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Directions and Trends in Economic Cybernetics *

In reviewing the stages covered by economic cybernetics up to now, this paper particularly dwells on the dynamic character of the economic cybernetic systems and the ascertaining of their optimum development, equilibrium and stability conditions.

On the background of the tremendous advance of modern science, of its assertion as a decisive factor of the human civilization progress, cybernetics stands out as one of the major sciences for the development of the most important field of social activities: the production of material values.

From Norbert Wiener up to now cybernetics has been the object of a rapid development, thanks to the contribution of tens of thousands of scientists throughout the world. The application of cybernetic computation methods in view of analyzing and elucidating biological, physical, technical, economic and other phenomena, has resulted in the hastening and the thorough extension of the research process, in the widening knowledge of possibilities and practical activities of man. Thus, cybernetics has become a significant factor of the productive forces development în modern society.

Without diminishing the importance of the basic concepts of cybernetics and its theoretical co-ordinates, we must emphasize the fact that the specific force of this science as a *means of knowledge and effective action* for the benefit of society and man consists *mainly in the specificity of the technical means it employs.* In investigating the natural and social phenomena man is bound to receive, analyze and transmit an appreciable amount of information. The analysis of the increasingly complex aspects of material production development requires a considerable amount of information, its efficient utilization, rapidity in data collection, transmission and processing. The

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present technical, economic and social progress supplies us with the opportunity of witnessing an actual "information outburst."

The tremendous development of electronic systems and data processing methods — the chief technical tools of cybernetics — and the application of electronic computers in every possible field of activity have all an outstanding importance for the advance of human society.

On account of its capacity to store and process huge amounts of information, at a speed not accessible to human brains, the electronic computer is at the present moment an irreplaceable auxiliary of human mind, a genuine "extension" of man's computing capacities, an amplification device of man's *informing* and *deciding* abilities.

One of the most important fields where the extension of cybernetic concepts and the application of its technical means have proved their maximum efficiency is the economic area. Although still very young, the new science, designated economic cybernetics, has developed useful methods for the control and optimum management of economic processes, *conceived as cybernetic systems.*

Owing to its scientific function, economic cybernetics has attracted an increasingly wide range of research workers. The cybernetic way of thinking, understanding, organizing and managing the economic systems and processes is at present an undeniable fact, whose soundness is fully acknowledged through the successes of cybernetics and of electronic computers in the economic area. The application of economic cybernetics methods to the solution of problems concerning economic organization and management has come to be an essential constituent of scientific management.

Considering the above-mentioned facts, we will try to delineate the progress of economic cybernetics, the chief directions and trends of development of this science, beginning with the exchange of opinions, the confrontations and the debates which took place on the occasion of the International Congress of Cybernetics held in Namur, as well as during other international meetings of experts. These lines of development and trends point to both the *subject matter of economic cybernetics* and *the investigation methods* used.

One of the most important trends, conspicuously evolving from the debates at the Namur Congress, concerns *the progress and the contents of the general notion of system, in economic cybernetics.*

Some three or four decades ago, the limited number and the narrow range of mathematical methods applied to economics, as well as the *mechanographical stage* of development of technical means of data processing, did not allow a thorough study of micro- and macroeconomic processes, the exhaustive and efficient knowledge of the grounds and motives inducing a specific direction for the progress of these processes; hence, *the informational resources and decision possibilities were insufficient in the economic activities.*

The supplementation of the mathematical equipment of economic cybernetics, as well as the advent of electronic systems for the rapid information processing, have supplied the necessary conditions for the scientific approach of economic systems and processes, on the vast background of their interconnections. In this way, the economic field of investigation has acquired much more accurate means of *information, decision and forecasting.*

An essential feature of cybernetic systems in economy — insistently emphasized during the works of the Namur Congress — consists in their *dynamic character*, expressed in terms of their continuous progress in time. The dynamic character of economic processes, conceived as cybernetic systems, is due both to the effect of objective laws of social development and to the conscious activity of man. Obviously, the dynamic properties of a cybernetic system in economics concerns not only the system as a whole; they define at the same time the total complexity of interactions between its elements, as well as its relationship with the external environment. These interactions were examined at the International Congress of Cybernetics in a number of papers, among which we recall that referring to management science and to the contribution of cybernetic models (G. Guéron — France). In this respect, economic cybernetics becomes the *science of big complex systems* — where man, as a deciding factor, takes a basic place — a science not only aiming to study economic phenomena "per se", but the *framework of their development* as well.

In order to illustrate the concept of cybernetic systems in economy, as well as the concept of its dynamic behaviour, we may stop to look at the group consisting of an economic process, the social body controlling this process and the electronic computing unit. The presence of a continuous flow of information supplied by the computers and referring to the development of the economic process allows the social body to take efficient steps towards controlling the process. It stands to reason that man may interfere any time, in order to impart a specific trend to the process development, depending on the information received and according to the tasks of the social development.

We would like to mention, on the ground of this example, that the increasingly remarkable integration of the electronic computers in the life of contemporary people, in controlling the various actions and activities, in carrying out decisions, has lead to the advent of qualitatively new elements in the economic activities of human society. One of the most important among these new elements consists of the increasingly accurate featuring of a *new kind of feedback*, in the total group of interconnections between man and the processes controlled by him, and which was suggested by the above-mentioned illustration. A consequence of the existence of such a feedback consists in the gradual change of the views on the management activity performed by man.

Another central problem, focussing the efforts of numerous scientists and experts, consists in *ascertaining the conditions of optimum development of economic cybernetic systems*. The concept of optimizing the process development is at present a prevailing characteristic in the organization and management of micro- and macroeconomic processes, in all developed countries. It is interesting to recall that, according to the nearly unanimous views expressed in the scientific circles, the concept of optimum development has not a statistical implication; a dynamic content, full of principled and practical consequences, is at present assigned to this concept. The optimum development of an economic process is nowadays conceived as a permanent dynamic adjustment to the multitude of objective conditions, instead of a total coincidence of the phenomena development, according to the desired programme. This continuous adjustement is intended to draw the performances of the economic process as near as possible to their optimum values previously set up.

Closely connected with optimizing the processes and the economic cybernetic systems is the task of ascertaining their *equilibrium* or *stability* conditions, the concepts of equilibrium and stability being defined for the various stages of the system's general development. From the economic cybernetics point of view, stability of an economic cybernetic system is to be conceived as its quality of remaining near its optimum development, except certain permissible limits, whose transgression would compromise the final achievement of the requested performances. In this respect, stability investigation aims at finding the means by which such a system could be maintained within the limits of the development, approximating as nearly as possible the optimum level. Securing a forecasted course of events, as part of an economic cybernetic system, obviously implies a careful knowledge of its anatomy, of the existing connections between elements and of the manner in which they change in the course of time.

One of the outstanding present trends in economic cybernetics constantly emphasized during the scientific meetings, as well as at the Namur Congress, is the *configuration synthesis of some economic cybernetic systems having an optimum evolution.* Conceived as a complex of co-ordinated actions, implying the technical-economic representation of the system, as well as the forecasting of its future behaviour, in view of achieving certain objectives, the synthesis of economic systems through cybernetic methods is intended to solve highly complex tasks, whose approach requires the mobilization of significant scientific capacities.

The scope of synthesis problems may be suggested by an example. Thus, in an *industrial enterprise*, for which the *output data* of the economic cybernetic system — consisting of the enterprise and the data dynamic variation in time — are known, the task is to set up the *internal configuration* of the economic system, i.e. the enterprise, as well as the *input data* so that the system approximates an optimum situation as closely as possible. *Output data* are expressed in this case in terms of the magnitude of orders, the volume, structure and value of production, the size of profits, etc., while the *input data* are meant in terms of technical and material supply programme, manpower requirements, funds assigned for investments, etc.

Obviously, this example cannot exhaust the actual complexity of the synthesis problem. In practice, the optimum situation has to be characterized — with the exception of the level agreed upon of the so-called input quantities — by a series of restrictive conditions, such as the reduction of production costs, the redemption of capital invetsments in the shortest possible interval, the minimum cost of products, and so on.

Choosing the *optimum configuration* of the economic system implies a great number of different problems. This configuration must include for instance, the network of collecting, transmitting and processing the information required for the efficient management of the system; it must imply an optimum assignment of the *decision function at the different levels of authority* and also secure a rational balance of centralizing and decentralizing the activities of performance and management, etc., with a view to the possible integration in a system actually admitting an optimum operation.

While the synthesis of optimum economic cybernetic systems is still one of the most recent problems of economic cybernetics, the intensity of

efforts made by the experts in this area and the scope of scientific information from all over the world, lead us to the idea that in the relatively near future, accurate quantitative methods will be available for ascertaining the internal configuration and forecasting the development of the economic systems and processes.

In bringing forward — of course, very concisely — some of the present problems of the *object of economic cybernetics*, we would like to expose briefly some of the conclusions resulting from the debates which took place during the International Congress of Cybernetics, referring to the development of *inquiry methods* in economic cybernetics.

One of the outstanding directions in the field of *economic cybernetics methodology* consists in the large scale utilization of increasingly *advanced, refined* and *varied modelling techniques.*

Among the most recent achievements in this field, reported on the occasion of international scientific sessions, we would like to recall *the modelling of the process of sequential inspection and of correcting the course of an economic process*, leading to the determination of stationary solutions of the Markov type, for *optimum strategies* to be adopted, in view of achieving these inspections.

Moreover, in connection with the sequential control of economic process developments and with the introduction of appropriate corrections to each sequence, *stochastic modelling* receives an ever increasing attention. The paper on the utilization of this modelling technique in the complex economic cybernetic systems analysis roused much interest at the International Congress of Cybernetics, held in Namur (John W. Halina — Canada).

Along the same lines of thought, we would like to emphasize the interest roused at the Congress by the report on the modelling principles of organization process in terms of relational algebra (Henryk Greniewsky — Poland).

It is a well-known fact that one of the basic problems of informatics is the information exchange in a complex computation system. As an auxiliary to this problem are the studies referring to informational and programming languages, as well as those on organizing data multiple processing. Along the same lines, among the papers submitted at the International Congress of Cybernetics held in Namur, we recall those concerning the formalization of complex objects description and its achievement (T. G. Evans — U.S.A.), as well as the modelling of logical information process with the aid of the machine-languages, directed towards the problems (T. G. Tamm — U.S.S.R.).

A peculiar character of the interest for the modelling of economic processes and systems is the involvement of *an increasingly abstract and specific mathematical apparatus.* The considerably growing amount of mathematics introduced in economic cybernetics — taking place in the general context of the merging of mathematics and other sciences of our century — allows at the present moment the development of increasingly accurate models, representing economic realities.

An outstanding scientific interest was roused by papers concerning the pattern recognition (L. Kalmar — Hungary), the relations between information, intelligence and imagination (R. J. van Egten — Belgium), as well as by those referring to the use of real time electronic computers, with procedures originally not completely specified. The field of application of

such concerns includes numerical and non-numerical algorithms analysis, characters recognition, data evidence, transmission, storage and processing. The use of such models makes possible the performance, with an increasingly higher accuracy, of the analysis and synthesis of economic systems, making available an ever stronger instrument for forecasting the future progress of processes or systems under investigation.

A conspicuous trend of cybernetic modelling techniques used in economy — emphasized by the debates of the Namur Congress, as well as at the International Congress of the Institute of Management Science, held in Mexico City in August 1967—is pictured by the shifting of priorities in the choice of the model principles toward the *euristic point of view*. A great number of experts insist on the advisability of the application of this point of view, especially in the development of planning models. The recent wide utilization of *euristic models* is quite natural, if we take into account the fact that the present computation technique and the increasingly accurate mathematical methods make possible the continuous supplementation of our representation of the economic processes and systems with the consequent *correction of the euristic model originally chosen*, which may thus approximate gradually, ever more closely, the reality it is simulating.

We have outlined very generally some of the *directions* and *trends* of the present concerns in the field of economic cybernetics, resulting from the scientific research and from the worldwide practice of using cybernetic methods in economy.

The limited space allotted to this paper has not allowed an exhaustive portrayal of the wide framework within which research is carried on in the field of economic cybernetics. Scientists all over the world are sure that economic cybernetics has definitely compelled recognition as an efficient means of investigation and analysis of economic activity, as a valuable auxiliary to the optimum management of economic processes and decision making. The scientific potential existing in our country and the results reached so far by Romanian experts in cybernetics are quite a positive prerequisite for the continuous development of our investigation in this field, intimately linking it to the the practical demands of national economy.

ORIENTATIONS ET TENDANCES DE LA CYBERNETIQUE ECONOMIQUE

La cybernétique s'inscrit dans le développement de ce facteur déterminant de la société qu'est la production matérielle, comme un des facteurs scientifiques majeurs, fournissant à l'homme un puissant instrument de connaissance et d'action dans toute une série de phénomènes de la biologie, de la physique, de la technique et de l'économie.

L'analyse de ces phénomènes qui, surtout dans le cas de la production matérielle, acquièrent une complexité et un volume de plus en plus importants, exige des quantités considérables d'informations. L'utilisation opérative et efficace de ces informations, leur transformation et leur transmission à une grande vitesse réclament l'utilisation des calculateurs électroniques, en tant que véritables amplificateurs des possibilités humaines d'information et de décision, indissolublement liés à la réalisation des concepts de la cybernétique économique.

Dans ce contexte, l'ouvrage analyse d'une manière succinte les étapes parcourues jusqu'ici par la cybernétique économique, synthétise ses tendances actuelles et fait des prévisions

sur son développement futur. L'auteur s'occupe surtout du *caractère dynamique* des systèmes cybernétiques économiques et indique que ce dynamisme caractérise, non seulement l'ensemble du système en question, mais aussi la totalité des interaction de ce système avec le milieu environnant.

L'auteur aborde également une autre question centrale, à savoir, d'*établir les conditions de la meilleure évolution des systèmes cybernétiques économiques*, ainsi que les conditions de leur *équilibre* ou de leur *stabilité*.

Du point de vue de la cybernétique économique, la stabilité d'un système cybernétique économique doit être comprise comme la propriété de ne pas s'éloigner de sa meilleure évolution plus que ne le permettent certaines limites, dont le dépassement compromettrait l'obtention en finale des performances voulues.

La présente communication s'est également occupée de la *synthèse de la configuration de certains systèmes cybernétiques économiques dont l'évolution est la meilleure possible et* de la *prévision* du comportement futur d'une pareille configuration.

Le fait de choisir la *meilleure configuration* du système économique soulève des problèmes extrêmement variés. Cette configuration doit contenir, par exemple, le réseau de recueil, de transmission et de travail sur les informations nécessaires à la direction opérative du système ; elle doit comporter la meilleure distribution de la *fonction de décision à différents niveaux ;* elle doit également assurer un équilibre rationnel de la centralisation et de la décentralisation de l'exécution et de la direction, etc.

НАПРАВЛЕНИЯ И ТЕНДЕНЦИИ В ЭКОНОМИЧЕСКОЙ КИБЕРНЕТИКЕ

В развитии решающего сектора общества — в материальном производстве — кибернетика является одним из важнейших научных факторов, обеспечивающих человека мощным инструментом познания и, одновременно, воздействия на целый ряд биологических, физических, технических, экономических явлений.

Исследование этих явлений, особенно тогда, когда речь идет о явлениях материального производства, становится все более сложным и все болсе объемным, требует значительных количеств информации. Оперативное и эффективное использование этой информации, её очень быстрая обработка и передача приводят к необходимости использования электронных вычислительных машин, представляющих настоящие усилители возможностей человека в усвоении информации и решений, неразрывно связанные с осуществлением понятий экономической кибернетики.

В данном контексте коротко анализируются этапы, пройденные экономической кибернетикой до настоящего момента, синтетизируются её современные тенденции и предвидится её будущее развитие. Автор особенно касается *динамического характера* экономических кибернетических систем и показывает, что такой характер имеет не только какой-то один ансамбль соответствующей системы, но и весь комплекс её взаимодействий с внешней средой.

Другой центральной проблемой, которой занимается автор, является *определение условий оптимального развития системы экономической кибернетики*, установление условий её *равновесия* или *стабильности*.

С точки зрения экономической кибернетики, стабильность экономической кибернетической системы должна пониматься как её свойство не отдаляться от своей оптимальной эволюции больше некоторых допускаемых границ превышение которых привело бы к комирометированию конечного достижения желаемых результатов.

Обобщение конфигурации некоторых систем экономической кибернетики с оптимальной эволюцией и *предвидение* будущего поведения подобной конфигурации также затронуты в данном сообщении.

Выбор *оптимальной конфигурации* экономической системы ставит разнообразные вопросы. Например, эта конфигурация должна охватывать сеть сбора, передачи и обработки информации для оперативного руководства системой, нести в себе оптимальное распределение *функции решения на различных уровнях*, обеспечить рациональное равновесие централизации и децентрализации операций по исполнению и руководству и т. д.