Introduction into macroeconomic modeling foundations

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CONTENTS

Papers

INTRODUCTION INTO MACROECONOMIC MODELLING FOUNDATIONS*

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Through their goals, the macroeconomic policies aim to the near or farther future, this being the reason for which evolutions have to be anticipated. Deliberately or not, the decision-makers continuously operate with mental schemes of prospective nature. Many times, these procedures are purely empirical. But, no matter how much 'trained', the intuition has its own limits that can be overcome only through rigorous modelling techniques. Modern economy management placed itself unequivocally on the second path. This impulse, together with the progress in macroeconomics and computational techniques formed the background for the spectacular development of macroeconomic modelling in the second half of the 20th century.

There are many data banks for macromodels. One of the most comprehensive seems to be the one built and continuously updated by the Hamburg Institute of Statistics and Quantitative Economics. In mid 2001 there were around 4500 such models (see Appendix 1), an amount – we must admit, impressive – that indicates the very high interest in the entire world in this instrument of analysis and forecasting. The first place was held by United States, with 495 models, but also other developed countries were recorded with important figures: Germany (Federal and former Democratic together) - 343, United Kingdom - 213, Japan - 207, France - 152, Italy - 130, Canada - 126, the Netherlands - 122, etc. In other regions, including the Central and East European countries, modelling also expanded significantly. In fact, since 1967 – under the aegis of the United Nations Organization – the LINK Program is carried out, which promotes this technique at world level, with the participation of well-known specialists.

The current paper aims to examine the following issues:

A. What is an economic model?

B. Economic models typology,

C. The sequences of the numerical modelling process.

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A. What is an economic model?

I shall begin by presenting several definitions (given by dictionaries or specialists) of the model in general, and the economic model in particular (see Appendix II). Naturally, the selection gives priority to the mathematical models. In the absence of a rigorous theme classification criterion, I have decided for chronological ordering of citations (namely according to the moment of formulation of the considered theses). Among the cited specialists there are celebrities such as Keynes, Popper, Georgescu-Roegen, Malinvaud, Leontief, Kantorovici, Baumol, R. Hall, Taylor, Mankiw, Maddala, Samuelson, Friedman, and Koopmans.

2. The presented definitions both overlap and differ (as expected), and I shall try to synthesize them.

2.1. Directly or only implicitly they connect the model (MO) with a real object (RO). I shall not go into the philosophical details of this discussion, keeping only the following approach of the <real>: "From a logical point of view, the real opposes both the *possible* and the *necessary*. From the point of view of the perception of the world, the real opposes the *apparent*. Metaphysics has succeeded in making a distinction (Descartes) between the notions of *real* and *existence*: an idea from the spirit is something real, though it has nothing to do with 'existent', the latter term being reserved for the material bodies. Generally, the real opposes the *unreal* and *imaginary*". [D. Julia, *Dictionaire de la philosophie*, Larousse 1991; Romanian version, Univers Enciclopedic Publishing House, 1996, p. 287]. This interpretation is adequate to economics, whose functioning cumulates existential processes (production, circulation and consumption of goods), but also expectations, propensities, and decision-making behaviours.

2.2. The model cannot be a direct replica of the real. Kant was firm in this respect (*Prolegomena to any future metaphysics*): about "das Ding an sich" (the thing in itself, o.n.), we have only representations, it cannot be known as such. Even the adverse theories consider the cognoscibility of material world as a recursive, continuous (practically infinite) correction process of the human representations about it. From this perspective, the definitions that relate the model not directly to the real corresponding object, but to our images (IM) of it (theories, sets of intuitions, etc.) look more appropriate to me. Because of many reasons (pursued goals, amount and quality of available information, approach angles, etc.) several images may exist (more or less different) about the same real object.

2.3. The homomorphism between IM and MO does not yet has a widely accepted interpretation. I shall specify the sense that will be attributed below, with a particular reference to the mathematical models - the most often used in economics.

The model is the translation into mathematical language of a certain image (wholly or partially) about the studied object, with the aim to rigorously check the coherence of the considered image; expand this image both through the deductions allowed by this language (usually inaccessible to the mental reasoning) and through the connection to additional empirical inferences; allow the statistical and predictive testing of the considered image.

During these operations, discrepancies between the model and the image it configures may arise, due either to image "translation" errors, or to inconsistencies of the image itself. Reconciliation is compulsory; otherwise the model ceases to be the replica of the starting image. This implies, depending on the case, correction of the model or reconsideration of the corresponding image. In other words, the IM-MO homomorphism tends to its upper limit - isomorphism.

3. In a simplified representation, the RO-IM-MO relationships look as follows:

Scheme 1

Interconnections object-image-model

The solid line from RO to IM refers to the existential component of the real object; it is *unequivocal because the simple existence of an image (since it is not an action) cannot in any way influence this component.* The dotted line - that refers to the spiritual part of the real object - is placed in feedback connection to the image; formation of expectations in economy is a significant example of the feedback exerted by the way the operators become aware of the environment in which they are operating.

As presented above, for IM↔MO the relationship is bi-directional. In other words, each of the systems S_1 and S_2 is the model of the other if a homomorphic image of system S_1 (IM_1) and a homomorphic image of system S_2 (IM_2) exist, and these images IM_1 and IM_2 are isomorphic between themselves.

4. The content of an economic model may be formalized in the following way:

$$ST_T = \Phi\,[ST_t, EX_\tau, AP_T, OP_T, R] \qquad [1]$$

where the vector of indicators that characterize the state of the economic system at moment T (denoted as ST_T) is defined depending on:

- The so-called historical information (ST_t, where $t<T$), representing data related to the previous state of the system; this information is also called statistical inputs of the model or lags.
- Expected or planned variables (EX_τ), representing the anticipated evaluation of certain indicators that significantly influence the economic operators decisions; in this case $\tau \geq T$.
- Information obtained through computational algorithms outside the considered model (AP_T), such as expert estimations, technical data, additional models, etc.

- Optional or command parameters (OP_T) that particularly characterize the policies having major impact upon the business environment (direct and indirect taxation systems, public expenditures, international position of the economy, monetary policy, customs duty system and trade policies, social security legislation, market functioning regimes, etc.).
- Finally, there is a set (R) of relationships through which certain variables are connected to others; they can be defining identities or equilibrium relationships, behavioural equations, constraints represented as inequalities, and objective functions.

5. In principle, the variables resulting after solving the model are called endogenous and are included in ST_T; the others (namely ST_t, EX_r, AP_T and OP_T) form the set of the exogenous variables. "The endogenous variables are also described as being *jointly dependent* variables. It is usual to make a distinction between exogenous and lagged endogenous variables, despite the fact that values of both can be considered as having been determined already for any time period of interest. Exogenous and lagged endogenous variables together make up what are described as the *predetermined* variables in a system". [W. W. Charemza, D. F. Deadman, *New Directions in Econometric Practice - General to Specific Modelling, Cointegration and Vector Autoregression*, Edward Elgar Publishing Ltd., UK 1993, p.173] "Structural econometrics distinguishes between the *endogenous* and *exogenous* variables of an econometric model. Generally, but not very precisely, the endogenous variables are those which are explained by the structure of the model, and all the remaining variables are the exogenous variables. In so-called *full* econometric models (nearly all known structural econometric models are full) the number of endogenous variables is equal to the number of equations". [W. W. Charemza, D. F. Deadman, *New Directions in Econometric Practice - General to Specific Modelling, Cointegration and Vector Autoregression*, Edward Elgar Publishing Ltd., UK 1993, p.251-252].

B. Economic models typology

The structure formalized in [1] allows us to give shape to a typology of economic models; that will be presented in connection with the systematisations used in the literature. I shall insist upon five classification criteria.

1. Criterion I: Nature of composing elements.

From this perspective, three broad categories of models may be distinguished: logical, qualitative-analytical and numerical.

a) In the logical models, Φ comprises unambiguously defined notions, but not necessarily quantifiable, which describe the structure of the studied object, the causality relationships, etc. "The logical models are propositional sequences that describe the structure and functioning of a real object, generating a relatively invariant representation of it. In this case the model comes close to the *ideal type*, a Weberian term denominating a particular class of logical homomorphic models". [C. Zamfir, L. Vlăsceanu, *Dicționar de sociologie*, Editura Babel 1993, p. 366]. "En économie, il existe deux types de modèles, les modèles qualitatifs et les modèles quantifiables. Ainsi, la "concurrence pure et parfaite" est un modèle abstrait don't on sait qu'il ne traduit pas la situation réelle dominante; elle relève de la première catégorie". [J. Brémond, A. Gélédan, *Dictionnaire économique et social*, Hatier, Paris 1990, pag. 261].

b) The qualitative-analytical models operate also with notions, this time compulsorily measurable, provided by the existing informational system or deductible from it, or *in extremis*, for which there are premises to be introduced in the system. Additionally, the interdependencies among the notions involved are defined as functional relationships. The sense of this influence has to be explicit. Here are some examples:

The neo-classical production function:

$$\underset{(+)(+)(+)}{Y = f(K, L, Q)} \qquad [2]$$

where Y is the economy output, K – the capital stock, L – the labour force used and Q – the cumulated effect of the qualitative changes in the capital stock (performance of equipment and technologies), in the labour force (professional training level, experience), and also of the mutations in the institutional system (in its broadest acceptation). None of these factors is numerically dimensioned, but all of them can be evaluated either directly from the official statistics (K and L), or indirectly through econometric methods (Q). The way in which each of them acts upon output is clear (the signs under the symbols).

The Keynesian consumption function:

$$C = c(1)+c(2)*Y_D \qquad [3]$$

$$c(1) > 0$$

$$0 < c(2) < 1$$

where C is the consumption and Y_D – the household's disposable income. Their values are given by the official statistics or are computable on their basis. Here, the direction of the disposable income influence upon consumption is even more precisely defined than in the previous case. It is stated not only that c(2) is positive, but also that it ranges between zero and one. By this determination, c(1) reflects the stable part (relatively autonomous) of consumption, which obviously can be only positive.

The money demand monetarist function:

$$M^d = f(Y, P, r_B, r_E, r_D) \qquad [4]$$

$$(+)\ (+)\ (-)\ (-)\ (-)$$

where M^d is the money demand, Y – output, P – price level, and the next three symbols represent the return of other types of assets in which money can be placed (treasury bills, shares, and durable goods). In this case, too, the involved variables do not look like numerical values, but may be computed from the available statistical data. Moreover, the way the money demand depends on the right side factors is clearly expressed.

The qualitative-analytical models are also called theoretical models; we shall use interchangeably of both syntagmas.

c) Unlike these, the numerical models resort to concrete indicators, with time and spatial references. They are differentiated according to:

- the units in which the indicators are expressed: physical (natural), values (current or constant prices), and conventional;
- the scales used: cardinal, ordinal, combined;
- the degree of determination of the considered indicators: strictly delimited, fuzzy;
- the character of their modification: continuous, discrete, mixed variables.

From the many forms of quantification of the economic indicators it results a huge possible variety of numerical models.

For illustration, I shall mention "Klein's Model I" [L. R. Klein, *Economic Fluctuations in the U.S. 1921-1941*, New-York, Wiley, 1950], computed by Zellner and Theil [A. Zellner and H. Theil: "Three-Stage Least Squares: Simultaneous Estimation of Simultaneous Relations", *Econometrica*, vol.30, 1962, pp.54-78], in the form described in R. S. Pindyck and D. L. Rubinfeld, *Econometric Models and Economic Forecasts*, [Fourth Edition, McGraw-Hill International Editions, 1998, pp. 363-364].

$$C=\alpha_0+\alpha_1\Pi+\alpha_2(W_1+W_2)+\alpha_3\Pi_{-1}+u_1 \qquad [5]$$

$$I=\beta_0+\beta_1\Pi+\beta_2\Pi_{-1}+\beta_3K_{-1}+u_2 \qquad [6]$$

$$W_1=\gamma_0+\gamma_1(Y+T-W_2)+\gamma_2(Y+T-W_2)_{-1}+\gamma_3t+u_3 \qquad [7]$$

$$Y+T=C+I+G \qquad [8]$$

$$Y=W_1+W_2+\Pi \qquad [9]$$

$$K=K_{-1}+I \qquad [10]$$

where C is consumption, Π - the profits, W_1 - wages in the private sector, W_2 - wages in the public sector, I - investments, G - government expenditures, K - capital stock, Y - national income, T - indirect taxes, t - time (in years), u - regression residuals. In order to understand function [7], remember that (Y+T) approximates the net national product. On the whole, the model contains 6 endogenous variables and 8 predetermined ones, of which 5 refer to the previous year (Π_{-1}, K_{-1}, Y_{-1}, T_{-1}, and W_{2-1}), and 3 may be optional exogenous; obviously, the endogenous and optional variables are interchangeable. The values of the parameters α_i, β_i, γ_i, obtained by two estimation methods (that will be discussed later) are:

Table 1

Three-Stage and Two-Stage Least-Squares Estimates of Parameters

Equation	Coefficient	3SLS Coefficient estimate	3SLS Variance of coefficient estimator	2SLS Coefficient estimate	2SLS Variance of coefficient estimator
Consumption	Π	0.0479	0.0131	0.0173	0.0139
	W1+W2	0.8170	0.0014	0.8102	0.0016
	$Π_{-1}$	0.1897	0.0109	0.2162	0.0115
	Constant	16.1923	1.6900	16.5548	1.7450
Investment	Π	0.2111	0.0285	0.1502	0.0300
	$Π_{-1}$	0.5667	0.0252	0.6159	0.0264
	K_{-1}	-0.1472	0.0012	-0.1578	0.0013
	Constant	17.9210	52.5160	20.2782	56.8920
Demand for labour	$Y+T-W_2$	0.4282	0.0012	0.4389	0.0012
	$(Y+T-W_2)_{-1}$	0.1543	0.0014	0.1467	0.0015
	t	0.1356	0.0008	0.1304	0.0008
	Constant	1.6935	1.3020	1.5003	1.3170

Thus, in the case of numerical models, the relationships among variables are defined not only in principle and relative to their direction of influence, but as concrete estimates (the values α_i, β_i, γ_i). Let us comment briefly on the table:

- the current wages are mostly destined to consumption;
- the profits go mainly to investments;
- in the latter case, the negative influence of the capital stock is significant, which might mean that the economy has a large amount of under-utilized capacities;
- the shares of the profits allotted to investments and consumption depend to a larger extent on their previous level than on the current one;
- an ascending trend in the dynamics of wages in the private sector (coefficient γ_3) is clearly emerging, and for an understanding of the process a more thorough study is required (coefficient β_3 contradicting such a trend).

In its numerical form, the model becomes usable for testing certain macroeconomic hypotheses, for forecasting, and thus for shaping governmental policies.

2. Criterion II: the character of interdependencies among variables.

a) First it is the problem of the form of the functional relationships that is involved. Some models comprise only linear equations (of the type of functions [3] or [5]-[10]). Others may also include non-linear relationships.

b) The models differ also in relation to the nature of the functional dependency among the used variables.

Most of them are deterministic, in which case the regression residuals are also ignored.

In the past decades, the probabilistic models (more plausible under uncertainty constraints) were used more often. The financial markets, characterized by a high volatility, were the most important beneficiaries.

3. Criterion III: aggregation level of the entities included in the model. Four such levels may be distinguished.

a) The first would correspond to the maximum desegregation of the national economy. All the economic agents show up as distinct entities, with their own behavioural functions. For illustration, the theoretical Walrasian system might be considered. Because of obvious reasons, the applications – the computable models of general equilibrium – only partly comply with such conditions; some derogations that drag them closer to the next category (b) are accepted.

b) The intermediate national aggregation does not operate with individual economic agents, but with different groupings of them, preserving the country demarcations.

- From this perspective, the economy can be structured, for example, from the institutional point of view. The Romanian National Accounting operates with the classification of economic agents in the following institutional sectors: non-financial companies and quasi-companies, financial institutions, insurance companies, public administration, private administration, households, and to complete the picture "the rest of the world" as a global entity. Certainly, this structure may be enlarged, for instance, dividing the companies according to the type of ownership and the households according to their income level.
- Frequently, the economic activity is divided by sectors – it is the especial case of the well-known input-output tables.
- The regional profile (territorial-administrative units or the development regions) is also often used as benchmarks for classification of the economic agents.

The national intermediate aggregation may be symmetrical (in all the segments of the model the same criterion is applied) or asymmetrical (if the criteria change).

c) The national maximum aggregation is equal to considering the economy as a single entity. The behavioural and equilibrium functions of the model are conceived exclusively on that scale.

Usually, macroeconomic models are those in the classes b) and c).

d) Finally, in the past decades international aggregations (geographical areas, interstate unions, and world economy as a whole) are more often used.

4. Criterion IV: the goal of modelling.

I shall discuss this issue using a very simple example [from R. S. Pindyck and D. L. Rubinfeld, *Econometric Models and Economic Forecasts*, Fourth Edition, McGraw-Hill International Editions, 1998, pp.386-381].

$$C_t = a_1+a_2Y_{t-1} \quad [11]$$

$$I_t = b_1+b_2(Y_{t-1} - Y_{t-2}) \quad [12]$$

$$G_t = ? \quad [13]$$

$$Y_t = C_t+I_t+G_t \quad [14]$$

where C is consumption, I - investments, G - government expenditures and Y - gross national product. The system has thus 4 variables and an equal number of relationships, if the status conferred to G_t is definited. According to the goal of the model, three situations may be distinguished.

a) If [13] is an econometric relationship, for instance $G_t=c_1+c_2(Y_t - Y_{t-1})$, the model may be considered as descriptive-explicative. "The descriptive-explicative models are built through the generalization of a series of empirical situations" [C. Zamfir, L. Vlăsceanu, *Dicționar de sociologie*, Editura Babel 1993, p. 366]. In such a form, the model helps us to more precisely identify the quantitative dependencies among the involved indicators, but - all these being pre-determined - it can say almost nothing about the possible future evolution of the economy.

b) When G_t is an optional exogenous (as in the book from which the example was taken), we may speak about an explorative model (also called simulating model), which facilitates the study of economy reactions to G_t changes. If we maintain the econometric relationship of G_t (as in point a)), then other indicators from among the involved ones might become an optional exogenous variable.

c) It is also possible that G_t be considered as endogenous variable (without including a special relationship for this indicator), but attaching to the system an objective function. Such an approach might involve:

- determination of extremes for certain endogenous variables, such as Y_t = max, C_t = max, etc., or
- minimization of the deviation of their computed level from the corresponding target-level, for instance $(C_t-C^*)^2$=min or $(G_t-G^*)^2$=min, where C^* and G^* are the levels to be reached.

Other desirable restrictions may be also introduced, with the constraint, of course, that the system remains solvable.

Through such adaptations, the model becomes normative. "The normative models set floors or *a priori* values for the object parameters and are then used to measure the empirical situations" [C. Zamfir, L. Vlăsceanu, *Dicționar de sociologie*, Editura Babel 1993, p. 366].

5. Criterion V: time behaviour.

From this point of view, the following categories of models may be delimited:

a) strictly static (they do not establish any connection between several successive time intervals);

b) quasi-stationary (such a connection exists, but neither the econometric functions, nor the optional exogenous variable or expectations change within the successive intervals considered); in other words, it is like the economy evolves within a "frozen framework";

c) dynamic – with the modification – in short, medium and long run – of the optional exogenous variable and even of certain (or all) econometric functions (their shapes and parameters).

6. All the above-mentioned considerations may be synthesized as follows:

Scheme 2

Economic models typology

Classification criterion	Categories of models
Nature of composing elements	• logical, qualitative-analytical, numerical
Character of interdependency among variables	• linear, non-linear • deterministic, probabilistic
Level of entities aggregation	• maximum disaggregating, intermediate aggregation, maximum national aggregation, international aggregation
Modelling goal	• descriptive-explicative, explorative, normative
Time behaviour	• strictly static, quasi-stationary, dynamic

C. Sequences of the numerical modelling process

The segmentation of such a complex process, impregnated by multiple feedbacks, can be only conventional. In Appendix III we present some more recent approaches to this issue. The systematisation proposed below considers them, but its referential remains the system of relationships presented in Scheme 1. It distinguishes 5 sequences of functional nature; the sequences may intersect or be carried out simultaneously.

1. Naturally, the first is the shaping of the modelled object, namely the conceptual identification of the perimeter in which it circumscribes itself, definition of its components and structure, of the most important inner joints and external connections that validate its identity. Economic theories are the most important support to this approach, irrespective of their inspiring paradigms and the elaboration level reached at the considered moment. The documentary studies, opinion sample surveys (general or specialized), as well as any other *a priori* information play a significant part most of the time. The researcher's own intuitions must not be underestimated since, even if not logically or inductively sustainable, they may complete or shade the image of the modelled object in a manner that might subsequently prove to be correct.

This sequence is not necessarily equivalent to a single option (explicit or implicit). More images may be accepted – sometimes significantly different – of the same object. A famous example is provided by the consumption function, for which - as it is known –

different hypotheses were provided (the already mentioned Keynesian function, the life-cycle hypothesis, that of the permanent income), and the applied econometrics made significant efforts to formalize and test them all. However, it is obvious that to each of the concurrent images of the same object a congruent model or models will correspond (because here also plurality is possible).

Usually, this sequence materializes in a set of (definition or functional) assumptions regarding the modelled object. Even if sometimes this set of assumptions is not deciphered, it is always involved in the modelling process.

2. Further, we define the behavioural relationships, identities and equilibrium equations that adequately formalize the assumptions accepted (directly or indirectly) in the context of the previous sequence.

2.1. I shall specify the acceptation in which the three notions are used in the current paper.

a) *Behavioural* is considered any relationship in which the intensity (including null) and sometimes even the direction of the independent variable influence on the dependent variable are not a priori determined, differentiating from one case to another. This interpretation is larger than that limiting to "the response of an individual or group to the economic stimuli" [*Macmillan Dictionary of Modern Economics*, Fourth Edition, General Editor D. W. Pearce, 1992; Romanian version, Editura CODEX, 1999, p.140]. It also covers relationships where the human action (current or previous) appears to be mediated by technical (the production and cost functions), or institutional processes (degree of budgetary revenues collection or openness of the domestic market), etc. Since the parameters of the behavioural functions are not directly accessible, needing to be determined through estimation techniques, these functions are also called econometric functions or relationships.

The "salt and pepper" of a model rests in its behavioural relationships. On their truthfulness depends the plausibility of the model itself, its capability to correctly simulate, statically and dynamically, the functioning of the economy.

b) By *identities* we understand the relationships resulting from the way the involved variables are conceived (in theory or statistics). For instance, domestic absorption (DAD) cumulates, as it is normal, the private consumption (CH), governmental consumption (CG) and the gross capital formation (GCF). The equality

$$DAD=CH+CG+GCF \qquad [15]$$

is automatically true in any circumstances. In order to emphasize it, sometimes the special symbol of identity (≡) is used; but currently the symbol of equality (=) is used.

c) The *equilibrium equations* indicate something else, namely the compulsoriness that the variables that have different behavioural determinations reach the same level. For instance, money demand (M^d) depends on certain factors, and money supply (M^s) on others (or in the case of common ones, in a different manner), thus forming distinct curves. The equality $M^d=M^s$ shows that the economy will effectively function only where these two curves intersect, namely at the output, price index, interest rates and resource utilization structure that allow the two categories of factors to balance their influences.

For the brevity of the presentation, the equilibrium identities and equations are together denominated as accounting relationships. Making use of this terminology, easier and frequently used, we must never ignore their different content.

2.2. Due to the more rigorous character of the operation, the definition of behavioural and accounting relationships, namely of what it is also called the qualitative-analytical or theoretical model, may bring back into discussion some of the hypotheses that configured the image of the modelled object (sequence 1). Translation into mathematical language of some literarily formulated hypotheses, based on intuition or arbitrary numerical exercises, etc., has identified serious logical faults in their structure. "The transformation problem" is a famous example (Appendix IV). Consequently, between the first two sequences of the modelling process a significant feedback connection is forming.

3. Building the database for the considered behavioural and accounting relationships is another important sequence of the numerical modelling.

3.1. Unlike other sciences, economics cannot resort to the information resulted from conducted experiments (except some extremely rare cases and at the micro level). The main sources remain: the official statistics (periodical or occasional); the surveys performed (also regularly or at certain intervals) by different public and private institutions; assessments made by the international institutions; specialized papers and magazines; numerous bulletins issued by the governmental agencies and local authorities, the banking system and rating companies, the employers' associations and large firms, the trade unions, etc.; the mass media; direct discussions with experts. Three exigencies are essential for the building up of the necessary database.

a) Primordial is the credibility. If several sources that we can access provide information regarding the same phenomenon, priority must be given to the sources generally or largely accepted by the scientific community, economic and financial media, and public opinion. The quality of data is always transferred to the model built on their basis.

b) Consistency of the estimating technique of a model parameters usually stems from the law of large numbers: even if using small samples their expansion through artificial procedures is considered, or the strictly punctual character of the considered application is admitted from the beginning. Before any econometric processing started, we must ensure that the database was supplied with all (of course, as a maximal goal) credible available information. The long series do not automatically guarantee the model relevance, but are one of its major premises.

c) Coming from different sources (frequently even when belonging to the same source), the data do not comply – more or less – with the identities assumed in the previous sequence. Incompatibilities may arise from the methodological or recording discrepancies, from computational differences of the derived indicators. Eliminating these incompatibilities, ensuring the data base coherence are essential for the quality of the resulted model.

3.2. It is possible that due to informational reasons some *behavioural and accounting* relationships become unapproachable from an econometric point of view, while others - omitted initially - become interesting. Also, the proper data base analysis might suggest corrections even of the very starting image of the modelled object. That is why feedbacks with the previous sequences (1 and 2) are almost inevitable.

4 The coupling of the behavioural and accounting relationships system with the database is made through the computation of the model parameters. The results are subject to a series of econometric tests that evaluate the consistency of the obtained estimates, the confidence interval within which these fall, the extent to which they are in accordance with the data used, etc.

Modern econometrics offer a large range of such techniques that consider the character of the involved interdependencies, the level of aggregation of entities, the time behaviour and goal of the model, the specific features of the available data series. Usually, in a given system of relationships more such procedures are used, and from among them the better placed one from the point of view of econometric tests is kept. For instance, in the above-mentioned case of "Klein's Model I", the 3SLS method ensures superior estimates (lower variances) as compared to 2SLS.

Frequently, the computation of the model parameters generates new problems. The algebraic signs of the partial derivatives of some of the estimated functions may be reversed as compared to those considered as plausible in the qualitative-analytical model. Other such functions may prove irrelevant after the econometric tests. Thus it is necessary to come back to the way in which the relationships are defined (sequence 2), as well as to the data series used (sequence 3), looking there for the likely source of the failure to estimate the model parameters (sequence 4). If these investigations remain inconclusive, the insofar-accepted image of the modelled object has to be brought again into focus (sequence 1).

5. The resulted version of numerical model has to face two more extremely serious check ups.

5.1. First, it is necessary to confirm the plausibility of the model properties as a whole, that is as an integrated system. It is the case both of the static properties (which appear in the simulations performed within the time limits for which the model was built - year, quarter, month) and of the dynamic properties (revealed by the simulations performed for several such successive intervals). For illustration only, Appendix V presents an example regarding Romania (for the case of dynamic approach).

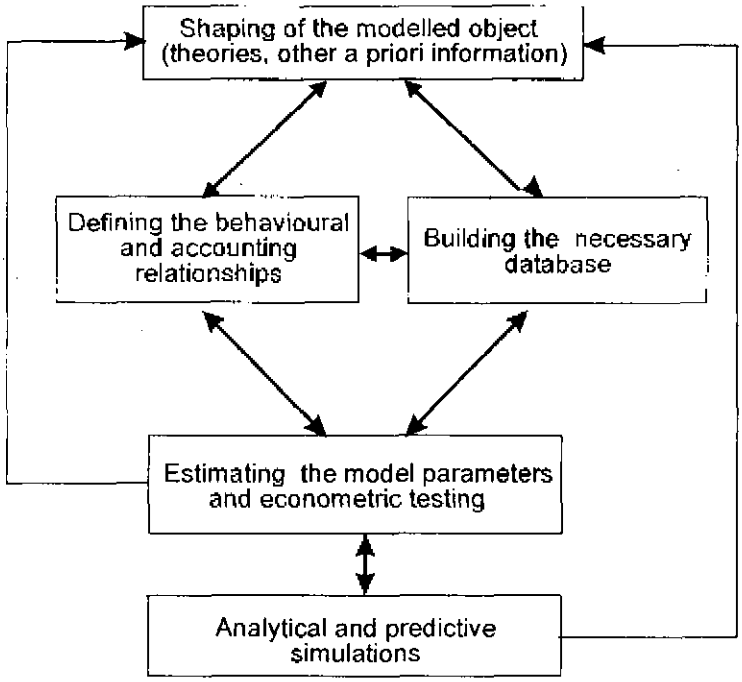
If this type of simulations reveals implausible behaviours of the model, according to the specific features of the identified problems, one has to return to the econometric analysis (sequence 4), or even to the image that the analysis materializes (sequence 1).

5.2 Finally, the model is used for forecasts. Their confrontation with reality will show how performing the model is from the practical point of view. In the case of some systematic prediction errors it is necessary to identify the part really imputable to the model, because such discrepancies may also stem from the defective conception of scenarios. If it is confirmed that the part imputable to the model prevails, an updating of the model is required, retracing the above-sketched sequences.

6. That entire cycle may be synthesized as follows:

Scheme 3

Sequences of numerical modeling process



During the last century academic research and practical applications were continuously marked, directly or indirectly, by the conflict between the uniqueness of the modelled object - either in the case of a company or a household, of a national economy or an integrated inter-state complex - and the plurality of the explicative theories. Three attempts to solve the dilemmas associated with this binominal were taking shape.

The first "forces" the econometric functions in order to make them compatible with a certain preferred paradigm. Such dogmatism has proven more and more vulnerable under the circumstances of current technological and cultural mutations.

Its radical alternative stakes on the application of auto-regression vector without restrictions regarding the involved variables, number of lags and estimates' algebraic signs. This a-theoretical econometrics also does not stand the relevance tests. It became more and more clear that a model couldn't be consistent without being isomorphic to a certain coherent image regarding the studied phenomenon. When Lawrence

Klein, in its famous dispute with Thomas Sargent and Christopher Sims pathetically exclaimed, "Without theory and other a priori information we are lost" [*Economic Theory and Econometrics*, ed. by J. Marquez, University of Pennsylvania Press, Philadelphia 1985, p.155], he eloquently expressed exactly this idea.

The practice of modelling revealed another way, namely the specification of the econometric functions making simultaneously use of the assumptions accepted in several concurrent doctrines or even of certain *ad hoc* hypotheses. We are thus coming closer to what could be named the particularized conceptual mix. Modelling ceases to be a simple numerical replica of the theory, forming together with it an interdependent and dynamic couple. Such an approach raises, of course, new epistemological issues, whose clarification requires perseverance and inspiration, but mainly very much hard work performed in the critical-rationalistic manner described by Karl Popper: "A problem - he noted - is a difficulty. To understand it means to experience this difficulty, and this can be done only by finding that there is no easy and visible solution" (*Mitul contextului în apărarea ştiinţei şi a raţionalului*, Editura TREI, 1998, p.134). It is easy to notice that Scheme 3 conforms exactly to this perception.

Appendix I

List of Macromodels by Country (2001)

Country	Mod.	Country	Mod.	Country	Mod.	Country	Mod.	Country	Mod.
Afghanistan	2	Congo	5	Indonesia	52	Nicaragua	13	Sri Lanka	30
Algeria	9	Costa Rica	11	Iran	32	Niger	4	Sudan	14
Angola	1	Cuba	1	Iraq	10	Nigeria	41	Swaziland	2
Arabia	1	Cyprus	6	Ireland	26	N-Korea	3	Sweden	60
Argentina	33	Czech	3	Israel	14	Norway	46	Switzerland	54
Asia	2	Denmark	59	Italy	130	OECD	5	Syria	7
Australia	78	Dominican Republic	0	Ivory Coast	12	Oman	3	Taiwan	72
Austria	50	EEC	35	Jamaica	8	Pakistan	51	Tanzania	11
Bahrain	2	Ecuador	12	Japan	207	Panama	9	Thailand	71
Bangladesh	31	Egypt	43	Jordan	7	Papua	1	Togo	5
Barbados	4	El Salvador	10	Kenya	23	Paraguay	2	Trinidad Tobago	9
Belarus	0	United Arab Emirates	4	Kuwait	18	Peru	27	Tunisia	15
Belgium	90	Estonia	2	Latvia	3	Philippines	57	Turkey	47
Benin	2	Ethiopia	7	Lebanon	2	Poland	59	Uganda	7
Bolivia	4	Fiji	1	Liberia	3	Portugal	16	UK	213
Botswana	4	Finland	37	Libya	3	Puerto Rico	4	Ukraine	2
Brazil	58	France	152	Lithuania	2	Qatar	4	Uruguay	3
Bulgaria	13	Gabon	5	Luxembourg	8	Romania	15	USA	495
Burkina Faso	2	Gambia	2	Madagascar	3	Russia	0	USSR	37
Burma	6	Ghana	30	Malawi	3	S. America	1	Vanuatu	0
Burundi	1	Greece	56	Malaysia	49	Saudi Arabia	20	Venezuela	29

Country	Mod.	Country	Mod.	Country	Mod.	Country	Mod.	Country	Mod.
Czechoslovakia	37	Grenada	1	Mali	1	Senegal	7	Vietnam	4
Cameroon	5	Guatemala	10	Malta	4	Serbia	0	W-Germany	304
Canada	126	Guyana	4	Mauritania	1	Sierra Leone	5	E-Germany	22
Country	Mod.	Country	Mod.	Country	Mod.	Country	Mod.	Country	Mod.
Central Africa	2	Guinea	1	Mauritius	2	Singapore	19	Germany	17
Central America	9	Haiti	2	Mexico	66	S. Korea	104	World	54
Chad	1	Honduras	9	Morocco	15	Slovakia	1	Yemen	1
Chile	32	Hong Kong	11	Mozambique	1	Slovenia	2	Yugoslavia	38
China	34	Hungary	41	Nepal	3	Solomon Islands	1	Zaire	5
CMEA	7	Iceland	4	Netherlands	122	South Africa	17	Zambia	9
Colombia	29	India	128	New Zeeland	36	Spain	46	Zimbabwe	4
						Total		4457	

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Graduate Students

Appendix II

Acceptations of the economic model concept

- J. M. Keynes: *The General Theory of Employment, Interest and Money*, McMillan, London, 1967; Romanian version, Editura Ştiinţifică, 1970

"The recent <mathematic> economy consists of a too large proportion of simple speculations, as vague as the initial presuppositions they are based upon, allowing the authors to ignore, in their labyrinths of pretentious and useless symbols, the real world's complexity and interdependencies" (pp. 305-306).

- R. Faure, A. Kaufmann, M. Denis-Papin: *Mathématiques nouvelles*, Dunod, Paris, 1964; Romanian version, Editura Ştiinţifică, 1969

"Through <modelling> an artificial, accurately enough, reconstruction of a real phenomenon is understood, in order to get information about this phenomenon that can be of abstract or concrete nature " (p. 433).

- Karl R. Popper: *Popper Selections*, edited by David Miller, Princeton University Press, 1985; Romanian version *Filosofie socială şi filosofia ştiinţei*, Editura TREI, Bucureşti 2000; Capitolul 29 "Principiul raţionalităţii" (1967)

Popper distinguishes between "two kinds of problems regarding explication or prediction.

The first is to explain or predict a *single event* or a very small number of such *events*...

The second is to explain or predict a certain *genre* or *type* of events...

The difference between these two kinds of problems is that the first can be solved *without elaborating a model*, while the second may be much easily solved *through the elaboration of a model.*

I believe that in the theoretical social sciences it is almost impossible to answer the first type of questions. The theoretical social sciences function almost always on the basis of elaboration of the typical conditions or situations – namely on the basis of elaboration of models " (p.388).

"...the central element of the situational analysis is that we do need, in order to <animate> it, only the supposition that different involved persons (or agents) act *accurately or as they should do*; or, in other words, according to the considered situation... In the literature it is known as <the rationality principle>..." (pp. 389-390).

"If you examine the rationality principle from the point of view we have adopted here, you will find that it has nothing or very little to do with the empirical or psychological assertion that the man acts most of the time in a reasonable manner... The principle may be stated like this: once the model (our situation) elaborated, we presume only that the actors act in accordance with its terms, or that they are practically enforcing what *implicitly* existed in the situation. As a parenthesis, the term <situational logic> also refers to that". (p. 390).

"We must admit that the tests of a certain model are not easily to get, and usually they are not very clearly configured. But such a difficulty appears also in physics. It is, of course, connected with the fact that the models are always and necessarily rudimentary, that they are always and necessarily schematic over-simplifications. Their schematic character attracts a relatively low degree of testability, because it is difficult to decide if a discrepancy is due to the necessary schematic character or to a mistake, an infirmity of the model. Nevertheless, sometimes we may decide through tests which of the two (or more) rival models is the best" (p. 390).

"...I consider the principle of action suitability (namely the *rationality principle*) as a component part of any, or nearly of any verifiable social theory But if a theory is tested and found as erroneous, then we should always have to decide which of its numerous component parts is guilty of its failure. My thesis is that to decide as to deem responsible the rest of the theory and not the rationality principle - namely the model - is a correct methodological strategy...

The discovery that this is not entirely true does not tell too much to us: we already know this fact. Moreover, despite its falsity, it represents a rule that largely enough approximates the truth.... The attempt to replace the rationality principle with another seems to give an absolutely arbitrary character to the building of the model..." (p. 392).

"On another hand, <the rationality principle> has nothing to do with the *supposition* that the man is a rational being, in the sense that he/she always takes a reasonable attitude. It is more likely a minimal principle (because it presupposes only the suitability of our actions to our situations, in the way we are seeing them) that animates all or nearly all our explicative situational models, so that even if we know it is not true we have certain reasons to consider it close to the truth "(p.395)

- N. Georgescu-Roegen: *The Entropy Law and Economic Process*, Harvard University Press, 1971; Romanian version, Editura Politică, 1979

"...an economic model is not a precise pattern, but an *analytical sketch*... Being only such an analytical sketch, an economic model can serve only as a guide to the initiated one that formed his analytical power of discernment through a laborious training. Economic craft cannot miss the use of <finesse and subtleness> - let us call it art, if you like it...". (pp. 533-534)

"We must accept the fact that the models that use complex theoretical and mathematical notions and instruments did not provide better results, in most of the existing tests, than the most simplistic and mechanical extrapolating formulae". (T. C. Koopmans: "Three Essays on the State of Economic Science", New York 1957, p. 212)."Naturally, the assertion refers to the success of models in *predicting future events*, and not in *adjusting the past observations* used in the evaluation of parameters". (p. 540)

"Maybe the most obvious merit of an arithmomorphic model recognized by nearly all the critics of mathematical economy is unearthing important errors in the papers of literate economists that reasoned in a dialectical manner... The second role of the arithmomorphic model is to *illustrate certain aspects of a dialectic argument in order to* make them more intelligible... These two roles of the mathematical model circumscribe the reason to exist of what is currently considered <economic theory>; that is to provide for our dialectical reasoning a <solid backbone>". (pp. 540-541).

"In the end, a <simplistic> model may be a more explanatory representation of the economic process, with the constraint that the economist has developed his skill to such an extent that he is able to choose several significant elements from the multitude of the disparate facts. The choice of the facts that matter is the main problem in any science - as a 'perfect' econometrician - James Tobin - prevented us. A <simplistic> model that comprises only few factors carefully chosen is also a less misguiding 'road map' to action". (p. 546).

- E. Malinvaud: Méthodes statistiques de l'économétrie, Dunod, Paris, 1964

"Un modèle consiste en la représentation formelle d'idées ou des connaissances relatives à un phénomène. Ces idées, souvent appelées <théorie du phénomène>, s'expriment par un ensemble d'hypothèses sur les éléments essentiels du phénomène et des lois qui le régissent. Elles sont généralement traduites sous la forme d'un système mathématique, dénomé <modèle>. Le raisonnement sur le modèle nous permet d'explorer les conséquences logiques des hypothèses retenues, de les confronter avec les résultats de l'expérience, d'arriver ainsi à mieux connaitre la réalité, et à agir plus efficacement sur elle". (p. 52)

- *Mic dicționar enciclopedic*, Editura enciclopedică română, 1972

"Model in science and technique. Systems built in order to study another more complex system, to which the first one is analogous from certain points of view. The models may be ideal, when it is the case of a logical-mathematical representation or construction (e.g. the model of atom's nucleus), or material (e.g. the scale-model of a ship)... The economic model is a formal, symbolic representation of an economic process or phenomenon. Economic models are usually mathematical models..." (p. 597).

- W. Leontief: *Essais d'économiques*, Calmann-Lévy, France, 1974

"Grâce à leur simplicité commode et malgré leur nécessaire imprécision, les descriptions des phénomènes quantitatifs telles que les agrégats et les moyennes se révélèrent utiles, voire indispensables aux économistes. Les purs théoriciens eux-mêmes les utilisent - sans doute plus souvent qu'ils ne le devraient - comme procédé pédagogique pour prêter à leurs modèles schématiques d'équilibre général l'apparence du réalisme. Certains de ces modèles prétendent décrire le fonctionnement du système économique entier selon cinq, quatre, ou même trois variables agrégatives. Si on veut en faire des substituts de l'analyse et de la généralisation théoriques, ces procédés de simplification sont évidemment sans valeur. Dans la mesure où ces vastes agrégats ne sont pas directement observables (et peu d'entre eux le sont), mais doivent être établis d'après des mesures distinctes des variables composantes, leur usage ne permet de réaliser aucune économie dans l'exploitation des observations primaires.

L'étude directe des faits et les descriptions quantitatives des propriétés structurelles du système économique, détaillées dans leur contenu, complètes dans leur recouvrement et systématiquement conçues pour remplir les conditions spécifiques d'un schéma théorique approprié, semblent constituer les seules voies capables de conduire à une compréhension – valable du point de vue empirique – des caractéristiques du fonctionnement de l'économie moderne". (pp.108-109)

- N. P. Fedorenko, I. V. Kantorovici, V. I. Danilov-Danilian, A. A. Konüs, E. Z. Maiminas, I. N. Ceremnih, I. I. Cerneak: *Matematika I kibernetika v ekonomike*, Izdatelstvo Ekonomika, Moskva, 1975; Romanian version, in *Editura Ştiinţifică şi Enciclopedică*, Bucureşti, 1979

"...a conventional image of the research (or management) object. The model can have a practical importance only under the circumstances when its analysis (through active experimentation, deductive research, etc.) with the means available to the subject of research. is more accessible to that than the simple study of the object... There are many definitions (several dozens) and classifications of the model in accordance with the tasks of different sciences.

The most strict and general is based on the notions of homomorphism and isomorphism. The image of the researched object that takes shape in the mind of the observer according to his aim, is simplified-homomorphical, because abstraction, neglection of those properties of the object that are not essential from the point of view of the considered aim is a necessary condition for every research. In the following, the observer builds the proper model: an abstract or material system. isomorphic to the simplified, previously formed image regarding the set of established attributes (or relationships)". (p. 347)

- *Petit Larousse illustré*, Libraire Larousse, 1977

"Modèle mathématique, représentation mathématique d'un phénomène physique, humain, etc. réalisée afin de pouvoir mieux étudier celui-ci". (p. 662)

- T. F. Dernburg: *Macroeconomics: Concepts, Theories and Policies,* McGraw-Hill Book Company, 1985

"The unifying principle of macroeconomics is the macroeconomic model of the economy that began with the classical model of pre-Keynesian days. In nearly all cases, subsequent major developments can be conveniently and profitably absorbed into that model as refinements or extensions. Keynes himself viewed his efforts as an attempt to make the model more general, claiming that the classical model was a special case of a more general scheme of things. The analysis of monetary and fiscal policies is most successfully conducted within the framework of the model, and the monetarist-fiscalist debate cannot be disentangled without this model. The model has always had a demand side and a supply side. Keynes's emphasis on demand did not reflect ignorance of the supply side but rather came in response to the problems that were most pressing in his time. Similarly, concern with supply issues in the 1970s did not mean that demand economics was obsolete; it meant that for some time insufficient attention had been paid to the supply side and that the supply components of the model were in need of sharpening. Finally, inflation meant that ways had to be found to replace the price level on the axis by the inflation rate and that the analysis had to be directed toward how the economy behaves when it is in a state of constant disequilibrium". (p. 11)

- H. R. Varian: *Intermediate Microeconomics-A Modern Approach*, W.W. Norton & Company, New York, 1987

"Economics proceeds by making models of social phenomena, which are simplified representations of reality". (p. 18)

- G. Abraham-Frois: *Economie Politique*, Fourth edition, Editura Economică, 1988; Romanian version, Editura Humanitas, 1994

"What is a model? A model is a simplified representation of a process, of a system. Although it is not necessarily made of equations (we may talk about the Ricardian model) it is no less true that actually the building of models frequently employs mathematical formalizations; a model thus appears as an ensemble of equations, being a simplified construction of an economic system, which is used mostly to reveal the reciprocal action, interconnection, interdependency of certain phenomena". (pp. 15-16)

- J. Brémond, A. Gélédan: *Dictionnaire économique et social*, Hatier, Paris, 1990

"A départ il y a un objet ou un phénomène réel; il s'agit le plus souvent de représenter cet objet dans le pensée, pour n'en retenir que l'aspect particulier que l'on veut connaitre. On ne retiendra donc de l'objet que certains éléments significatifs en fonction de ce que l'on recherche; ces éléments seront exprimés abstraitement dans le modèle soit par des matériaux phisiques (maquette), soit par des traits (plans, dessins). soit par des mots et par des règles logiques permettant de déduire des propositions nouvelles qui seront ensuite traduites en conséquences concrètes dans le monde reel". (p.260)

"Il faut bien connaitre les définitions et les hypothèses de départ et donc les limites de chaque modèle avant d'utiser les résultats". (p.263)

- W.J. Baumol, A.S. Blinder: *Economics - Principles and Policy*, Harcourt Brace Jovanovich, Inc., 1991

"An *economic model* is a representation of a theory or a part of a theory, often used to gain insight into cause and effect. The notion of a <model> is familiar enough to children; and economists - like other scientists - use the term in much the same way that children do. A child's model automobile or airplane looks and operates much like the real thing, but it is much smaller and much simpler, and so it is easier to manipulate and understand. Engineers for General Motors and Boeing also build models of cars and planes. While their models are far bigger and much more elaborate than a child's toy, they use them for much the same purposes: to observe the workings of these vehicles <up close>, to experiment with them in order to see how they might behave under different circumstances. (<What happens if I do this?>). From these experiments, they make educated guesses as to how the real-life version will perform.

Economists use models for similar purposes. A. W. Phillips, the famous engineer-turned-economist who discovered the <Phillips curve>... was talented enough to construct a working model of the determination of national income in a simple economy, using coloured water flowing through pipes. For years this contraption...has graces the basement of the London School of Economics. However, most economists lack the Phillips's manual dexterity, so economic models are generally built with paper and pencil rather than with hammer and nails" (pp. 13-14).

An econometric model is a set of mathematical equations that embody the economist's model of the economy" (p. 285).

- R. E. Hall, J. B. Taylor: *Macroeconomics - Theory, Performance, and Policy*, Third Edition, W.W. Norton & Company, N.Y., 1991

"At the core of any macroeconomic theory is an explanation of how the economy responds to economic forces. How does GNP adjust when a new technology is introduced, or when foreigners decide to purchase a smaller amount of U.S. exports, or when Americans decide to import rather than buy similar domestically produced goods? What if there is a decrease in demand for new factories and machines because of a massive reduction in defence spending? What if the price of oil is quadrupled because a cartel of foreign producers cuts back on oil production? In constructing an explanation of how the economy responds to these forces, the macroeconomist constructs a model.

A model is simply a description of the economy expressed in graphs or equations. It shows how the decisions of consumers and firms interact with each other in markets to determine output and other variables".(p.12)

- G. Bannock, R.E. Baxter and E. Davis: *Dictionary of Economics*, Penguin Books, London, 1992

"Econometric models. The representation of a relationship between economic variables as an equation or set of equations in which statistical can be attributed to the parameters linking the variables" (p. 125).

"Model. A representation of an economic system, relationship or state, that takes any of a variety of forms. At its most formal, a model can be said to consist of a *verbal description* or *analogy* of some real-world phenomenon. It may take the form of a *diagram* (for example, the graph of the cobweb model), or *a set of equations* setting out the relationship between variables (consumption as a function of income, for example). In applied economics, a model is likely to be expressed in a computer program or *spread-sheet* in which data (the <input>) are processed and manipulated to produce results (the <output>)" (p. 287).

"Models have a variety of uses. First, they can illuminate and describe systems clearly by stripping them of all unnecessary complications. Second, computer models in particular are useful for simulation. A variable, such as unemployment, is defined in terms of the values of a set of other variables, and by simulating a change in these, the effect of different policies on unemployment can be estimated. Third, forecasts of the behaviour of variables can be made, based on past observations. Finally, the specification of models is a prerequisite to the testing of different theories" (p. 288).

- R. C. Amacher, H. H. Ulbrich: *Principles of Macroeconomics*, Fifth Edition, South-Western Publ. Co., Cincinnati, Ohio, 1992

"Economic theorists, like other scientists, develop theories that will yield testable hypotheses. Then they test these hypotheses by comparing them with the facts and seeing if they are consistent. A model is a formal statement of the theory, usually in the form of graphs or equations. In the simpler model of the production possibilities curve as a straight line, we assumed that all productive resources were alike. As a result, the relationship between outputs of the two goods was a constant one. In the more complex model, we introduced an alternative assumption - that all resources were not alike. The model then predicted that increased production of one good would require increasing sacrifices of the other. An economic model will generate one or more "if-then" hypotheses about what will happen in the real world. These hypotheses are then tested in real situations or experiments" (pp. 14-15).

- C. Zamfir, L. Vlăsceanu: *Dicționar de sociologie*, Editura Babel, 1993

"Model (in latin *modus*, <measure>): physical, logical or mathematical representation of the structure of an object, phenomenon or process. In this case, the term of structure refers to the parameters, behaviours and specific shape of the respective object. The building of the model may have as aim explanation, discovery or representation. The model can be built in two ways: through *isomorphism* - in the case when each component of the real object has an identifiable correspondent, strictly similar to a component of the model, or through *homomorphism* - in the case when the model is a simplified representation of the real object" (pp. 365-366).

- D. R. Henderson (Editor): *The Fortune Encyclopaedia of Economics*, Warner Books, New York, 1993

"An econometric model is one of the tools that economists use to forecast future developments in the economy. Before econometricians can make such calculations, they need what is called an economic model, or a theory of how different factors in the economy interact with one another" (p. 190).

"An econometrically based economic forecast can...be wrong for several reasons:

1. incorrect assumptions about the <outside>, or exogenous, variables, which are called input errors;

2. econometric equations that are only approximations to the truth.., which are called model errors;

3. some combination of input error and model error" (pp. 192-193).

- E. S. Pecican: *Econometrie*, Editura ALL, Bucureşti, 1994

"In order to formulate an expanded econometric model, comprising many regression equations, it is necessary to consider the following aspects: a) the national economy, as any other important economic process, is characterized by a self structure, and by a way to function in order to reach the pursued goal; b) the economic modelling represents an important stage in the process of knowing the economic mechanisms and the econometric models distinguish themselves through the statistical approach of the relationships presupposed by economic theory, in the context of certain hypotheses defined by a larger model from the mathematical economy; c) though formed by a large number of equations, what supplies an econometric model is however a simplified image of the essential features of the reflected process" (p.228).

- N. G. Mankiw: *Macroeconomics*, Second Edition, Worth Publishers Inc., N.Y., 1994

"Macroeconomics address many different questions. For example, they examine the influence of fiscal policy or national saving, the impact of unemployment insurance on the unemployment rate, and the role of monetary policy in maintaining stable prices. Macroeconomics is as diverse as the economy. Because no single model can answer all questions, macroeconomists use many different models. One of the most important and difficult tasks for the student of macroeconomics is to keep in mind that there is no single <correct> model. Instead, there are many models - each of which is useful for a different purpose...Remember that a model is only as good as its assumptions and that an assumption that is useful for some purposes may be misleading for others. When using a model to address a question, the economist must keep in mind the underlying assumptions and judge whether these assumptions are reasonable for the matter at hand" (pp. 12-13).

"Model: A simplified representation of reality, often using diagrams or equations, that shows how variables interact" (p. 490).

"Macroeconometric model: A model that uses data and statistical techniques to describe the economy quantitatively, rather than just qualitatively" (p. 490).

- Y. Bernard et J. C. Colli: *Vocabulaire Economique et Financier*, Seuil 1989; Romanian version, Humanitas, 1994

"Model. Formalized representation in a system of equations that form a coherent ensemble of relationships among the economic phenomena". (p. 278)

- Dictionary of Money and Mathematics, Claremont Books, London, 1995

"A model is a mathematical projection or design. Combination of numbers or a formula can also be used as models" (p. 93).

- S. Dobson, G. S. Maddala, E. Miller: "Microeconomics", McGraw-Hill Book Company Europe, London, 1995

"We might, therefore, say that *a model is a simplified representation of the real world*. Many scientists have argued in favour of simplicity, because simple models are easier to understand, communicate, and test with data. For instance, the philosopher Popper says: <simple statements, if knowledge is our objective, are to be prized more highly than less simple ones because they tell us more; because their empirical content is better, and because they are testable> [K. Popper: "The Logic of Scientific Discovery", Hutchison, London 1959, p.142]. Friedman also argues: <a hypothesis is important if it 'explains' much by little, that is, if it abstracts the common and crucial elements from the mass of complex and detailed circumstances surrounding the phenomena to be explained and permits valid predictions on the basis of them alone>. [M. Friedman: "Methodology of Positive Economics", in "Essays in Positive Economics", University of Chicago Press 1953, p.14] The choice of a simple model to explain complex real-world phenomena often leads to two criticisms (1) the model is oversimplified: (2) the assumptions are unrealistic. To the criticism of oversimplification, we can argue that it is better to start with a simplified model and then progressively construct more complicated models" (p. 4).

- P. A. Samuelson, W. D. Nordhaus: *Economics*, McGraw-Hill, 1995; Romanian version, Teora 2000

"In order to better know the future, the economists created econometric forecasting models by computer. Due to the pioneering work of the Nobel Prize winners - among whom we recall Jan Timbergen and Lawrence Klein - the macroeconomic prediction increased its plausibility during the past 25 years...

How are these economic models created with the help of computer? Generally, the modellers start with an analytical framework made of equations that represent both the aggregate demand and the aggregate supply. Using the techniques of modern econometrics, to each equation the data collected along time is <associated> in order to estimate certain parameters (such as marginal propensity to consumption, the shape of the currency demand equation, increase in the potential GDP, etc.). Moreover, in each stage the modellers make use of their own experiences and their own judgements in order to appreciate if the obtained results are reasonable." (pp. 662-663).

- J. Black: *Dictionary of Economics*, Oxford University Press, 1997

"Model: A simplified system used to simulate some aspects of the real economy. Economics is bound to use simplified models: the real world economy is so large and complicated that it cannot be fully described in finite time or space. A good model concentrates on the point it is studying and leaves out anything not essential to this. Models vary between the very simple, for example the *IS-LM* model, and large econometric models with thousands of equations.

The results of any change in the assumptions of an economic model can be worked out, either by theory or numerical calculation: whether the results generalize to the real world can only be found out by experience. If model-builders have picked the right aspects of reality to include in their models, there will be some approximate resemblance between the model's prediction and the real economy" (p. 302).

- M. Andreica, M. Stoica, F. Luban: *Metode cantitative în management*, Editura Economică, București, 1998

"The structure of a model comprises: a) endogenous and exogenous variables, b) constants and parameters, and c) relationships among variables and parameters. In the following we are enumerating several of the principles of mathematical modelling of the economic processes.

1. Any model is based upon a previously created economic theory in order to explain the modelled process, and the parameters with which it operates are -usually - economic categories or parts of these.

2. The models ignore a series of sides and peculiarities of the reflected process, though maintaining their cognitive role. The models' isomorphism (identity to reality) is not a compulsory restriction for an object to be the model of another object.

3. The model expresses the similitude not only of an isolated economic process, but a whole class of such processes, so that any model is a generalization, a synthesis to a certain degree. The larger the area of the processes represented through the model, the most important is its degree of generalization and synthesis.

4. A model cannot be built without making use of a system of symbols, which may represent economic categories and do not overlap upon the current alphabet or the figures used in computations " (p.36).

- E. Dobrescu: *Macromodels of the Romanian Transition Economy*, Second edition, Expert Publishing House, Bucharest, 1998

"1)... In order to avoid possible misunderstandings, it is necessary to define, from the beginning, the notion of <econometric model> used in this book. I shall adopt the following interpretation: a set of interdependent equations (from which at least one is econometric) approximating a particular, given class of statistical data in accordance with the modeller's image of functional relations among respective series.

1.1) From the first feature of this definition a very important consequence follows. Therefore, if the model reflects a <given class of statistical data>, it is obvious that we can use it only for the analysis of this information. Forecasts are acceptable exclusively in the proximity of the time interval covering the used series...Even in this case, it is compulsory to compensate the overlooked factors and influences by choosing adequate exogenous variables.

1.2) The psychological characteristic of the model emerges from its dependence on the modeller's image about the represented economic processes. The same <image> is considered in the generally accepted sense by the modern social psychology... This image is a mixture of theoretical assumptions adopted (explicitly or implicitly) by the modeller and, at the same time, of his beliefs, intuitive representations, attitudes and even desires concerning the system. The image can be understood in two stages. The first one motivates the initial form of the econometric functions included in the model and its general structure. The simulations operated with this preliminary version can reveal some unexpected implications. Subsequently, the modeller corrects his own initial visions and this derived image can be different relative to the former one. The comparison of model's estimations with the corresponding empirical information can oblige the modeller to change his view; the comparison mentioned here is interpreted, of course, in the sense developed by Friedman in his famous "Essays in positive economics". In other words, the econometric model can be considered as a psycho-cognitive construction. Consequently, for every economic system a large variety of models are possible depending on the conceptual premises of their creators. This relativism although possibly intellectually uncomfortable, is nevertheless a natural implication in econometric modelling"(pp. 60-61).

- R. S. Pindyck, D. L. Rubinfeld: *Econometric Models-Econometric Forecasts*, Fourth Edition, Irwin McGraw-Hill, 1998

"...we examine three general classes of models that can be constructed for purposes of forecasting or policy analysis. Each involves a different degree of model complexity and presumes a different level of comprehension about the processes one is trying to model. Time-Series Models: In this class of models we presume nothing about the causality that affects the variable we are trying to forecast. Instead, we examine the past behaviour of a time series in order to infer something about its future behaviour. The method used to produce a forecast may involve the use of a simple deterministic model such as linear extrapolation or the use of a complex stochastic model for adaptive forecasting...

Single-Equation Regression Models: In this class of models the variable under study is explained by a single function (linear or non-linear) of a number of explanatory variables. The equation will often be time-dependent (i.e., the time index will appear explicitly in the model) so that one can predict the response over time of the variable under study to changes in one or more explanatory variables...

Multi-Equation Models: In this class of models the variable to be studied may be a function of several explanatory variables, which now are related to each other as well as to the variable under study trough a set of equations. The construction of a multi-equation model begins with the specification of a set of individual relationships, each of which is fitted to available data. Simulation is the process of solving those equations simultaneously over some range in time"(pp. XV-XVI)

- D.W. Pearce - General Editor: *Macmillan Dictionary of Modern Economics*, Aberdeen Economic Consultants, 1992; Romanian version, Codecs, 1999

"Model. Formal or informal framework of analysis through which is searched to separate from among the real world complexity those characteristics of the economic system that are essential to the understanding of the behavioural, institutional and technical relationships that characterize the considered system. The aim is to facilitate the explanation of economic phenomena and to elaborate economic predictions" (p. 256).

- G. S. Maddala: *Introduction to Econometrics*, Macmillan Publishing Company, New York, 2000

"What is a model? A *model* is a simplified representation of a real-world process. For instance, saying that the quantity demanded of oranges depends on the price of oranges is a simplified representation because there are a host of other variables that one can think of that determines the demand for oranges. For instance, income of consumers, an increase in diet consciousness ("drinking coffee causes cancer, so you better switch to orange juice," etc), an increase or decrease in the price of apples, and so on. However, there is no end to this stream of other variables. In a remote sense even the price of gasoline can affect the demand for oranges.

Many scientists have argued in favour of simplicity because simple models are easier to understand, communicate, and test empirically with data.

This is the position of Karl Popper [K. F. Popper, "The Logic of Scientific Discovery", London, Hutchinson, 1959, p.142] and Milton Friedman [M. Friedman, "The Methodology of Positive Economics", in "Essays in Positive Economics", Chicago, University of Chicago Press, 1953, p.14]. The choice of a simple model to explain complex real-world phenomena leads to two criticisms:

1. The model is oversimplified.
2. The assumptions are unrealistic.

For instance, in our example of the demand for oranges, to say that it depends on only the price of oranges is an oversimplification and also an unrealistic assumption" (p. 2).

"To the criticism of oversimplification, one can argue that it is better to start with a simplified model and progressively construct more complicated models. This is the idea expressed by Koopmans [T.C. Koopmans, "Three Essays on the State of Economics Science", New York, McGraw-Hill, 1957, pp. 142-143]. On the other hand, there are some who argue in favour of starting with a very general model and simplifying it progressively based on the data available [This is the approach suggested by J. D. Sargan and notably David F. Hendry]. The famous statistician L. J. (Jimmy) Savage used to say that <a model should be as big as an elephant>. Whatever the relative merits of this alternative approach are, we will start with simple models and progressively build more complicated models.

The other criticism we have mentioned is that of <unrealistic assumptions>. To this criticism Friedman argued that the assumptions of a theory are never descriptively realistic. He says: "The relevant question to ask about the <assumptions> of a theory is not whether they are descriptively <realistic> for they are, but whether they are sufficiently good approximation for the purpose at hand. And this question can be answered by only seeing whether the theory works, which means whether it yields sufficiently accurate predictions".

Returning to our example of demand for oranges, to say that it depends only on the price of oranges is a descriptively unrealistic assumption. However, the inclusion of other variables, such as income and price of apples in the model, does not render the model more descriptively realistic. Even this model can be considered to be based on unrealistic assumptions because it leaves out many other variables (like health consciousness, etc.). But the issue is which model is more useful for predicting the demand for oranges. This issue can be decided only from the data we have and the data we can get.

In practice, we include in our model all the variables we think are relevant for our purpose and dump the rest of the variables of the variables in a basket called <disturbances>" (pp. 2-3).

Appendix III
Theses regarding the economic modelling sequences

- D. K. H. Begg: *The Rational Expectation in Macroeconomics-Theories and Evidence*, The Johns Hopkins University Press, Baltimore-Maryland, 1982

"Economic theories should be confronted with economic data. A large part of the ensuing discussion is concerned with empirical work in macroeconomics. Econometricians consider how the theory of mathematical statistics can be used to provide rigorous criteria for the analysis of economic data. This analysis may be divided into four areas: quantification, testing, prediction, and policy evaluation". (p.6)

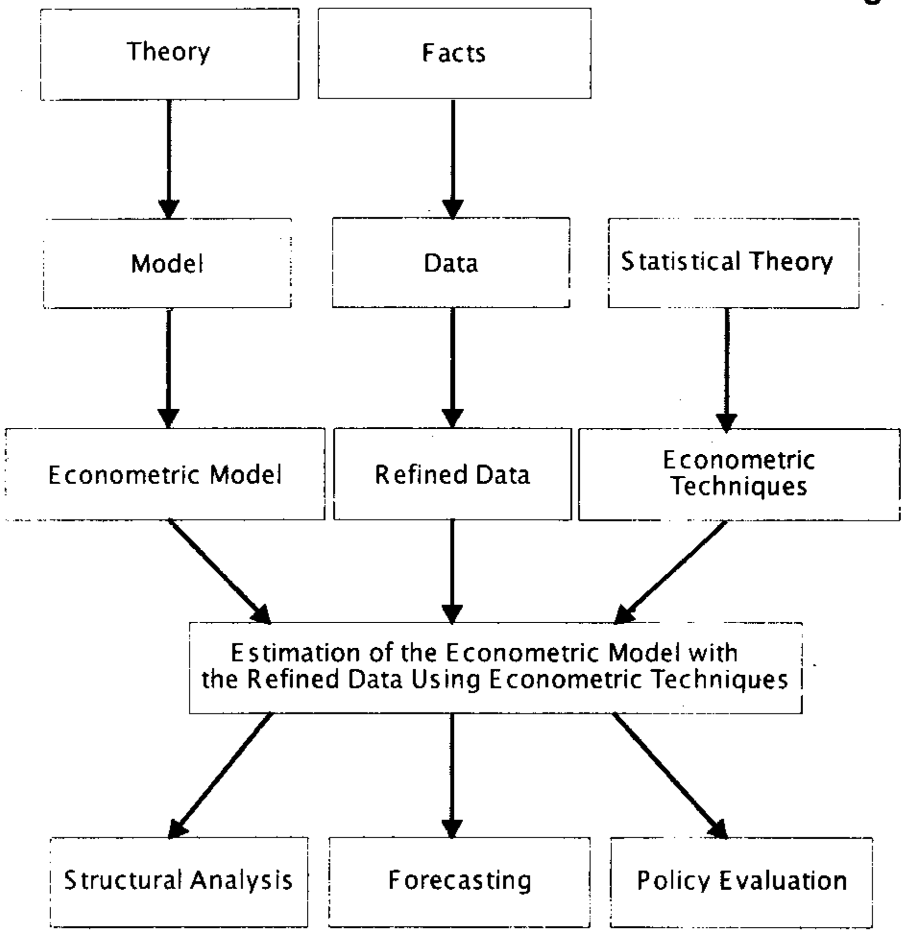
- G. Bannock, R. E. Baxter and E. Davis: *Dictionary of Economics*, Penguin Books, London, 1992

"Model-building usually consists of two main stages. The first stage, inspired by economic reasoning, is to develop the structure of the model – setting out what factors affect which variables. Often, this is as far as construction goes. The second stage, using econometrics, is to estimate the actual strength (parameters) of the relationship postulated" (pp. 287-288).

- L. L. Albu: *Exploration of Economic Systems in the Transition Period*, Romanian Economic Review, Tome 37, No.1, 1993

"Figure 1 summarizes the econometric approach. There are two basic ingredients in any econometric study – theory and facts. Indeed, a major accomplishment of econometrics is simply that of combining these two ingredients. By contrast, a considerable amount of work in economics emphasizes one of them to the exclusion of the other. The "theory-only" school is concerned solely with purely deductive implication of certain postulate systems involving economic phenomena. The "facts-only" school, by contrast, is concerned solely with developing and improving data on economy. Theory is one of the basic ingredients in any econometric study, but it must be developed in a usable form. The most usable form for the purposes of econometrics is typically that of a model, in particular an econometric model. The other basic ingredients in an econometric study are a set of facts, referring to events in the real world relating to the phenomena under investigation. These facts lead to a set of data, representing observations of relevant facts. In general, the data have to be refined, or "massaged", in a variety of ways to make them suitable for use in an econometric study (this refinement includes various adjustments such as seasonal or cyclical adjustments, extrapolation, interpolation, merging of different data sources, and, in general, the use of other information to adjust the data). The result is a set of refined data. The next and central step in the econometric approach, which combines these two basic ingredients, is the estimation of the econometric model. That step requires the use of a set of econometric techniques, which are extensions of classical methods of statistics, particularly statistical inference. Extensions of the classical methods are needed to account for certain special problems encountered in estimating an econometric model. The result of the process is an estimated econometric model, in which certain magnitudes, known as parameters, are estimated on the basis of relevant data. The estimated model provides a way of measuring and testing relationships suggested by economic theory." (pp. 16-17)

Figure 1



- C. Zamfir, L. Vlăsceanu: *Dicționar de sociologie*, Editura Babel, 1993

"The stages of model building are the following:

a. identification of variables – components, parameters or constants – that characterize the real object;

b. specification of physical, logical or mathematical relationships among the identified variables;

c. definition of restrictions concerning the shape, functioning and structure of the model as compared to the functioning of the object in real circumstances;

d. experimentation and testing of the functioning of the model in determined circumstances;

e. rephrasing of those parameters of the model that prove to be erroneous as compared to the real object ".(p.366)

- R. Smith: *The Macro modelling Industry - Structure, Conduct and Performance*, in "Applied Economic Forecasting Techniques", edited by S. Hall, Harvester Wheatsheaf, 1994

"Econometric analysis in the past-war period has been dominated by four statistical techniques or models, which have bridged the gap between theory and observation in quite different ways.

Single equation and multivariate regression models dominated the period up to the 1970s. In the regression model the conditional mean of some endogenous variable is explained in terms of some exogenous variables.

Regression was the basis of what Hylleberg and Paldam (S. Hylleberg, and M. Paldam: "New Approaches to Empirical Macroeconomics", Scandinavian Journal of Economics, 93(2), 1991, pp.121-128) call the <traditional strategy> of doing empirical research: of bridging theory and observations. This <traditional strategy> emerged from the work of Tinbergen, Haavelmo and the Cowles Commission (see M. S. Morgan: "The History of Econometric Ideas ", Cambridge University Press, 1990, for details). Central to it was a dichotomy between theoretical and empirical activities: the theorist provided the model and the econometrician estimated and tested it. This proved a highly productive strategy that dominated empirical econometrics until 1970s and still remains healthy: it is the basis of most large modelling in the United States. It was effective because the theory involved (IS-LM, static demand theory, explanations of cycles in terms of stochastic linear difference equations) could easily be cast in the form of a linear or simple non-linear regressions"(p.77).

"The second statistical model was the multivariate regression model in which a number of endogenous variables were explained by the same vector of exogenous variables. The reduced form of a linear simultaneous equation model was of this form and the role of theory was then to provide the identifying restrictions that allowed the structural form to be estimated plus over-identifying restrictions that could be tested. Complete systems of demand equations, which were developed following Stone (J.R.N. Stone: "Linear Expenditure Systems and Demand Analysis", Economic Journal, 64, 1954, pp.511-527), also took the form of multivariate regression models. In this case, the theory imposed a set of restrictions on the system (adding up, homogeneity, symmetry and negativity), which could be used to improve the efficiency of estimation or be tested.

The third statistical model was the univariate autoregressive integrated moving average ARIMA (*p, d, q*) model. This represented a single variable (after it had been differenced sufficiently, say *d* times, to induce stationarity) in terms of *p* auto regressions (lagged values of itself) and a moving average of *q* lagged disturbances. Although these models were initially <a-theoretical>, using no information from economic theory, there were cases where economic theory did impose restrictions on the form of an ARIMA model" (p.78).

"The VAR is the fourth of the statistical models that has been widely adopted in econometrics. In this structure each variable (measured either in levels or first differences) was treated symmetrically, being explained by lagged values of itself and other variables, there were no exogenous variables, no identifying conditions and the only role of theory was to specify the variables included. Cooley and Leroy (T. C. Cooley, and S. Leroy: "A-theoretical Macroeconometrics: a Critique", Journal of Monetary Economics 16, 1985, pp.283-308) provide a critique of such a-theoretical econometrics. But the VAR was not necessarily a-theoretical, it could provide a statistical framework within which the restrictions imposed by theoretical models could be imposed. One route was to use the VAR as the reduced form of a traditional structural model...An alternative route used theoretical rational expectations or equilibrium models as a way of interpreting and imposing cross-equation restrictions on vector auto regressions" (p.80).

- E. S. Pecican: *Econometrie*, Editura ALL, Bucureşti, 1994

"Shaping of the single-sector model as well as its use involves the stages:

1 - analysis of the economic variable dependency on the possible factors, taking into account what is admitted by the economic theory in the considered field of interest, the aspects revealed by the economic practice in the considered interval and economic area, as well as the existence of numerical data or the possibilities to obtain them;

2 - checking the theoretical assumptions through the perspective of the variables' behaviour the way it is revealed by the data, which involves the use of certain specific statistical methods (graphs, significance tests, etc.);

3 - proper drawing up of the model in the circumstances when it follows preservation of a small number of maximum relevance factors, as well as compliance with the shape of the relationship the way it is described by the data referring to the parallel evolution of variables;

4 - estimating the model's parameters and obtaining in that way certain numerical characteristics regarding the influence exerted by the factors upon the effect variable;

5 - checking the quality of the model to schematically reproduce the evolution of a phenomenon in connection with its causes (factor variables), as well as checking the significance of parameters;

6 - obtaining forecasts or generating values simulated with the help of the model.

All these stages search for answers to the questions:

- Which is the shape of connection between the effect variable and presumed factors?
- To what extent a unit change (percent, 1 ROL, a person, etc.) in the factor generates a change in the effect?
- Is the change generated by the factor significant or is due to certain conjuncture or random circumstances?

- What levels will reach the effect variable in the circumstances when the factors will record certain pre-established levels?
- What probabilistically determined guarantees exist regarding the significance of parameters, quality of the model, veracity of forecasts?

To have the answers to all these questions is of real interest both for the theory and the economic practice, because it brings precision where more or less evasive assumptions are formulated, and projects a ray of light, be it diffuse and limited, into the future." (p. 48)

- C. Allen and S. Hall (editors): *Modelling in a Changing World*, John Wiley and Sons Ltd, 1997

"Theory, in its general form, does not need to specify explicit functional forms. When we come to implement this theory in an empirical model...we cannot avoid the use of some explicit function in specifying production, cost or utility functions. Many researchers have opted for relatively simple functional forms but the underlying modelling philosophy presented in this book is that models must both conform to a well-specified theory and be data admissible.

That is to say, the model must embody sound theory but it must also be a good representation of the data as we observe it. Models that are based on simple functional forms often have the advantage of being easy to understand and implement, but in our experience they generally do not provide good representation of the data. This is not a criticism of the theory as such, but it is a criticism of the simple forms that have been assumed to implement the theory.

However, empirical models that fit the data well are often <ad hoc> and may, at worse, violate the basic requirement of consistency with theory, and at best not fully exploit the information offered by theory. We would argue that one compromise between these two extremes is to base a model around a well-specified theoretical framework which is implemented through a set of functional forms that are sophisticated enough to provide a good representation of the data" (p.17)

- R. S. Pindyck, D. L. Rubinfeld: *Econometric Models-Econometric Forecasts*, Fourth Edition, Irwin McGraw-Hill, 1998

"We begin by briefly reviewing the steps involved in the construction, evaluation, and use of time-series models. One begins with a model *specification*. This first requires a decision about the degree of homogeneity in the time series, i.e., how many times it must be differenced to yield a stationary series...often the correct choice is not clear and several alternative specifications must be estimated.

Once a model (or a group of models) has been specified, it must be *estimated*...afterward, one performs a *diagnostic check*. This involves looking at the autocorrelation function of the residuals from the estimated model. A simple chi-square test can be performed to determine whether the residuals are themselves uncorrelated. In addition, one should check that the parameter estimates are consistent with *stationarity*..

The model must then be *evaluated* to determine its ability to forecast accurately and to provide a better understanding of its forecasting properties...

One means of model evaluation and analysis is to perform a *historical simulation* beginning at different points of time...In addition, one can perform an *ex post forecast*, comparing the forecast to actual data to evaluate its performance" (p.580).

- G. S. Maddala: *Introduction to Econometrics*, Macmillan Publishing Company, New York, 2000

"The aims of econometrics are:

1. Formulation of econometric models, that is, formulation of economic models in an empirically testable form. Usually, there are several ways of formulating the econometric model from an economic model because we have to choose the functional form, the specification of the stochastic structure of the variables, and so on. This part constitutes the *specification aspect* of the econometric work.

2. Estimation and testing of these models with observed data. This part constitutes the *inference aspect* of the econometric work.

3. Use of these models for prediction and policy purposes. During the 1950s and 1960s the inference aspect received a lot of attention and the specification aspect very little. The major preoccupation of econometricians had been the statistical estimation of correctly specified econometric models. During the late 1940s the Cowles Foundation provided a major breakthrough in this respect, but the statistical analysis presented formidable computational problems. Thus the 1950s and 1960s were spent mostly in devising alternative estimation methods and alternative computer algorithms. Not much attention was paid to errors in the specification or to errors in observation. With the advent of high-speed computers, all this has, however, changed. The estimation problems are no longer formidable and econometricians have turned attention to other aspects of econometric analysis" (p.4).

"The important things to note are the feed-back

1. From econometric results to economic theory.

2. From specification testing and diagnostic checking to revised specification of the economic model.

3. From econometric model to data"(p.7)

- Th. Popescu: *Serii de timp - Aplicații în analiza sistemelor*, Editura Tehnică, București, 2000

"We are further presenting the main stages and elements that have to be considered when building time series models. The following discussion will be focused on the building of models for prediction and control.

1. Understanding the *problem* and the *goal* of the model building.

2. Understanding the *decision-making system* for which the model will be used.

3. Establishing the way in which the model will be *implemented*.

4. *Structuring* of the qualitative model, through the building of a conceptual model of the system in which that will operate, including the representation of the involved mechanisms.

5. Careful selection of *data*, understanding their limitations and their representation in different ways.

6. Drawing up in a first stage of some *simple models*, with few variables, and their subsequent development only if necessary.

7. The *recursive* building of the model will go through the following stages:

- Identification of the model
- Estimating the model's parameters
- Validation of the model

8. Obtaining of models with a minimum number of parameters and avoiding the over-parameterisation of the model.

9. Understanding the fact that the model has to accurately represent the data.

10. Performing of certain *experiments* using the model (simulations in order to understand its limitations).

11. *Presenting* the obtained results to those that are going to use the model, in the simplest possible way" (pp. 270-271).

- R. C. Mittelhammer, G. G. Judge, and D. J. Miller: *Econometric Foundations*, Cambridge University Press, 2000

"In economics, much of the data underlying the search for data constraining properties of probability-econometric models are not the result of a controlled experimental design. This leads to a situation in which

1. there are typically many plausible specifications of probability-econometric models that do not contradict our knowledge of human behaviour or of the economic and institutional processes from which economic data are sampled, and

2. we must proceed through the model-discovery phase of an econometric analysis using a strategy of non-experimental model building. Therefore, in most econometric analyses there is significant uncertainty regarding an appropriate specification of many of the components underlying an econometric model. Correspondingly, given the possibility of model misspecification, there is uncertainty concerning the appropriate choice and the performance of estimation and inference procedures.

What makes the model selection problem especially challenging is that in most instances we must use a given sample of data to accomplish many objectives at once, including

1. choosing model-restricting constraints relating unknowns to sample data,

2. choosing an appropriate estimation procedure for recovering values of unknowns,

3. estimating the unknown parameters,

4. choosing appropriate inference procedures for assessing hypotheses, generating confidence regions about unknowns, or both, and

5. making inference decisions.

Although we often enter into econometric analyses with some non-sample information about characteristics of the inverse problem and the underlying range of possible models, the goal of achieving all of the varied objectives (1-5) sill places a large burden of information recovery on one finite sample of data"(p. 498).

Appendix IV

"The Transformation Problem"

The classical school (A. Smith, D. Ricardo) manifested certain inconsistencies in the price theory, considering sometimes only human labour as the source of the value, other times the whole capital - both that destined to employees' remuneration and that invested in machinery, buildings, technologies, inventories, etc. The profits tend to form according to the labour costs in one case and according to the whole capital supplied in the other. K. Marx admitted the first principle in Volume I of the "Capital", and the second one in Volume III, also supporting their "compatibility". His proposal raised many controversies for a century. I shall present it for the simplest case (capital rotation is identical in all the sectors and equal to the production cycle), uniting in a single table the numerical illustrations used by the author (K. Marx, F. Engels: "Opere", vol 25, partea I, Bucureşti, Editura Politică, 1969, pp.158-159, 167-168).

Sectors	Inputs	Labour cost	Profit acc. the 1st principle (rate=1 applied to Col.3)	Price acc. the 1st principle (Col.2+ Col.3+ Col.4)	Profit acc. the 2nd principle (rate-0.22appl ied to [Col.2+ Col.3]	Price acc. the 2nd principle (Col.2+ Col.3+ Col.6)
Col.1	Col.2	Col.3	Col.4	Col.5	Col.6	Col.7
I	80	20	20	120	22	122
II	70	30	30	130	22	122
III	60	40	40	140	22	122
IV	85	15	15	115	22	122
V	95	5	5	105	22	122
Total			110	610	110	610

Based on these data, K. Marx formulated the following theorem: "The sum of profits of all production areas (namely those according to the second principle - our note) has to be equal with the sum of surplus values (namely the profits according to the first principle - our note), and the sum of the production prices of the total social product (namely the prices according to the second principle - our note) has to be equal with the sum of its values (namely the prices according the first principle - our note) (K. Marx, F. Engels: *Opere*, vol 25, partea I, Bucureşti, Editura Politică, 1969, p.176). The above-mentioned numerical example contains the two equalities.

Even at the end of the 19th century, E. von Böhm-Bawerk considered that "The theory of average profit rate and production price cannot be reconciled with the theory of value" (E. von Böhm-Bawerk: *Zum Abschluss des Marxschen System*, 1896, p. 218, cited from N. N. Constantinescu: *Teoria valorii muncă în lumea contemporană*, Bucureşti, Editura Politică, 1984, p. 73).

Nearly a decade after Böhm-Bawerk the problem was more analytically reconsidered by L. von Bortkiewicz, who imputed to Marx that "he did not succeed to keep a rigorous demarcation between the two principles for the computation of value and price" (L. von

Bortkiewicz: *Value and Price in the Marxian System*, International Economic Papers, No. 2. 1952, p.8). Following the logic of Böhm-Bawerk and Bortkiewicz let us examine the problem in a mathematical language.

We shall use the denominations:

a_{ij} - technological coefficients of the inter-sector relationships (i,j=1, 2,...,n);

X_i - total output (in natural units) of sector i;

y_i - final product (also in natural units) of sector i;

w_i - wages (in monetary expression) per unit of output in sector i;

p_i^1 and p_i^2 - prices (also in monetary expression) per unit of output in sector i formed according to the 1st and 2nd principles;

λ^1 and λ^2 - corresponding rates of profit formation;

π_i^1 and π_i^2 - profits (in monetary expression) per unit of output in sector i according to the two principles.

The following system will result:

$$X_i=\Sigma_j a_{ij}X_j+y_i \tag{1}$$

$$p_i^1=\Sigma_j a_{ij}p_j^1+w_i(1+\lambda^1) \tag{2}$$

$$p_i^2=(\Sigma_j a_{ij}p_j^2+w_i)(1+\lambda^2) \tag{3}$$

$$\pi_i^1=w_i\lambda^1 \tag{4}$$

$$\pi_i^2=(\Sigma_j a_{ij}p_j^2+w_i)\lambda^2 \tag{5}$$

$$\Sigma_i X_i\pi_i^1=\Sigma_i X_i\pi_i^2 \tag{6}$$

$$\Sigma_i X_i p_i^1=\Sigma_i X_i p_i^2 \tag{7}$$

Relationships (6) and (7) formalize Marx's theorem. For the simplification of the discussion, the magnitudes a_{ij}, y_i and w_i are exogenously given. Thus, there are (5n+2) endogenous variables, namely X_i, p_i^1, p_i^2, π_i^1, π_i^2, λ^1 and λ^2. One can easily see that the system has the same number of equations (5n+2); we shall admit that it is compatible.

Why such a system cannot be validated? Because it ignores the equilibrium restriction between demand and supply, and between the real and the nominal economy, respectively. In the considered case, the sum of wages and profits should be equal to the monetary expression of the final product. Compulsorily, the following relationships are added:

$$\Sigma_i y_i p_i^1=\Sigma_i X_i(w_i+\pi_i^1) \tag{8}$$

$$\Sigma_i y_i p_i^2=\Sigma_i X_i(w_i+\pi_i^2) \tag{9}$$

In other words, the number of equations becomes larger than the number of endogenous variables, with the well-known impact upon the system solutions. In order to overcome the difficulties we must choose between

- Subsystem A:

$$X_i=\Sigma_j a_{ij}X_j+y_i \tag{10}$$

$$p_i^1=\Sigma_j a_{ij} p_j^1+w_i(1+\lambda^1) \quad (2)$$

$$\pi_i^1=w_i\lambda^1 \quad (4)$$

$$\Sigma_i y_i p_i^1=\Sigma_i X_i(w_i+\pi_i^1) \quad (8)$$

having (3n+1) endogenous variables (X_i, p_i^1, π_i^1 =i λ^1) and also (3n+1) relationships, and

- Subsystem B

$$Xi=\Sigma jaijXj+yi \quad (1)$$

$$pi2=(\Sigma jaijpj2+wi)(1+\lambda 2) \quad (3)$$

$$\pi i2=(\Sigma jaijpj2+wi)\lambda 2 \quad (5)$$

$$\Sigma iyipi2=\Sigma iXi(wi+\pi i2) \quad (9)$$

also compatible.

Consequently, we either accept the first principle for price formation (subsystem A) or we admit the second one (subsystem B). Except the trivial case when matrix a_{ij} is null, they cannot simultaneously function. Marx's table is based on such a mixture: inputs prices are in accordance with the first principle, and the resulted commodities prices are in accordance with the second principle.

Inconsistency was facilitated by the absence of explicit presentation of relationships $X_i=\Sigma_j a_{ij} X_j+y_i$. Translation of theoretical assumptions into matrix language expressed that undoubtedly.

"The transformation problem" may be correctly approached from a mathematical point of view, but only in certain dynamic models, of gradual transition from the first to the second principle of price formation. For details, one may examine (Emilian Dobrescu: *Again about "the Transformation Problem"*, Romanian Economic Review, Tome 33, No.2, 1989, pp. 05-232).

Appendix V
Dynamic Properties of the Romanian Macromodel

[Emilian Dobrescu: *Macromodels of the Romanian Transition Economy*, Third Edition, Expert Publishing House, 2000]

"The dynamic properties can be revealed solving the macromodel for 5-6 consecutive years, in order to identify its behaviour within a medium-term time horizon...three questions have to be clarified:

a) How does the system function if all the exogenous variables do not change?

b) Which is the system behaviour under shocks? and

c) Does it contain possible vicious circles?

...Obviously, all the simulations resort to identical demographic predictions. The data for 1999 are used as statistical inputs. Six consecutive years (noted 1...6) are computed.

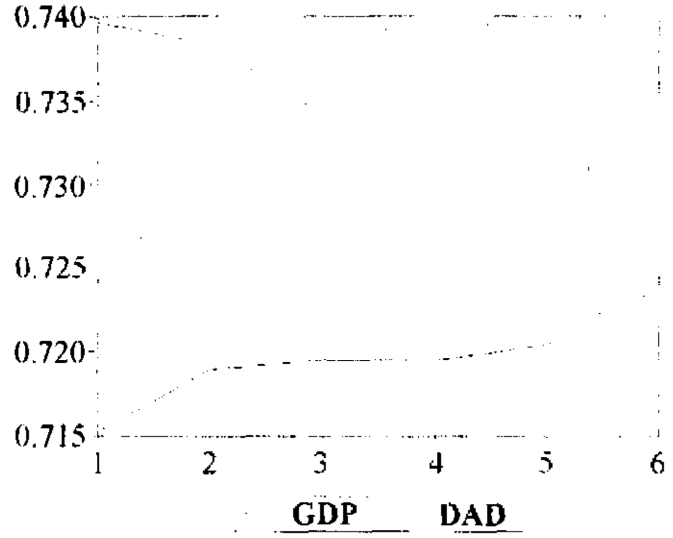
<Frozen Framework>

In this case, all the exogenous variables...are fixed during the entire period...

Graph FROZ1 shows the evolution of the main macroeconomic indicators - gross domestic product (GDP) and domestic absorption (DAD) (both at 1990 prices, trillion ROL), under these absolutely constant conditions. The real output shows an obvious stagnating trend. In contrast, the domestic absorption clearly decreases. Can we consider such a peculiarity as real and correctly reflected by the model? In my opinion, there are explanations sustaining an affirmative answer. As it is known, the Romanian economy experienced persistent and large external deficits during the last decade. If it continues to stagnate, the access to foreign financial resources inherently becomes more and more difficult. Consequently, the current account has to be balanced using internal resources, which fact is possible (in the absence of a growing production) only through the compression of domestic absorption. The investment in fixed assets diminishes first, inducing a decline in capital endowment.

"Despite its hypothetical character, "frozen framework" simulation is useful not only because it represents a strong test of the coherency of the model's econometric and accounting relationships, but also as a preliminary exercise for other tests involved in the examination of <shock waves>"(p.132).

Graph FROZ1



<Shock Waves>

How does a certain economy respond to shocks - is an unavoidable modelling problem. I propose to simulate it through changing significantly one or several exogenous variables, as a spectacular and punctual break in the functioning of the model. Subsequently, the effects of such fractures can be considered as shock waves.

In the case of the Romanian economy, I suggest to retain for such a situation the sudden variation in the nominal income (income shock) and in the money supply (monetary shock). Each of them will be examined under three hypotheses:

a) as an irreversible action (permanent shock);

b) the pre-shock conditions are immediately (next year) restored (temporary shock); and

c) the pre-shock conditions are gradually (in two-three years) re-established (transitory shock).

1. The income shock consists in an abrupt increase in EXGDP (expected nominal GDP), associated with a larger budget deficit...The rest of the exogenous variables used in the <frozen framework> do not change. The income shock will be analysed in the following alternatives:

a) the changes are maintained in all coming years;

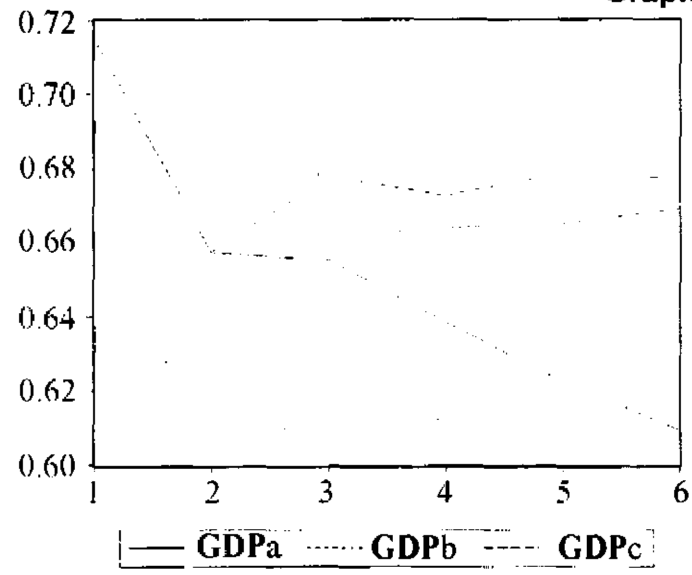
b) from the third year, EXGDP and the ratio of budget expenditures return to the levels of the first year;

c) the initial conditions are also re-established, but step by step...

These variants will be analysed simultaneously; the results will be differentiated by the suffixes a, b, and c, respectively.

1.1. Graph INSH-GDP describes the evolution of the real output (trillion ROL 1990 prices).

Graph INSH-GDP



The gross domestic product in constant prices (GDP) sharply decreases...in the second year, due to the high inflation and the subsequent reduction in real money supply, which remains constant in nominal terms. After this general contraction, the three simulations start showing differences.

According to variant a, the third year means practically a "zero growth", followed by a new decline, but with decreasing negative growth rates...

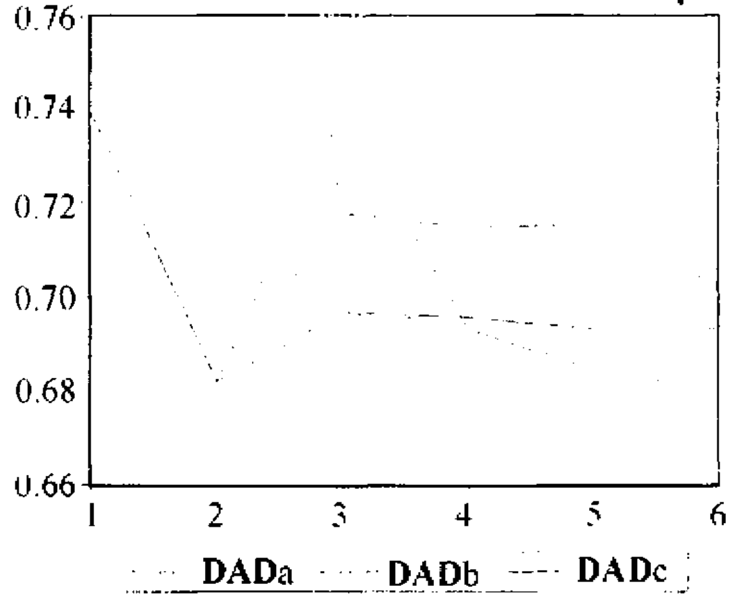
I remind that according to variant b, EXGDP and the ratio of budget expenditures return immediately to the pre-shock levels. Due to the constancy of the rest of exogenous variables, especially of the money supply and trade parameters, the drastic reduction in nominal income in the third year acts as a new shock, but with contrary effects in comparison with the previous ones. Such an effect is temporary; the production decreases again (fourth year), after which it tends to stabilise.

According to variant c, the real output increases also in the third year, due to the compression of the nominal income under the constancy of money supply and other macroeconomic policy parameters, but the growth rate is moderate. The relative stagnation is again obvious in the second part of the examined period.

Comparative analysis shows that, in the medium-run, the best results belong to the variant c, whilst the variant a seems to be the worst. But in all the possible ways, the income shock involves a significantly lower gross domestic product (at constant prices) than in the case of the <frozen framework>. This behaviour comes from the fact that the income shock has been conceived with the initial negative influence on real output. This question will be re-examined after the presentation of the monetary shock, which is built on an opposite assumption...(pp.133-5).

1.3. The domestic absorption at constant prices (DAD) takes up the shock fully, as well...In all the variants the third year shows a pattern of growth, but differentiated, depending on the variant (Graph INSH-DAD, trillion ROL at 1990 prices).

Graph INSH-DAD



In the case of domestic absorption at constant prices, it is again the variant c of the income shock which is the best on the medium-term; instead, the variant a appears to be more favourable than b"(pp.136-7).

2. The monetary shock is simulated operating, in the second year, with the following changes in comparison to the "frozen framework" scenario:

- the monetary base (M0) increases...;
- the reserve requirements ratio (rr) falls...; and

the real interest rate also decreases...

The rest of the exogenous variables used in the <frozen framework> simulation do not change.

There are also three variants for this scenario:

a) these new monetary exogenous variables do not change until the end of period;

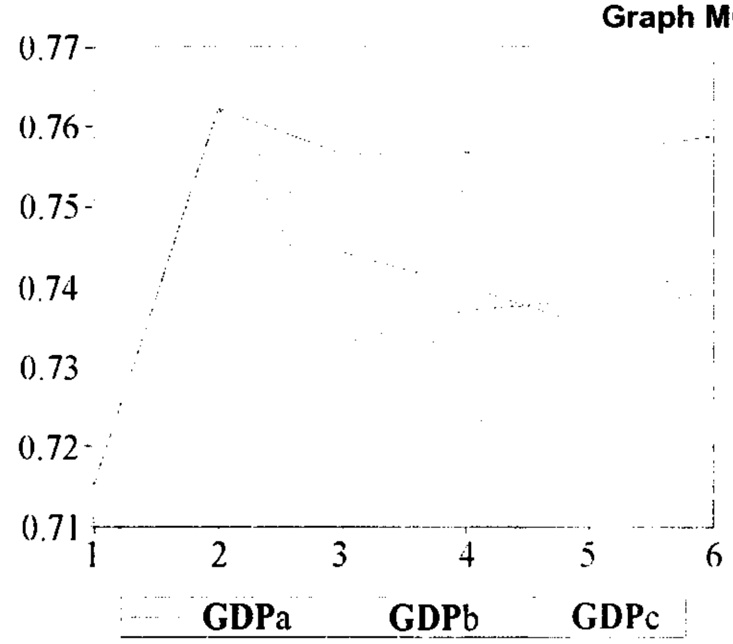
b) the changes are cancelled from the third year, when the pre-shock levels are re-established;

c) the initial conditions are re-established, but gradually...

The indicators resulted from these three hypotheses are differentiated by the suffix a, b, and c, respectively.

2.1. The Graph MOSH-GDP describes the comparative evolution of the gross domestic product at constant prices (trillion ROL at 1990 prices).

Graph MOSH-GDP



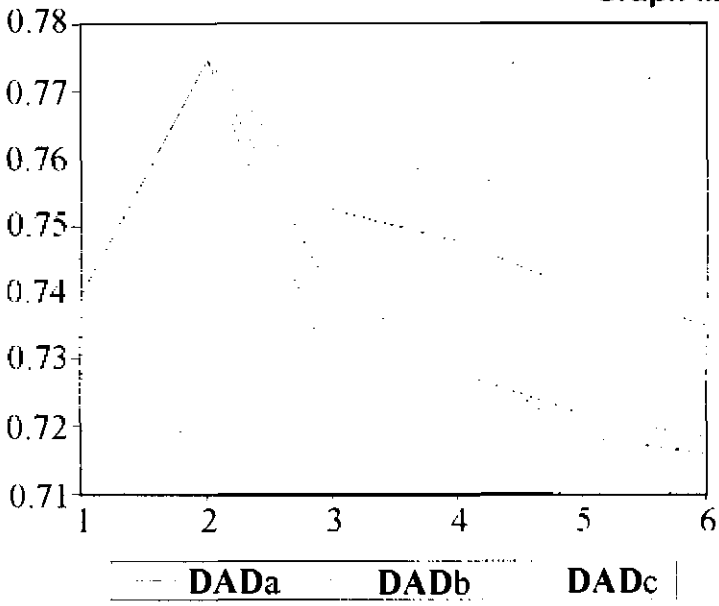
A substantial growth of the gross domestic product at constant prices in the second year is normal. The increase in money supply and the reduction in the real interest rate are simulated under constant nominal income, which means that the national economy is significantly re-capitalised. The monetary distortion is compressed.

Depending on the evolution of the exogenous variables involved in this shock, the subsequent results are different. If the exogenous conditions are maintained (variant a), the real output stabilises on the level close to the one reached after the shock; the market works in the absence of monetary distortion. If the initial conditions are re-introduced, when the real output decreases (sharply in variant b, or slowly in variant c); the monetary distortion is reactivated.

But, in all the cases, after the monetary shock, the gross domestic product at constant prices exceeds its level corresponding to the <frozen framework> scenario. Unlike the income shock scenario, the monetary one begins with a positive effect on the real output. Why? Most econometric estimations assign a decisive role to the previously achieved level of the respective indicators. Consequently, if a shock starts with a positive effect on output, this effect is maintained during the following years. The situation is reversed if the shock (like the income shock) begins with a negative effect on output (pp.140-2).

2.3. The domestic absorption at constant prices (DAD, trillion ROL at 1990 prices) is expanding in the second year (Graph MOSH-DAD). Its growth rate...is, however, lower than the one for GDP...

Graph MOSH-DAD



However, after the shock is applied, the domestic absorption generally diminishes: slowly in variant a, quickly in variants b and c. This evolution cumulates especially the effects of the variations in interest rate and in the gross domestic product.

It is worth mentioning that at the end of the period, the variant b is characterised by a higher level of the domestic absorption than variant c, despite their inverse position during the third and fourth years. The situation was similar in the case of real output (pp.143-4).

Obviously, the macromodel allows one to search for other possible shortcomings in the economic evolution. For instance, an essential deterioration or, conversely, improvement of the international position of the country may be also simulated. This would imply to correspondingly adapt the exports, imports, and the exchange rate parameters..., and the exogenous variables related to the access to foreign capital markets. Such a commercial-financial shock would begin with a negative impact on the real output (in the case of deterioration of the international position of the country) or, conversely, with a positive impact (if this position improves).

I have limited the illustration of the discussed problem to the income and monetary shocks, considering them relevant enough in the process of evaluation of the dynamic properties of the macromodel. Besides, their analysis is a good introduction to the following issue.

3. It is essential to mention that as long as the economy is working under the current conditions:

- with a microeconomic objective-functions involving an inefficient allocation of resources;

- with a considerable share of the non-accounted sector;
- with a lot of de-capitalized firms; and
- under accentuated monetary distortion;
- the Keynesian prescriptions may contain serious risks, though the reduced level of domestic consumption and the existence of underutilized capacities seem to justify such an approach.

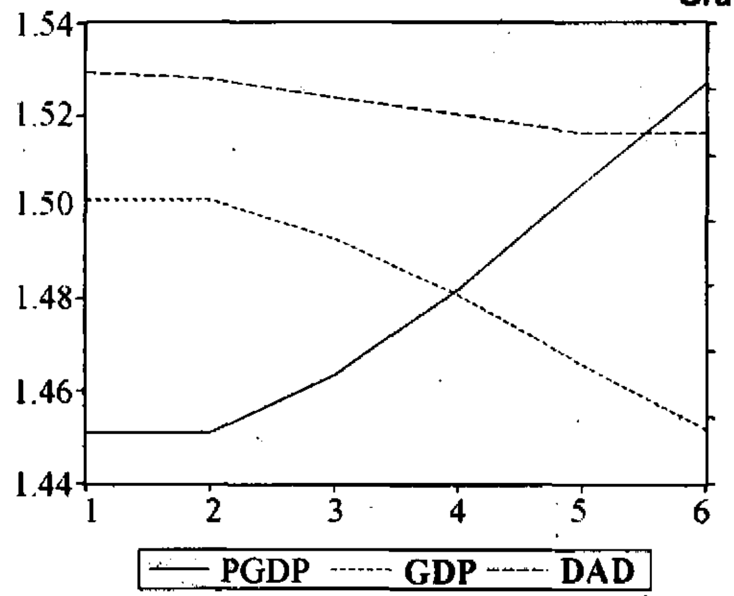
We shall also simulate the consequences of a policy mix that stimulates the domestic demand by increasing nominal income as well as the budget deficits. The main assumption is the automatic indexation of all the nominal incomes, through the introduction in the model of the relationship EXGDP=GDP(-1)*PGDP(-1). The ratio of budget expenditures increases as well...The rest of the exogenous variables of the <frozen framework> scenario do not change.

3.1. The first simulation accepts that the monetary base expands proportionally to the previous gross domestic product deflator: M0=M0(-1)*PGDP(-1). Therefore, the money supply accommodates. Graph VIICa presents the main macroeconomic indicators within this simulation (left scale GDP deflator, right scale gross domestic product and domestic absorption in trillion ROL 1990 prices).

As one can see, the stimulus - in the above-mentioned manner - on the domestic demand, not only does not increase the real output, but also conversely contracts it. Even the domestic absorption in real terms is diminishing. Obviously, under such circumstances, the inflation re-enforces. What is the explanation of such a paradox?

The macromodel seems to reflect correctly the contradictory situation in which the Romanian economy is now: on the one hand, the inflationary expectation is extremely strong; on the other hand, the real economy is dramatically undercapitalized.

Graph VICCa



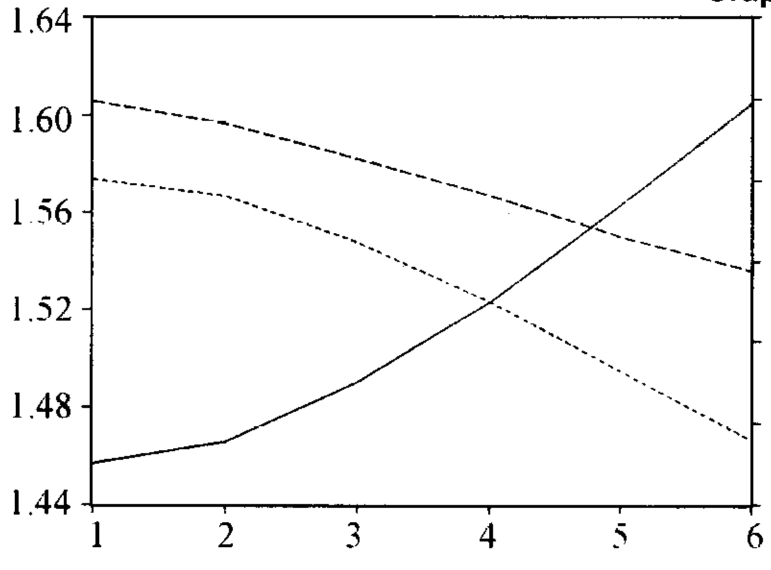
The <scissors> shown in Graph VICCa are generated by the following mechanism: the growth of nominal income favours at first the increase in prices; this phenomenon is deepening the under-capitalisation problem with negative influence on supply; the increasing market disequilibrium is restored by a new inflation wave, and so on. Therefore, an authentic vicious circle is present.

As a result of this mechanism, inflation closely follows and even gets ahead of income growth; that is why the growth of nominal demand may not translate into growth of real demand - the only one able to stimulate the output effectively...

3.2. It is important to underline that a restriction on money resources should not have major effects even on inflation. Graph VICCr presents the implications for the same policy mix of stimulating the domestic demand by increasing the nominal income and the budget deficit, but for a more limited expansion of money resources. Therefore, the monetary base follows the relationship M0=M0(-1)*PGDP(-1)*0.95. The reserve requirements ratio (rr) increases...; during the same interval, the real interest rate (dir) increases...

The left scale of Graph VICCr represents GDP deflator and the right scale - gross domestic product and domestic absorption, trillion ROL at 1990 prices.

Graph VICCr



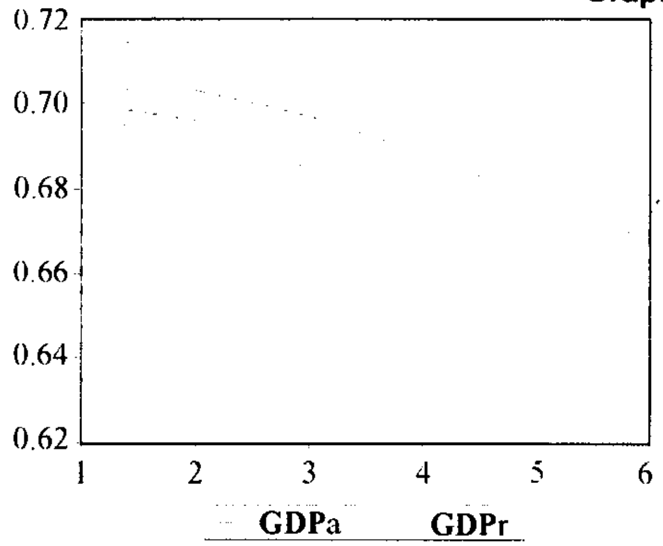
The picture described by the above simulation practically does not change.

The gross domestic product and domestic absorption at constant prices are decreasing, but the inflation remains high. Why is such a correlation possible?

As mentioned before, the economic activity takes place under a considerable monetary distortion, induced especially by the presence of massive inter-enterprise arrears"(pp.147-50).

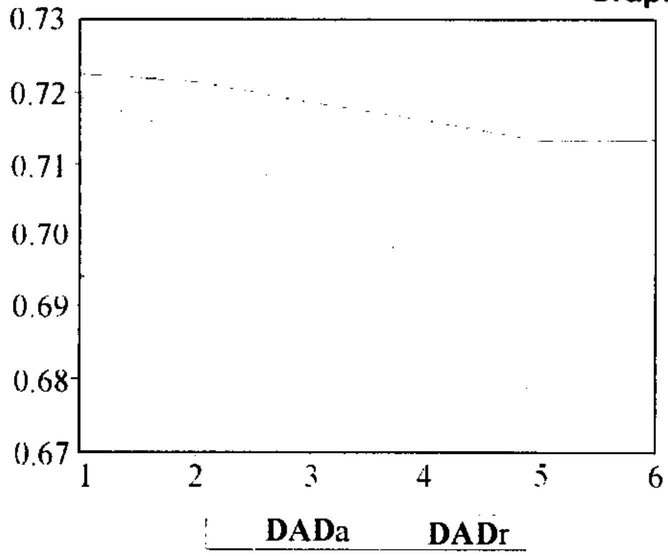
3.3. I finish this analysis, comparing the latter two variants; the indicators resulted from the first simulation (accommodating money policy) are denoted by suffix a, the other - by r. The real output (trillion ROL at 1990 prices) is presented in Graph VICC-GDP.

Graph VICC-GDP



The reduction in the real output is more severe under the conditions of expanding monetary distortion. It is worth mentioning that the domestic absorption at constant prices is also smaller in this case compared to the one obtained for the accommodating money policy (Graph VICC-DAD, trillion ROL at 1990 prices).

Graph VICC-DAD



(pp. 150-1)

"In my opinion many properties of the macromodel are only a <stylised> description of the transition Romanian economy itself. Of course, the precautions imposed by the inherent limits of such a construction (as a rough and always perfectible approximation of the real world) must not be forgotten."(p.153)