SCHRIFTEN DER GESELLSCHAFT FÜR WIRTSCHAFTS- UND SOZIALWISSENSCHAFTEN DES LANDBAUES E.V.

Boussard, J. M.: Induced effects of projects, theory and practice: the case of irrigation policy in France. In: Buchholz, H.E., Neander, E., Schrader, H.: Technischer Fortschritt in der Landwirtschaft – Tendenzen, Auswirkungen, Beeinflussung. Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues e.V., Band 26, Münster-Hiltrup: Landwirtschaftsverlag (1990), S. 103-110.

INDUCED EFFECTS OF PROJECTS, THEORY AND PRACTICE: THE CASE OF IRRIGATION POLICY IN FRANCE

von

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The economic appraisal of an irrigation project can be tackled from two different points of view. First, as an investment,it increases the stock of capital goods in the economy. As such, it is justified if the opportunity cost of capital is lower than the social benefit which it brings about - whatever the precise meaning of "opportunity cost of capital" or of "social benefit", two very controversial words. But, second, an irrigation project is also a technical progress, which modifies input output coefficients. In that context, it can be evaluated as a technical change, in a general equilibrium framework, by comparing the two situations ("with" and "without") of the whole economy.

Of course, the two points of view are closely related. Especially, the shadow pricing theory provides a bridge between the two. It can be shown that, under reasonable assumptions, shadow prices are related to the dual solution of a mathematical programming model of the whole economy (CHERVEL, 1971). In addition, separability theorems (cf BESSIERE and SAUTER, 1968) show that shadow prices provide a way of designing a project in a purely microeconomic setting, just as if it were the result of a macroeconomic optimization. Since, in general, project evaluators are also project designers, it is not surprising that they prefer the more practical shadow price approach. But things are different from the point of view of a government, which is not directly involved in design, and which may have to finance a large number of small projects. In such a context, the aggregate project may be so big as to make unjustified the shadow price invariance assumption. In addition, one may be interested in other considerations, such as the redistributive effects of projets, or their impact on macro economic variables, such as rates of exchange or wages. Then, a full general equilibrium model is needed. It is the purpose of this paper to present an attempt along that line.

Before entering into the thrust of this paper, let us point out a peculiarity of technical progress in agriculture, tied with the low clasticity of demand for agricultural products.A parable will serve to introduce the main idea. Imagine a primitive tribe, insulated from the rest of the world, and so poor that agriculture is the only consumption good. Suppose that, by a sudden and unexpected gift of God, all technical coefficients are divided by two, in such a way that productivity and incomes are doubled. According to Engel's law, the aggregate demand for food increases, but is not multiplied by two. An excess of agricultural commodities will therefore take place. At the same time, a demand for non agricultural goods is not satisfied. In this context, dramatic structural changes must occur in this economy. Either non food production activities are to be put in action, or foreign links must be established, in order to exchange excess quantities of food against industrial commodities, or both. If none of these possibilities is open, then the technical change is useless, and cannot have any impact of the tribe 's welfare, except, perhaps, by providing unwanted leisure time.

This story is at the point of departure of many studies in development economics, beginning with Arthur LEWIS (1954), and continued with JORGENSON (1967), LELE and MELLOR (1981) and many others. It has been first envisaged as the core of intersectoral equilibrium and capital accumulation theories. But it goes beyond that, by showing that technical change in agriculture does not generate its own demand. Therefore, agricultural progress is necessarily associated with a reorganization of the entire economy. It is another purpose of this paper to investigate available means of studying such changes.

I - Alternative models of national economies.

Thus we are seeking a model which must reflect general equilibrium considerations, and describe how is production distributed and consumed or saved. It must allow for technical choices, since a project is basically a technical innovation. It must be multisectoral, in order to show the interactions between agriculture and other sectors. It should be dynamic, although using properly discounted values makes this necessity less stringent.

Computable General Equilibrium Models (CGEM's) represent a possibility in this respect[1]. They are derived from Social Account Matrices (SAM's). A SAM is a generalized Leontieff table, the entries of which are not only the various productive sectors (as in an interindustry table), but also the factors which distribute added value among various categories of institutions, as well as these institutions themselves (which can buy comodities for consumption or saving).

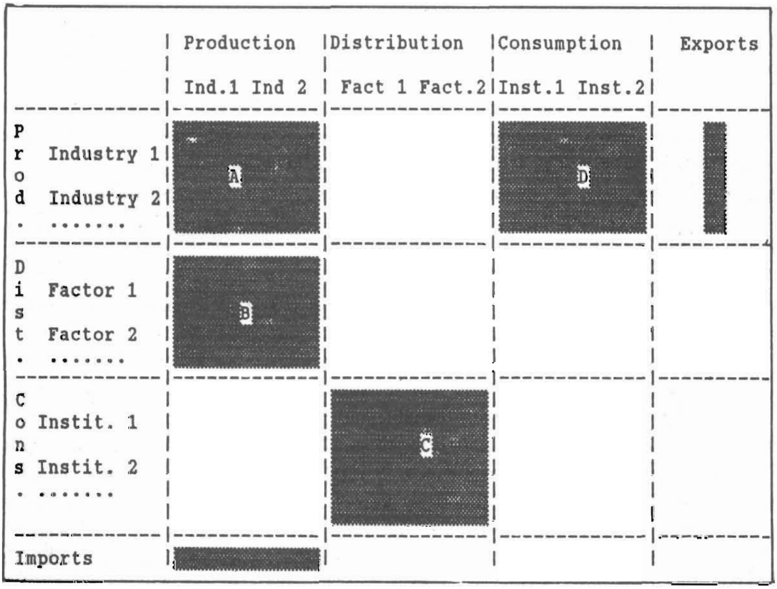
Therefore, the general layout of a SAM resemble the table of figure 1, where the matrix A is an ordinary input output interindustry table, whereas matrix B shows how is value added distributed across factors, matrix C how does income accrue to institutions,and matrix D how are institutional incomes spent over commodities[2]. Imports and exports close the accounts, in such a way that the sum of each row accross columns equals the sum of the corresponding column accross rows.

T being the original SAM ,a matrix H can be derived from T by dividing each column by its across rows total. H is then a technical coefficient matrix, expressed in \$ per \$. H itself can be converted into a true technical matrix Q, in "tons per tons", by dividing each cell by the corresponding row and column prices. Formally:

(1) $$Q = P^{-1}HP^{-1},$$

1) The initiator of this type of model, after Leontieff, is certainly JOHANSSEN (1960). Many books of the 80's deal with related matters, especially WAELBROECK ans GINSBURGH (1985).
2) Description of SAM's, and guidelines to built them can be found in PYATT and ROE (1977), as in many other publications, especially from the World Bank (cf PYATT and ROUND, 1985).

Figure 1: Typical layout of a SAM



where P represents the diagonal matrix coresponding to the price vector P,and Z the vector of activity levels. Z and P are related to Q by : (4)

(2) $(I-Q)\ Z = Z$, and $(I-Q')P=P$.

Since Q is square, this provides 2^n equations for 2^n unknowns. But this is not sufficient to fully determine P and Z, because, by the very construction of Q, the matrix (I-Q) is singular. Therefore, the system has to be closed by additional equations. Discussions about the correct way of doing it are not going to an end, despite the well established fact that the choice of a "closing rule" is determinant for the outcome of this type of model[3].

Three kinds of possibilities exist in this respect:

1°)Make matrix Q price dependant,throught the use of production or of consumption functions (This is especially the case for the submatrices of Q corresponding to matrices A,B, and D in figure 1).Thus:

(3) $Q=F(P)$

3) cf BELL (1979), TAYLOR and LYSY (1979), or RATTS (1982).

2°)Defining import supply and export demand functions,as well as a rate of exchange between domestic and international prices P and P_w.Then:

(4) $X=G_x(P'_w-P)$, and: $M=G_m(P_W -P)$

where X and M are exports and imports,respectively, whereas G_x and G_m are the corresponding supply and demand functions[4]. The rate of exchange is then determined throught money supply. The latter is the difference between export and import values, which impiges on prices throught an analogue to the famous Fisher equation:

(5) $PZ=KP'(X-M)+e_0$

where e_0 represents an exogenous money creation,and K a constant (tied with the "velocity of money").

3°) Defining factors adjustment rules. For instance in a "neoclassical" setting, it will be assumed that the price of labour is variable,and the labour quantity fixed. Then, the equilibrium will determine the labour price in such a way as to make all available labour fully employed. But it may be contended that this is not actually the way the labour market is cleared in developped countries. Rather,the domestic price of labour is fixed by arrangements between governments and unions,so that the market is cleared by leaving a certain portion of the labour force unemployed. In that case, a "Keynesian" closure will produce quite different results.

Introducing such considerations into models sligthly complicate them, without really removing the superb simplicity of equations (2). Of course,the model is no more linear. But since we are not interested in computing the general equilibrium from scratch, but, rather, to examine the behaviour of the solution in the vicinity of an existing equilibrium, it is always possible to linearize the problem by taking the first derivatives of all equations, and solving for differentials by a simple matrix inversion.

To some extent, models of this kind[5] can be considered as proxies for the general planning model of the economy alluded to above. They are not dynamic, and this is a serious drawback. But it is possible to give them a dynamic flavour, by solving them recursively, the capital available at period t being deduced from capital of period t-1, increased by net saving[6]. On the other hand, if the social utility function is defined as the maximisation of the sums of consumers and producers surpluses[7], the two models are basically identical, but for "details", such as aggregation levels, or closing rules. Unfortunately, these details are important, and are the subject of many discussions among

4) Alternatively, it is also possible to define X and M as different commodities, with a possible substitution to domestic commodities in production or in consumption. This increases the size of matrices to be inverted.
5) A full description of the model reported here can be found in BOUSSARD et al. (1985).
6) No attempt in this direction has been made for the present study. But the idea has been used in another context, cf BOUSSARD (1987).
7) That is, if it is assumed that the governmental's goal is to make the economy closer to the pattern which would theoretically emerge in an ideal free market situation.

general economists. Without trying to summarize them, let us now report an application to irrigation policy in France.

II - Application

A - French irrigation into the CGEM

Irrigation policy in France is an outstanding example of governmental intervention into the definition of agricultural input/output relationships. The question arises, therefore, of the effects of these interventions on the general french economy.

In order to give it an answer ,a 33*33 Social Account Matrix (Called T hereafter) was built up for each of the 11 years (1970-1980) of the study, at the national level,using data from the regularly issued 15*15 interindustry table of the french national accounts, and additional information from various sources. Then, the ex post primary effects of the "French Irrigation Project" (FIP) were determined. The FIP is the aggregate of all known subsidized irrigation projects between 1960 and 1980. In fact, only a sample of these projects was selected, from the files of local representatives of the Ministry of Agriculture. For each of the selected projects, investment costs were computed from records, and broken down in categories comformable with the headings of table T. Similarly, local experts were requested to indicate what would have been the agricultural evolution of commanded areas in the absence of irrigation, thus permitting the preparation of classical "with/without" tables. The latters were also tailored in order to fit the table T pattern. They were added year by year to the investment tables. This is discussable, because this means that the benefits of one project will serve to pay for the costs of another. But it makes sens at the national policy level. At the end of the process, a set of 11 dT^* tables, entirely superposable with the corresponding T, were available[8].

The next step was to compute, for each year, the FIP induced changes in national accounts. This was done using the following equation:

(6)
$$(Q+dQ_C)\left[Z+dZ-dZ^*\right]+p^{-1}dT^*=(Q+dQ)(Z+dZ)$$

where:

-Q is the already defined input output coefficient matrix.dQ is the total response to the exogenous change dT^*.Q_C is the induced response only, that is, the total change in Q, less the exogenous change dT^*/T.

-dT^* is the exogenous transaction matrix already defined.

-dZ^* is the diagonalized exogenous change in activity levels ascribable to the project (that is, the output of project).

8) These tables are "small changes" to table T: this is the reason for why they are considered as differentials. Moreover, they are exogenous: hence the star.

-Z and P are the diagonal matrices deducted from the activity and price vectors respectively. dZ and dP are the corresponding differentials.

This equation simply states that the total change in every cells of T is the sum of an exogenous and of an endogenous change. After suitable transformations, (and taking account of other relations, such as (4), (5), and 6)), it can be cast under the standard form of a system of linear equations in dQ,dZ,and dP.

B Results

The direct effects of irrigation in France, as derived from the projects sample, consist in investment costs which growth from 484 million constant 1890 Francs in 1971 up to 8838 million Francs in 1980. The benefits are of the same order of magnitude, so that the overal benefit cost ratio is always near 1, although it may vary considerably (from 0.5 to 2) from one project to another.

The "central" run of the model suggests that irrigation develops large and, in general, highly beneficial effects: By decreasing costs of production, it lowers agricultural prices, even more nominal wages, and retail prices, through the transmission of induced effects. As a consequence, the rate of exchange is improved, and the situation of non irrigating farmers worsened. But the households real income increases,as well as real saving. Agricultural exports decrease, and non agricultural exports increases, because the fall in agricultural prices is less than, and the fall in non agricultural prices is greater than, the appreciation of the domestic currency.

There results were obtained using "favorable" values for the most difficult to evaluate parameters of the model. It was assumed that the foreign demand was elastic enough for that increased quantities could be absorbed by international markets without significant price changes. It was also assumed that the elasticities of substitution of the CES functional forms which represented production possibilities were relatively high (O.5., that is something between 1, which corresponds to the Cobb Douglas production fonction, and which is definitely too large, and 0, which corresponds to fixed coefficients,and which is certainly too small).

But under "bad" conditions, with zero foreign demand elasticity, and zero substitutability in the economy,almost the opposite is true. Then, retail prices and nominal wages increase, as well as agricultural prices. The rate of exchange is deteriorating. Employment and households incomes fall. Ironically, agricultural production increases, because the fall in the rate of exchange prevents importing agricultural commodities from the outside.

By contrast, other runs of the model do not support the ideas according to which results could be sensitive to parameters such as the velocity of money,or the mode of project financing (either throught tax increases[9]),or by mere money creation). Similarly,the level

9) Tax increases can be accomodated for in this model if one of the institutions is the "government", the resources of which depend upon specific "technical coefficients" representing in fact taxations rules.

of agregation (The model was run in aggregate form, with only two production sectors instead of 15, without noticeable changes) was not found to be important, at least for the general physionomy of results.

CONCLUSIONS

How can these findings be interpreted ? The most striking result is that large losses or benefits can occur under circumstances completely out of control of the authorities which deliver subsidies. In effect, the degree of substitutability or the foreign demand for exports are not under control of national authorities. The latters, therefore, perform bad or good whithout knowing what they really are doing.

In addition, although predictable on purely intuitive grounds, the above findings concerning the importance of flexibility and of substitutability are impressive by their magnitude. This is probably the main lesson to be drawn from this exercise: the same project, the same innovation ,in exactly the same price system, can have very different consequences according to the context within which it is inserted. Now, the causes of economic rigidities are numerous: Factor fixity is one of them, but also, transaction costs, uncertainty, institutional setting, etc.. There is therefore a wide field for further research in:

i-Checking the assertion according to which flexibility and substitutability are important in CGEM,and determining why is it so.

ii-Identifying the sources of these rigidities,and interpreting them in terms of technical, economical and sociological analysis, especially in developping countries.

Insofar as the methodology just described is not only applicable to project analysis, but also to the consequences of any technical change[10)],it is worth of consideration for agricultural economists.

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10) See BOUSSARD (1987) for dynamic applications to the consequences of various typical technical changes.

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