

The Use of Econometric Models for Long-Term Policies: A Critical View (*)

Introduction

1. In the countries of Western Europe a widespread need is felt to undertake long-range economic policies, involving an appraisal of the growth possibilities of the systems so as to direct and control, if the necessity arises, their actual development. This has provided an incentive to the production of *ad hoc* econometric models, having the purpose of consistently organizing the required quantitative knowledge and of bringing out the constraints and implications of long-term plans in a precise framework of coherent relationships. A first appraisal of the contribution that econometric models can make to economic policy is now possible, owing to a recent conference on the work done in this field in the EEC area: the proceedings of the conference, which include all the main models so far prepared in the Common Market countries, offer a good sample of the "state of the arts" (1).

I shall not be concerned in this paper with a detailed exposition or criticism of the individual models — a task which was already attempted in a report presented at the conference (2). Though still in connection with the available models, I shall try to develop here a more general analysis. Some preliminary remarks are first of all needed, in order to define what problems must be faced and what instead can be neglected.

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(1) *Modelli econometrici per la programmazione*: Atti del Convegno di studi sui modelli di programmazione nei paesi della Comunità economica europea, edited by G. PARENTI, Scuola di statistica dell'Università, Firenze, 1965 (all the main reports are in English or French).

(2) L. SPAVENTA and E. VOLPE, *Economic Structure and Uses of Medium-Term Models*, pp. 325 ff. of the Proceedings quoted above.

2. First, any discussion on the desirability, the objectives, the instruments of one or the other sort of planning is of no interest here. All we need as a context is a non-socialist economy, in which the authorities, being somehow concerned with the future trend of the system, desire to gain some knowledge of its characteristics and fix targets for their action. Amongst the various means by which the information necessary for a consistent long-run economic policy can be attained there are also econometric methods, which in some cases may be indispensable: any abstract discussion on the use of such methods in general is therefore irrelevant.

The econometric models of the various economies prepared for planning, or more in general for long-run policy purposes, are but a particularly ambitious variety of means of information: in principle, they should be the synthesis of all the others, as they aim at representing, through a coherent set of quantitative relationships, all the relevant aspects of the economic system. But the models are nonetheless, as was said, "handicraft products" (3), made to order for specific ends: as such, therefore, they must be valued instrumentally, in connection with the particular requirements they ought to serve, and not *per se*, as having an import of their own. It follows that what matters is not so much whether a model is good in itself, as whether it is useful for the purposes for which it was built: in the case considered here, long-term economic programs. This view, that it is the value of the information that counts, runs counter to the "fetishist approach" (4), for which "a given model assembles all the relevant information" and the adoption of a particular model is "a preliminary operation indispensable for a rational definition of an economic program" (5).

In order to appraise the available models for long-term economic policy in their true capacity of means of information, the following steps will here be taken. First the kinds of information provided, obviously different according to the characteristics of the model, will be briefly reviewed. Then the reliability of the information obtainable will be examined in the various cases. Finally it will be seen to what extent the information acquired is relevant and useful for economic policy purposes. To deal with the first point, features and results of the available models will be summarized. The second

(3) By G. PARENTI, in his introductory remarks, Proceedings, p. 17.

(4) Thus defined by B. DE FINETTI in his intervention, Proceedings, p. 436.

(5) *Ibid.*

point implies an analysis of the economic meaning of the models and of the individual relationships of which they consist. It will then be possible, in the third part, to draw some conclusions on the directions of research which appear more fruitful from the point of view of economic policy.

I

3. All the econometric models considered here provide a more or less accurate description of the state of the economic system in some future moment of time, t . First: what interpretation should be given of the state of the economy at t ?

It may be a mere forecast, without definite targets to be attained, and therefore without degrees of freedom to be eliminated by assigning a desired value to otherwise endogenous variables. Only the values of those variables which are either determined outside the system (e.g. the price of raw materials) or traditionally controlled by public authorities will be independently set or estimated. In addition there may be constraints reflecting some equilibrium requirement, for instance in the balance of payments. The aggregate Dutch model (6), the German model (7) and to some extent the Belgian models (8) are examples of this kind.

The state of the economy in t might instead be a sort of desired state, as the one which is compatible with the attainment of some pre-fixed targets: for instance a certain growth rate of income, as in the Italian model (9), or of consumption, as in the studies made for French planning (10); full employment; a certain sectoral and territorial distribution of resources (as, again, in the case of the Italian model).

The state of the economy at t may be such as to insure not only the attainment of certain targets at t , but also further desired

(6) C. A. van den BELD, J. H. van de PAS, H. S. T'JAN, *A Medium-Term Macro-Model for the Netherlands*, pp. 23 ff. of the Proceedings.

(7) W. KRELLE, *A Model for Medium and Long-Term Forecasting in the Federal Republic of Germany*, pp. 175 ff. of the Proceedings.

(8) V. GINSBURGH, J. WAELBROECK, *Le Modèle a moyen terme de Bruxelles*; J. PAELINCK, *Le modèle économétrique d'exploration utilisé par le Bureau de Programmation Economique Belge*, pp. 119 c. and pp. 219 ff. of the Proceedings.

(9) Centro di Studi e Piani Economici, *Modello econometrico di sviluppo e di ripartizione delle risorse nell'economia italiana*, pp. 41 ff. of the Proceedings.

(10) G. DELANGE, *Les modèle employé pour l'élaboration du Vème Plan Français*, pp. 101 ff. of the Proceedings.

development in successive periods $t+1 \dots t+n$, in which case the level and composition of investment, for instance, might not be the same as in the previous case: examples of such procedure are to be found in the Stone model (11) and in the studies, already mentioned, for the French plans.

Last, the state of the economy at t may be an optimal state, in a strict sense: that is, one obtained by maximizing some explicitly defined target function, subject to given constraints set by technical possibilities, distribution, etc. The maximand is likely to be the sum of consumption plus investment at t , or at t and one or more successive periods. Instances of such procedure are the two optimization models for Holland (12) and France (13).

4. Next: what features of the state of the economy at t do these models purport to describe? In this connection, the distinction between aggregate models and models based on interindustry analysis is relevant. The former determine the main flows of national accounts, and, according to the degree of aggregation, their components, but not the intersectoral transactions, nor, therefore, the composition of output and demand: hence technical and behaviour coefficients are estimated or given in aggregate terms, and in the same terms other variables of the model (such as price and wage levels, factor shares, etc.) are expressed. In the second case, instead, a more or less detailed input-output table provides the skeleton of the model: once the vectors of final demand are somehow given, sectoral outputs are obtained.

The technical characteristics of the models are also tied to this distinction. The bulk of aggregate models consists of a set of simultaneous aggregate relationships. In the second class, while there is always an input-output table for the system at t whose coefficients are independently estimated, the flexibility of the model and the variety of cases are greater. Recourse can be made to a true aggregate model in order to obtain the overall values of investment and consumption and then to determine the vector of final demands for

(11) R. STONE, ed., *A Programme for Growth: 1 - A Computable Model of Economic Growth*, Cambridge, 1962.

(12) J. SANDBE, *An Experimental Phased Sector Model for the Netherlands*, pp. 291 ff. of the Proceedings.

(13) A. NATAR, *Variante marginale d'un plan. Problèmes d'ajustement*, pp. 197 ff. of the Proceedings.

each sector in relation to those values (14). Or the aggregate components of final demand may result from *a priori* estimates or *naïfs* methods of extrapolation (15). Or all the elements which are external to the interindustry system can be defined by means of suitable and mutually independent submodels, where constraints and targets, if any, can find their proper place (16). Obviously in the case of optimization models there is no question of previously setting or estimating the aggregate levels of final demand, as the relevant values are obtained from the maximization of the target function.

Except in this last case, therefore, a structural model always rests on some kind of aggregate analysis: the necessary hypotheses on the overall trends of the system, however, may be quickly and easily specified, if desired, without recurring to a huge number of simultaneous relationships.

5. Finally: from which point of view and by means of which relationships is the formalization of the working of the economic system undertaken? The models prepared for national economic programs are all, with the exception of the German model, supply models. Given the available quantities of factors, national product is obtained; or, once the level of national product is fixed, the required amounts of factors are determined. In both cases, the level of national product at t depends on the changes in the employment of factors between 0 and t , whereas the trend of demand in the same time interval remains outside the picture. Of the components of final demand at t , moreover, one of them must necessarily be obtained as a residual. In this approach production relations of a technical character (between output and all various inputs) prevail upon behaviour relations. Besides, only production relations cover the whole time interval, whereas behaviour relations — by which, for instance, consumption or wages or prices are determined — concern only t , as it is only in t that their variables acquire any relevance. It follows from this that the models in question are altogether static: the only possible exception are those models, mentioned

(14) As in the model by Ginsburgh and Waelbroeck, quoted above.

(15) As in the model by Paclinek.

(16) This is the approach of the French planners, and to some extent of the Stone model: the former do not seem to worry about a full formalization. V. in this connection the interesting points raised by Delange.

above, in which the structure of the system in t is defined in view of some desired evolution in the following periods.

It is not surprising, therefore, that none of these models provides any indication on how the system should attain the situation described for t . The only approximation to determining a growth path is to be found in optimization models where the time interval is split into phases and the optimization procedure yields the desired structure of the system in each phase. Nor is any indication offered as to the characteristics of the solutions obtained for t : it is never specified whether or not there is some mechanism, implicit in the relevant functions, which can bring the system back to the state described by the model if a random shock prevents one or more of the variables from assuming the values indicated in the solution; or whether instead the solutions are unstable; or whether there exist multiple equilibria. Distinct from these two problems — the path to the described situation, the equilibrium and stability characteristics of the solution — is the other, as will better be seen later, of the variants to the main solution, which is dealt with in some of the models. This latter problem is one of determining the effects of a small change in one or more of the exogenous variables or the coefficients on the endogenous variables. This can be done by working out the reduced form of the models (17): this method is followed especially in structural models, but it is also used in the aggregate Dutch model.

II

6. In order to appraise the reliability of the information provided by the models, and especially by aggregate models, their main relationships — production, consumption, price and wages relationships — will be examined, first individually, then together, from the point of view of their simultaneous working in the context of the whole model. For it is first necessary to see whether the available knowledge offers univocal indications as to the choice between alternative relationships purporting to represent the same phenomenon. If not, it might be a matter of indifference to choose one or the other when that phenomenon is viewed in isolation: but the choice cannot be indifferent when the relationship is to become part

(17) V. SANDEE, pp. 406-7 of the Proceedings.

of a set of simultaneous equations, as it will affect the very structure of the model in the way which will be specified below. It is therefore not sufficient to check the reliability of the individual relationships: the overall information obtained from the model as a whole must also be considered.

The following considerations will mostly be concerned with aggregate models, whether they are independent of further sectoral analysis or serve as a prelude to the latter: the set of balance equations of which an interindustry flow table consists present no problems of substance, as the reliability of the results only depends on the accuracy of the projections of technical coefficients to the final period.

I shall concentrate upon the economic meaning of the individual relationships and of the models as a whole, in the belief that this problem is preliminary to the debate on the methods of estimation, which only acquires meaning with reference to individual cases (18).

7. First production relationships will be examined. To determine the level of national product at t or factor requirements between 0 and t , recourse is made in the models: to downright production functions, usually supposed linear and homogeneous, along which capital and labour are fully substitutable and which shift over time under the action of technical progress; or to relationships which attempt to explain the growth of output per man over time, rejecting any distinction between effects of capital accumulation at unchanged techniques and effects of technical progress, and to marginal capital coefficients calculated with reference to past experience; or to analytical estimates at the sectoral level; or to simple projections of the trend of aggregate coefficients; or to a combination of these different methods. Whereas in these latter cases we are confronted with empirical rules of thumb, which are different in each case, the first two groups of relationships lend themselves to some general remarks.

7.1 The objections that can be moved against the use of production functions in econometric models are in my opinion such as to deprive the results obtained from the functions of any meaning or value.

(18) On estimation methods see the report by J. S. CRAMER and L. B. B. MENNES, *Estimation in Medium-Term Econometric Models: the Experts' Practice*, pp. 325 ff. of the Proceedings, and also the remarks by DE FINETTI, p. 449.

It must first be observed that purely statistical difficulties in measuring the functions make by themselves any estimate of the coefficients very dubious: such difficulties are connected on the one hand with the unreliability and scarce significance of the basic data (especially of those referring to capital), and on the other with more complex problems of multicollinearity in the case of time series and, in all cases, of identification and aggregation (19). Identification problems are of course avoided if the value of the coefficients is obtained from factor shares: on the hypothesis that factors are paid the value of their marginal product, and since in national accounts factor shares exhaust the product by definition, from Euler's theorem linear and homogeneous production functions are obtained. But, even apart from the fact that in this case no meaningful test is possible, the hypotheses on which such procedure is based and its internal logic are open to several criticisms of an economic nature.

Linear homogeneity is by itself neither a necessary nor a sufficient condition for the marginal productivity theory of distribution: for Euler's theorem to be interpreted as a law of distribution it must be supplemented by the assumption that perfectly competitive conditions occur on product and factor markets; otherwise the partial derivatives of the function would not correspond to factors' remunerations. Other assumptions equally difficult to swallow are connected with the linear homogeneity of the aggregate function: its component microfunctions must all be linear and homogeneous, or, if not, must present increasing and decreasing returns in a particular combination. The first case is unreal insofar as it rules out any possibility of increasing returns; the second case is inconsistent with the long-run competitive equilibrium necessary if the marginal laws of distribution are to hold. If on the other hand one or the other of these hypotheses — perfect competition or linear homogeneity — is abandoned, it is no longer possible to identify the function by means of distributive shares (20).

Often in the models coefficients are attributed *a priori* values which "appear" plausible inasmuch as they are near to the values which are normally found for distributive shares (e.g. two thirds — one third). It is moreover admitted that internal and external

(19) V. A. A. WALTERS, *Production and Cost Functions*, "Econometrica", January-April 1963.

(20) These points are developed in L. SPAVENTA, *Note critiche in tema di funzione di produzione*, "La scuola in azione", n. 19, 1962-63.

economies might be present and that the aggregate function might shift as a result of change in the composition of output: the resulting effects however are included in the trend term introduced to explain technical progress and obtained as a residual. Such procedures can find no justification: if the coefficients of the function must practically be invented and if effects pertaining to different causes must be hung on the peg of a generic residual term without any possibility of distinguishing amongst them, the use of a precise functional relationship adds nothing, for the knowledge of facts, to the use of even rough projections: an illusory precision is obtained at the risk of real errors.

From a logical point of view it must first be observed that the very existence of a unique relationship between capital intensity and profit rate, which is fundamental for neoclassical theory in general and for the neoclassical production function in particular, is now being denied with arguments that have not yet been, and probably cannot be, refuted (21): it is hard to see how a theory that cannot stand on its own feet even in its most abstract and allegedly most rigorous form can give any satisfactory interpretation of reality. Second, even if the basic criticisms to marginal theory were to be neglected, the production function could be legitimately used in economic analysis only if interpreted as a strictly *ex ante* concept. Given the technical alternatives available, factor prices will influence entrepreneurial choices. But the choice, once made, is irrevocable: the structure of the capital stock in the economy embodies, at any given moment, all the choices that have been made up to that moment, but cannot be adapted to all the other alternatives which remain possible in principle. On the other hand, owing to technical progress, at a different moment of time any choice will be made under different technical conditions, and therefore amongst different alternatives. Thus what we observe *ex post* is not a function but a succession of points belonging to different virtual functions of which nothing is known (22). Everybody is free to guess the shape of a

(21) Initially by P. SRAFFA, *Production of Commodities by Means of Commodities*, Cambridge, 1960; on the following dispute v. L. L. PASINETTI, *Changes in the Rate of Profit and Switches in Techniques*, mimeo., to be published in the "Quarterly Journal of Economics".

(22) On these points see: N. KALDOR, *Capital Accumulation and Economic Growth*, in F. A. LUTZ and D. C. HAGUE editors, "The Theory of Capital", London, 1961; J. ROBINSON, *The Accumulation of Capital*, London, 1956 and *Essays in the Theory of Economic Growth*, London, 1962; F. H. HAHN and R. C. O. MATTHEWS, *The Theory of Economic Growth: A Survey*, "The Economic Journal", December 1963, part II.

function from a single point and to believe that it remains unchanged through all the shifts: but we must be aware that this is guess work, not econometrics.

Additional difficulties arise from the fact that technical progress is mostly embodied only in new machines: to the extent to which it does not benefit all the existing plants, it makes productive capacity depend also on the age composition of capital goods. Even if this last obstacle by itself can in principle be overcome (23) (though the task was not attempted in any of the models considered here), it reinforces the difficulties previously mentioned. Taking everything into account, it would seem that the use of production functions in econometric models represents a typical attempt "to find answers to questions that do not exist" (24): it leads one into a sea of theoretical troubles without offering any gain in precision or refinement. As moreover all available estimates impute the largest part of the increase in productivity to the residual term, and as the value of the product at t is usually arrived at by extrapolating the value of the residual obtained for the past, the results obtained by using a production function are bound to largely coincide with those one gets from a simple projection of past trends: nothing is gained in the knowledge of facts, and only a spurious precision is added.

These considerations do not apply to those optimization models, in which available techniques are specified *ex ante* in disaggregated terms and the outcome of the maximization procedure also yields the determination of the technique to be chosen for each different set of factor prices.

7.2 The second group of production relations alternative to a true production function is immune from many of the criticisms listed above. Relationships between output per man and investment or between output per man and level of output do not attempt any distinction between effects of capital accumulation and effects of technical progress and can be used at the sectoral level to appraise the effects of the scale of production on labour productivity and on the pace of technical progress. None of the relations so far adopted,

(23) V. R. SOLOW, *Investment and Technical Progress*, in K. J. ARROW, S. KARLIN and P. SUPPES editors, "Mathematical Methods in the Social Sciences", Stanford, 1960; and also F. H. HAHN and R. C. O. MATTHEWS, quoted above.

(24) J. ROBINSON, in the debate on *The Present Position of Econometrics*, in "Journal of the Royal Statistical Society", 1960.

however, authorizes the inference of precise and uniquely valid indications for what happens at the aggregate level. It is not yet clear whether the level or the rate of change of investment or the level or the rate of change of production should be preferred as explanatory variable; and above all there is no valid argument sufficient to prove the stability of these relationships and therefore to assign a precise technical and economic meaning to the values of the calculated coefficients. These relationships, moreover, only explain the trend of labour productivity, while the determination of capital requirements is left to a naïve application of marginal capital-output coefficients, calculated on the basis of past experience. Also in this case, therefore, if the desired or foreseen rate of growth of income is near to that occurred in the past, the functions discussed here cannot yield results which are appreciably different or more significant than those that can be obtained from mere projections: and in any case it will be preferable to undertake detailed estimates at the sectoral level, on the basis of direct knowledge or of functions to be fitted case by case.

8. In addition to technical relationships, only few more functional relationships — which are neither mere identities nor constraints imposed *a priori* — are to be found in an aggregate model: the more important are the consumption (or saving) functions and the relations explaining the level of prices and wages, in aggregate terms or with reference to a few final sectors.

As far as consumption functions are concerned, the introduction of different propensities for labour incomes and other incomes offers an approximation which is probably satisfactory and certainly meaningful, insofar as it embodies hypotheses liable to be verified or disproved (25). The static nature of the models, however, makes necessary the assumption of an instantaneous adjustment, while it would certainly be preferable to estimate the coefficients also with reference to the incomes of previous periods.

Considerable doubts must instead be cast upon any attempt to define, in the present state of knowledge, meaningful quantitative relations determining the average levels of prices and wages. It

(25) It does not appear, however, that consumption functions of different type (implying for instance a dependence of savings on the rate of growth of income) have been tried.

will certainly be true that the wage level is somehow related to the trend of average productivity in the system, to relative labour scarcity and to the price level: we can by no means be sure, however, that a function calculated on the basis of extremely short time series faithfully reflects a stable pattern of behaviour of the trade unions and is not, instead, the *ex post* result of a complicated interplay of variables (such as monetary policy, relations between government and trade unions and the like), which will not necessarily operate in the same way in future. In the case of price formation, we can immediately discard such oversimplified interpretations according to which any divergence between rise in wages and rise in productivity causes corresponding changes in the price level: if this were the case, as is assumed in the Italian model, distributive shares should always remain constant, whichever the movements of wages — this being also contradicted by past and recent experiences of our and other economies. Greater reliance can instead be placed on more complex explanations, in which account is taken not only of wages and labour productivity, but also of other costs (e.g. of raw materials), of foreign competition (prices of import goods), of possible pressures on the demand side: and one might think of other explanatory variables, reflecting the behaviour of profit margins. But the relations which allow for all these complications also appear of rather doubtful validity: on the one hand the highly aggregated coefficients, being a weighted average of elementary relationships (26), can hardly be stable; on the other hand the functions, being expressed in the form of linear approximations, do not admit of any relevant difference between the actual value of exogenous variables and that which had originally been calculated in building the model (as might well be the case, for instance, for the price of imported raw materials), without compelling the re-estimation of all the coefficients.

9. Up to this point the main relationships of aggregate models have only been considered one by one: this, however, is not sufficient, because the task and pride of such models — their *raison d'être* — is to work out the interdependence of all the relations adopted. In actual facts this interdependence is more apparent than real: Cramer and Mennes have shown that of the coefficients found

(26) V. G. U. PAPI, *Statistica e macroeconomia*, in G. U. PAPI ed., "Study keynesiani", Milan, 1953.

in the models submitted to the Florence conference, which could in principle be estimated, only a very small fraction (in some cases no more than .5 per cent) was given a non-zero value (27). But at any rate, the main relationships adopted in a model should not, at least in principle, be chosen independently one of the other. This requirement arises not only in the determination of coefficients, which should be estimated simultaneously if true interdependence is desired (2), but also when attention is paid to a global economic interpretation of the model. The choice of one or the other relationship does not merely imply a choice of one or the other interpretation of the individual phenomenon to be explained, but affects the whole model and the resulting vision of the economic system: which is only too often neglected.

In order to clarify this most important point, it may be useful to go through a small exercise in comparative statics with reference to the two distinct, but not altogether different, models of an economic system reproduced below.

Variables of the models:	constant prices	current values
National product	y	Y
Sum of investment between 0 and t	Δk	
Investment	i	I
Output per man	h	
Employment		N
Unit wage		m
Wage bill		W
Profits		P
Savings		S
Price level		p
Balance of foreign payments		B
Dummy variable		γ

Parameters: a, b, c, d, e_1 , e_2 ($e_1 < e_2$).

(27) V. CRAMER and MENNES, report quoted above, pp. 352-5 of the Proceedings.

(28) In actual facts, as Cramer and Mennes have observed, only the roughest methods of estimation are employed — the more refined being a simple regression, which is used only for a few coefficients. V. pp. 355-8 of the Proceedings.

All variables refer to moment t , except those underscored 0, which refer to the base period.

Model (A)	Equations common to both models	Model (B)
	(1) $y = y_0 + a\Delta k$	
	(2) $i = b\Delta k$	
	(3) $N = y/h$	
(4a) $h = h_0 + c\Delta k$		(4b) $h = \varphi(y)$
(6a) $p/p_0 = 1 + m/m_0 - h/h_0$	(5) $m/m_0 = 1 + d\Delta h/h_0$	(6b) $p/p_0 = 1 + m/m_0 - h/h_0 + \gamma$
	(7) $W = mN$	
	(8) $P = Y - W$	
	(9) $S = e_1W + e_2P$	
	(10) $I = S - B$	
	(11) $Y = y \cdot p/p_0$	
	(12) $I = i \cdot p/p_0$	

These are two very simplified models, but sufficiently representative of those worked out for long-term policy purposes (29). They only differ in the equation for productivity, which is in one case a function of investment and in the other a function, written in a generic form, of the production level (4a and 4b); and in the price equation, which in one case only reflects the effects of possible divergences between relative changes in wages and relative changes in productivity between 0 and t , while in the other case it embodies an additional dummy variable, which, as we shall see presently, may be taken to represent effects on the demand side (6a and 6b) (30). Let in both models the desired level y of real national product to be attained in t , by means which have somehow been defined, be fixed. As in model (B) there is one degree of freedom, let $\gamma = 0$. Considering that both (4a) and (4b) often yield satisfactory results on the same time series, the two models will give, for the same economy, values of the variables which are identical in some cases and quite similar in others. Let us now assume, beginning our exercise, that the value of one coefficient, for instance a , the reciprocal of the

(29) Model (A) is nearer to the Italian model, model (B) to the Dutch aggregate model.

(30) A more explicit relationship could be introduced to account for effects on the demand side: of the type, for instance, of that used by Kaldor, in *op. cit.*

marginal capital-output ratio, is changed relatively to the value that was initially adopted, leaving all the rest unchanged. We shall now compare, between them and relative to the situation with the original value of a , the two sets of results that are obtained from the two models for a different (higher or lower) value of a .

Obviously new values of Δk and i will be obtained, equal in both models, but higher or lower than in the original case according to whether a is lower or higher. In model (A) this in any case implies respectively: a higher or lower level of productivity, a lower or higher level of employment, a higher or lower wage rate. Moreover, if trade unions comply with some incomes policy, so that $d \leq 1$, the equilibrium between the level of investment in real terms and investment at current prices as obtained from (10) will have to occur through a new value of the net balance of foreign payments: respectively a higher or lower level of B . In model (B), instead, output per man, employment and wages remain unchanged. A different value of the net balance of foreign payments is not moreover a condition necessary to the new equilibrium: the balance may remain fixed at its previous value, because an explicit constraint is introduced or as a result of external forces. In this latter case γ will assume a positive or negative value, respectively, and the price level will be accordingly higher or lower: as a consequence, higher or lower values of investment at current prices, profits and savings will insure equilibrium. The new equilibrium will thus be characterized in one case by a different level of wages and the balance of foreign payments, and in the other by a different level of prices, profits and savings (31).

10. It thus appears that two apparently similar models, which give very similar results for a certain original situation, yield altogether different results, which imply a different working of the system, when merely one parameter is changed. This conclusion is to be connected to what was said above on the individual functions. The validity of some of these (production functions, wage relations) is more than doubtful even when they are considered individually.

(31) Only if $d > 1$, prices profits and savings will be respectively higher or lower also in model (A), without there being a lower or higher value of the balance of foreign payments. For, in model (A) the sign of the first derivatives of p/p_0 , P , S and B with respect to a depends on the value of d : such derivatives are negatives if $d > 1$, nul or positives if $d \leq 1$.

In other cases we do not possess sufficient elements to make a choice amongst alternative functions (for instance between the two types of technical relationships exemplified by (4a) and (4b), or between the various price relations). Still, the option for one or the other type of relationship usually affects all the information obtainable from the model and not only that provided by the individual function: which just shows how illegitimate it is to introduce, as is often done in the econometric work considered here, the relationships one by one, trying for each of them, in successive approximations, different and more complicated forms, without bothering to check what the consequences for the rest of the model are (32). In such conditions not much reliance can be placed on the results of the models.

II. A final word of warning must be said on some inferences frequently drawn from these models, which appear altogether unjustified. In our exercise above, care was always taken to develop the argument in strict terms of comparative statics: that is to compare different values of the variables, without ever referring to *variations* of the latter and without implicitly assuming the existence of an adjustment mechanism. This and no more than this is what a model of equilibrium (in the limited sense that all relationships should be simultaneously satisfied) allows us to do: a mere comparison of equilibrium situations (in the said sense), in which some data are different, without any indication as to the possibility or probability that the system can move from one to the other situation. Lacking any adjustment mechanism, therefore, nothing can be inferred as to the dynamic effects induced by the variation of one of the magnitudes involved. For the same reasons no causal statement can be deduced from the models. Thus, referring to the previous example, one is not authorized to say that a fall in the capital-output ratio causes a rise in the surplus of the balance of payments in the case of model (A), or a fall of prices and profits in the case of model (B). Thus, to quote a more concrete example, the authors of the Dutch aggregate model are not authorized to presume, on the

(32) This is the impression one gets especially from the Italian model, in which it is announced that a relationship between output per man and investment will, in a future version, be substituted with another, deemed more satisfactory, between output per man and level of production: it was seen in the text how different are the implications of the two. On the practice of introducing the relationships one by one, see CRAMER and MENNES, p. 354 of the Proceedings.

basis of the solution of a variant to the model embodying an exogenous increase of wages, that a rise in wages causes a fall of production, employment and consumption and a substitution of capital to labour. Any such effect can only be the result of a process occurring through time, and time does not appear in the model: to determine the direction and the intensity of the processes it would be necessary to take into account what happened in the past and what is expected to happen in the future, to specify the structure of the stock of capital at a given moment, to find out how the relevant behaviours adapt themselves to the new situation: if all adjustments take place from the very beginning, with perfect forecast, recourse can be made to a new equilibrium model, which must differ however from the previous one because the coefficients are different (independently of the necessity of reestimation for large changes); otherwise one has to proceed in terms of disequilibrium dynamics — a field of inquiry which is much more fruitful but in which the models discussed here are of no use (33).

It follows that only within very narrow limits can any meaning be attributed to the estimates of the variants to a certain situation. Such limits are set on the one hand by the scarce reliability of the relationships of the models and by the diversity of general results according to whether one or the other relationship is used; and on the other hand by the lack of any adjustment mechanism capable of expanding the passage from one situation to the other. This second kind of criticism especially applies to consistency models for forecasting purposes, where the estimate of the variants has very little meaning, if any; it applies less to optimization models, which only define a hypothetical optimal situation without implying anything as to the possibility that such situation be actually attained by the system.

12. Econometricians engaged in building these models often complain of the inefficiency of economic analysis, which, instead of providing hypotheses and relationships ready for econometric test and application, indulges in sterile theoretical disputes: from this they draw the conclusion that it is better to do without theory alto-

(33) Analogous worries were voiced at the conference by V. TRAVAGLINI, p. 409 of the Proceedings. These points are also expressed with vigour by J. ROBINSON, *Essays in the Theory of Economic Growth*, cit. and, more recently, by J. R. HICKS, *Capital and Growth*, Oxford 1965, especially part. II.

gether (34). Even if the complaints may be justified, the conclusion certainly is not. Economic theory may have left many problems unsolved: but it has at least identified the existence of many problems, uncovering their nature and implications. When such contributions are neglected, it is difficult to avoid the risk of dangerous errors in appraising the significance and the interpretative power of the models, and it becomes impossible to choose amongst alternative representations of the same phenomenon, each of which excludes the others but can boast empirical evidence, duly proved by one or other statistical method.

III

13. It must now be seen what utility the more or less reliable information provided by formal models purporting to represent the hypothetical or desired situation of the economy at a certain date can have for economic policy decisions.

It must first be remembered that none of these aggregate models explicitly gives any restriction as to the path that the economy should follow to reach the situation described for t . Lacking as a consequence any specification of the conditions of dynamic equilibrium, the values obtained from the solution for many of the variables are largely arbitrary from an economic point of view, as they are not necessarily connected with the attainment of the foreseen or desired situation and/or are not sufficient to ensure it. For instance, the same overall amount of investment required to reach a certain level of income, set as an objective for the final year, is compatible with annual investment growing at a constant or at an increasing or at a decreasing rate between 0 and t . As a consequence the same final level of income is compatible with more than one final ratio between investment and consumption: lacking further information, there is no reason to set one particular ratio for the final year (normally the one corresponding to a hypothesis of exponential growth) as a necessary target for economic policy. On the other hand it is doubtful whether the same model can be used indifferently for all final ratios between investment and consumption, that is for all distributions over time of the overall amount of required investment: if a certain model

(34) See the debate on *The Present Position of Econometrics*, "Journal of the Royal Statistical Society", 1960.

implicitly assumes exponential growth, it is to be thought that some relationships only hold for this case and change if the growth path is different (35). Another instance can be found in the wage and price relationships. In the models we are discussing the total change of prices between 0 and t depends on the ratio between total change in wages and total change in output per man in the same interval. But it is difficult to infer from this a meaningful criterion of economic policy: the behaviour of prices as well as of other variables depends not only on the extent to which wages have increased relative to productivity, but also on how the increase is distributed over the time interval, so that a slightly higher wage rise uniformly distributed over time may be preferable to a smaller but concentrated rise which could set in motion factors of instability.

14. It might be observed that aggregate models are always necessary, if only to make sure that some targets, e.g. the rate of income growth, are consistent with a certain distribution of resources or with external equilibrium. They are moreover the first step in the making of a disaggregated model (36), for the vector of final demand can only be obtained from a preliminary estimate of total income, or at least of foreign consumption and foreign demand. This is certainly true: but in both cases, if the necessary knowledge is available and the relevant constraints are set, the essential results are easily reached with a few calculations from a very small number of relationships, most of which are accounting identities: all the rest that can be obtained from these powerful aggregate models is inessential for the purpose (37).

It is also true that the available disaggregated models, just like the aggregate ones, only offer a snapshot of the flows of the system at t without any information as to how such state is to be reached. Unlike the mere determination of aggregate flows, however, the definition of the sectoral composition of production in t may be of

(35) If accumulation first proceeds at a slower pace and then speeds up, the relationship between investment and output per man is bound to be affected. Instead the Italian model will almost certainly be re-calculated without any change in the relationships and applied to the "sliding" of the five-year program made necessary by the recent slowing down of the growth process.

(36) On the various stages followed in making planning models, see F. di FENIZIO, *La programmazione globale in Italia*, 2^a ed., Roma, 1963.

(37) The Italian five-year program was prepared with such empirical methods, quite independently of the econometric model made for the purpose.

some relevance for the authorities wishing to watch the developments of the economy. In the former case only a condition of macroeconomic equilibrium at t is available, simply consisting of the equality between total demand and total supply, without even, as was seen in the previous section, any meaningful restriction as to the aggregate components of either. In the latter case, instead, *sectoral* conditions of equilibrium between demand and supply are obtained, which offer the opportunity of singling out in advance possible symptoms of disequilibria arising from excessive or insufficient growth of capacity in the individual sectors between 0 and t . Moreover, the joint analysis of sectoral targets or forecasts and of technical elements (such as the length of the gestation period of individual investment projects) may provide some restrictions as to the path that the system should follow.

15. One of the main reasons why most econometric schemes available for long-term policy are of very little use is, as we have seen, their altogether static nature, which makes it impossible to determine whether and how the system can attain the described situation, whether and which policy interventions are necessary, whether the described situation is endowed with sufficient stability. One could nearly think that these models are devised for economies in which the powers of decision as to the amount and direction of investment are strictly centralized and no problem arises on the side of effective demand, rather than for "mixed" economies, where, within known limits, the rate of growth is determined by how and how fast effective demand develops and finds a balance with existing capacity and where no simple causal relation can be established between the availability of investible surplus and the rate of accumulation. From this point of view it is wrong to believe that a model in which the growth of the system appears determined by individual decisions of consumption and investment (as well as by public expenditure) is of no use for a planning policy having the purpose of somehow correcting and controlling such natural developments. The contrary is true. In order to know to what extent and in which form correction and control are required for ensuring steady growth and the attainment of certain targets, it is indispensable to obtain an adequate knowledge of the dynamic properties of the system and of the relationship between growth of demand, as determined by investment and consumption decisions, and growth of capacity.

Only thus it becomes possible to specify conditions of dynamic equilibrium which can serve as guiding criteria for economic policy.

It is not to be thought, however, that an aggregate demand model, based on a consumption function and on an aggregate investment function, is sufficient for the purpose. Aggregate investment functions, as is well known, are very unreliable tools of analysis, implying altogether unreal hypotheses of uniformity of behaviour, constancy of composition, stability of the parameters (38). A more promising line is the study of investment relations at the sectoral level and/or by classes of firms grouped according to size: the shape of the function will probably vary with the technical characteristics of the sector and with the size of the firms in the sector (39). Any such inquiry should of course be based on the determination of sectoral demands by an input-output table, and its results could integrate the analysis of the required or projected levels of sectoral production. It would instead be difficult, and after all rather useless, to give such a disaggregated analysis the garb of a fully formalized model: this task would absorb energies which, from the standpoint of the information required for economic policy, can be better employed elsewhere.

16. The outcome of the above analysis can be summarized as follows. First, at least up to now, there is no available econometric model from which reliable and useful information can be obtained for planning and for economic policy in general. Second, no reliable and useful indication is ever likely to be obtained from so-called consistency models, whose core is a set of simultaneous aggregate relations, referring to a given period of time: such are the criticisms to which their main relationships are exposed, such the limitations and disadvantages of a rigidly static approach, such the

(38) See all the criticisms put forward by L. L. PASINETTI, *Cyclical Fluctuations and Economic Growth*, "Oxford Economic Papers", 1960.

(39) For Italy the only attempt to work out disaggregated investment functions, though only for final sectors, was made by G. ACKLEY, *Un modello econometrico dell'economia italiana*, Roma, 1962.

(40) In this sense see F. CARRÈ, *Sistematica e tecniche della politica economica*, I, Roma, pp. 242-48. There are however in the field of multi-sector analysis interesting theoretical developments, which may provide useful indications also for empirical research: v. L. L. PASINETTI, *A New Theoretical Approach to the Problems of Economic Growth*, Pontificiae Academiae Scientiarum Scripta Varia, Tiré-à-part du Volume "Semaine d'Etude sur le Rôle de l'analyse économétrique dans la formulation de plans de développement", 1965.

difficulty of extracting any relevant information, for purposes of economic policy, from their results. Thirdly, structural analysis can give instead very useful indications. The preliminary research which it requires is by itself an important contribution to a factual knowledge of the economic system, and the information which it offers in terms of sectoral composition of demand and output could not be obtained otherwise and is important for economic policy. A further advantage of structural analysis is the flexibility it allows in the alternative use of estimates, projections or true functional relationships: the price to be paid for this is the difficulty of framing all the results in a fully formalized set-up. But from the point of view adopted here, that models are of value to the extent to which they are of some use, this cannot be considered a great loss: the purpose of economic, statistical and econometric research undertaken for economic policy must be to provide relevant information, and not to build models. Even if scientific rigour were the reward, usefulness should not be sacrificed in this field: when, as we have seen to be the case, nothing is lost in rigour and much is gained in knowledge, a better utilization of the scarce energies available is all the more desirable.

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