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Ü. ENNUSTE

ON DESCRIBING SIGNIFICANT EVENTS AND STABILITY IN A MODEL OF PLANNING REGIONAL SOCIO-ECONOMIC DEVELOPMENT

Presented by K. Habicht

Generalization of dynamic models of optimal stochastic planning of regional socio-economic development by significant events and stability indicator is explained. A schematic description of a generalized basic model and its approximate solution is presented. Next, questions of rendering the basic model more concrete are discussed, and finally the construction of the respective systems of models is treated.

1. Introduction

1. Events that may affect the future socio-economic development of a region include such ones whose consequences or results are especially wide-ranged and sudden. Let us call such events significant. As to their origin, significant events may be natural, technologico-economic, social, etc. According to their desirability, the events are divided into negative and positive ones. The former are called catastrophic, to the latter no general term has been attached.

It is evident that an adequate model of regional socio-economic planning must describe significant events and inherent problems. Of the latter let us mention here the stability of development as well as activities and indicators enabling to plan the level of stability.

2. Up to now, numerous models and their systems describing various aspects of development and applying different modelling techniques have been compiled for regional socio-economic and economic planning, in particular (for a brief survey of such models see [1]). In general these models are deterministic and dynamic. In a few cases random variables have been included. However, as far as known, significant events have not been described in these models. Below an attempt will be made to explain, in principle, the possibilities of generalizing stochastic models so as to describe in them significant events and the resulting problems (a survey of stochastic models and methods is in [2]).

3. At present, a significant event is assumed to be an uncertain event whose probability is not given, and the values of the parameters of the stochastic model (distribution of random variables of the model) depend on its realization.

Stability of development is characterized by a simplified indicator, the idea of which is as follows. The stable value of the indicator is assumed to be preassigned. Instability is characterized by the deviation of its expected value from the preassigned stable one.

As already said, the description of significant events and stability in models makes it necessary to describe also the respective stabilizing activities. Let us distinguish between preparatory and adapting activities. The former help describe such activities which increase the system's resistance before the realization of the significant event. The latter describe such activities which stabilize the system after the realization of the significant event. Thus it becomes clear that all the system's activities must be described by alternative or variable stability rates in the model.

Significant events being generally of a local territorial character, it is suitable to use subregions as blocks of the model and supplement them with communication blocks.

We can see that a consideration of significant events and stability in planning models makes the models considerably more complicated, and, thus, their solution much more difficult. In solving so complicated models it is not advisable (or sometimes possible) to look for a mathematical optimum. Instead, an analysis and approximate solution of the model should be conducted. One possibility here is to decompose the model into systems consisting of simpler submodels, and solve the submodels approximately by means of simulation and search methods.

4. The paper is built up as follows. § 2 presents a schematic description of the construction and approximate solution of the so-called basic model. In § 3 the concretizing of basic models is explained, and, finally, in § 4 principles of forming systems of models are discussed.

2. A schematic description of the basic model and its approximate solution

1. A schematic description of a stochastic dynamic optimum planning model comprising significant events is given. For simplicity's sake the structure of the block of the model is not discussed here, this will be done in the next paragraph. Finally a schematic description of a technique for analyzing the described model and finding its approximate solution is presented.

2. Let $t \in T = \{1, \ldots, v\}$ denote intervals of the planning period. Significant events in the interval t are denoted by $\omega_{kt} \in \Omega_t$, $k \in K = \{1, \ldots, p\}$. The event becomes realized at the end of the interval, and the set of events Ω_t comprises also the event «nothing significant has happened».

Possibilities of significant events may be described at various levels of complexity (consideration of correlations of the events within the interval and the period). Here it is assumed that during the whole planning period only one event $\omega_k = (\omega_{k1}, \ldots, \omega_{kv}) \in \Omega$ becomes realized.

Let the set of the model's blocks (sectors) be $R = \{r | r = 1, \ldots, z\}$. Let the plan of the block r in the interval t be $x_{rt} \in X_{rt}$, where X_{rt} is a given direct constraint on the plan. Let the result function (input—output, etc. function) of the block r in the interval t be $\alpha_{rt}(\omega_k) x_{rt}$, where $\alpha_{rt}(\omega_k)$ is a random matrix, the distributions of whose elements depend on the event ω_k (e. g., $\alpha_{rt}(\omega_k) = \alpha_{rt} + a_{rtk}$, where α_{rt} is a given random matrix, and a determined matrix a_{rtk} is given in accordance with the event ω_k). It is assumed that the result function of the interval t $\alpha_t(\omega_k)x_t=\sum_r \alpha_{rt}(\omega_k)x_{rt}$, where $x_t=(x_{rt})$, $r\in R$ and $\alpha_t(\omega_k)=(\alpha_{rt}(\omega_k))$, $r\in R$. Next it is assumed that the result function of the whole planning period is $\sum_t \alpha_t(\omega_k)x_t$. On the event ω_k let a lower bound be imposed on the result of the whole planning period as a random vector $\beta(\omega_k)$.

Let the effect of the block r in the interval t be described by the objective function $\varphi_{rt}(\gamma_{rt}(\omega_k), x_{rt})=\gamma_t(\omega_k)x_t-q[\gamma_t(\omega_k)x_t-c_{ktr}]^2$. Here the last member expresses instability; c_{ktr} is a given «stable» value and q is the weighting factor of instability; $\gamma_t(\omega_k)$ is a random vector on the event ω_k and contains the «ordinary» coefficients of the objective function. Let the total effect of the interval t be $\varphi_t(\gamma_t(\omega_k), x_t)=$ $=\sum_r \varphi_{rt}(\ldots)$.

3. Using the above symbols and assumptions, a two-stage problem is formulated with the first interval $t=1$ forming the first stage, and the other intervals $t=2, \ldots, v$ forming the second stage. So the plan of the first stage is a fixed plan. Let the plan of the second stage depend on the event $\omega_k: t>1, x_t=x_t(\omega_k)\in X_t(\omega_k)$. To determine the model, the operator of the mean value E over α, γ and the operator min over ω_k is used. Now we obtain:

$$\max_{x_1\in X_1} \min_{\omega_k} E[\varphi_1(\gamma_1(\omega_k), x^1)+$$

$$+\max_{x_t\in X_t} \sum_{t=2}^{v} \varphi_t(\gamma_t(\omega_k), x_t) \mid \sum_{t=1}^{v} \alpha_t(\omega_k)x_t \geqslant \beta(\omega_k)]. \quad (1)$$

4. For an analysis and approximate solution of problem (1) (in case of its small dimensions), the techniques suggested in works [3] and [4] might be used. Their idea is as follows. The problem is solved either for all or for some extreme significant events only, (e. g., nothing significant happens, a certain significant event takes place at the beginning of the period, etc.). These are problems of quadratic programming. The obtained solutions are analyzed with the help of model (1) for all the significant events. On the basis of the analysis, an approximate solution with a non-formalized procedure is formed.

3. On the description and grouping of activities

1. As already noted, the peculiarity of describing socio-economic activities (of sectors, technologies, and the like) in the models observed consists in the following: 1) the descriptions must comprise the idea of variable or alternative stability, and 2) the model must include the so-called preparatory and adaption activities.

The stability of activities consists in the strength of the dependence of their parameters upon significant events. For example, the value of the parameter i of an activity j may be expressed as follows: $\alpha_{ij}=$ $=\hat{\alpha}_{ij}\hat{s}_{ijk}+s_{ijk}$, where $\hat{\alpha}_{ij}$ is a given random variable, and the parameters $\hat{s}_{ijk}$ and s_{ijk} are determined by the significant event $k\in K$. If $\hat{s}_{ijk}\approx 1$ and $s_{ijk}\approx 0$, $k\in K$, the parameter α_{ij} is approximately stable.

To vary the stability of activities, alternative activities with differing parameters of stability rates can be used. For example, the parameters of the activity j' alternative to the activity j are: $\hat{s}'_{ijk} \neq s_{ijk}$ and $s'_{ijk} \neq \neq s_{ijk}$.

2. If significant events are of a local territorial effect, it is expedient to group the activities by 1) subregions and 2) communications. It is easy to see that this facilitates the estimation of the stability parameters of the activities, s_{ijk}, and in order to simplify modelling, it is advisable to separate the communications (networks of roads, electric lines, etc.) that run through several subregions.

To model subregions, the existing regional stochastic dynamic models could be applied after respective generalizations. Communication models belong to the class of transportation models; however, if necessary, they can be regarded as production-transportation models (e. g., the production of electric energy together with transmission lines).

4. On constructing systems of models

1. Generalized applied models of regional socio-economic growth have so big dimensions that it is advisable to use systems of models to analyze them. In our case it is suitable to use models of subregions and communications as submodels, and co-ordinate them with the help of the centre's model by distributing resources or limitation. However, a complicated system of models may be chosen as a basis of generalization, e. g., the system presented in [5], comprising models of regions, sectors as well as transportation complexes. The system may likewise be decomposed temporally. In this case submodels are static models of the region.

2. In the above-described system of models, the task of the models of subregions is to make effective use of the resources given by the centre and to define the marginal efficiencies of resources. On the basis of the latter, the correction of resources is conducted in the centre's model.

3. The construction of the systems of models should begin with working out and testing a few typical submodels. This experience is then used to increase the number of submodels. The first submodels could be, e. g., the model of some town, transportation or power complex, or the like.

5. Summary

1. To consider significant events and stability of development in a model of regional socio-economic optimum planning, generalization of the existing stochastic dynamic models is required. One way of doing it is as follows. The parameters of the model are described as dependent upon significant events. In case of random parameters their distributions depend on significant events. An indicator of stability is added to the objective function of the model. The activities of the model are described by alternative stabilities, and the set of activities is supplemented by preparatory and adapting activities.

2. Because of the complexity of the structure of a generalized model it is expedient to analyze it instead of making an attempt at its strictly mathematical solution. To this end, optimum quadratic planning and simulation methods are suited. On the basis of the analysis obtained, an approximate solution is synthesized.

3. In practice the problems turn out to have so big dimensions that it is advisable to use systems of models for analyzing them. Models of subregions and communications are suitable submodels here, and centralized distribution of resources might be used for co-ordination. The construction of systems of models should begin with working out and applying a few typical submodels.

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Academy of Sciences of the Estonian SSR,
Institute of Economics

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Ü. ENNUSTE

OLULISTE SÜNDMUSTE JA STABIILSUSE KIRJELDAMISEST REGIOONI SOTSIAAL-MAJANDUSLIKU ARENGU PLANEERIMISE MUDELITES

On selgitatud regiooni sotsiaal-majandusliku arengu optimaalse stohhastilise planeerimise dünaamiliste mudelite üldistamist oluliste sündmuste ja stabiilsusnäitajatega. Skemaatiliselt on kirjeldatud vastavalt üldistatud põhimudelit ja selle ligikaudset lahendamist, vaadeldud põhimudeli konkretiseerimise võimalusi ning käsitletud vastavate mudelsüsteemide moodustamist.

Eesti NSV Teaduste Akadeemia
Majanduse Instituut

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Ю. ЭННУСТЕ

ОБ ОПИСАНИИ СУЩЕСТВЕННЫХ СОБЫТИЙ И СТАБИЛЬНОСТИ В МОДЕЛЯХ СОЦИАЛЬНО-ЭКОНОМИЧЕСКОГО РАЗВИТИЯ РЕГИОНА

Поясняется обобщение динамических моделей стохастического оптимального планирования социально-экономического развития региона посредством существенных событий и показателей стабильности. Схематически описывается соответствующая обобщенная основная модель, а также ее приближенное решение. Рассматриваются конкретизация основной модели и составление соответствующих моделей.

Институт экономики
Академии наук Эстонской ССР

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