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AN INDETERMINISTIC OPTIMIZATION PROBLEM IN THE METHODOLOGY OF MATHEMATICAL FORECASTING OF SOCIO-ECONOMIC DEVELOPMENT OF A REGION

The paper elucidates that an indeterministic (with incomplete information) dynamic optimization problem is sufficiently general to be used as an initial model for a mathematical methodology (theory) of forecasting long-term socio-economic development of a region. At that, the generally used mathematical forecasting models turn out to be special cases of this initial model, finding their proper place within the methodology. The same can be said about considering the object's internal information and respective external information.

1. Today forecasting is a formed element within the management system of socialist economy which is interrelated with planning, day-to-day management, development concepts, etc. It is concerned with manageable national economic processes, and, differently form planning, likewise with unmanageable ones. Its task is to ascertain objective development trends of the processes investigated in probabilistic and alternative forms. Forecasting does not mean the preparation of a plan project but the preparation of initial data for planning with special attention paid to development problems and bottlenecks.

The forecasting of a region's comprehensive development is a highly complicated methodological problem which can be solved with the help of systemic forecasting. In systemic forecasting subforecasts are compiled by means of an iterative co-ordination process, as a result of which a single forecast of comprehensive development is obtained. Because of the extraordinary complexity of the object, it is advisable to work out subforecasts proceeding from various aspects and sections. Here we could distinguish subsystems, levels, resources, functions, exogenous and endogenous aspects, aspects of approach (inertial and adaptive), methodical aspects (deterministic and indeterministic), etc.

A number of methodological problems concerning subforecasts as well as systems of forecasting models and principles of their co-ordination have already been elaborated. However, it seems to be too early to speak of the existence of a mathematical methodology of systemic forecasting.

2. At present the main mathematical tools in forecasting long-term socio-economic development of a region are statistical models, models of optimum planning, and, to a lesser extent, simplified indeterministic optimization models.

If statistical models (econometric, regression, trend, etc. models) are used, forecasting is carried out by describing and using inertial moments of development. In so doing, the statistics of the object being forecast is the only source of information. The adaptive and teleological aspects of development, that is consideration of the effect of planning (management) are described in these models to a smaller extent, if at all. Likewise, all relevant information that is beyond the statistics of the object

(projects, experimental results, theories, statistics of analogous objects, etc.) is not made use of here.

Socio-economic development of a region being essentially an adaptive teleological process with an extensive use of external information in planning, inertial forecasts can naturally be of a limited significance only. Above all, they point to difficulties of development which would arise if the present trends were to continue (alarming forecasts, "doomsday forecasts", etc.).

Models of optimal planning (deterministic) do not exhibit the above shortcomings. They describe the objectives and plans of development as well as external information. However, the incompleteness of information is abstracted here. As a result, only one deterministic development forecast with a realization probability approaching zero is obtained. All the remaining possible development trajectories are neither analyzed nor described. From the standpoint of forecasting, this is a serious deficiency.

To a lesser extent, indeterministic (stochastic, uncertain, fuzzy, stochastic-uncertain, etc.) optimization models are also used today to forecast the socio-economic development of a region. In principle, the latter models are free from the shortcomings of the two former classes of models. However, in practice they are used in an extremely simplified form. This is, above all, due to the complexity of their solution. However, from the standpoint of elaborating mathematical methodology of forecasting, it is also expedient to formulate more general abstract models or the so-called initial models. There is no need to quantify and directly solve the latter. This is their decomposition analysis, from which the system of special cases and subproblems is derived, whose interpretation serves as a mathematical theory of forecasting.

3. The principles that should underlie a general mathematical model of long-term forecasting of a region's socio-economic development are as follows. Besides the inertial moments of development, the model should describe possibilities of adaptation, that is, also forecast plans and their effect. In order to forecast plans, however, it is necessary to forecast also the objectives of development, at which planning is aimed. Note that, unlike planning models, forecast models should not seek fixed plans (point plans); instead, it is advisable to formalize them as intervals, random variables, fuzzy variables, etc. When describing the objectives of development, it is essential to consider their adaptability, i.e., their dependence upon the previous development and the situations realized in it. Next, it is important to describe the possible development alternatives ensuing from the object's internal information as well as additional external information. Likewise, on the basis of new external information, it is essential to describe the possibility of such events that the statistics of the object does not yet comprise.

4. It is easy to see that the above principle can be described by a dynamic indeterministic optimization problem. Its structure might be outlined as follows. The problem gives a dynamic description of alternative socio-economic activities whose intensities (plans) are the variables to be forecast. At that, both material and non-material activities are described as socio-economic activities [1]. The forecasting of alternative plans is carried out on the basis of an objective function (generally a vector function) as well as a system of constraints. Differently from deterministic planning models, the objective function must be adaptive, i.e., in some forecast year dependent upon the realization of the whole previous development.

Thus, the system of constraints is analogous to ordinary dynamic optimization models. For a formalized description of incomplete information, a combined use of random variables and uncertain variables

(intervals) seems to be the most suitable here [2]. It is important to describe the interdependence of parameters in the problem. This can be approximately accomplished with the help of the concept of significant events [3].

5. At the initial stage of forecasting it is advisable to decompose the initial problem by aspects [4]. This means a division of the initial problem into a system of subproblems describing simpler aspects. To begin with, it is expedient to distinguish between the inertial and adaptive aspects of development. In case of the former, the objectives and alternatives of development as well as external information are abstracted. This yields ordinary econometric models. For further simplification, it is, for example, possible to abstract interdependence of development indices. In this way a set of regression models is obtained. There the factors of development can be aggregated into one factor (time), and this results in a set of trend models. The latter are models with which forecasting begins to move toward an application of more adequate models.

In order to achieve a clearer description of adaptive aspects and a simpler consideration of external information, it is advisable to simplify the problem by giving up the assumption of indeterminacy, not taking dependence of parameters into account, etc. This will yield a simple optimizing model. By further simplification (eliminating the objective functions and alternativeness), a balance model is obtained, etc.

The final forecast must be composed here by combining the two trends (inertial and adaptive). It is evident that more serious development problems arise in case of indices for which bigger deviations occur between different trends.

In later stages of forecasting where more complex models are used, it is expedient to decompose the initial problem temporally, by programme, sectorally, territorially, etc.

6. The co-ordinated solution of indeterministic subproblems is, in its turn, a complicated task. When the subproblems are stochastic, their determination is an important element of solution. To obtain as adequate (equivalent) approximations as possible, multi-aspect determination [2] should be used here. In general, the solution of subproblems should be aimed at analyzing the problem and evaluating development zones [5] rather than finding a mathematical optimum. At that it is plan zones, and not trajectories that are appraised. It is only after transition from forecasting to planning that the plans are fixed as trajectories.

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INDETERMINISTLIK OPTIMUMÜLESANNE REGIOONI SOTSIAAL-MAJANDUSLIKU ARENGU MATEMAATILISE PROGNOOSIMISE METODOLOOGIAS

On selgitatud, et vaeginfoga dünaamiline optimumülesanne on küllalt üldise püstituse puhul (adaptiivne sihifunktsioon, prognoosplaanid, välise info arvestamine, võimalike oluliste sündmuste kirjeldamine jne.) sobiv regiooni pikaajalise sotsiaal-majandusliku arengu prognoosimise matemaatiliste mudelite süsteemi metodoloogia aluseks. Tavaliselt kasutatavad prognoosimismudelid (statistilised mudelid, optimumplaneerimise mudelid jne.) osutuvad selle lähtemudeli erijuhtudeks ja leiavad nimetatud metodoloogias oma õige koha. Sama toimub ka sisemise ja välise infoga (statistika).

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ЗАДАЧА ИНДЕТЕРМИНИСТСКОЙ ОПТИМИЗАЦИИ В МЕТОДОЛОГИИ МАТЕМАТИЧЕСКОГО ПРОГНОЗИРОВАНИЯ СОЦИАЛЬНО-ЭКОНОМИЧЕСКОГО РАЗВИТИЯ РЕГИОНА

Объясняется, что динамическая оптимизационная задача с неполной информацией при соответствующей постановке (адаптивная целевая функция, прогностические планы, учет внешней информации, описание возможных существенных событий и т. д.) — достаточно общая, чтобы быть подходящей исходной моделью для методологии математического прогнозирования долгосрочного социально-экономического развития региона. При этом применяемые в настоящее время математические модели прогнозирования (статистические модели, оптимизационные модели планирования и т. д.) — частные случаи этой исходной модели — находят свое место. То же самое получается с внутренней информацией объекта и соответствующей внешней информацией.

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