/}

31. As regards the competing imports a preferable solution is to distribute the total supply (domestic and imported) of commodities rather than just the amounts locally produced, and to charge the domestic producers with the cost of the competing imports. Under this treatment, each row will show the disposition of the total supply of the commodity or group of commodities, and each column the inputs including the cost of the imports disposed of in the row. This arrangement improves the stability of coefficients involving commodities which are partly imported, and also disposes of the statistical difficulty mentioned. The solution, although frequently adopted, is nevertheless not completely satisfactory, because the cost structure of the domestic producer of a product which is also imported is made to depend on how much of the commodity is imported. This drawback can, however, be removed by treating the import not as a purchase by the producer but as his negative output (as by recording competing imports in a column rather than a row and entering here the negative figure).^{18/}

32. Given that the emphasis in input-output is on the relationship between inputs and the outputs into which they are converted, it is clear that the distributive industries such as transport and trade through which almost

^{17/} It appears that in the Puerto Rican input-output study all imports are regarded as non-competitive. See "Input-Output Analysis of the Puerto Rican Economy" by Amor Gosfield in Input-Output Analysis: an Appraisal, Studies in Income and Wealth, Vol. 18, Princeton, 1955, pp. 346-347. The distinction between competitive and non-competitive is not always easy to make in practice; hence the tendency to route all imports in a uniform way in input-output tables without regard to the aspect of competitiveness.

^{18/} See, e.g., the Italian Study, Op. cit., table following page 41. A consequence of this treatment is that the computation of input coefficients comes to be based on domestic production rather than the total supply of production.

all commodities pass cannot be shown as buying and selling these commodities, for such a literal picture of inter-industry transactions would obscure the technical relationships between outputs and associated inputs. The distributive industries must therefore be regarded as producing and distributing only their services, which are costs of production to the other industries. Because these services intervene between producers and users of commodities, the question arises as to whether transactions should be stated in terms of the prices which the producer receives or the prices which the purchaser pays.

33. The use of producers' prices for recording transactions implies that every industry purchases from distribution the distributive services involved in providing the industry with its inputs (just as if distribution were a processing activity whose output was needed by the industry); further, when producers' values are used for sales to final buyers it is necessary that the mark-ups and other distributive costs associated with final sales be shown as a separate sale to final buyers by distribution.

34. Where inter-industry sales are shown at purchasers' values, all inputs are already valued inclusive of distribution costs. Hence each industry instead of being charged by distribution with the costs associated with its inputs is charged with the distribution costs associated with its output. Sales to final buyers being shown at buyers' values, no separate sale of distributive services to final buyers is called for.

35. From the standpoint of statistical convenience the use of purchasers' values has definite advantages, since to the extent that input requirements are known they are normally expressed in buyers' prices, and additional data or assumptions are required to eliminate the associated distribution charges. In both methods the total output of "distribution" is the cost of providing the services of wholesale and retail trade, transportation, storage, etc., but in the first (purchasers' prices) in the row or rows for distribution this output is allocated according to the services rendered in distributing each industry's inputs, in the second (producers' prices) according to the services rendered in distributing the industry's output. As regards the treatment of the distributive industries themselves, the method of purchasers' prices again is the easier one to apply. Indeed, in many cases a table at producers' prices could only be

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arrived at by starting with one at purchasers' prices. Furthermore, for most input-output studies it is a distinct advantage to have final expenditures already expressed at buyers' prices because they are then in agreement with the expenditures at market prices comprising final demand in the national income accounts; and the necessity for charging consumers, etc. with a separate large total for distribution costs is eliminated.

36. While in fact purchasers' values are often used, the consensus appears to favour tables in terms of producers' values as a basis for analytical studies on the grounds that distributive margins vary according to classes of users, and that shifts in the patterns of sales - e.g. in the proportion of total output sold at retail or exported - thus introduce an element of instability into technical coefficients based on buyers' values. It is, however, a moot point whether this theoretical advantage is not actually more than offset in numerous cases by the loss in accuracy entailed in adjusting readily available data at purchasers' prices to a producers' price basis.^{19/}

VI. Applications

37. It has been shown how the level and structure of production corresponding to a given final demand schedule may be derived from an input-output table under the assumption of constant input-output ratios. The potentialities of input-output analysis for planning purposes are suggested by this predictive character of the input-output table. It is not, of course, the size and character of final demand which is projected by an open system of analysis, but only the production requirements necessary to sustain the demand. Final demand must either be given, as for a goal or "plan", or else estimated by techniques quite distinct from inter-industry analysis.^{20/} This is necessarily so because an open system of the

^{19/} This same doubt is raised in the article "Input-Output Tables: Recent Experience in Western Europe", Economic Bulletin for Europe, ECE, Geneva, May 1956, page 49.

^{20/} Forecasts of total final demand may be based, for example, on projections of such factors as employment and productivity. This approach is used in Long-Range Projections for Economic Growth: The American Economy in 1970, National Planning Association, Washington, 1959.

kind under consideration, deals only with the supply side like any other production function, and not with demand. Even after final demand has been specified, whether as an outright assumption, or, as a forecast, it must be translated into final demand for the output of each of the various industries by means of regression analysis of time series or household budget data, or some other technique.

38. Despite these limitations, input-output analysis is probably the best available technique for tracing out the implications, in terms of production levels and requirements, of a specified final demand pattern. In economic planning these derived data may be of utmost importance by revealing in detail the new industrial structure implied by a plan and by providing a basis, when resources are also taken into account, for judging its reasonableness. Analysis may reveal, for example, that a plan is not feasible because the supply of scarce resources such as skilled labour or foreign exchange is simply not equal to supporting the final demand as projected. The fast-growing industries can also be identified by the analysis, and these dynamic sectors of production become logical candidates for study in any industrialization or development promotion scheme.

39. The expansion of domestic production and imports required to support an investment programme, or even the construction of a single large project like a dam to generate hydroelectric power, can be examined by use of the inter-industry technique. In this case the direct requirements of inputs for investment in additional capacity must somehow be determined, and the bill of final demand must take these additional demands into account (as well as the additional final expenditure that will be induced by the higher level of investment activity) so that the full impact on the economy of the programme or project can be assessed. Even if a given investment programme proves feasible, further analysis may show it to be deficient in the sense that the expanded productive potential of the economy after completion of the programme may still be too small to support the desired level of final demand, or may be larger than necessary, or may be badly

balanced.^{21/} Although the technique is useful for discovering a programme that appears feasible and is consistent with the achievement of the desired level of final demand deliveries, the selection of the optimum investment programme calls for more powerful methods - and also more information and assumptions - such as linear programming.^{22/}

40. In testing for feasibility, the total requirements of "ultimate" resources can be determined because fixed coefficients are assumed to hold for imports, labour and other primary inputs. If competitive imports are freed of this restriction in the interest of a more realistic model, it should be noted that they can no longer be derived but must be specified. This is an inherent limitation reflecting the fact that many considerations may enter into determining the extent to which commodity requirements will be filled by domestic production as against importation. In any test of feasibility, the total amount of foreign exchange needed to finance imports of all kinds must be examined in the light of existing exchange reserves, exports and the developing balance of payments situation as a whole.

41. Analyses along these lines are carried out in general without explicit attention to the consequences of changes in relative prices; in other words, the cost structure of the base period is assumed to hold. Another class of applications, however, is concerned with investigating the consequences of changes in costs, either assumed or foreseen, the real structure of production being considered as given.

42. Since the direct and indirect content of wages, imports and other price determinants can be established for the various industries, changes in the price levels of the goods and services produced by the various industries can be

^{21/} The programming of investment by inter-industry analysis is discussed in detail in How to Select Dynamic Industrial Products, International Cooperation Administration, Washington, D.C. This "manual" takes an optimistic view of the possibilities offered by input-output in the solution of such problems. An opposite position is taken in Ronald W. Shephard, A Survey of Input-Output Research, The Rand Corporation, Santa Monica, California, July 1952, a study concerned not with investment programming per se but with mobilization or military planning.

^{22/} Linear programming is treated briefly in a note appended to the present paper.

calculated given the change in wage rates, import prices, etc. For instance, the change in the cost of living that could be expected to result from a general wage increase of x per cent (or from a specified change in import prices or indirect taxes) can be determined by calculating the resulting changes in the costs of the components of the index and then combining them with appropriate weights. While the resulting figure will of course reflect the assumptions underlying the analysis, the approach yields at least a first approximation through a general, as distinct from partial, analysis of the problem.

43. Applications of the sort described are by no means the only ones which could be mentioned, although they are by far the most important. Other applications frequently require the development of a special model to study a specific kind of problem. An interesting example is the application of input-output techniques in the investigation of regional as opposed to national development. Where the regions of a country have substantial differences in income levels, techniques of production, etc., a variant of the customary input-output model can be devised to take account of the regional aspects of supply and demand. The model can take the form, for example, of treating commodities and services produced and consumed in the various regions as if they were distinct commodities. Such a model is obviously better adapted to the study of the regional implications of development schemes than a national model, and some experimentation with such special-purpose models with an eye to practical results has been carried on in a few countries.^{23/}

44. In addition to the analytical or predictive uses to which the input-output table lends itself, the statistical description of the interdependence of industries which it provides is in itself of course a valuable contribution to factual knowledge. The extent of the claims that have on occasion been advanced for input-output tables as a tool in analysis has led to counter-claims in which this aspect has tended to be forgotten. But it would seem to be undeniable that input-output tables, like the national income accounts, are of interest and value even when they do not form the basis of analytical studies.

45. The systematic reconciliation of a vast amount of statistical data on output and costs of production which the preparation of input-output tables necessitates

^{23/} See the Italian Study, op. cit., Chapter V.

may also contribute to an important degree to the improvement of national statistics, for instance by disclosing inconsistencies and gaps.^{24/} Where the work is carried on in conjunction with the calculation of national income statistics a sounder basis is inevitably provided for the latter.^{25/} Quite apart from these statistical considerations, the detailed studies which are often undertaken for key industries in inter-industry research - and which might otherwise not be attempted - are providing new and potentially valuable insights in depth into the workings of these industries.

VII. Limitations of the input-output model in under-developed countries

46. Whatever the qualifications of the input-output table as an analytical device in industrialized countries, still other limitations enter the picture in under-developed countries. These new limitations arise mainly from the dominant position of agriculture and the nature of industrial interdependence in these countries.

47. As regards agriculture, one difficulty is the absence of a persistent relationship between inputs and output owing to the influence of external factors, such as the weather. The implications of the resulting erratic fluctuations for the assumption of stable coefficients in practical investigations are obvious. While unpredictable fluctuations in agricultural output are also a drawback to input-output analysis in those developed countries which have a large agricultural sector, the mechanized and scientific character of the farming operations generally serves here to reduce the play of chance factors (the greater control of livestock epidemics through breeding and modern veterinary services, the development of more resistant seed strains and water conservation are a few examples that can be mentioned). The use of an average for a number of years is one way of providing a better approximation to "normal" relationships between agricultural inputs and output. At the same time the use of averages is

^{24/} Australia and Canada, among other countries, have emphasized this point.

^{25/} Furthermore, the deflation of gross national product by the industrial origin approach and the analysis of productivity change into structural and technical aspects would be greatly facilitated.

undoubtedly a complicating factor in the construction of a table and in most applications, and averages covering only a few years may furthermore not eliminate the effects of large chance fluctuations.

48. The broad range of outputs of agriculture presents another problem where the product-mix is subject to important changes in composition, whether due to chance factors such as growing conditions or in response to changing market conditions. While at first glance it would seem that a solution might be to distinguish separately major groups of products, there are theoretical and practical reasons why such a "solution" would be illusory. In the first place, the specific input-output coefficients would probably prove to be even less stable than a general coefficient for agriculture as a whole, since the latter coefficient, relating as it does to a whole complex of activities, serves at least to average out to some extent the influence of factors making for instability. In the second place, separation of outputs implies separation of inputs. It is well known from experience that allocating inputs according to agricultural outputs where mixed farming is the rule is extremely difficult in practice. While technological considerations are helpful in establishing the input-mix required to carry on manufacturing processes, the technical links between purchased inputs and output are much less specific in agriculture, so that even cost studies for specialized farms may not furnish answers that are very useful for projection.

49. For those under-developed countries in which the state of the economy is dependent to a very large extent on one or a small number of agricultural exports - coffee, rubber, sugar, bananas, cotton, etc. - it is uncertain whether input-output studies can be of very much assistance in resolving questions centring on these items. It is true that from a statistical standpoint these products can easily be separated from the balance of agricultural production and that, especially where the products are for the most part grown on estates or plantations, typical input patterns can be established. But leaving aside the question of the stability of the input-output relations, the fact that these products are mainly exported rather than used by other industries within the country and the inputs required from other industries are relatively small suggests that an inter-industry matrix is a less useful device for studying agricultural problems in these circumstances than is sometimes supposed.

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50. As regards countries which are still at a very early stage in their economic development, the absence of pervasive inter-industrial relationships - not only between agriculture and other industries, but in general - greatly reduces the usefulness of the input-output table as an analytical tool. Such studies as have been made for the more primitive kinds of economies show that inter-industry transactions are negligible, most of the inputs being either imports or factor services and most of the outputs being sold directly to domestic final buyers or exported. In such circumstances it is mainly the emerging or anticipated inter-industrial relationships that will be of interest.

51. For countries at a higher stage of development where domestic processing activities are already significant and rapidly becoming more so, another difficulty arises. Growing industrialization implies that certain important changes will take place rather rapidly in the character of inter-industry relationships. The construction of a large modern plant, for example, will create a whole new network of transactions with consequences far beyond those that would occur in an already thoroughly industrialized economy. Under these conditions an assumption of fixed coefficients can hardly be justified. Furthermore, the continual emergence of new products connected with the growing diversification of industry could only be disregarded at considerable risk to the usefulness of the model in projections.

52. These difficulties point not so much to the limitations of input-output analysis per se as to the need for abandoning the completely static model and introducing modifications to take into account emerging patterns of activity. While in the industrialized countries technological innovations and their consequences are difficult to anticipate, it is probable that a great deal of the scope and impact of new developments can be foreseen in the less developed countries. Genuinely new developments play a much smaller role in the latter since almost all advances result from the application of already existing knowledge and processes. In addition, the number of units concerned is comparatively small. Thus, the possibilities of working with a more dynamic model would seem to be favourable. There has, however, been very little experimentation along these lines in countries where the usual assumptions underlying input-output analysis may be so unrealistic.

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VIII. Country practices

53. The growing interest in input-output relations is evident from the number of countries now engaging in these studies. With certain exceptions the work is being carried on at an official level, in some cases, particularly in Europe, in close association with the preparation of national income estimates. The brief notes on country tables that follow can do no more than describe some of the main features of the tables. In many cases more detailed information is available from the national publications cited below as sources.

54. In addition to the countries covered by the notes, several others have prepared or are preparing input-output tables. Among such countries, for which published studies are not in most cases yet available so far as is known are Belgium, Chile, Finland, Haiti, India, Ireland, Israel, Mexico, Poland, Puerto Rico, Spain, Sudan, Sweden, Tunisia, Yugoslavia and the USSR.^{26/}

Algeria

An input-output table for the year 1954 prepared for the Ministère de l'Algérie has been published in an official study, Perspectives décennales de développement économique de l'Algérie, March 1958.

The table distinguishes twenty-seven industries, of which five refer to agricultural activities; the rows, however, are further subdivided, making a

^{26/} The Puerto Rican inter-industry study is described in detail in the article by Amor Gosfield, "Input-Output Analysis of the Puerto Rican Economy" to which reference has already been made. The completed table itself, however, is not shown in this source, although it is to be found as an appendix in How to Select Dynamic Industrial Projects, International Cooperation Administration, Washington, D.C. The table, which refers to 1947-48, is shown with thirty-four producing sectors. In India, a number of tables have been prepared in the Planning Division of the Indian Statistical Institute and are shown in its Working Paper Series, e.g. a 12 x 12 table for 1950-51, a 36 x 36 table for 1951-52 and a 36 x 36 table for 1953-54 condensed from a 116 x 116 sector classification of production. As regards France, input-output tables of the usual kind have not been prepared, but for the year 1951 tables have been compiled which show the sales of forty-two sectors by type of product and separately the products purchased by these same sectors; an input-output matrix cannot be derived from these tables because the product classification cannot be reconciled with the industry classification. See Tableau économique de l'année 1951, Ministère des affaires économiques et financières, 1957.

table of 79 x 27. The basis for these subdivisions is the nature of the products or services produced. For this purpose nine categories are recognized, viz. agricultural raw materials, other raw materials, energy, intermediate goods, intermediate services, foodstuffs, other consumption goods, final services and capital goods. For each industry column, total inputs are summarized on this basis at the foot of the table.

Total availabilities of intermediate and of final goods and services are shown separately in special columns before the usual intermediate and final demand sectors. The columns record individually domestic output, imports and the trade margins on local production, imports and exports.

Value added by each industry is divided into seven components; the rows concerned relate to wage and salaries, social insurance contributions, indirect taxes, depreciation, subsidies, direct taxes and profits.

Because of the arrangement of the table, exports and changes in stocks are shown separately for intermediate goods and for final or finished goods. Other final demand sectors are combined public and private consumption, and fixed capital formation.

Inter-industry transactions are recorded at purchasers' prices. Values are also shown for intra-sector transactions. An inverted table does not appear to have been published. A similar input-output table for the year 1967 in prices of 1954 appears in the same source as a forecast of the economic situation at the end of the planning period.

Argentina

As part of its study entitled The Economic Development of Argentina issued in 1958, the United Nations Economic Commission for Latin America has prepared an input-output table for the year 1950. The tables distinguish twenty-three industries, viz. agriculture, livestock, mining, fifteen branches of manufacturing, construction, transport, communications and trade, electricity and sanitary works, personal and financial services, and dwellings. The final demand sectors are consumption (public and private), fixed investment, changes in stocks and exports. The column for stock changes includes statistical discrepancies. All figures are shown in terms of purchasers' prices and intra-sector transactions have been

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included. The following primary inputs are shown: imports, wages and salaries, and other incomes plus net indirect taxes. Imports are distributed according to using industries.

The 1950 table is based on a more detailed analysis involving some 200 sectors.

Australia

A forty-industry input-output table for the fiscal year 1953-54 has been published in an article entitled "New Aspects of Australia's Industrial Structure" by B. Cameron which appears in The Economic Record, Melbourne Univ. Press, December 1958 issue. The table was prepared with the advice and assistance of the Department of Trade and the Commonwealth Bureau of Census and Statistics.

Of the forty industries distinguished, two refer to agriculture (sheep and other), three to mining, twenty-six to manufacturing, one each to electricity, gas and construction, four to transport (rail, road, air and coastal shipping), one to trade and one to all other services. Also shown separately are the following primary inputs: wages, other factor income, depreciation, net indirect taxes and imports. Imports have been divided into competitive and non-competitive; competitive imports are recorded as inputs into the competing industries while non-competitive imports are treated as inputs into the industries where they first enter domestic production. The final sectors shown are private consumption, government consumption, fixed capital formation, changes in stocks and exports.

The table is shown in purchasers' prices. Intra-sector transactions are excluded; i.e. the principal diagonal is left blank. The inverted table has been published in the same source.

A summary twenty-industry table has also been calculated for this year and for 1946-47 and 1955-56. For the year 1946-47 a small research team at University College, Canberra, produced a 106 industry by 266 commodity transactions table to test the comprehensiveness and consistency of official statistics (published in The Economic Record, December 1957). There also exists a matrix of technical input coefficients based on 119 industrial sectors for 1953-54.

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Canada

An input-output table for the year 1949 covering forty-two industries in a square matrix has been published in a study by the Dominion Bureau of Statistics, The Inter-Industry Flow of Goods and Services, Canada, 1949, Ottawa, 1956. The classification of industries is on an establishment basis and in close agreement with the Canadian Standard Industrial Classification. Unallocated inputs and outputs have been assigned to a row and column and are treated as one of the industries.

Final demand is shown in five columns covering the usual categories, except that fixed investment of general government is included with government current expenditure rather than with other capital formation. The figures in the inventory change column refer to the change in stocks of goods produced by each industry irrespective of where the goods are held rather than to the change in the industry's holdings of all goods; changes in an industry's input stocks have therefore been attributed to the industries in which the goods originated.

The rows for primary inputs distinguish, besides imports, employee compensation, corporate profits, other income, import duties, other indirect taxes less subsidies, and depreciation. Imports are distributed according to the industries in which they are first used.

Intra-industry transactions are included in the principal diagonal. All values are in terms of purchasers' prices. The inverse matrix has not been calculated.

A revised version of the table at producers' prices and the matrix inverse are due to be published shortly in D.B.S. publication 13-513, Supplement to the Inter-Industry Flow of Goods and Services, Canada, 1949.

Colombia

An input-output table for 1953 was prepared as part of the report, Analyses and Projections of Economic Development: The Economic Development of Colombia, United Nations Economic Commission for Latin America, 1957. The table, however, does not cover the entire national economy and relates mainly to manufacturing, of which sixteen separate branches are distinguished. While sales to these branches are shown, purchases not only from manufacturing but also from agriculture

and mining are recorded, so that the intermediate flow matrix comprises eighteen rows and seventeen columns (one for intermediate sales to non-manufacturing industries). For each of the eighteen rows output is divided into domestic production and imports. The final demand sectors are exports, capital goods, durable consumers' goods, non-durable consumers' goods, and fuels and lubricants. This last-named category is stated to have been included in final demand owing to the impossibility of allocating fuel production among consuming industries.

Denmark

The two most recent input-output tables are for the years 1947 and 1949 and have been prepared in conjunction with the national income accounts. The tables appear in National Accounting, 1938 and 1947-54, Statistical Department, 1955.

The published tables cover twenty industries but are based on investigations using twenty-eight industries; the 20 x 20 tables treat manufacturing as a single industry whereas in the twenty-eight-industry format sub-branches of manufacturing are distinguished. For three of the industries, viz. domestic services, use of dwellings and government services, the whole of the value of production is charged to consumption. The usual final demand sectors are shown except that private and public consumption are combined and gross domestic fixed capital formation is divided into eight distinct categories. Primary input is divided into imports (allocated to users), indirect taxes, wages, other factor income and depreciation (including maintenance and repairs). The inter-industry figures are shown in terms of producers' prices except where producers distribute or transport their own products. Intra-industry sales are included in the table. The 1947 table has also been prepared in prices of 1949. The various tables have been inverted but the inverse matrices have not been published.

For the pre-war period input-output tables were compiled for each year of the 1930-1939 decade and form the basis of the national income estimates. These tables distinguish ten industries, of which four are further divided into durable commodities and non-durable commodities and services, resulting in a 14 x 14 flow matrix. Unlike the later tables, purchasers' prices were used and imports were allocated to the domestic industries producing similar goods. These tables have not been inverted.

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A table for 1953 similar to the post-war tables described but in greater detail is now being completed.

Italy

The most detailed study relates to 1950 and was prepared as part of the U.S. Mutual Security Agency report, The Structure and Growth of the Italian Economy, Rome, 1953. The basic input-output table is rectangular and comprises 200 product groups (rows) and fifty-six industries (columns), the rectangular form being preferred so as to provide sufficient commodity detail to enable the use of specific imports to be traced. Since the commodity classification used permitted the commodities to be regrouped according to the fifty-six industries, a square matrix could be derived. This inter-industry flow table was further reduced to square matrices of twenty-two and sixteen industries, of which the smaller was inverted. The usual final demand sectors are shown except that separate columns are provided for stock increases and stock depletions (based on inventory movements of individual commodities allocated to industries). Individual primary inputs are not distinguished: one row shows the aggregate value added in each industry. Imports are also shown but as a column rather than row, so that imports (all of which are considered competitive) are in fact treated as negative outputs of the corresponding industries. Consequently, domestic production rather than total availability is used as the denominator of the input coefficients.

Purchasers' prices are used in recording transactions for statistical convenience. No unallocated sector is used since unallocated outputs have been transferred to the most likely consuming industries. Intra-sector transactions are included in the table.

A regional model for the same year based on the twenty-two-order matrix has been developed and is discussed in the same report. In this model Northern and Southern Italy have been distinguished in order to trace the regional implications of investment programmes being undertaken in the south.

An input-output table for 1952 has also been prepared and is published in Relazione generale sulla economia del paese, presentata al Parlamento dal Ministro del Bilancio, 31 March 1954. The 25 x 25 industry table is based on an

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unpublished rectangular table of 300 rows (commodities) and twenty-five columns (industries). The 1950 study was followed in most respects in preparing this later table.

The most recent table, also published in the Budget Ministry's Report to the Parliament (1955), refers to 1953 and is similar to the 1952 version.

Japan

Tables have been prepared for the years 1951-1955 based on a detailed table for 1951 prepared in terms of 527 x 182 industries and reduced to 182 x 182; the summary version of the latter is a square table of thirty-six industries and has been inverted. A similar thirty-six-industry table for 1954 in terms of 1951 prices has also been prepared. These tables were compiled by the Ministry of International Trade and Industry. The basic 1951 table is described in Interindustry Analysis of the Japanese Economy, MITI, Tokyo, 1958 (in English).

Another table for 1951 which distinguishes only nine industries was prepared by the Economic Planning Board. An eighty-industry table for 1953 has also been compiled by this agency. Only the earlier table has been inverted.

These various tables have been prepared in terms of producers' prices. Inputs have been divided into competitive and non-competitive categories. Whereas the Economic Planning Board studies charge indirect taxes to consumers, they are charged to industries in the tables of the Ministry of International Trade and Industry. Except for the fact that industrial activity is classified according to "activity" (commodity), the form and methods employed are understood to follow closely the 1947 U.S. inter-industry study.

In addition to these tables, special tables for various years have been compiled, e.g., input-output tables on a regional basis, inter-industry capital account transactions and detailed sector accounts for agriculture.

Work is proceeding at the present time on a 300 x 300 industry input-output table for the year 1955 under the direction of the Statistical Standards Bureau of the Administrative Management Board.

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Netherlands

Input-output tables have been prepared for each of the years 1938 and 1946 to 1953 by the Central Bureau of Statistics and appear in various publications of the Bureau, e.g. Nationale Jaarrekeningen, 1948-50, 1953 and National Accounts of the Netherlands, 1948-1949, 1952. While the tables often differ from one another in certain respects, in general twenty-seven industries are covered of which about fifteen are for manufacturing. For the final demand sectors additional columns show government consumption, private consumption, exports, fixed investment and changes in stocks; these sectors are broken down in various ways, e.g. stock changes into changes in work in progress, stocks in the hands of producers and in trade. The rows outside the inter-industry flow matrix proper are usually twenty-two in number and refer to payments of various kinds to government, consumers, rest of the world, capital account and insurance funds. The most important of these actually allocated industry-wise are indirect taxes and subsidies, wages, social insurance contributions, profits, imports, depreciation and consumption from stocks.

Imported materials are allocated to consuming industries, whereas imported final goods are routed to final demand sectors separately through the industry "commerce". The tables are in terms of producers' prices. Intra-sector transactions are included.

A number of tables with preliminary figures have appeared on a quarterly basis in conjunction with quarterly statistics of national income. In general the work on input-output is pursued in association with the preparation of the national accounts.

More detailed tables starting with the year 1948 are in preparation. These tables distinguish fifty-three industries based on the ISIC.

New Zealand

A special study, Report on the Inter-Industry Study of the New Zealand Economy in 1952-53, Wellington, 1957, has been published dealing with input-output for the fiscal year 1952-53. In addition to giving a table of current account inter-industry transactions, tables showing transactions on combined current and capital account and on capital account alone are provided. The 1952-53 current

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account input-output table is a revised version of a similar table first published in the official national accounts report for the year 1955-56.

The tables distinguish twelve industrial sectors, viz. farming, forestry, and logging, hunting and fishing, mining, primary produce processing, other manufacturing, building and construction, public utilities, transport and communications, wholesale and retail trade, banking and insurance, and services. Transactions are given in producers' prices, and values are included for intra-sector transactions. The usual categories of final demand are shown, including the change in stocks. The primary input rows comprise "sales by final demand users" (purchases from households, public administration and defence), net domestic output, imports (allocated to users), depreciation and net indirect taxes. The inverse matrix based on the current account table is also shown. Two methods of inversion were tried and it was found that the method of reducing a "bordered determinant" was greatly superior to the method of expansion by "power series".

In 1959 a comparable set of tables for 1954-55 was published under a similar title. Recognizing the need for smaller and more homogeneous groupings, the Department of Statistics is now planning a 40 x 40 industry table.

Norway

Since work on input-output has always been pursued in conjunction with the national income accounts, input-output tables have been prepared for every year since 1930. Only the tables for 1948 and 1950 have, however, been published. These appear, respectively, in National Accounts, 1930-1939 and 1946-51, 1952 and National Accounts, 1938 and 1948-1953, 1954, Central Bureau of Statistics, Oslo.

The table for 1948 distinguishes thirty industries and an unallocated sector. Additional columns are shown for exports, government plus household consumption, the change in stocks and gross fixed investment, which together make up the final demand. Additional rows give imports (shown in two rows, one for all imports and the other for commodity imports excluding ships), wages and salaries, entrepreneurial income, indirect taxes, subsidies and depreciation.

Inter-industry sales are shown at purchasers' prices. Commodity imports are allocated directly to users and are also recorded at purchasers' prices. Intra-sector transactions are omitted. The corresponding inverse matrix has been prepared but not published.

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The 1950 table covers twenty-seven industries but is based on an unpublished 78 x 78 industry matrix. The table for the later year is nearly identical in form with the 1948 table, except that sellers' prices are used.

Peru

Tables for the years 1955 and 1956 are shown in the Central Reserve Bank of Peru national accounts publication, Renta Nacional del Perú, 1942-1956, 1958. For each of these years a summary 8 x 8 industry input-output table is shown which can be reconciled with the national accounts statistics given in the same source. A more elaborate input-output table is also provided for 1956 with twenty-five industries, of which eighteen refer to manufacturing (treated as a single industry in the summary table). Two final demand columns show the total of consumption and domestic investment, inclusive of stock changes, and exports. An additional column supplies the amounts incorporated in final demand for the change in stocks. Eleven rows are devoted to showing the components of value added, including depreciation, for each industry, and a twelfth row shows imports.

The tables appear to be in terms of producers' prices. The value of intra-sector sales is shown. The total value of imports has been divided between the two industries, "commerce" and "services". The tables have not been inverted.

Tanganyika

In order to determine the relative importance of inter-industry relations in this country, an experimental 14 x 14 industry table has been prepared containing tentative estimates for 1954. The table appears in Peacock and Dosser, The National Income of Tanganyika, 1952-54, U.K. Colonial Office, 1958.

From the tables it appears that the degree of industrial interdependence is small, with imports and factor services as the main inputs and with households and exports as the main destination of outputs.

United Kingdom

The latest table is for 1954 and comprises eleven major industry branches. The classification accords with the U.K. Standard Industrial Classification, and the following industries are distinguished: agriculture, forestry and fishing;

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mining and quarrying; chemicals and allied trades; metals, engineering, and vehicles; textiles, leather, and clothing; food, drink and tobacco; other manufacturing; building and contracting; gas, electricity and water; other production and trade; and other industries. The industry "other production and trade" covers transport and communication, distributive trades, insurance, banking and finance and other services, while "other industries" refers to public administration and defence, public health and educational services, ownership of dwellings, domestic services to household and services to private non-profit-making bodies.

The customary final demand sectors are shown as additional columns. The figures for the change in stocks refer to the change in the stocks of goods produced by the various industries or imported, the change in input stocks held by each industry being removed in all cases to the industries of origin. The column shows the value of the change in the stocks described, i.e., an adjustment for "stock appreciation" has been included. The adjusting figures are given in a separate column for reference.

Four rows are shown for primary inputs: imports; income from employment; gross profits, other trading income and rent; and net taxes on expenditure. Imports are allocated directly to the using industry or to final demand.

Intra-sector transactions are excluded. All values are in terms of producers' prices.

The table in question and its inverse appear in the 1958 report on National Income and Expenditure issued by the Central Statistical Office. The concepts and sectoring are consistent with the national income accounts. A description of the tables is to be found in National Income Statistics, Sources and Methods, Central Statistical Office, London, 1956, pp. 52-55. A similar table for 1950 appears in the 1955 and 1956 national income reports.

Apart from the work of the CSO, the Board of Trade and the Department of Applied Economics of Cambridge University have been engaged in preparing a large 1948 table, originally planned as a 400-sector table. Up to the present time only a table with fifty producing sectors has been published (I.G. Stewart, "Input-Output Table for the United Kingdom", The Times Review of Industry, London and Cambridge Economic Bulletin, new series No. 28, pp. vii-ix). The entries in

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this table are at purchasers' values. For imports a distinction is made between those which compete and those which do not compete with home production. Competitive imports are shown as a negative item of final demand for the products of the domestic competitor, who consequently is treated as distributing the total available supply. Non-competing imports are charged directly to the using industry or to final demand. The corresponding inverse matrix has been calculated but not published. A summary 8 x 8 industry table for this same year originally appears in National Income and Expenditure, 1946-1951, 1952.

The first input-output study for the United Kingdom was the work of T. Barna and the resulting tables, which referred to the year 1935, were published in T. Barna, "The Interdependence of the British Economy", Journal of the Royal Statistical Society, Series A (General), Vol. CXV, Part 1, 1952, pp. 29-81.

United States

The last official study of inter-industry relations is for the year 1947. The work was carried out mainly at the Bureau of Labor Statistics in collaboration with other interested federal agencies. A detailed description of the 1947 table is given in the article by Evans and Hoffenberg, "The Interindustry Relations Study for 1947", published in the May, 1952 issue of The Review of Economics and Statistics.

The basic data were compiled in terms of 500 sectors approximating the four-digit level of the U.S. Standard Industrial Classification in manufacturing areas, with broader aggregation for other activities. No single table covering the 500 sectors has, however, been published because of the space which such a detailed square table would require; the largest version which has been made available is a table of some 200 sectors. The article referred to above presents a table comprising forty-five processing industries and it is this table which is best known. This summary table will form the basis of the comments below, and readers are referred to the article for further details.

Five final demand sectors are shown in addition to the forty-five industry branches: additions to stock, exports (including invisible earnings and foreign investment income), government, gross private capital formation and households. The corresponding input rows cover stock depletions, imports, government,

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depreciation (left blank and included with households) and households. The entries in the row for government refer primarily to taxes and miscellaneous receipts. The household row covers, in addition to depreciation and other capital consumption allowances, wages and salaries, interest payments, payments for entrepreneurial services, and some other minor income payments. Most imports are regarded as competitive and therefore recorded as inputs into the competing industry, which is then shown as distributing them along with domestic production; only coffee, cocoa beans, jute, burlaps and tea are regarded as non-competitive imports, and these are shown as inputs into the industry where they first enter domestic production. The row includes, in addition to merchandise imports f.o.b., foreign ocean transport, travel abroad, gifts and other unilateral payments.

The input-output table includes intra-sector transactions. All figures are in terms of producers' values. One of the sectors is a synthetic industry labelled "undistributed" and consists of production costs (shown as a row) and sales (shown as a column) which could not be allocated according to supplying and purchasing industries. The inverse of the table has been published and appears in the aforementioned article.

In addition to the 1947 study, earlier tables for 1919, 1929, and 1939 were prepared under the direction of W.W. Leontief. The 1939 table was compiled in terms of ninety-six sectors and later reduced to forty-two sectors, in which form it was used mainly. The tables are contained in W.W. Leontief's The Structure of American Economy, 1919-1939, Oxford University Press, 1951.

Appendix

A Note on Linear Programming

Closely allied to input-output as an instrument for planning economic development is the technique of linear programming, which postulates a given set of economic variables subject to certain constraints which may be equalities or inequalities, for instance that at the target total exports equal imports, or resources for gross capital formation are not to exceed a predetermined figure. The problem is conceived as that of finding the values of the economic variables which, subject to the constraints, afford the maximum or minimum of a prescribed function (the "target function"), for instance total value of consumption (as a maximum). All functions involved are linear in the economic variables.

The mathematical formulation is very simple. There are n variables x_1, x_2, \dots, x_n , with k constraint equations

$$(1) \quad \sum_{j=1}^n p_{ij} x_j = b_i, \quad i = 1, 2, \dots, k, \quad k < n,$$

and m constraint inequalities

$$(2) \quad \sum_{j=1}^n q_{ij} x_j \leq c_i, \quad i = 1, 2, \dots, m.$$

The target function to be maximized or minimized is

$$(3) \quad u = \sum_{j=1}^n a_j x_j$$

All the coefficients a, b, c, p, q , are presumed to have given numerical values, positive or negative. The problem is to find the positive or zero values of the variables x which yield a maximum or minimum value of u according to formula (3), and, of course, the optimum value itself. Mathematically speaking, the problem of finding a maximum or a minimum is identical, since the minimum problem can be converted into the maximum by changing the signs ($/$ or $-$) of the coefficients a_j in (3). The " \leq " symbol is also quite general, since an

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economic formulation which prescribes " \geq " can be converted to " \leq " by changing the signs of the coefficients and of the c_i involved.

Typically, most of the constraints in the form of equations are furnished from a suitable input-output table which, in the application of the technique in countries at an early stage of economic development, may be partly hypothetical, as distinct from actual, e.g. based on engineering data for planned industries. The variables x in this case would be the value of output of the respective industries and some of the constraints (1) would assume the form

$$(4) \quad x_i - \sum_{j=1}^n d_{ij} x_j = F_i, \quad i = 1, 2, \dots, r,$$

where F_i is the final demand (which may be analysed into its constituents) and r the number of industrial sectors. The d_{ij} are the input-output coefficients. There will usually be other equations in the system (1), e.g. capital-output ratios for some or all industries, perhaps in the form of a given value of the ratio of annual capital formation to change in output.

To be realistic the system must contain many variables and constraints; as a matter of fact the mathematical formulation must be a fairly complete conspectus of the planned economy of the country. Of course, the linear programming technique can be applied for special purposes to sections of the economy: it is now fairly widely used at the individual factory or farm level for determining most profitable combinations of activities given certain constraints. For national economic planning it is necessary, however, to take the global view, though simplifications can be made by the omission of variables of lesser importance or by their absorption in larger groups.

The most commonly used technique for the solution of the linear programming problem is termed the Simplex Method, due to G.B. Dantzig.* According to this method, inequalities (2) are converted into equalities by the introduction into the left side of each of an additional non-negative variable so that the system becomes

* "Maximisation of a Linear Function of Variables Subject to Linear Inequalities", Activity Analysis of Production and Allocation, T.C. Koopmans, Editor (1951).

$$(5) \quad x_{n+i} + \sum_{j=1}^n a_{ij} x_j = c_i, \quad i = 1, 2, \dots, m,$$

the new variables being the x_{n+i} , often termed the "slack variables". The system then contains $n+m$ variables constrained by $k+m$ equations (1) and (5). It is easy to show that the final solution will be found to consist in not more than $k+m$ variables with positive values and the remaining $n-k$ (or more) variables zero. The complexity of the problem arises from the necessity of making the selection of variables, for if one knew the identity of the maximising variables in advance, the ascertainment of their actual values would merely be a matter of solving a set of simultaneous equations. One is, however, faced with a choice of a particular set of variables amongst $\binom{n+m}{k+m}$ possible combinations, usually an astronomically large figure. The Simplex technique was designed to make the choice systematically.

This technique consists in starting with any set of $k+m$ variables with positive values (called the "basis"), the remaining $n-k$ being zero. Subject to this condition the actual values are found from the $k+m$ equations (1) and (5). The corresponding value of u is found from (3). In general, this first value will not be the required maximum. According to rules laid down, an exchange is made between one variable in the basis with one outside in such a way as (in general) to increase the value of u . One has then a new basis of $k+m$ variables, on which the procedure is repeated. Ultimately a stage will be reached for which tests that are available will show that the maximum has been attained. Of course, the foregoing account is on the broadest lines with no qualifications as to special situations, for which recourse must be had to the literature.

The volume of calculations required for the Simplex solution of a linear programming model with any pretensions to exhaustiveness is exceedingly large and would be impracticable unless an electronic computer were available. The linear programming approach has just the advantage that it enables a global view to be taken. One can be quite certain that, within the constraints, one has achieved the best solution. With the input-output table alone and with assumptions about development of the different industries it is possible to check for, and to correct for, inconsistencies in such a way as to attain balanced development. The process is essentially one of trial and error;

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however, even when a balanced plan is attained, there is no assurance that it is the best plan, given resources. On the other hand, the trial and error method may be more flexible than that of linear programming by making it possible to attain more than one economic or social objective (good if not the best) and, in the working, throw much light on the detailed evolution of the plan. According to the Simplex procedure, when the problem has been set up more or less in the manner indicated above, the solution is automatic: no special economic significance attaches to the steps from one basis to the next.

As with all planning and forecasting procedures it is easy to point to the weakness and deficiencies of the linear programming approach. As already observed, it postulates a single function of predetermined form to be maximized or minimized whereas the objectives of a plan may be many (and even conflicting), maximum rate of increase in consumption or capital formation, full employment, "equitable" income distribution, "equitable" distribution of capital between economic and social objects and all the rest. It may be quite impossible to formulate many of the objectives of policy in statistical terms though economic considerations alone may lead to the removal of some of the more obvious conflicts in objectives. The single function to be maximized may be made a composite one, weighted in some way, e.g. by economic and social values, but the resulting function will of necessity be somewhat arbitrary and so will the solution. The proponent for linear programming will argue that all desirable objectives cannot be attained simultaneously and that he is prepared to write into his constraints in modified form the prescribed desiderata, e.g. that employment should exceed nine-tenths of the projected labour force, his target function being consumption per capita (to be maximized). Of course, every active constraint introduced diminishes the ultimate target value (if this is a maximum).

Another objection to linear programming in its macro-economic application is the very large number of assumptions involved in its application, in fact all the coefficients etc. of the type specified above. It is, however, a weakness in all systems that so much data must be assumed given in advance. One can only hope that as the actual linear programming solution involves so few variables compared to the amount of data that variations within fairly relaxed

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limits in the latter may not affect the final result too seriously. This, of course, remains to be seen.

In a certain degree the Simplex procedure can be used to control some of the basic assumptions - those in the constraints initially involving inequalities, i.e. as specified by (2) above. In the final solution some of these will be active, i.e. the sign of equality will apply, the corresponding slack variables being zero. It is certain that if the prescribed constants c_1 in the active constraints could be changed in the right direction the target function could be improved; not only this, but the Simplex technique shows by how much. For example, if one of the active constraints is related to maximum permissible imports of steel it may be possible to say that an increase of \$1 in steel would result in \$2 increase in the target function, whereas an increase of \$1 in some other active constraint would increase the function by only \$1/2. It may be practicable to redistribute the constraints so as to improve the target, e.g. in the example by increasing the limit for imports of steel and lessening it in the case of the other constraint at no extra cost to the economy.

As a very interesting recent application of the linear programming technique, reference may be made to the long-term planning model for India constructed by J. Sandee, United Nations Technical Assistance Expert.* In Mr. Sandee's model (the experimental character of which he emphasizes) there are 30 variables, 16 equations and 35 constraint inequalities. The target function is material consumption. The variables, all related to increases between the years 1960 and 1970 at constant prices, include agriculture, large-scale food manufacturing, steel, fertilizer, housing etc. as well as consumption (the target function) C and investment I. Most of the coefficients in 12 of the 16 equations are the coefficients of an Indian input-output table for 1953-54. The four investment variables (heavy equipment, other equipment, construction and increases in stock) are based on capital-output ratios, so that increases in investment categories are linearly related to output. That increase in agricultural output is deemed to be dependent only on fertilizer, irrigation and agricultural instruction furnishes the thirteenth equation. The last three equations express the

* "A Long-term Planning Model for India", prepared for the Government of India by J. Sandee, appointed by the United Nations Technical Assistance Administration (Report No. TAA/IND/22).

condition that there would be no change in the current foreign trade balance between 1960 and 1970, that global increase in investment equals the sum of sector constituents and that increase C in consumption equals the increase in the six commodity groups taken into account.

The first group of inequality constraints relates to foreign trade. Additional imports of steel and equipment are not to exceed one quarter of additional domestic output of the respective products. One very important constraint is $I \leq 0.32C$. Several constraints pertain to the consumption pattern, upper and lower limits being imposed to give this pattern an Engel lock. Lower limits are set on consumption from products of large-scale industry. Finally, limits are imposed on increases in irrigation, fertilizer and agricultural instruction, on grounds of practicability. The computations to obtain the optimum were executed on the electronic computer of the Indian Statistical Institute.

On the assumptions of the model, consumption would rise by more than 60 per cent in the ten years. Output would increase to much the same extent in agriculture, large-scale food manufacturing, steel, transport, large-scale industry, construction and housing. Very much larger percentage increases would be required in heavy engineering, fertilizer, electricity, equipment and agricultural instruction.

There are 14 active constraints, of which 6 relate to foreign trade. Imports of steel and heavy equipment are at their permitted maximum. For the other four commodities, exports are pushed to the limit. Of course investment is at its maximum. Five constraints set a lower limit on consumption. Fertilizer output and agricultural instruction are also at their maximum.

From the 16 original equations together with the 14 equations afforded by the active constraints (in which the slack variables are zero), i.e. 30 linear simultaneous equations in all, the values of the 30 variables were obtained. These are the values which, within the constraints, yield the largest possible increase in consumption. The solution is displayed in the form of a table showing in crores (10 millions) of rupees the increase in output and investment between 1960 and 1970 in 14 sectors, in the form of a partial input-output table.

In Mr. Sandee's view the plan derived from the model is not its most interesting result since "any reasonable model will produce a plan which after

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some adjustments will be more or less acceptable". The strength of a model lies in its ability to show how a plan depends on its assumptions, i.e. how the plan is affected by changes in these assumptions. To this end he inverts the coefficient matrix of the 30 equations yielding the optimum solution. This shows, for example, that the target function (one of the 30 variables)

$$(6) \quad C = 6331 + 0.630d_1 + 0.777d_2 + \dots - 1.625d_{17} - 1.477d_{18} + \dots,$$

where the d's are assumed changes in the constraints of the equations, d_1 pertaining to agriculture, d_2 to large-scale food manufacture, ..., d_{17} to exports less imports of agricultural products, d_{18} to exports less imports of manufactured food, ...

The constraint term 6,331 is, of course, the optimum value of the increased consumption (excluding electricity deemed autonomous at 150 crores) between 1960 and 1970. It may be inferred, for example, that if the economic situation in 1970 were such as to permit a decrease in exports of one crore of manufactured food, the consequential increase in consumption would be 1.477 crores.

The author applies the coefficients in (6) to answer such questions as: would it be to India's advantage to substitute home-manufactured oil (from coal produced in India) for imported oil? Large capital investment would be required. The answer is No, since while the diminution of imports in consequence of the elimination of oil would increase welfare by 11 crores, home manufacture would diminish welfare by 48 crores, a net loss of 37 crores. On the other hand replacement of imported copper by home-produced aluminium would have little or no effect on welfare.

Mr. Sandee is careful to emphasize that the inferences to be drawn from the model are only as reliable as the data on which it is based, though he adds that many of these are the data used in connexion with the National Plans. This reservation applies to all economic development plans. He would probably agree that linear programming is only one approach to national planning. He has found, in fact, that the linear programming optimum is quite close to that found by the planning staff using more elementary methods.