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The Integration of System Analysis into Economic Cybernetics

The major idea of the works is that of the possibility and even the necessity of integrating System Analysis into Economic Cybernetics. This will allow, on the one hand the inclusion into a conception of great generality of a method much used in practice but which, at present is lacking a satisfactory theory support and, on the other hand, will contribute to extending the practical applicability of the Cybernetic-Economic Theory.

It is pointed out in the study that the Systemic Analysis is equivalent to the empiric determination of the transfer function of a Cybernetic System and proposes a form of the transfer function which takes into account the decision-making processes and the technological and psycho-sociological conditionings.

1. THE THEORETICAL AND PRACTICAL TOPICALITY OF THE PROBLEM

System Analysis well known and largely practised by specialists in data processing is a complex of methods aiming at improving the general activity of the social-economic organizations, by examining the information and decision-making processing which are taking place in the respective organizations.

The general problem of the System Analysis as a practical method for improving social-economic activity was presented at length in a recent article published in Revista Economică[1]. On this occasion the idea was also outlined about the possibility and even the necessity of integrating this method into the framework of general theory, now being materialized, of Economic Cyber-

[1] See "Revista Economică", no. 12/6 September 1974.

netics. (We refer to the meaning of Economic Cybernetics as results from the works of Academician, Professor Manea Mănescu[2]).

The integration of System Analysis into Economic Cybernetics is of particular theoretical importance and topicality due to the fact that it will allow the inclusion into a conception of great generality of a method much used in practice but, at present, lacking a satisfactory theoretical support.

As regards the practical importance of integration, it consists in enlarging the concrete applicability of the Cybernetic-Economic Theory especially through a closer correlation of the macro with the micro-economic aspects.

In this study, we propose to approach in detail the problem of the integration of System Analysis into Economic Cybernetics. To this purpose, in the second part of the study we shall briefly present an example of cybernetic-system approach to the economic problems and in the third part, considering the fact that the general ideas of the Systemic Analysis are known from the above-mentioned article, we shall present concrete proposals for integration.

We underline the character of a scheme of the last part of the study, on the one hand, in order to explain some of the defects inherent of the present stage of our studies and, on the other hand, to urge specialists to improve, to complete and eventually to continue the present endeavour.

2. A REPRESENTATIVE EXAMPLE OF THE CYBERNETIC-SYSTEMIC APPROACH TO ECONOMIC PROBLEMS

In order to present a cybernetic-systemic approach to economic problems, we shall use the well known book of Iános Kornai entitled: "Anti-equilibrium" [3]. A few preliminary specifications are necessary. In his "Anti-equilibrium, Iános Kornai proposes to elaborate a critical study of the theory of general equilibrium of Walres. The way chosen by the author for fulfilling the aim pursued is quite unusual, because, in fact, he builds a cybernetic-systemic scheme of his own of the economic mechanism and critically analyses the ideas of the theory of equilibrium, by constantly referring to the built up scheme. In the following, we shall not dwell on the critical theses of the work but especially in the reference scheme elaborated by Kornai which, in our opinion, is a remarkable example of a systemic-cybernetic approach, to the economic process, both as regards the conception in general and the treatment of a high scientific level (the indisputable and widely recognized qualities of the work do not prevent us from having opinions different from those of Kormai, the differences being mainly the consequence of our attempt to synthetize the general theoretical prospects of economic cybernetics with the practical-applicative ones of the system analysis).

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2) See:

— Manea Mănescu: "*Considerations on the Application of the Principles of Cybernetics in Economy*", Studii şi Cercetări de Calcul Economic şi Cibernetică Economică, no. 5, 1968;

— Manea Mănescu: "*Economic-Mathematical Modelling*", Studii şi Cercetări de Calcul Economic şi Cibernetică Economică, no. 3, 1970;

— Manea Mănescu: "*The Role of Cybernetics in Forecasting the Economic-Social Development of Romania*", Studii şi Cercetări de Calcul Economic şi Cibernetică Economică, no. 1, 1972.

3) Kornai Ianoş: "*Anti-equilibrium*", Editura Ştiinţifică, 1974.

Before passing on to the presentation of Kornai's ideas about the structure and systemic-cybernetic functioning of the economic mechanism, we shall underline as an essential characteristic of the study the concern for distinguishing the logical-mathematical sciences in which thezes can be inferred from axioms by a purely logical way from the real sciences in which "the only criterium of truth is experience and the confrontation with reality...". The strict observance by the author, in his entire work, of the character of "real science" was, perhaps, the main argument for choosing Ianos Kornai's construction as a representative example of cybernetic approach to the problem of the functioning of the economic mechanism.

The first chapters of the work are devoted to defining the concepts which will be used, parallel with a first general description of the structure and functioning of the Economic System.

After defining the concepts of *organisation* ("a social formation built of people united with a view to carrying out certain established social-economic functions", *input* (material or information entrances into the system) and *output* (material or information exits), the author introduces the distinction between the *real processes* which are taking place in the system (material, physical and production processes) and the *control processes*[4] which are intellectual processes for the observation, transmission and processing of data, the preparation of decision and the decision proper.

The division into real and control processes, which Kornai calls a *dualistic description of the economic system* is important from his point of view. A first consequence of this separation is the definition of two entities, components of an organization, namely the *real unit* (which achieves real processes) and the *control unit* (which achieves control processes). On the whole of economy (the economic system), the set of all real units represents the *real sphere* and the set of all adjustement units, the *control sphere.* The main consequence of the dualistic description is, however, the way in which it approaches the problem of the functioning and control of the economic mechanism. It is pointed out that for each unit (real or control) of the economic system, the connection can be established between input and the initial state, on the one hand and the output and the final state, on the other hand, with the aid of the so-called *reaction functions*[5] which may be:

a) reaction functions for real units, of the form:

$$[y_i(t), \vec{x}_i(t)\vec{u}_i(t)] = \varphi_i[y_i(t-1), \overleftarrow{u}_i(t), \overleftarrow{x}_i(t)]$$

where $y_i(t)$ is the state of the real unit in period t expressed by the stock of products, $\vec{x}_i(t)$ is the output of products in period t, $u_i(t)$ is the output of messages in period t, $y_i(t-1)$ is the state of the unit in the period prior to t, $\overleftarrow{u}_i(t)$ is the input of messages in period t and $\overleftarrow{x}_i(t)$ is the input of products in the same period;

4) We have proposed a similar division, but, into three types of processes (technological, informational and decisional) in the book "Information and Decision Processes in Economy", Editura Ştiinţifică, 1973.

5) A name much used in Cybernetics for the function establishing the connection between the inputs and outputs in a system is "transfer function".

b) reaction functions for control units of the form:

$$[v_i(t), \vec{u}_i(t)] = \varphi_i[v_i(t-1), \overleftarrow{u}_i(t)]$$

where $v_i(t)$ is the state of the control unit i at moment t expressed by the vector of the storage content (which indicates the messages "stored" in unit i), $\vec{u}_i(t)$ and $\overleftarrow{u}_i(t)$ have the same significance as in the previous formula and $v_i(t-1)$ is the state of the unit at moment $t-1$.

We notice the importance granted in the description of the control process to outlining the messages and their measuring by the vectors of the storage content. As a matter of fact, a whole chapter of the study is devoted to the analysis of the structure of messages mainly establishing that three main categories of messages are circulating within the economic system: 1) the circulation of money, 2) messages having the character of price and 3) messages having not the character of price. The analysis of the messages refers in detail also to aspects, such as the direct or indirect reflection of the economic processes, the number of canals, the transmission of data, the synchronism or asynchronism to the events it refers to, the complexity of messages, etc. As regards the function of messages in the economic system, Kornai defines five *control subsystems* within which specific messages are circulating, namely: a) the market subsystem; b) the monetary and credit subsystem, c) the subsystem of the planning of national economy; d) the subsystem of technical progress and scientific information and e) the subsystem of the distribution of labour (in the third part of this article we shall propose another way of defining the systems and subsystems, having both an execution and control role).

The author further devotes several chapters to analyse in detail the complex mechanism of control, especially from the point of view of the multitude of the complex decisional processes taking place in the economic system. Worth mentioning, in the first place, as regards these problems, is that the cybernetic description of the functioning of the economic mechanism is considered possible both at a general level of "black box" (a paragraph of the study points out that the economic system can be described as a complex automaton) and, in detail, by following the behaviour of the component units of the system, with the aid of the reaction functions.

The penetration into the black box of the mechanism of the economic system is consistently continued by Kormai in the chapters devoted to the decision-making process. Analysing the control process at several levels, the contradictions and compromises within the organizations, the game of preferences and the operations of the decision-makers, in one word, the whole complex mechanism of decision, he establishes, in fact, a general framework for determining the reaction functions of the control units.

In the light of descriptive outlook, he considers that the desiderata of rationality and consequence in establishing preferences and in effectively choosing decisions, as required by the theory of decision, are as a rule, not applied by the decision-makers with the decision processes in economic practice. In the author's opinion, the main role in the behaviour of the decision-makers and of the economic mechanism in general, is played by individual and collective aspirations, by routine and hazard.

We shall put an end to the presentation of Kornai's point of view about the Cybernetic Mechanism of the Economic System by underlining once more its particular qualities and also by showing that it does not solve the problems in detail of the cybernetic management of economy. Thus said, the elaborated construction has a marked general-theoretical character.

3. PROPOSALS FOR AN EFFICIENT ACHIEVEMENT OF INTEGRATION

To surpass the general-theoretical character of Kornai's construction, in our opinion, it is necessary, in the first place, to consider in detail, on the one hand, and to combine the descriptive with the normative prospect, on the other hand.

Let us examine, from the first point of view, the structure and sense of the reaction functions.

A first remark as regards the reaction functions proposed by Kormai is their very global character. We refer to the fact that the technological, decisional and psycho-sociological conditionings are not explained in the expression of the functions. Thus said, the output sizes in the left term of the equalities of defining the reaction functions, depend, in reality besides the input sizes written in the right term, on technological aspects (the state of equipment, the correctitude of technological solutions, the quality of raw and related materials, etc.), on the operative decisions of management and on the psycho-sociological parameters of individuals and groups of individuals in the System.

Another remark will refer to the practical inapplicability of the reaction functions differentiated on real and on control units. In the economic reality, there are no real nor control units but bigger or smaller economic organisms which, as a rule, achieve both real and control processes. We also notice the lack of practical indications as regards the way of establishing the reaction functions for various concrete cases.

In the following, we propose more detailed expressions of the reaction functions through which we shall try to take into account the above remarks.

The functioning of the System will be described by a *single reaction function in the form*:

$$[y_i(t), \vec{x}_i(t), \vec{u}_i(t)] = F_i[y_i(t-1), \overleftarrow{u}_i(t), \overleftarrow{x}_i(t), D(t), T(t), S(t)]$$

where variables y_i, x_i and u_i will preserve the significance granted by Kornai $D(t)$ represents the vector describing the decision process which takes place in the system, in period t, $T(t)$ is the vector of technological conditionings and $S(t)$ is the vector of psycho-sociological conditionings, both in period t.

Functions F_i outline the possibility of describing the behaviour of a certain system and the dependence on decisional, technological and psycho-sociological factors. Besides this detailing in the forms of the reaction functions indicated by Kornai, in the following we shall propose a method for the empiric determining of functions F_i, for concrete economic situations. This method is based on System Analysis.

Consider a System of a certain level the behaviour of which we want to examine with a view to improving it.

The knowing of the behaviour of the System in a certain period is equivalent to the detailed determination of its reaction function, namely of establishing the connections existing between the inputs of products and data, technological, decisional and psycho-sociological characteristics, on the one hand, and the outputs of products and information, on the other hand. The complexity of these connections is very big, in the first place because of the huge number of elements conditioning each other and secondly, because of the numerous and subtle influences which appear between these elements. Thus, in our opinion, there can be no question of establishing the analytic expression of such connections. But, we can try identify the main connections and we shall do it with the aid of graphs the points of which will represent the elements conditioning each other and, the arcs, the connections between the elements. If these graphs refer to a past period they will play the role of reaction functions with a descriptive character, or in the language of the System Analysis, they will represent the knowing of the situation existing in the System (the revealing of the existing situation). If the graphs anticipate a future period, they represent the detailing of reaction functions with a normative character, that is they will equivalete to the designing of the improved system. The downstream-upstream method will be used in elaborating these graphs[6]. The first of the two types of the above-mentioned graphs will be called *relevant-systemic graphs* and the second type — the *design-systemic graphs.*

We shall further present an example of the elaboration of a design-systemic graph, deliberately chosen to be as much reduced as possible, considering the limited space.

Let us consider the problem of the scheduling of production in an industrial enterprise.

Supposing we have described the functioning of the system at present (or better said for a very near past period) and that we want to design the improved functioning of the system in the future, we shall start by explaining the desired outputs from the systems.

They include, on the one hand, the downstream objectives of *the system which* refer to real processes (in the meaning of Kornai) and, on the other hand, the information outputs which will result as necessary. Let us for the time being, refer to the former.

The downstream objectives of the System will be established by setting out from the general objectives of the enterprise. In our example, we shall consider the following general objectives of the enterprise: 1) the fulfilment of the physical annual plan; 2) the fulfilment of the annual value plan; 3) the carying out of the annually planed profits; 4) the fulfilment of the planned productivity and 5) the drawing up of reports to the higher bodies. From these objectives of the enterprise, we shall have to infer the downstream objectives of the considered System, the latter representing the sub-objectives of the former. There is at present no rigorous treatment of the problem of operating into the universe of objectives, but, in practice, the upstream inferring of an objective B from another A situated downstream can be by answering the question "what should be done in order to attain objective A" ? By putting this question

6) See: A. Delville's work "L'information dans l'entreprise", Dunod, 1969

as regards objectives 1,2,3,4, and 5 of the enterprise (see Fig. 1), a set of upstream connections are obtained.

With the aid of a question similar to the above one, we can pass from the upstream objectives of the System to other subobjectives which we shall call *activities*. In our graph, points 7 and 9 represent such activities. A more special type of activity is that represented at point 8; such an activity called decisional knot will allow us to follow the covering of various variants of sucessions of activities, in keeping with the existence or inexistence of certain conditions (in our example, if the daily plan is fulfilled, the production process is continued on the basis of the initial program, if not, an updating is necessary).

By simplifying the operations to maximum, we have considered that the system of the efficient programming of production includes only objective 6 and activities 7,8 and 9. In the figure, we have delimited the system with an interrupted contour line. We notice that a number of arrows come out of the contour of the system, arrows on which we wrote the abbreviation INF. They represent the informational outputs necessary to be taken into consideration for our system and the fact is noticeable that except for 7—5 which is a conditioning leading to an objective of the enterprise, all others lead to other systems of the enterprise, that is they outline the information connections between the functional systems of the enterprise.

Thus, the desired outputs of the system are the downstream objectives (vectors $y_i(t)$ and $\vec{x}_i(t)$ as well as the necessary information to be produced by the system vector $\vec{u}_i(t)$. The establishment of the elements of these vectors is made in the next stage and will consist in detailing the objective, the activities and the information connections.

As has already been shown, the mechanism of operating with the objectives of the systems is an open problem preoccupying many researchers. [7]) In the event of a hasty and provisional solving of the problem, we shall underline that after the design-systemic graph is elaborated in which the objetives and activities as well as the connections between them are putlined with rough approximation, their more detailed description with the aid of *detailing files* will be necessary. All the informational-decisional characteristics designed for the objectives of the activities and the informational connections in the graph will be included in these files, namely the answers to the questions "*when the operations should be carried out*?", "*who solves them*?" "*how are they solved*?" The way of answering these questions is of decisive importance for the quality of the solution which, according to the nature and standard of the methods applied, can be a naive, artisan solution, or one based on the modern methods of management (methods of operations research, informatics, ergonomy, psycho-sociology of organization, etc.).

As the design systemic graph with the annex detailing files represeants an empiric way of establishing a reaction function with a normative character, let us dwell, in brief, on the correspondance existing between them. We

7) Among the recent works dwelling on this problem, we mention "Multiple Criteria Decision Making", published at University of Santa Carolina Press, 1973, under the editorship of James L. Cochrane and Milan Zeleny, in which are grouped over 60 articles written by specialists in this matter.

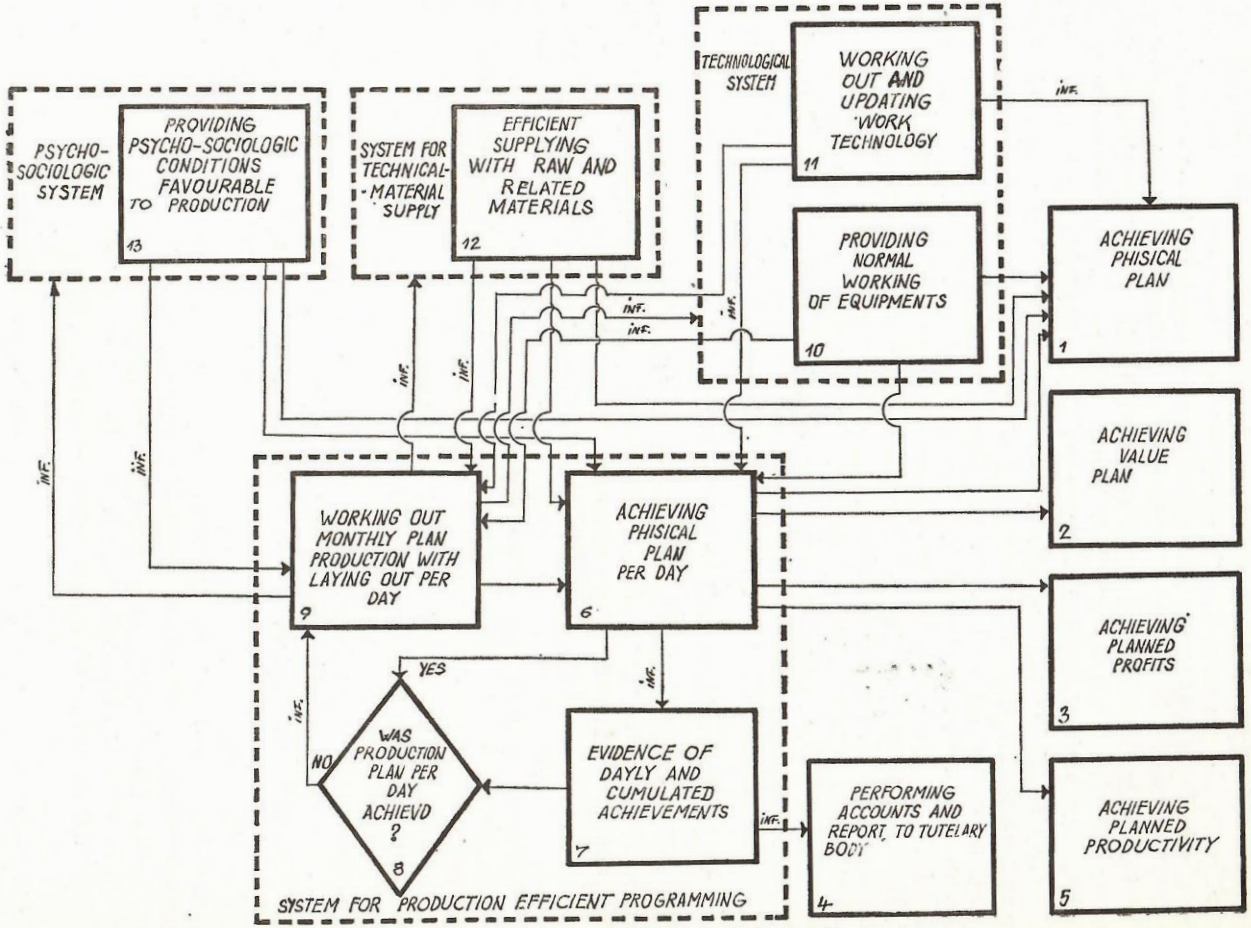


Fig.1. Systemic diagram – project of the production efficient planning into an industrial enterprise

in the left term of the reaction functions appear in the graph and how they have seen how the vectors representing the outputs from a System included are detailed in the files. But, where shall we find again in the systemic design the inputs into the system which are included in the right term of the reaction functions? Examining Fig. 1, we notice that arrow 12—6 (which represents the input of raw and related materials, thus vectors $y_i(t-1)$ and $\vec{x}_i(t)$), as well as arwos 11 — 6, 12 — 9 and 13 — 9 (which represent the input of data, thus vector $u_i(t)$) "enter" the system. As regards the vectors of the decision processes (D(t), of the technological processes ($T(t)$, and of the psycho-sociological ones $S(t)$, they will be represented by the objectives, activities and data in the graph which have a decisional, technological and psycho-sociological character and are detailed by corresponding files.

We note that although we proposed to exclusively dwell on the System of the scheduling of production, the mechanism of design compelled us to include into the graph also other systems (the Technological System, the Supply System, the Psycho-Sociological System), as a result of the necessity to take into consideration the connections existing between them and which include all these Systems of the same level, into a System of a higher level, enterprise N.

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In conclusion, let us examine in brief to what extent we have succeeded in achieving the integration of the System analysis into Economic Cybernetics and if so, what are the characteristics of this integration.

The fact that we have established an equivalence as regards concept between the reaction functions which are the main instrument of Economic Cybernetics and the products of the System Analysis (the systemic graphs and the detailing files), is, in our opinion, proof of the fact that the System Analysis is a method of a cybernetic essence and that integration proposed is, if not achieved, at least solidly substantiated.

The main characteristic of integration is its contribution to bringing the Cybernetic-Economic Theory nearer practice. If this fact is obvious for the small Systems (functional subsystems in an enterprise, sections, even enterprises), for the big Systems (industrial group, branch, national economy), the application of the methods of Systemic Analysis and design in the Cybernetic-Economic Analysis will imply considerable efforts. It remains to be checked whether the ampleness of these efforts might not be an impediment for generalizing the method at a macro level. In this case, more concise methods might eventually be conceived, which would allow if not a designing in detail, at least the solving of the programs of the informational, decisional structure also at a macro-level. Anyhow, the importance which is granted to this method of decisional design make us appreciate that it would considerably contribute to improving the condition noticed by Kornai as regards the irrational aspects which appear in certain decisional processes, from practice, and this makes us believe that it is worth blending the seeking and experimenting efforts.

INTEGRATION DE L'ANALYSE DES SYSTEMES DANS LA CYBERNETIQUE ECONOMIQUE

L'idée centrale de l'ouvrage est celle de la possibilité et voire de la nécessité d'intégrer l'analyse et la projection sous forme de système à l'aide de la cybernétique économique. Cela permettra d'une part, d'englober dans une conception généralisable une méthode ayant une large utilisation pratique, mais depourvue pour le moment d'un support théorique satisfaisant, et qui, d'autre part, contribuera à élargir l'applicabilité pratique de la théorie cybernétique-économique.

Dans le présent ouvrage l'auteur fait observer que l'analyse et la projection en système sont équivalentes à la détermination empirique de la fonction de transfert d'un système cybernétique et propose une forme de la fonction de transfert, qui prenne en considération les processus décisionnels, les conditionnements technologiques, ainsi que ceux psycho-sociologiques.

ИНТЕГРАЦИЯ АНАЛИЗА СИСТЕМ В ЭКОНОМИЧЕСКОЙ КИБЕРНЕТИКЕ

Главной идеей настоящей статьи является возможность и даже необходимость интеграции анализа и системного проектирования в экономическую кибернетику. Это позволит, с одной стороны, включить в очень общем виде метод, часто применяемый на практике, но лишенный в настоящее время удовлетворительного теоретического обоснования, и, с другой стороны, будет способствовать расширению практической применяемости кибернетико-экономической теории.

В статье указывается, что анализ и системное проектирование соответствуют эмпирическому определению функции переноса кибернетической системы, и предлагается форма функции переноса, которая учитывает процессы принятия решений, технологические и психосоциологические обусловленности.

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