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Management, Command, Control and Regulation System. Logistic Equation of Management

The national economy represents a cybernetic system of great complexity composed of numerous systems and subsystems, in which activities of production, distribution, movement, consumption research and development, forecasting and planning affect each other. For the highest efficiency of every component of the national economy in regard to the fulfilling of the tasks imposed by the general strategy for economic-social development, considerable effort is needed to coordinate and synchronise in time and space every activity within the national economy space, as well as the interchanges by which optimal interaction with the world economy space and international division of labour is achieved. The ever increasing complexity of the processes of the national economy space, the fast changes taking place in every field of the economic-social life, as influenced by the contemporary techno-scientific revolution, the rapid paces in the development of the components of the national economy space, the necessity for wider use of human, material and financial resources in order to ensure optimal, balanced, proportional economic growth — all these represent important factors contributing to the decisive part management-control activity plays in every aspect of the growth process.

All the components carrying out management and control activities in the topology of the general cybernetic-system are grouped into the management, command, control and regulation systems, which play a central part in coordinating the development process of all systems of the national economy space for optimal conditions. They form a nervous system, which coordinates, checks, commands, controls and synchronises the movements and the development of every constituent part of the general cybernetic system of the national economy. These systems have a very complex struc-

ture, being formed by a multitude of components organised in hierarchical networks. A decisive part is played by the macro-economic decision body which maps out the essential coordinates of the optimal trajectories of proportional and balanced growth within the national economy space and the tasks of the components within the general economic system, according to the general strategy of the country's economic-social development (Fig. 1).

The management, command, regulation and control systems provide knowledge of the economic and social processes and of the realities in economy, based on which the long-term forecast of society's developement is formed. Starting from this, these systems ensure a proper control and organisation of every aspect of the economic-social life in order to provide optimal operation in all the departments, the achievement of a proper knowledge of the material and human resources, and the maintenance of optimal proportionality in their distribution between domains and sectors of the economic-social activity and over the country's territory.

The activities taking place inside each cybernetic-economic system which operate within the national economy space, are performed according to the commands received from the decision body. These commands are taken on the basis of knowledge of the development level reached by the given cybernetic-economic system and according to the tasks set for the general cybernetic system of the national economy.

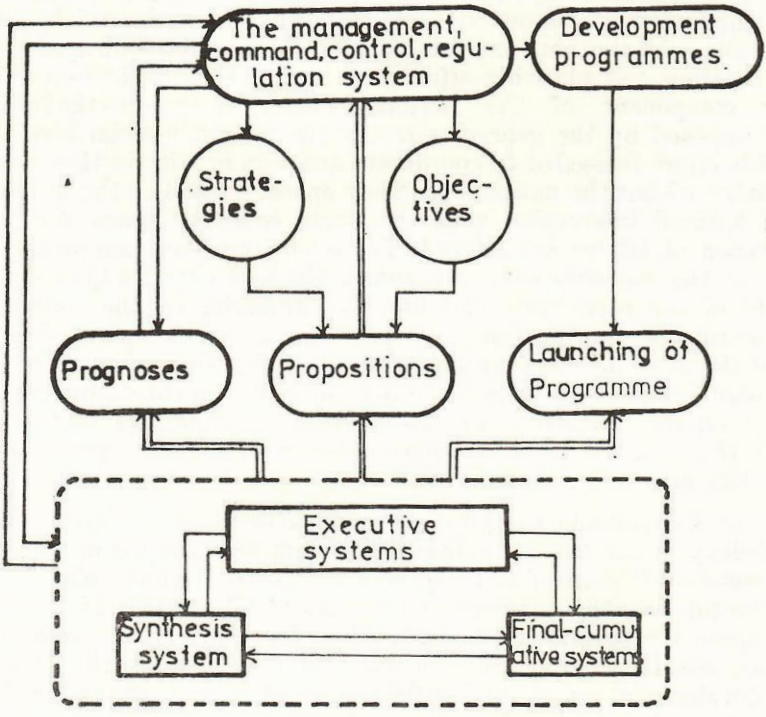

Fig. 1. The management system

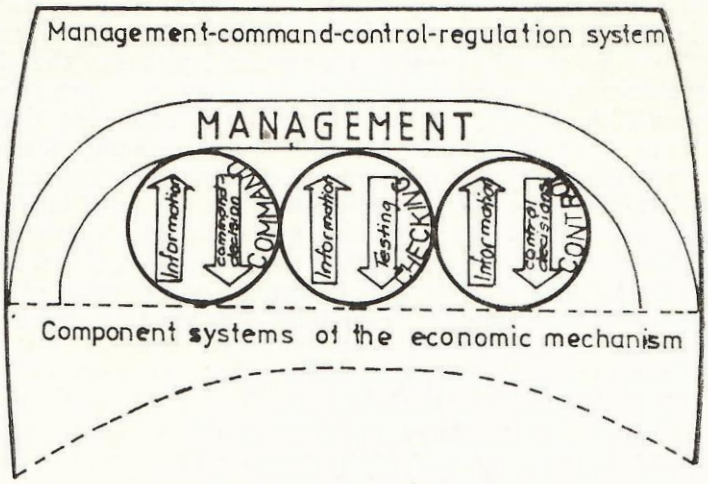

Fig. 2. The command checking control triad

The essential qualities of the management system are synthesised by the triad command-checking-control (Fig. 2). Each of these functions implies a display of the whole executive plan regarding the organisation and coordination of the activities, in order to achieve a decision in an optimal manner.

Decisions adopted by the management, command, control and regulation system are vectorial resultants of the dialectical process of combining the processes of diagnosis and forecast. The formation of every decision involves first a diagnosis, i.e. the sound knowledge of the development level reached by every system part, of its specific development laws, of the connections with other systems, and of the way of acting in the future.

Since a great deal of the adopted decisions are "penetrations" into the future, they are based on forecast studies regarding the development trends of the main processes inside both the national economy space and the world economy space. The essential qualities of management lie in estimating the effects following current decisions, and especially in investigating these decisions in connection with the predicted action of economic and social factors. The forecasting possibilities are improved by using the methods and models studied by economic cybernetics, thus emphasising the importance of cybernetics.

In the forecasting activity of establishing the growth trends of systems and subsystems within the national economy space, the identification based on quantum economy methods of the optimal economic time pertinent to every component of the national economy system, plays an extremely important part.

In order to form politico-economic decisions regarding the optimal, balanced and proportional growth trajectiores of the components of national economy and also the means of permanently improving every economic-social activity and of increasing its efficiency, the management, command, control and regulation systems use methods, techniques and models developed by economic logistics in the economic forecasting domain.

Starting from the essential coordinates established as parts of the strategy of a country's socio-economic development and from the economic political options, models of economic forecasting emphasise the characteristic movement laws of systems and subsystems operating within the national economy space (Fig. 3) and the long term trends regarding the following factors: Growth of the social product and of the national income; increasing of labour productivity and of economic efficiency (the reduction of costs of raw materials, materials and power consumption, the fixed funds efficiency and the optimal way of using productive capacities, the appropriate use of agricultural land, of every component of national income, etc. ...,; growth of population and the structure of the labour force; dynamics of production in industrial, agricultural and other branches; production development for

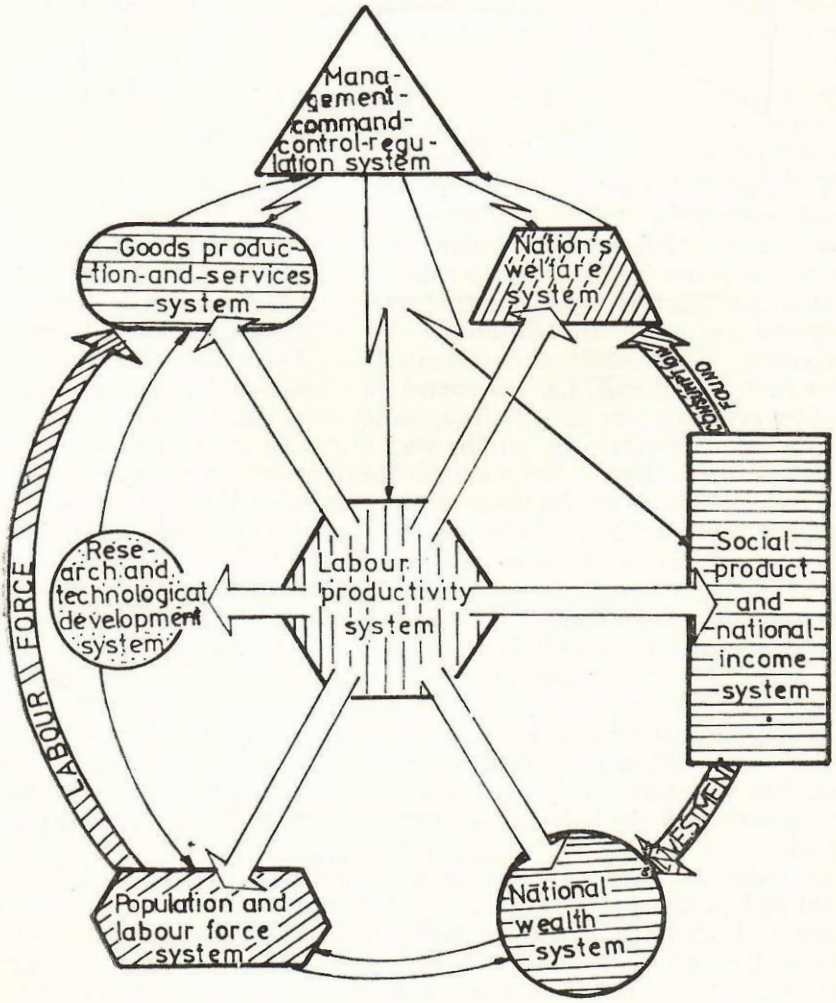

Fig. 3. Models of economic forecasting

main products and groups of products; export and import volume and their structure for the main groups of products and markets top priority domains of the national science development; individual training; dynamics on social groups and of the people's income from wages and from consumer social funds; consumption of main products; dynamics of housing and of other urban construction, etc. ...

The analysis carried out for the long-term development trends o each system and subsystem apart, as much as of the general cybernetic system of the national economy as a whole, and the computer simulation of various "scenarios" allow the decision body to establish strategies regarding the most efficient economic growth process. A very important part in the fondation of the decisions pertinent to the growth trajectories of the components within the national economy system, is played by the forecasts made for every system and subsystem, regarding the structural changes which are expected in their evolution, which emphasise their growth potential. In this way, prognoses are made for the population and labour force systems regarding the country's population and its structures according to age and sex groups, of urban and rural media, etc... Forecasts are now made for population migrations, depending on the economic and social development of the country, and on the territorial allocation of the labour force. For the labour force itself forecasts are made regarding its allocation between branches, subbranches and sectors of economic-social activity.

These predictions made on the basis of economic models for production and services emphasise the development stage of branches, subbranches, products and groups of products of this system. In this way, forecasts are made regarding electrical and thermal power production, metallurgy, machine buildings, chemical industry, building materials industry, timber industry, light industry, food industry, agriculture, transport, commerce and services for people, etc. ... The forecasting models of production and services must concurrently emphasise the ways of parmanently increasing labour productivity, of reducing the raw material, material and power consumption, of increasing the general efficiency and the profitability of the whole production, and of ensuring the growth of production quality, and of the technical level and competitive character of all goods in the foreign market.

The economic models built for the research and development system emphasise the main development trends of research fields strongly connected with the world's science development, and with its contribution to the national income growth, to the highly efficient use of resources, to the increase of national wealth and to the growth of the standard of living and educational level. The forecast for developing an international economic relations system emphasises the optimal means of the country's participation in international labour division, pointing out the forms of cooperation and assistance, both with the developing and industrialised countries. The forecasting models of the international economic relations system concurrently play the part of identifying the foreseeable trends within the world economy space in the field of demand and supply, of products and groups of products, of external prices on various markets, of credits and interests, of international transport, and so on.

The prediction of growth trajectories of the national wealth system stresses the development trends of the natural resources, of power potential; it estimates water resources and the possibilities of satisfying the economy's requirements, the development of agricultural land and the improvement of soil structure, the growth of the forestry stock and that of the components of the accumulated goods subsystem i.e. fixed funds, raw materials, materials, and others. An extremely important part is played by the forecast regarding the growth of the nation's creative potential, of public education, of science and technology, of information and of culture of the country.

An essential part in the formation of an overall strategy of social economic development of a country is played by the forecast regarding the improvement of the national welfare system, a goal towards which all growth trajectories of the national economy system converge. This stresses the optimal ways of permanently increasing the people's material and cultural standard of living, the growth of its prosperity and of its degree of civilisation. The forecasting models of the national welfare system, strongly interconnected with those of the social products and national income system, emphasise the development trajectories of people's income as a result of wages and consumer social funds, depending on the national income's growth and on labour productivity. At the same time, they stress the dynamics of people's needs of food and of industrial goods, of services, the ways of improving health, sanitary and working conditions in order to increase the span of active working lives.

The methods, techniques and models of economic logistics used by economic forecasting allow computer simulation of numerous development alternatives, depending on the options of economic policy adopted and provide at the same time a correlation of the forecasting essemble within a unitary and convergent frame. There is a permanent exchange of information between the forecasts made for various components of the national economy system, so that their permanent updating and improvement is possible. Based on the strategies adopted by the macro-economic decision body, essential development coordinates are determined of every system and subsystem within the national economy space; in the end, long-term programmes for economic-social development are produced.

In the complex management process of the general cybernetic system of the national economy, multiple direct and feedback connections are formed between the activities of forecasting, establishing strategies and producing long-term programmes. The adopted strategies and programmes, for example, can modify the initially estimated developments by means of forecasting models and also their scope.

The development of the general cybernetic system and its transition from one state into another, are achieved by the labour force system and by the consumption of material resources supplied by the national wealth system. It follows that these two systems are "energetic pools" of the evolution within the national economic space and are amplified through the effects obtained by the research and development system, by the production system and that of international relations. To this end, the impact of synthesis systems is added, i.e. labour productivity, efficiency-profitability, economic information, and finance and prices; they realise the action of the mana-

gement, command, control and regulation system, and determine the developing parameters of the optimal trajectory for every component of the general cybernetic system, in macro and micro-economic processes and on a territorial level. The directing and maintaining of all the components of the national economy system along their growth trajectories are achieved on the basis of commands and decisions adopted by the management system, regarding all the systems and subsystems in the national economy space. These constitute the decisions spectrum. Thus the important command-directing function performed by the management system is emphasised.

Every components system of the general cybernetic system of the national economy, executing its actions which define its object and role, generates specific output variables characterising its dynamics, corresponding to the demands from the management, command, control and regulation system. These variables are grouped together in the achievement range and represent the response of every system to the decisions taken by the management system. The optimisation methods and techniques of economic logistics and of the quantum economy find enormous applications in forecasting and designing plans. At the same time, the economic logistics methods allow optimal correlation and harmonisation of solutions on a departamental, branch and territorial level.

An especially important part is played by the methods, techniques and models of economic logistics in the domain of investment optimisation and in the identification of optimal ways for developing and modernising all components of the general cybernetic system of the national economy.

The output variables return through multiple channels towards the management, command, control and regulation system and concentrate in the achievement range. The information type output variables return through the economic data-processing system, which covers like a nervous network the whole space of the national economy. Based on these, the management, command, control and regulation systems analyse the development of each system and subsystem, the way of fulfilling tasks, as much as the responsive and entropic states of the economic space. Thus the control function of the management, command, control and regulation system is achieved. At the same time, the economic data — processing system has the task of supplying the required information for the forecasting models and for the economic growth programmes constructed by the management, command, control and regulation system. In the case of deviations from the established trajectories regulation decisions are taken. In this way, another important function of the analysed system, the regulation, is achieved.

THE ECONOMIC-CYBERNETIC MODEL OF MANAGEMENT

In the prospective design activity of economic growth trajectories, along the path of progress, the management system widely uses methods, techniques and models from the management science arsenal. Within their frame a major part is played by the economic-cybernetic model of management — an important tool for computer simulation of economic optimal,

balanced, proportional growth trajectories. The economic-cybernetic system of management — a maximal synthesising structure — focuses upon and processes the main elements obtained by solving models of all systems operating in the national economy space. Its output variables represent decision parameters that define the evolution coordinates of all systems and subsystems within the national economy. In this way, the strong interrelations formed between the cybernetic-economic model of management and the other models of the national economy, and also its part in the ensemble of the cybernetic models of the national economy system, are emphasised.

The cybernetic management model — the nucleus of the whole models ensemble of the national economy system — is a dynamic model with discrete variables of which the state vector synthetically describes at any moment the position of the general system in the national economic space. Depending on the permanent information flow taking place between the management system and the other components of the general cybernetic system of the national economy, the state vector X_t, of the management model quantifies the elements regarding the following:

a. The country's population, i.e. the active population, its social-professional structure, sex groups, urban and rural environment, etc.

b. The components of national wealth i.e. human resources, ground and underground resources, fixed funds, materials stocks, currency reserves, the population's household stock, elements regarding the nation's creative capacity, etc. ...

c. The level of elements characterizing the nations welfare.

d. The labour productivity, the efficiency and the profitability of branches and subbranches of the economy.

e. The level of activities in the production and services system, in the research and development system, in the economic international relations system, etc. ...

f. The level of activities taking place in the finance and prices system.

g. The level of activities in the social product and national income system.

As regards the management vector, denotes by U_t, its components, the optimal value of which is obtained by solving the cybernetic management model, refers to fundamental macro-economic decisions as follows:

(i) The quota of national income allotted to the national fund for economic-social development and that allotted to the consumption fund.

(ii) The range of investment in the production and services systems, within the total national fund for economic-social development.

(iii) The weight of investment in the social-cultural field and in housing within the total national fund for economic-social development.

(iv) The quota of investment in the economy for the development of industry, agriculture, buildings, transport, circulation of goods, science and technological development, etc.

(v) The distribution of labour force among the branches and subbranches of the national economy.

(vi) The volume and structure of exports and imports

(vii) The level and the intensity of economic cooperation in industry and scientific-technical cooperation with other countries. The dynamic equation of the management cybernetic model, expressed in vectorial form, is

$$X_{t+1} = G_t(X_t, U_t; \sigma_t); \; X_0 = \alpha$$

Here, X_0 denotes the initial state of the system, and σ_t the input-coupling vector, the components of which quantify the information obtained by the management model from other models of the general cybernetic system of the national economy. In this way, this vector synthesises information regarding the necessary material and financial resources for providing the growth of the production and services systems, the people's consumption demand, the dynamics of research and development, the foreign exchanges development, etc. ...

The development vectorial equation of the cybernetic management model synthetically emphasises the state of the national economy's general cybernetic system at the moment t, depending on its state at the previous moment, on the adopted options and on the values of the input-coupling vector components value σ_t. Based on the logistic study of the model and depending on the actual-historical conditions and on the political options for economic-social development, the permitted command range, denoted by U is established. As a matter of fact, U is the Cartesian product of the sets U_i, i.e.

$$U = U_1 \times U_2 \times U_3 \times \ldots U_k$$

where U_i is the variation range of the component i of the management vector.

Several mathematical relationship, which quantify the constraints that the general cybernetic system has to respect in its evolution, are added to the development vectorial equation of the management model. They reflect the major economic policy elements regarding the way of using the natural resources, the land and forestry fund, etc. ... At the same time, they quantify for the developing countries several conditions regarding the growth rates, which have to be provided in order to achieve the gradual decrease and eventual elimination of delays, and also to reach the economic level of the advanced countries.

Many model equations refer to ways of satisfying the consumption needs of the population and of permanently increasing the nation's welfare. The corresponding equations of the cybernetic management model quantify the way in which the output variables of the national economy general cybernetic system have to behave in the period under consideration for the model.

The constraint set of the economic-cybernetic management model in a vectorial form, is

$$\sum_{t=0}^{T} H_t(X_t, U_t; \sigma_t) = \Delta$$

where T is the time period under consideration, and Δ the quantifying vector of the tasks resulting from the development programme.

By using forecasting methods and techniques from the economic logistics arsenal, one determines the observability, accessibility and controlling regions of the model depending on the permitted command range, on the structure of the development and constraint vectorial equations, etc. ...

Taking into account the fact that man's welfare with his ever increasing and diversifying needs is the goal, the management system settles the boundaries for each stage in the limits of the accessibility region, i.e. the general progress region, denoted by P_t. In establishing this, the macro-economic decision body takes into account the necessity of increasing the national wealth by harmoniously combining the nation's present interests with those in the future.

The control of the system's development in the "progress region" is made by means of the output variables vector, denoted by ω_t. The components of the vector ω_t refer to the value and the structure of the national income and of the components of the national wealth, to the indices characterising the nation's welfare, the productivity level and the economic efficiency, the intensity and the efficiency of the foreign trade exchanges, and so on. In order to ensure the development of the general cybernetic system in the progress region P_t, established by the macro-economic decision body, the following vectorial equations are inserted as part of the model

$$\omega_t = \rho_t(X_t, U_t; \sigma_t) \in P_t$$

Combining all the elements of this cybernetic management model the following vectorial form results

$$X_{t+1} = G_t(X_t, U_t; \sigma_t); \; X_0 = \alpha$$

$$\sum_{t=0}^{T} H_t(X_t, U_t; \sigma_t) = \Delta$$

$$\omega_t = \rho_t(X_t, U_t; \sigma_t) \in P_t$$

$$U_t \in \omega_t; \quad t = 0, 1, \ldots T$$

where T is the time period along which the development of the general cybernetic system of the national economy is analysed. The dimensions and the complexity of this model presented in a synthesised, vectorial form, may be extremely important. From the identification of the actual forms for numerous types of mathematical functions appearing within its frame, as much as of their parameters, extremely complex methodological, statistical and mathematical problems arise. It is necessary to point out that it is the task of an economic data-processing system to provide the required data base for building the numerical model, which is an extremely important problem.

The trajectory, which provides an optimal growth of the general cybernetic system within the national economy, is chosen from the multitude of the trajectories obtained from the cybernetic-economic management model, through an iterative optimisation process. In order to carry out the optimisation an objective function is decided upon. Taking into account the fact that the sensitive of the model trajectories depend on the actual form of the objective function, the way of selecting it is an extremely complex economic

problem. It is necessary, referring to economic logistics, to consider several objective functions of the cybernetic-economic management model and computer simulation of various growth trajectories. On this basis, the best fitted growth trajectory to the proposed tasks may be selected. The objective-functions attached to the cybernetic-economic management model must emphasise the growth trajectories which ensure a maximisation of the national income, of the national wealth and welfare. These have the form

$$maxim\ \tau(U,\ X) = max \sum_{t=0}^{T} \beta_t(X_t,\ U_t\ \sigma_t)$$

Thus, the cybernetic management model becomes a dynamic programming model with discrete variables. At the same time, the logistic study has to emphasise the way in which the optimal evolution trajectories are influenced by the input-coupling vector, σ_t of the parameters obtained from other models, and also given by the choice of parameters P_t and U_t of the cybernetic-economic management model.

The knowledge of the responsiveness of evolution trajectories, in connection with various elements of the model is extremely useful during the design stage of the numerical model. These make it possible to select the most suitable statistical-mathematical methods for preparing numerical information and computing the model parameters. The knowledge of the logistic properties of the model provides also useful information for economic analysis, as well as for building algorithms and actual computing programs for the optimal trajectories.

By using the economic logistics algorithms, the optimal control of the cybernetic-economic management model is obtained

$$\{\widetilde{U}_t\}_0^{T-1} = \{\widetilde{U}_0,\ \widetilde{U}_1,\ ...,\ \widetilde{U}_{T-1}\}$$

LOGISTIC EQUATION OF MANAGEMENT

The synthesis of the optimal control of the cybernetic-economic management system represents the logistic management equation

$$\widetilde{U}_t = \xi_t(\widetilde{X}_t,\ \widetilde{X}_{t-1},\ ...,\ \widetilde{X}_{t-k};\ \sigma_t,\ \sigma_{t-1},\ ...,\ \sigma_{t-k})$$

The information provided by the logistic management equation provides extremely useful elements for the design activity of the optimal, balanced and proportional growth trajectories.

The logistic management equation, in vectorial form, may be written in an expanded form as

$$\widetilde{U}_t^i = \xi_t^i(\widetilde{X}_t,\ \widetilde{X}_{t-1},\ ...,\ \widetilde{X}_{t-k};\ \sigma_t,\ \sigma_{t-1},\ ...,\ \sigma_{t-k})$$

components $\widetilde{U}_t^i$ quantifying the control-directing decisions of systems and subsystems within the national economy space.

The management algorithms (Fig. 4) represent the actual way in which the management system produces the optimal decision vector for each stage

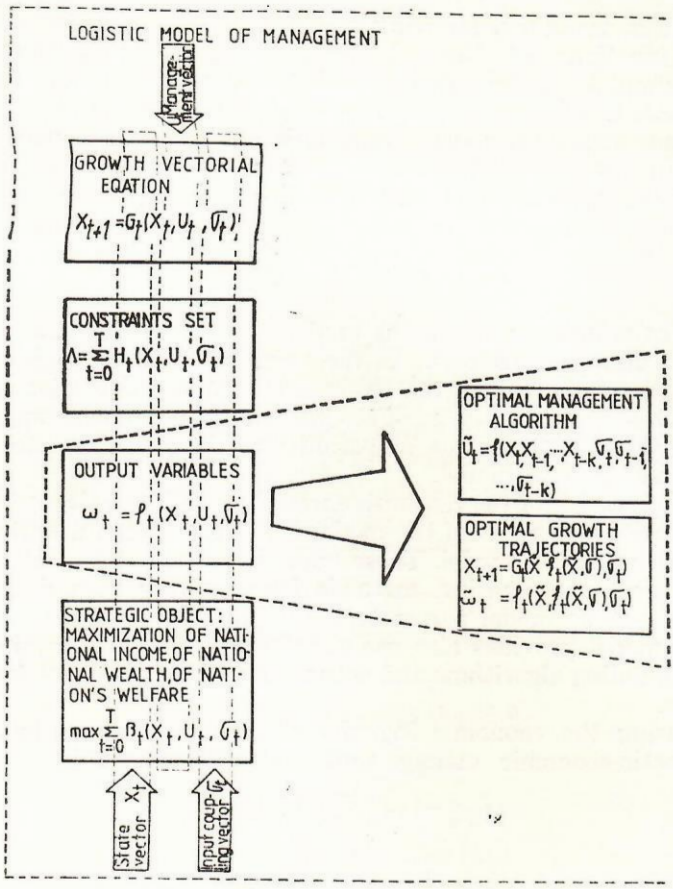

Fig. 4. Management algorithms

by using the management equation. The management algorithm study is one of the fundamental parts of economic logistics. The coordinates of the optimal, balanced and proportional trajectories of the general cybernetic system of the national economy are emphasised by the following vectorial equations

$$\widetilde{X}_{t+1} = G_t(\widetilde{X},\ \xi_t(\widetilde{X},\ \sigma),\ \sigma_t)$$

$$\widetilde{\omega}_t = \rho_t(\widetilde{X},\ \xi_t(\widetilde{X},\ \sigma),\ \sigma_t)$$

representing the logistic equation of the future. This supplies extremely useful elements for analysing the way in which to fulfil the tasks regarding the growth of general welfare and of the whole economic potential of the nation. The state and output variables obtained by solving the logistic equation of the future allows a permanent control of the way in which the tasks decided by the developing programmes are fulfilled. At the same time, the

elements of the logistic equation of the future provide information about the speed at which the evolution trajectories of the general cybernetic system of the national economy get closer to those of the economically more advanced countries.

There is a strong connection between the logistic equation of management and the logistic equation of the future. In fact, the evolution trajectories both in the state space and output space emphasised by the logistic equation of the future, are determined by relying on the information provided by the logistic equation of management.

The economic-cybernetic models of the management system, the logistic equation of management built by using the science of society management, represent essential elements of the whole ensemble of cybernetic-economic models of the overall system of the national economy.