A NOTE ON THE USEFULNESS OF INPUT-OUTPUT ANALYSIS APPLIED TO RESEARCHES OF PRICE MOVEMENTS IN JAPAN

— Reconsideration from a Methodological Viewpoint —[1)]

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1. INTRODUCTION

The present note is devoted to a critical consideration of existing input-output analysis applied to problems of price movements in Japan, as well as bringing out a number of controversial issues concerning the usefulness of the analysis, with a conclusion that it is not always adequate to conduct researches into price movements in capitalistic countries.

Rather than attempting to improve the input-output model, this note discusses the efficacy and limitations of input-output analysis in examination of price movements.

As is well known, Japan is one of countries that are the most advanced in operational use of this analysis. Construction of input-output tables has not only been regularized,[2)] but also input-output analysis has been applied to such fields that include projections of output and employment in individual industrial sectors and to studies of effects of technological changes, to say nothing of extended application of standard input-output analysis to investigations into effects which wages, profits and tax changes have on prices.

Of late years a great attention has been directed to application of this analysis in economic research and in policy making, as shown in economic literature authored by modern and even Marxian economists on the subject. Despite their efforts, however, even the most successful approach looks fairly pedestrian. Nevertheless, some of economists and statisticians continue to overestimate the significance of this analysis. The situation thus calls

1) This note is a slightly modified manuscript of my talk given at Third Hungarian Conference on Input-output Techniques (Héviz, Hungary) on the 4th of November, 1981.

2) The first publication on input-output tables was begun in 1953 for 1951 by the Ministry of International Trade and Industry and by the Economic Planning Agency, interdependently of each other. The latest contribution to the construction of input-output tables is the 1975 table compiled and published by the Japanese Administrative Management Agency. Subsequently, the 1965–1970–1975 link input-output tables were prepared by the same agency.

for reexamination and clarification concerning the role and significance of this analysis in the whole economic system. In this context a critical consideration of this analysis is looked on today as crucial and essential.

The present note is not intended to present a fully comprehensive review of all the practical developments in input-output analysis in recent years. Instead, it only discusses purely methodological issues on the usefulness of input-output analysis in dealing with questions about price movements.

The note is organized as follows:

Section 2 summarizes three views on the usefulness of input-output analysis applied to empirical economic problems, so that such a summary will be helpful in justifying how and to what extent discussions are being made thereof as a recent hot issue in Japan.

Next, Section 3 introduces some results of empirical and practical applications of input-output analysis to researches into price movements in Japan. Meanwhile, particular attention is concentrated on the experience described in the Economic White Paper of fiscal year 1980.

Then, Section 4 indicates some of the weak points of input-output analysis when applied to price movements, confining its examination mainly to a specific point of input coefficients.

Finally, Section 5 presents main concluding remarks, setting forth a view that price analyses using input-output models are not likely to be realistic, whereupon this section provokes a challenge to assumptions underlying the interindustry theory.

2. THREE VIEWS ON THE USEFULNESS OF INPUT-OUTPUT ANALYSIS

Before going into a full discussion of the efficacy of input-output analysis, it may be useful to mention three main views expressed on it out of a variety of views prevailing in Japan.

First of all, most modern economists in the academic world have persistently approved of the definite significance of input-output analysis. It is generally believed that during the past twenty-five years important progress has been made successfully in various areas of input-output analysis and also that in the near future further progress will be made in improving it. They fully approve of the concept by which those holding this first view have done input-output researches.[3)]

3) For example, they are: Hideo NAKANISHI "Input-output Analysis of Oil Prices," *Keizai Hyoron* (March, 1974), Toshiki HIROOKA "On the Market Mechanism and the Stability of the Economic Model of Japanese Economy," *The Journal of Japan Economic Research* No. 10, 1981, and Shozo ICHINO "Inter-industry Analysis of Price Indexes," *Hitotsubashi Daigaku Keizai Kenkyu* Vol. 27, No. 3, 1976.

The second view is represented by some Marxian economists. Combining input-output tables with the Karl Marx's two-sector schemes of extended reproduction some of them offer time-series research in the structure of reproduction and the rate of surplus value, while others carry on approximate calculation of labor value in terms of existing input-output tables. Their researches present the second view that the critical recomposition of input-output tables undoubtedly enriches the quantitative analysis of an actual economy.[4]

The third view is held by economists, who stress that the power of input-output analysis is so often and so much overestimated that one should not forget to offer methodological criticism against its misleading abuses.[5] According to them, another difficulty of it stems from incompleteness of economic statistics. In other words, original economic statistics composing an input-output table are so inaccurate that the entire input-output analysis stands on the extremely weak base. Special care is indispensable in the treatment of statistics because distortion of facts is unavoidable concerning much of statistics derived from private industries which operate under monopolistic or similar conditions. Even governments are not free from compiling false statistics. Under the circumstances, they cast grave doubt on the efficacy of input-output analysis *per se*. Their view contains some ideas worth considering.

The present note fully supports this view, particularly concerning critical comments on how capable input-output analysis is when it is applied to economic problems. This third view is dwelled on in discussion of the theme of this note in the sections that follow.

3. FOUR EXAMPLES OF INPUT-OUTPUT MODELS USED FOR PRICE ANALYSIS

This section refers to several recent results of empirical and practical applications of input-output models to the problem of price movements in Japan.

Japan had attained a high annual rate of economic growth in real terms for over fifteen years since 1955. Its economy went into a structual stagnation, however, in the first half of the 1970's; at the same time inflation

4) Publications by this second group include: Kishio YAMADA "The Statistical Research in the Structure of Reproduction and the Rate of Surplus Value" *Statistics*, No. 8, 1960, Kiyoko IMURA and Isao KITAHARA "Analysis of the Reproduction Structure of Japanese Capitalism" *Mita Journal of Economics*, Vol. 57, No. 12, Vol. 58, No. 7, 9, 10, Vol. 60, No. 5.

5) Masakatsu NAGAYA, "Inter-industry Analysis" in *Criticism to Contemporary Economics* (3), Edited by Kishio YAMADA, Tokyo, 1974.

grew at a high annual rate. Nowadays, most Japanese people are seriously worried about, saying that current inflation in this country is a mostly imported one as a result of increases in prices of raw materials, particularly sharp rises in prices of crude oil and oil products. Japanese industries also express a fear that such rises in prices may drive private fixed investments and personal consumption spendings to decrease and bring about business recession.

The situation has recently induced a number of government and private research groups to carry on empirical studies of price movements in Japan using input-output analysis.

The first example is concerned with Table 1, which provides the numerical results about increases in prices of domestic products and services as a result of the effects of markups in oil prices, which were obtained by drawing on the 1975 input-output table for Japan. As is well known, import prices of crude oil showed a more than fourfold increase in the fall of 1973 and early in 1974. It is obvious from Table 1 that such a unprecedented large increase caused a serious impact on the prices of domestic products and services as a whole.

The second example is given by an input-output analysis of price movements, which was used in the Economic White Paper of fiscal year 1980. A model for it is a specially designed one as a tool for analysis of price movements so that it allows to calculate and analyze the effect which is brought about on final prices by a given change in import prices resulting from the upward pressure of crude oil prices. This White Paper refers to the two input-output tables of both 1970 and 1975.

TABLE 1 EFFECTS OF FOURFOLD INCREASE IN IMPORT PRICES OF CRUDE OIL

1.	Crude Petroleum	1.118	11.	Paint	0.108
2.	Electric Power	0.226	12.	Air Transport	0.104
3.	Basic Industrial Nonpetroleum organic Chemicals	0.202	13.	Synthetic Resin	0.102
4.	Gas	0.167	14.	Other Basic Medicine	0.100
5.	Stone Quarrying	0.165	15.	Glass and Glass Products	0.092
6.	Basic Industrial Inorganic Chemicals	0.159	16.	Synthetic Fiber Yarn	0.084
7.	Cement		17.	Ferroalloy	0.084
8.	Synthetic Fiber	0.132	18.	Other Nonmetallic Mineral Products	0.084
9.	Road Freight Transport	0.110	19.	Whale Fishing	0.083
10.	Ocean Transport	0.108	20.	Chemical Fiber Material	0.082

Source: Ed. by Ken-ichi MIYAZAWA, *Sangyo Renkan Bunseki Nyumon*, 1979, p. 101.

This input-output model is as follows:

$$PD_i = (I - AD')^{-1} \cdot AG'(PG_i - PG_o) + (I - AD')^{-1} \cdot AM'(PM_i - PM_o) + PD_o,$$

where

AD': transposed matrix of input coefficients in the sector of endogenous domestic products (excl. raw materials, nonferrous ores, electricity, and gas),

AG': transposed matrix of input coefficients of exogenous domestic products in the sector of endogenous domestic products,

AM': transposed matrix of input coefficients of imported goods in the sector of endogenous domestic products,

PD_i: wholesale price index of endogenous products at i-th period (matrix),

PD_o: wholesale price index of endogenous domestic products at basic period (matrix),

PG_i: wholesale price index of exogenous domestic products at i-th period (matrix),

PG_o: wholesale price index of exogenous domestic products at basic period (matrix),

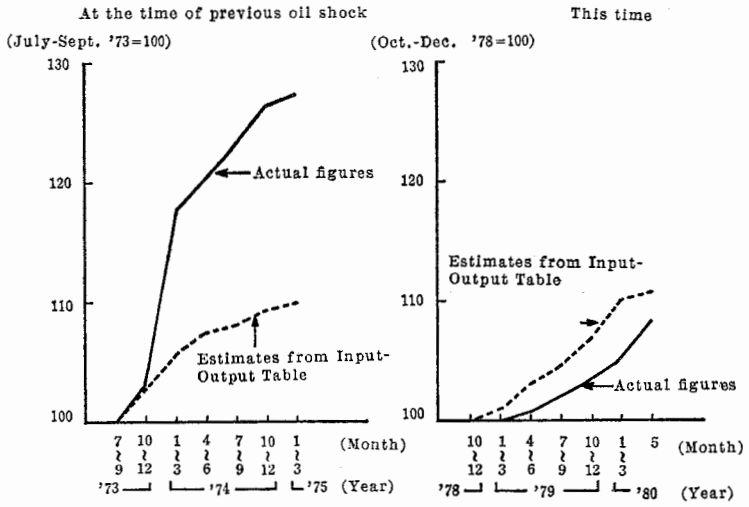
PM_i: wholesale price index of imported goods at i-th period (matrix),

PM_o: wholesale price index of imported goods at basic period (matrix).

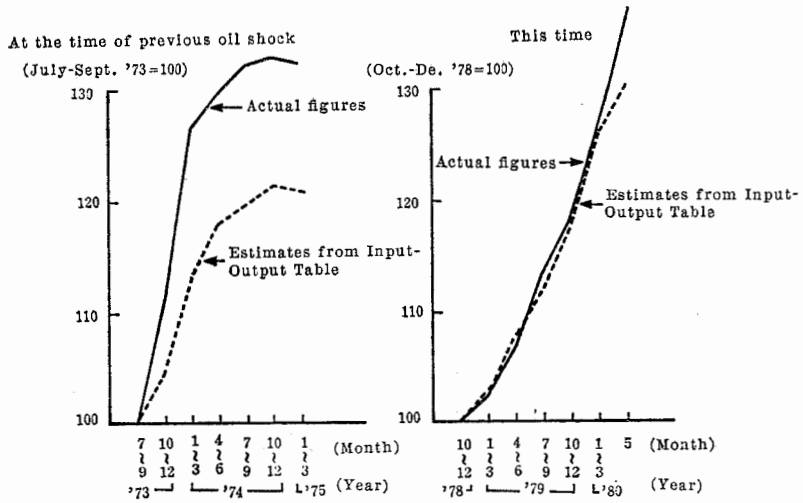
Using this model, the White Paper clarifies a difference in pattern of price increases between the case of the latest oil crisis and the case of the previous one. Then, it is assumed in the White Paper that "(1) the input-output structure and the value added ratio were constant for the years from both 1970 and 1975 onward and, (2) increases in costs were passed on to the prices of manufactured goods without any time lag."

Figure shows that "comparing the actual rate of price increases with the estimated rate of price increases" "in the latest case ..... the actual rate was considerably lower than the calculated rate so long as finished goods were concerned" and "the impact of increased import prices on wholesale prices ... was by far smaller than in the previous case. The White Paper further describes that "an estimation of wholesale prices from the input-output table is made on the assumption that the margin of profit remains the same as in the base period. However, actual corporate earnings continued to increase steadily. Theoretically, profits should not have increased because prices were raised only to offset increases in costs. In reality, however, profits increased."[6]

[6] Japanese Economic Planning Agency, *Economic Survey of Japan* 1979/1980 (English), Tokyo, 1981, pp. 78–81.



1. Wholesale Price Index (Finished Goods)



2. Wholesale Price Index (Intermediate Goods)

Fig. 1. Impact of Price Increase on Wholesale Prices

Source: Japanese Economic Planning Agency, *Economic Survey of Japan 1979/1980*, pp. 80–81.

Needless to say, such an analysis in the Economic White Paper seems useful to understand the price movements in recent years. At first sight, however, the analysis cited above is of some value, but it is limited in application, the main reasons being explained later.

Of course, statistical analysis of price movements by means of the input-

output model has its long history.[7] Since Leontief's input-output analysis of prices was introduced into Japan, one of the most important responses of Japanese economists to price problems has been about how to use this model. Immense efforts have been devoted to the application of input-output analysis to the problems of price movements.

Besides the two foregoing examples in the White Paper, the third example set forth now represents one of other experiences in this field of economic research. That is, Japanese National Railways attempted to calculate to what extent an increase in public railway fares in 1965 had an effect on the whole price system,[8] similar calculations having been carried out by other various kinds of organizations in Japan.

In this connection, Yukio Kaneko presented an other input-output model for the purpose of analyzing price changes.[9] He used a slight modified model of the traditional input-output model for use in price analysis. More strictly speaking, Kaneko's model is marked by some improvements over the latter : first, it is concerned with a readjustment between the endogenous and the exogenous sector ; secondly, it adopts purchasers' price instead of producers' price. On the basis of his model, he criticized JNR for the calculated results, stating that its underestimation of the effect of the increases in public railway fares went too far.

It should be pointed out, however, that there are some limitations of his model in defining the results of input-output price analyses. For instance, although the interindustry theory always emphasizes various intersectoral relations of a national economy, it fails to deal with more important relations coming about through capital movements.

Let us discuss some of the limitations which are inherent in an open Leontief system and stem from its application to price analysis.

4. UNREALITY OF ASSUMPTIONS

The third view mentioned in Section 2 on the usefulness of input-output analysis throws a reasonable doubt on the premise that input-output analysis always plays an outstanding role in studying price movements. In this context, we cannot agree to the idea that one of the most principal aims of the compilation of an input-output table is to make input-output price analysis by utilizing input coefficients and inverse coefficients. The reason is that such a table serves to keep a record of transactions in products between sectors of a national economy, but that it is not adequate

7) W. W. Leontief, *The Structure of American Economy, 1919-1939.* 2nd ed. New York, 1951.

8) Japanese National Railways, *Eigyo Kaihatsu Kiho,* No. 4, 1965 (October 1965).

9) Yukio KANEKO, Unchin Neage no Bukka eno Eikyo, *Keizai Hyoron* (February 1966).

to show the mechanism of price formation. In a word, the table reflects only a circulation of the social output produced in the course of the year.

Setting aside this question concerning the input-output table in this section, we shall consider the fundamental natures of an input-output analysis applied to studies of price movements.

As is well known, the standard input-output model is formulated by the following famous equation:

$$\begin{aligned} X &= AX + Y \\ Y &= (I - A)^{-1} X \end{aligned} \qquad (1)$$

where X: gross output,
Y: final demand,
A: matrix of input coefficients,
I: identity matrix.

For statistical and computational convenience, this production function is assumed to be unique and linear over a given range of outputs.

In a similar way it is possible to indicate the original input-output price model as follows:

$$P = \left[(I - A)^{-1}\right]' V \qquad (2)$$

where P: prices,
V: value added.

Thus, once an input-output model is given in physical terms, prices are determined independently of the physical system.

Let us consider this equation somewhat in more detail.

Suppose here that there is a simple economy consisting of two sectors, that is, agriculture and manufacturing. This example of an input-output table is depicted in Table 2. For simplicity, the table is constructed in the form of the open input-output model.

TABLE 2 INPUT-OUTPUT TABLE FOR PRICE ANALYSIS

	Input Coefficient		
	A Agriculture	B Manufacturing	Price
A Agriculture	a_{11}	a_{12}	P_1
B Manufacturing	a_{21}	a_{22}	P_2
Value added	V_1	V_2	

The symbols entered in columns of the table describe the input structure of each sector. In other words, the role of each sector as a purchaser of inputs is shown by columns A and B. In this case, the agricultural sector is assumed to require a_{11} units of agricultural inputs, a_{21} units of manufactured inputs, and V_1 units of value added to produce one unit of agricultural output. On the other hand, the manufacturing sector needs a_{12} units of agricultural product, a_{22} units of manufactured product and V_2 units of value added to make one unit of manufactured output. Further, if we assume the price per unit of manufactured product as P_1, the price per unit of agricultural product as P_2, the total production of each sector to produce one unit of output is equal to

$$\begin{aligned} P_1 &= a_{11}P_1 + a_{21}P_2 + V_1 \\ P_2 &= a_{12}P_1 + a_{22}P_2 + V_2 \end{aligned} \tag{3}$$

Then, we obtain from (3)

$$\begin{aligned} (1-a_{11})P_1 - a_{21}P_2 &= V_1 \\ -a_{12}P_1 + (1-a_{22})P_2 &= V_2 \end{aligned} \tag{4}$$

These equations state that the price of any product is equal to the value of the raw materials required from other sectors to produce it plus the amount of labor used directly per unit of output. Then value added essentially represents payments made to the exogeneous sectors, such as wages, profits, interests, payments made to government, and imports.

It should be noted here that interindustry relationships are explained by algebraic equations of the first degree in their variables.

The above two linear equations with two unknowns can obviously be solved for P_1 and P_2 in terms of given V_1 and V_2. The solution of the price equations is;

$$\begin{aligned} P_1 &= \frac{1-a_{22}}{(1-a_{11})(1-a_{22})-a_{21}a_{12}}V_1 + \frac{a_{21}}{(1-a_{11})(1-a_{22})-a_{21}a_{12}}V_2 \\ P_2 &= \frac{a_{12}}{(1-a_{11})(1-a_{22})-a_{21}a_{12}}V_1 + \frac{1-a_{11}}{(1-a_{11})(1-a_{22})-a_{22}a_{12}}V_2 \end{aligned} \tag{5}$$

The solution determined the prices of the products from the given values added in each sector.

Meanwhile, according to an idea of linear programming, if an input-output system in a physical term is regarded as a primal problem, then an input-output system in a money term is defined as its dual problem. There is a one-to-one correspondence between the former and the latter. Under the condition of this premise, if one wants to understand the nature of an input-output model as applied to problems of price movements, it is

better to concentrate on the weak points of input-output analysis in general use.

The reason that the input-output model for price analysis is not necessarily realistic stems from some assumptions made by the nature of input-output analysis. Now, in what follows, let us briefly review these assumptions generated from the nature of input-output analysis. In order to clarify the point at issue, we confine our attention mainly to the problem about plausibility of a fixed input coefficient.

To begin with, as is well known, the standard input-output model is constructed on the basis of a fundamental assumption of the fixed input coefficient. An intensive controversy about input-output analysis has arisen over the assumption of the constant input coefficient. Despite a large volume of researches on an assumption of the fixed coefficient, the question 〈Are input-output coefficients stable?〉 still remains at a theoretical level. Discussions on this subject appear regularly in monographs or on programs of conferences.

According to a brief summary by H. B. Chenery and P. G. Clark, economic meanings of the assumption are as follows:

(1) A given product is only supplied by one sector;

(2) There are no joint products;

(3) The quantity of each input used in production by any sector is determined entirely by the level of output of that sector.[10]

The assumption that all the inputs vary proportionally with all the outputs is evidently a simplification of reality. Because the relationships between phenomena observed are taken as linear, unique, constant, and essentially static. For these reasons it can be said that the main weakness of input-output analysis lies in a distinct gap between its central assumption and reality. Economic reality is continually changing and showing a varying rate of development. It should not be overlooked also that technical advances and changes in the structure of products within individual sectors alter technical coefficients. If we try to take a long period of time, the fixed input coefficient must lose its economic meaning. As a result, recently, even modern economists regard this assumption as, at best, only an approximation to the complex production functions of the real world.

The next criticism is concerned with the calculation which is made with the aid of the inverse matrix. The economics of the matrix can express the aggregate value of products from all sectors used for the production of the one unit value of a certain product. Namely, this interpretation can be accepted only with the following assumptions. The average cost structure of the aggregate of products of a certain sector, used in another sector,

10) H. B. Chenery and P. G. Clark, *Interindustry Economics*, London, 1968.

corresponds to the average cost structure of the total aggregate of products of the releasing sector.

Now, with the help of the matrix, we can calculate the final cost structure of each production sector. This procedure, however, is a purely formal, mathematical process. In concrete application of input-output analysis, several problems arise with the procedure.

First, it should be remembered that the basic question is how to exogenously plan value added. In this respect there is no hope that is offered by on input-output model. From the economic point of view, it is wrong to postulate that value added is given exogenously in advance. Secondly, a recursive approximation, which traces through the inverse matrix the direct and the indirect requirement of value added, is not always reasonable. Elegant as the method of recursive approximation may look mathematically, it is not likely to be realistic. Indeed, once the input-output inverse matrix has been calculated, the following calculations can only be performed by a computer irrelevantly to the process of a real economy. This is also evidently a simplification of a reality. As a matter of fact, price changes calculated by an input-output analysis do not always correspond to actual price changes. An important source of a discrepancy between the calculated and the actual prices is mainly a discontinuity in price changes, particularly public transport fares, monopoly prices and etc.

As a whole, strictly speaking, input-output analysis fails to reflect an economic reality. It must be borne in mind that these weak points, which are an inherent limitation of the input-output model for the determination of real output of each sector, can also be applied to the input-output price model. As already mentioned, the input-output analysis used in the White Paper of fiscal year 1980 assumes that the input coefficient is constant and that 100 percent of the cost rise is passed on to prices without a time lag. In this respect exactly the same criticism described above can be applied to the case of the White Paper. As a result the price analysis in the Paper remains only a superficial one about actual price phenomena.

Moreover, it is widely agreed that there are some other difficulties which derive from the very nature of price determination by input-output analysis.

A rough list of these difficulties is given below because the present note is too short in space to allow a description of them in detail.

Firstly, in the input-output analysis prices are determined as a markup on costs of production, because the price of each product produced can be expressed in terms of the costs of the primary inputs required in its production. For this reason, prices of outputs are assumed to be always based on their costs of production. Considering the actual complex price phenom-

ena in their complex in a modern capitalistic economy, the assumption is too one-sided. For instance, more important factors, such as monopoly prices and moment of demand-pull, are ignored in the analysis.

Secondly, value added should be determined endogenously in the model. However, in a traditional framework it is determined exogenously. To give an example, Leontief's model assumes that given wages rise uniformly throughout the national economy, and that each sector raises the price of its product accurately by the amount of increase in its labor costs plus the amount of increase in its input costs from other sectors.

Thirdly, input-output analysis of price is limited to determining the relative changes among prices of products. The results of the calculation are not regarded as process proportionate to values because total input factors do not always reflect socially necessary labor and the ratios of the value added are not necessarily equal to those of the values. It should be remembered that phenomena in the price system depend on the relations expressed in terms of value.

With all these reasons taken into consideration, it has been insisted that this kind of price analysis is far from an adequate way of resolving an actual price problem.

Price analysis by means of an input-output model does not seem to constitute well-founded economic research. The attempt in the Economic White Paper is but one of the possible, not necessarily the best approach to price analysis.

5. CONCLUSION

An attempt has been made in this note to put forward a number of controversial issues concerning the application of input-output models to economic analysis, the major points discussed having been concerned with problems of price movements.

It is undeniable that input-output analysis has been well developed both in theory and practice concerning national economic analysis in this country. Obviously, however, it continues to involve much difficulties. Moreover, generally speaking, input-output models seem to have had no prominent practical significance. Such a result and their shortcomings come about often from the inherent properties of the models.

This conclusion suggests that at the present time the chief value of Leontief's input-output analysis consists only in providing a tentative calculation useful for an initial empirical investigation into a field representing interindustry economic relations; in other words, it is important to warn users of input-output models that from the nature of the models the way things go is not so simple as allows a good grasp.