

The Semi-Input-Output Method: A Comment and An Extension

by

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The semi-input-output method, as presented by Tinbergen [1], is designed solely for the evaluation of investment projects. It tells us, given the criterion used, which sectors or industries should get priority in a development plan. The method does not tell us to what extent the production of an attractive industry should be increased. To solve this problem we need a planning model. The main aim of the present note is to show the possibility of formulating a planning model based on the semi-input-output method. As such, the present paper should be considered as an extension of the article by Tinbergen.

Before coming to our main subject however, I would like to make two comments on the paper by Tinbergen [1].

The first comment has to do with the treatment of additional consumption of national products. In Tinbergen's system the necessary change in volume of production of a national sector (v^h) is equal to the sum of interindustry deliveries to the international sector under consideration and to all national sectors, the change in consumption of the product or service produced in sector v^h and the change in investments taking the form of good h .

The reason behind the inclusion of the change in consumption of the national product h is not given. Most probably, however, the idea behind it is that an increase of income due to the expansion of production leads to an increase of consumer demand for all products, including national products. As national products by nature cannot be imported, the increased demand will have to be met from domestic production. As we have to include all indirect effects which are unavoidable we should include this change in consumer demand in our equations. Although this type of argument seems very reasonable at first sight, I would like to argue that the change in consumption of national goods should not enter the equation system. The reason for not including the change in consumer goods can best be illustrated in the following way:

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Suppose that the development plan aims at increasing the national income by x per cent. The semi-input-output method will then be applied in order to find those sectors where investment is most attractive. Now, the increase of consumer demand for all goods, including national goods and services, is determined by the increase in income, which is already fixed by the development plan, and the marginal propensities to spend. In other words, whether the income target is reached by a change in the production of automobiles or cotton textiles, it does not affect the increase of consumer demand for national goods and services. Therefore, the consumer demand elements should not be included in the equation system.

Of course, this does not imply that no attention should be paid to the increase in consumer demand for national goods and services. This is however a problem to be solved in a programming model and should not be included in the appraisal of investment projects.

My second remark refers to the treatment of investment. No doubt the changes in investment demand for national goods should be taken into account if the commodity composition of the needed investment depends on the industry in destination. However I am not so sure that this should be done as mentioned in Solution A. There Tinbergen adds those investments originating in national industries needed in order to realise the bunch of investment projects and subtracts all investments originating in national industries in period 0. This would be correct if only one international sector is to be chosen. If more than one international sector is chosen for investment however, it may be expected that the new investments necessary to realise one bunch of investment projects will be smaller than the total investments originating in national industries in period 0. In that case all bunches will show a negative change in investments, despite the fact that total investment originating in national sectors in period 1 will be equal or higher than in period 0.

For that reason I feel that Solution A is not correct. I would like to point out however that I am unable to suggest improvements. Here we have to do with a rather intricate problem, the solution of which might become very cumbersome.

A Semi-Input-Output Programming Model

As a rule the drawing-up of a development plan starts with a simple aggregate model. In order to illustrate the possibilities of a programming model we shall assume the simplest version of a macro model. This is done only for simplicity's sake. Other macro models could be used without impairing the working of the method.

Our simple aggregate model has one target: a fixed increase of national income, and only one instrument: investment. The necessary amount of investment can be found by multiplying the planned increase of national income by the overall capital coefficient. This necessary volume of investments should be equal to the estimated availability of funds for investment purposes. If this is not the case we have to revise the income target.

The next stage in the planning procedure is the sector stage. What we have to do now is to divide the investment funds in an optimal way over the sectors of the economy. Here we should use the semi-input-output method in order to determine the attractiveness of sectors producing international goods.

Assuming that the commodity composition of investment is independent of the industry of destination, we get the following equations determining the change of production of the national industries.

$$\left. \begin{aligned} v^7 &= a^{7h}v^h + a^{77}v^7 + a^{78}v^8 + a^{79}v^9 \\ v^8 &= a^{8h}v^h + a^{87}v^7 + a^{88}v^8 + a^{89}v^9 \\ v^9 &= a^{9h}v^h + a^{97}v^7 + a^{98}v^8 + a^{99}v^9 \end{aligned} \right\} \dots\dots\dots(1)$$

It will be noted that equations (1) do not show the changes in consumer demand for national goods and services. The reason for this is explained above.

Adding to this the definition of the change in income for sector h:

$$y^h = (1 - a^{1h} - a^{2h} - a^{3h} - \dots - a^{9h}) v^h \dots\dots\dots(2)$$

we can with the capital coefficients per industry find the composite capital coefficient for each bunch. Calculating this for all possible bunches (6 in this case) we can rank the international sectors according to relative attractiveness.

Now, if the only limit to the extension of production was the availability of investment funds, the planning model could be solved very easily.

After allowing for the changes in final demand for national goods and services, all investment could take place in the most attractive bunch. The international sector in the bunch would produce mainly for export demand and the goods and services originating in other international sectors would be imported. This, however, is not a very realistic situation, as it would imply the possibility to export an unlimited amount of a product without change in price. Therefore, more than one bunch will have to be chosen.

This makes necessary an estimation of the upper level to which the international sectors can be extended. The maximum amount with which the production for final demand can be increased can be expressed as:

$$f_p^h = c^h + e_p^h + j^h + m_o^h \dots \dots \dots (3)$$

Here the symbols with a lower index p indicate possible changes.

f_p^h = the possible change of production for final demand

c^h = the change in consumption of commodity h

e_p^h = the possible change in exports of commodity h

j^h = the change of demand for investment goods originating in sector h

m_o^h = the amount of imports of commodity h in period 0.

The change in consumption depends on the change in income

$$c^h = q^h y \dots \dots \dots (4)$$

e_p^h is determined outside the model. m_o^h is predetermined.

$$j^h = \bar{j}_1^h - \bar{j}_0^h \dots \dots \dots (5)$$

where the lower indices refer to time and the bars indicate absolute values.

\bar{j}_0^h is given. \bar{j}_1^h is defined in equation (6).

$$\bar{j}_1^h = \sum_h j^{hh} v^h \dots \dots \dots (6)$$

Denoting the possible increase of production of commodity h for inter-industry demand by a_p^h we get:

$$a_p^h = \sum_h a^{hh} v^h \dots \dots \dots (7)$$

The total possible increase of production (v_p^h) is the sum of equations (3) and (7):

$$v_p^h = a_p^h + f_p^h = \sum_h a^{hh} v^h + c^h + e_p^h + j^h + m_o^h \dots \dots \dots (8)$$

Finally we know that for the national industries:

$$v^h = v_p^h \dots \dots \dots (9)$$

and for the international industries:

$$v^h \leq v_p^h \dots \dots \dots (10)$$

With this set of equations we can calculate the optimal allocation of investment projects. This is essentially a process of successive approximation as the

terms at the righthand side of equations (6) and (7) are dependent on increases of gross production, which still have to be determined.

First we look at the national sectors 7, 8 and 9. The increases of consumption of these sectors have to be produced domestically.

In equations 1:

$$v^7 = c^7 + a^{77}v^7 + a^{78}v^8 + a^{79}v^9$$

$$v^8 = c^8 + a^{87}v^7 + a^{88}v^8 + a^{89}v^9$$

$$v^9 = c^9 + a^{97}v^7 + a^{98}v^8 + a^{99}v^9$$

c^7 , c^8 and c^9 are determined by equation (4). Therefore, we can solve these equations for v^7 , v^8 and v^9 . With the aid of equation (2) we can determine the income created in sectors 7, 8 and 9. Multiplying these income increases with the sectoral capital coefficients we obtain the investments necessary to realise c^7 , c^8 and c^9 .

It will be noted that the equations do not have a term for the increase of demand for investment goods. The reason for this is that it is not clear in this first step, whether there is an increase of investment demand for the products of the sectors under consideration. This we can only find out at a later stage. Once we know that there is an increased demand for investment purposes we should take this into account as well.

The next step is to increase the production of that international sector which is most attractive. Let this be sector 2. We know from equation (8) that the maximum value of v^2 is equal to:

$$v_p^2 = \sum_{h'} a^{2h'} v^{h'} + c^2 + e_p^2 + j^2 + m_0^2$$

of which e_p^2 and m_0^2 are given, and c^2 is determined by equation (4). For the reasons given above j^2 can only be determined at a larger stage. As we do not know as yet the values of $v^{h'}$ we cannot determine the value of $\sum_{h'} a^{2h'} v^{h'}$.

Therefore we have to determine this value in several steps.

The production increases of national sectors as determined in the first step require inputs from sector 2. As the v 's of the first step are known we can calculate how much input from sector 2 is required for the first step. Let us call this s^2 . We further know that the expansion of sector 2 requires additional production in the national sectors. Therefore, the provisional maximum value of v^2 can be determined by solving the following equation system:

In equations II:

$$\begin{aligned}
 v^2 &= c^2 + e_p^2 + m_o^2 + s^2 + a^{22}v^2 + a^{27}v^7 + a^{28}v^8 + a^{29}v^9 \\
 v^7 &= a^{72}v^2 + a^{77}v^7 + a^{78}v^8 + a^{79}v^9 \\
 v^8 &= a^{82}v^2 + a^{87}v^7 + a^{88}v^8 + a^{89}v^9 \\
 v^9 &= a^{92}v^2 + a^{97}v^7 + a^{98}v^8 + a^{99}v^9
 \end{aligned}$$

We now have four equations with four unknowns. In the same way as in step I we can determine the income created and investment needed.

The third step is to increase the production of the second most attractive international sector to the maximum. Let this be sector 5.

The procedure is essentially the same as in step II. There are, however, two differences:

- 1) We have to allow for the interindustry demand for products of sector 5 in step I as well as in step II.
- 2) In this third step additional interindustry demand for the products of sector 2 will be created. As sector 2 is more attractive than sector 5 we should take this increased demand into account.

In equations III:

$$\begin{aligned}
 v^2 &= a^{22}v^2 + a^{25}v^5 + a^{27}v^7 + a^{28}v^8 + a^{29}v^9 \\
 v^5 &= c^5 + e_p^5 + m_o^5 + s^5 + a^{52}v^2 + a^{55}v^5 + a^{57}v^7 + a^{58}v^8 + a^{59}v^9 \\
 v^7 &= a^{72}v^2 + a^{75}v^5 + a^{77}v^7 + a^{78}v^8 + a^{79}v^9 \\
 v^8 &= a^{82}v^2 + a^{85}v^5 + a^{87}v^7 + a^{88}v^8 + a^{89}v^9 \\
 v^9 &= a^{92}v^2 + a^{95}v^5 + a^{97}v^7 + a^{98}v^8 + a^{99}v^9
 \end{aligned}$$

The y's and the investments are found in the same way as before.

In successive steps the same procedure should be carried out. At the moment it becomes clear that $j^h > 0$ we should take this into account as well. This should not be difficult as j^h can be treated in the same way as other components of final demand. We should continue our exercise until the income target is reached and/or the available volume of investment is used up. If the income target is reached before the investment restriction is reached, our target was too low. If the investment restriction is reached first, our target was too high. In both cases the targets should be revised and the exercise should be repeated until the income target and

the investment restriction are reached simultaneously. We then have determined the optimal way to reach the income target.

By adding up the v 's created in the successive steps we find the total increase of production per sector. In the same way we can calculate the total production for intermediate use as well as for final demand per sector. Deducting from final demand the changes in consumption and investment we find the changes in export per sector.

The programming model developed above should be considered as an alternative to a linear programming model. One of the advantages of the semi-input-output model is that it is easier to understand than the more conventional models. Therefore it will be easier to convince the policy-makers of the correctness of the sectoral production targets.

The amount of calculation work involved depends on the interdependency of the economy. Exercises going on at this moment with the aid of the Tims/Stern input-output table (54 sectors) suggest that the model can easily be solved with a desk-calculator. For some countries it might however be more economical to use a computer.

REFERENCE

1. Tinbergen J., "Some Refinements of the Semi-Input-Output Method" in this issue of the *Pakistan Development Review*.