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ON STOCHASTIC EQUILIBRIUM OF CENTRALLY CO-ORDINATED OPTIMUM PLANS

The paper presents a decomposition analysis of a macroeconomic stochastic optimum plan problem and its economic interpretation. The peculiarity of the initial problem consists in the description of two spheres of activities at two stages; at that a fixed plan is sought for the first stage and a preliminary one for the second stage.

The initial problem is decomposed by activities, and the subproblems are co-ordinated both by means of prices and limits. Co-ordination is extremely complicated since the co-ordination parameters are functions of the state of a stochastic environment; besides, there arise difficulties connected with conforming the prescriptive and descriptive goals of activities.

1. Introduction

Mathematical treatments of indeterminative equilibrium of centrally co-ordinated macroeconomic optimum plans are of great interest for the theory of planning a socialist economy. Namely, an indeterminative approach enables to get rid of an extremely simplified assumption as if it were possible to foresee with certainty the state of the economic environment. Thus, the modelling of a centrally co-ordinated planning system can be made considerably more adequate than earlier, and it will be possible to study its functioning mathematically.

The above-mentioned problem may be treated in different ways: compositionally or decompositionally, stochastically or fuzzily, etc. The greatest progress seems to have been made in the field of developing mathematical theories of compositional-stochastic or, in other words, economic stochastic equilibrium.[1,2] However, the author is of the opinion that this approach is above all suitable for describing principles of decentralized management. For this reason decompositional stochastic approach is used below, though research into it has started only recently.[3]

According to this approach, an initial problem of stochastic economic optimum planning is to be formulated first, and on the basis of its decomposition analysis the properties of the subproblems and the co-ordination are to be explained. Here the stochastic initial problem is formulated so that it would be possibly rich in economic contents. This makes its subsequent analysis complicated and forces the author to use heuristic reasoning in several cases.

[1] *Катышев П. К., Петраков Н. Я.* Стохастическое моделирование равновесия. — Экономика и математические методы, 1984, вып. 2, 295—308.
[2] *Grandmont, J.-M.* Temporary general equilibrium theory. — In: Handbook of Mathematical Economics, II. Amsterdam, 1982, 879—922.
[3] *Катышев П. К., Петраков Н. Я.* Стохастическое моделирование равновесия, 295—308.

A peculiarity of the initial problem is the description of two spheres of activities. One of them includes production activities, whose aim is only to guarantee the balance of the resources of the economy. The activities of the other sphere are non-productive, and their intensities serve as arguments of the problem's objective function. In addition it is assumed that the co-ordination of all resources by prices is not allowed.

The activities are described at two stages. In so doing, fixed plans are sought for the first stage, and preliminary ones for the second stage.[4] This circumstance permits to adapt plans on the basis of additional information on the state of the environment received in the course of the realization of the plan. It turns out that decomposition of such a model yields interesting economic interpretations.

The decomposition of the problem is accomplished by activities. Because of the peculiarity of the problem, the subproblems of activities cannot be directly co-ordinated either by prices or limits, though they can be co-ordinated by a combination of the two.

The paper describes the properties of the obtained co-ordinated subproblems and the respective co-ordination parameters. Some problems arising in connection with the correction and simplification of co-ordination and combining the prescriptive and descriptive goals of subproblems are discussed. Finally, the major results are presented.

2. The initial problem

1. The economic contents of the initial problem are the following. The initial problem describes stochastically two interconnected spheres of activities. One of them includes production activities and the other non-productive ones. At that the latter require the output of the former, and both kinds of activities require exogenous resources available for the whole system in limited quantities.

The objective of the activities of the first sphere is to balance inputs-outputs, therefore, the intensities of these activities do not occur in the objective function of the problem. Only the intensities of non-productive activities occur in the objective function. The objective function is additive by activities and is the sum of the expectations of the effects of the activities.

Both spheres of activities are described during two stages. The production activities of the first stage exert influence on the balance of resources of the second stage by which investments, stockpiling, exhaustion of natural resources, etc. are modelled.

For the first stage fixed plans of activities are sought, while for the second stage preliminary plans are looked for, i. e., the latter depend on the possible random events realized during the first stage. Thus, in the application of the plans of the second stage additional information received during the first stage will be considered.

As already said, the activities are constrained by the preassigned balances of exogenous resources. Besides, direct constraints are imposed on the intensities of the activities. The constraints must be satisfied for the realization of all possible random events. The assumption is made that it is in principle not possible to fix prices for some resources.

2. For the mathematical description of the problem the following denotations and additional assumptions are used. The state of the environ-

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[4] *Эннусте Ю.* Вводные методологические замечания по математическому прогнозированию и планированию адаптивного экономического развития. — Изв. АН ЭССР. Обществ. н., 1984, 33, № 1, 1—7.

ment during the planning period is expressed by the random variable $s \in S$, with the information on the realization of s being received by the beginning of the second stage. For the compilation of the plan the probability of s is given which is not affected by the plan, the set of the random variables S is likewise not affected by the plan. The stages are denoted by $t=1,2$, the production activities by $j=1, \ldots, k$ and non-productive activities by $j=k+1, \ldots, n$. Let the resources for which prices are allowed be $i=1, \ldots, e$, and those for which prices are not allowed $i=e+1, \ldots, m$. Let $x_{tj}(s) \in X_{tj}(s)$ denote the plan of the activity j at the stage t, where $X_{tj}(s)$ are non-empty closed convex sets with the probability 1.0, and $x_{1j}(s)=x_{1j}$.

Let the effects of the non-productive activities be strictly concave functions $f_{tj}(x_{tj}(s), s)$ with the probability 1.0. Let the results of all activities in the input and output of the resource i be also strictly concave functions $g_{tij}(x_{tj}(s), s)$, where $g_{ij}>0$ denotes output and $g_{ij} \leqslant 0$ input. The transfer of the resource i by an activity j from the first stage into the second one is denoted by a strictly concave function $g^1_{2ij}(x_{1j}, s)$, $j=1, \ldots, k$. Let the constraints of exogenous resources on the system be $b_{ti}(s)$ where $b_{ti}(s) \geqslant 0$ denotes the output of the resource i and $b_{ti}(s)<0$ its input.

3. The mathematical form of the initial problem is the following. Maximize on the basis of the plan $x(s)=(x_{1j}, x_{2j}(s))$, $j=1, \ldots, n$ the objective function

$$E \sum_{j=k+1}^{n} [f_{1j}(x_{1j}, s)+f_{2j}(x_{2j}(s), s)], \tag{1a}$$

where E stands for mathematical expectation, subject to

$$\sum_{j=1}^{n} g_{1ij}(x_{1j}, s) \geqslant b_{1i}(s), i=1, \ldots, m, \tag{1b}$$

$$\sum_{j=1}^{n} [g^1_{2ij}(x_{1j}, s)+g_{2ij}(x_{2j}(s), s)] \geqslant b_{2i}(s), \quad i=1, \ldots, m, \tag{1c}$$

$$x_{tj}(s) \in X_{tj}(s), \quad j=1, \ldots, n, \quad t=1, 2. \tag{1d}$$

where the constraints are satisfied with the probability 1.0. A solution $x(s)^0$ to the problem is assumed to exist.

3. Co-ordinated subproblems of activities

1. Let us decompose the initial problem (1) by activities. However, the choice of the co-ordination principles for the subproblems turns out to be rather complicated in case of the given initial problem. Firstly, the subproblems cannot be co-ordinated by prices alone since prices are not allowed to be used for all resources. Secondly, the subproblems cannot be directly co-ordinated by limits as the activities of the first sphere have no objective functions, and, consequently, optimum problems cannot be directly set for these activities.

However, the subproblems of the activities can be successfully co-ordinated by the following combined method. The systemic constraints of the resources for which prices are permitted, are co-ordinated by prices. In this way objective functions are obtained for all activities. The systemic constraints of the remaining resources for which no prices are allowed, are co-ordinated by means of limits.

2. To derive the instructions for the above-described combined co-ordination a Lagrangian function with partly systemic constraints (part of the

systemic constraints will remain) of problem (1) is used. The economic contents of the function are the following. The objective function of the initial problem (1) is modified by means of the equilibrium prices and the balances of the resources so that the maximizing plan of the modified objective function would also satisfy the balance constraints of the respective resources, $i=1, \ldots, e$.

Every state s of the environment having its own balance constraints, every state s must also have its own equilibrium prices. When compiling the plan, all the states are to be considered; for this purpose mathematical expectation is introduced into the Lagrangian function. Thus, equilibrium prices are here functions of the state s of the environment. When the states of the environment are described discretely, every state s has its own corresponding equilibrium prices.

On the basis of the above-said the following Lagrangian problem is obtained:

$$L(x(s), y(s)) = E\{\sum_{j=k+1}^{n} [f_{1j}(x_{1j}, s) + f_{2j}(x_{2j}(s), s)] +$$

$$\sum_{i=1}^{e} y_{1i}(s) [\sum_{j=1}^{n} g_{1ij}(x_{1j}, s) - b_{1i}(s)] + \tag{2a}$$

$$+ \sum_{i=1}^{e} y_{2i}(s) [\sum_{j=1}^{n} g^{1}_{2ij}(x_{1j}, s) + \sum_{j=1}^{n} g_{2ij}(x_{2j}(s), s) - b_{2i}(s)]\}$$

subject to

$$\sum_{j=1}^{n} g_{1ij}(x_{1j}, s) \geqslant b_{1i}(s), \quad i=e+1, \ldots, m, \tag{2b}$$

$$\sum_{j=1}^{n} [g^{1}_{2ij}(x_{ij}, s) + g_{2ij}(x_{2j}(s), s)] \geqslant b_{2i}(s), \quad i=e+1, \ldots, m, \tag{2c}$$

$$x_{tj}(s) \in X_{tj}(s), \quad j=1, \ldots, n, \quad t=1, 2, \tag{2d}$$

where $y(s) = (y_{ti}(s)) \geqslant 0$, $i=1, \ldots, e$, $t=1, 2$.

3. The systemic constraints (2b) and (2c) of the obtained problem (2) are decomposed by means of limits. Economically it means that the resources given with systemic constraints $i=e+1, \ldots, m$ are distributed between activities. As every state s of the environment has its own quantities of resources, the respective optimum limits are also functions of the environmental state s. No doubt, the best limits are those in case of which the value of the objective function (2a) is the highest, or in other words, optimum limits do not set additional constraints on the Lagrangian function (2a) in comparison with the constraints (2b)—(2c).

The above-said yields the following problem:

$$\max_{x(s)} L(x(s), s) \tag{3a}$$

subject to

$$g_{1ij}(x_{1j}, s) \geqslant d_{1ij}(s), \quad i=e+1, \ldots, m, \quad j=1, \ldots, n, \tag{3b}$$

$$g^{1}_{2ij}(x_{1j}, s) \geqslant d^{1}_{2ij}(s), \quad i=e+1, \ldots, m, \quad j=1, \ldots, n, \tag{3c}$$

$$g_{2ij}(x_{2j}(s), s) \geqslant d_{2ij}(s), \quad i=e+1, \ldots, m, \quad j=1, \ldots, n, \tag{3d}$$

$$x_{tj}(s) \in X_{tj}(s), \quad j=1, \ldots, n, \quad t=1, 2, \tag{3e}$$

where the prices $y(s)$ are fixed.

The limits $d(s)=(d_{1ij}(s), d^1_{2ij}(s), d_{2ij}(s))$, $i=e+1, \ldots, m$, $j=1, \ldots, n$ must satisfy the following condition

$$d(s) \in D(s)=V(s) \cap H(s),$$

where $V(s)=\{d(s) \mid \sum_{j=1}^{n} d_{1ij}(s)=b_{1i}(s),\ \sum_{j=1}^{n} d_{2ij}(s)=b_{2ij}(s)-\sum_{j=1}^{n} d^1_{2ij}(s)\}$;

and $H(s)$ is the set of such limits $d(s)$ for which problem (3) has solutions.

Let $G(d(s), s)$ denote the optimum value of (3a). Now it follows that the limits are the solution to the problem

$$\max_{d(s)\in D(s)} G(d(s), s). \tag{4}$$

4. Let optimum co-ordination parameters $y^0(s)$ and $d^0(s)$ be given. Then problem (3) breaks into co-ordinated subproblems. The subproblems of the production activities $j=1, \ldots, k$ are the following:

$$\max E\{\sum_{i=1}^{e} y^0_{1i}(s) g_{1ij}(x_{1j}, s)+\sum_{i=1}^{e} y^0_{2i}(s)[g^1_{2ij}(x_{ij}, s)+$$
$$+g_{2ij}(x_{2j}(s), s)]\}=k^0_j \tag{5a}$$

subject to

$$g_{1ij}(x_{1j}, s) \geqslant d^0_{1ij}(s), \quad i=e+1, \ldots, m, \tag{5b}$$

$$g^1_{2ij}(x_{1j}, s) \geqslant d^{1,0}_{2ij}(s), \quad i=e+1, \ldots, m, \tag{5c}$$

$$g_{2ij}(x_{2j}(s), s) \geqslant d^0_{2ij}(s), \quad i=e+1, \ldots, m, \tag{5d}$$

$$x_{tj}(s) \in X_{tj}(s), \quad t=1, 2. \tag{5e}$$

Thus; the co-ordinated objective function (5a) of the subproblems of production activities is the mathematical expectation of the difference between incomes and expenditures or profit over both stages. The profit is calculated at optimum prices $y^0_{ti}(s)$, $i=1, \ldots, e$, $t=1, 2$, which are random functions. We denote the optimum value of the objective function by k^0_j.

The objective function is maximized on the condition that the optimum systemic limits $d^0_{tij}(s)$, $i=e+1, \ldots, m$, $t=1, 2$, prescribed to the activities and direct activity constraints $X_{tj}(s)$ be satisfied. The limits are likewise stochastic functions.

It is easy to see that problem (5) consists in its turn of independent unconnected problems of both stages of the activity j.

5. The co-ordinated subproblem of the non-productive sphere can be written as follows:

$$\max E \sum_{j=k+1}^{n} [f_{1j}(x_{1j}, s)+f_{2j}(x_{2j}(s), s)] \tag{6a}$$

subject to

$$E \sum_{j=k+1}^{n} \sum_{i=1}^{e} [y^0_{1i}(s) g_{1ij}(x_{1j}, s)+y^0_{2i}(s) g_{2ij}(x_{2j}(s), s) -$$
$$-y^0_{1i}(s) b_{1i}(s)-y^0_{2i}(s) b_{2i}(s)]+\sum_{j=1}^{k} k^0_j=0, \tag{6b}$$

$$g_{1ij}(x_{1j}, s) \geqslant d^0_{1ij}(s), \quad i=e+1, \ldots, m, \tag{6c}$$

$$g_{2ij}(x_{2j}(s), s) \geqslant d^0_{2ij}(s), \quad i=e+1, \ldots, m, \tag{6d}$$

$$x_{tj}(s) \in X_{tj}(s), \quad t=1, 2. \tag{6e}$$

Here the constraint (6b) ensures an equilibrium of the mathematical expectation of the budget of the whole system; the proof of the application of this constraint is presented in the Appendix. Namely, this constraint has been derived from the objective function of the problem.

Thus, the objective function of the non-productive sphere is the maximization of the sum of the expectations of the goals of the activities $j=k+1, \ldots, n$ within the boundaries of budget constraints and resource limits and with satisfying direct activity constraints.

The credit side of the budget consists of the difference between the values of inputs and outputs assigned to the system at equilibrium prices and the profit from the production sphere. The debit side comprises expenditures of non-productive activities at equilibrium prices.

Problem (6) does not consist of independent subproblems of activities. In order to break it up, an additional mechanism involved in allocating the system's incomes between non-productive activities should be arranged.

4. On co-ordination problems

Below we shall discuss briefly how to find approximate equilibrium values of co-ordination parameters and possibilities of simplifying these parameters. A detailed and strict treatment of these problems is a subject of an independent study. Some other co-ordination problems resulting from a stochastic approach are also dealt with.

1. To approximately ascertain the equilibrium values of prices it is advisable to use here the method of iterative antigradient movement.[5] Let the initial approximation of prices be given. On its basis the respective approximations of plans are fixed. On the basis of the latter, prices are corrected applying the method of antigradient movement, etc.

Expression (2a) shows clearly that the imbalances of resources represented by the quantities in the two last brackets of (2a) are antigradients of prices. Thus, the prices of scarce resources should be raised, and vice versa. Schematically:

$$y^{v+1}_{ti}(s) = y^v_{ti}(s) - q^v_{ti}\Big[\sum_{j=1}^{n} g_{tij}(x^v_{tj}(s), s) - b_{ti}(s)\Big],$$

where v is the index of the step and q^v_{ti} is the factor of the step length.

It is somewhat more difficult to explain the line of reasoning underlying the correction of limits.[6] It turns out that here correction relies in principle on an equalization of the efficiencies of limits by activities, and this yields the following schematic instruction:

$$d^{v+1}_{tij}(s) = d^v_{tij}(s) + r^v_{tij}\Big[\sum_{j=1}^{n} y^v_{tij}(s)/n - y^v_{tij}(s)\Big];$$

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[5] *Эннусте Ю. А., Матин А. В.* Декомпозиция стохастических двухэтапных задач оптимального планирования и их экономическая интерпретация. — В кн.: Математические аспекты моделирования народного хозяйства. М., 1985 (в печати).

[6] *Эннусте Ю. А.* Вводные методологические замечания, 1—7.

where r_{tij} is the coefficient of the correction step and $y^v_{tij}(s)$ is the efficiency of the limit i in the activity j. Thus, limits should be increased for those activities where their efficiencies are higher.

The main difficulty of co-ordination in a stochastic case lies in the fact that the co-ordination parameters are not fixed quantities but stochastic functions whose arguments are variables s describing the state of the environment. In solving practical problems the use of stochastic functions as co-ordination parameters is too complicated and thus impossible. Consequently, simplified co-ordination techniques should be found, but, at the same time, the principle of stochasticity should be preserved.

One possible technique here is interval co-ordination[7] where upper and lower bounds of the co-ordination parameters are given. Now, in the course of solving problems of activities, the relations of the quantities falling between those bounds to the variable s are prognosticated (rationally).

2. An interpretation of the decomposition method of an optimum plan problem as a model of the planning system raises new co-ordination problems due to stochasticity. Below some of these problems are formulated. Namely, in case of a planning system the (local, group, etc.) goals of the planners of the activities must be taken into account; below these goals will be called descriptive goals of activities. These goals must be brought into line with the activity goals derived decompositionally from the goals of the system as a whole. The latter goals are called prescriptive goals of activities.

In the form of problem formulation we shall below discuss two fields of co-ordinating prescriptive and descriptive goals that are connected with a stochastic approach. One of them deals with co-ordinating risk rates and the other with guaranteeing the fidelity of interval data.

Firstly. The formulation of the objective function of a big system as a whole in the form of mathematical expectation or risk-neutral approach is advisable when the dispersions of the activity results of the system are considerable, but compensate one another to some extent. However, such a formulation results in risk-neutrality of the prescriptive objective functions of activities which may be unacceptable from the standpoint of the descriptive goal of the activity. To eliminate this controversy, additional insurance mechanisms should be applied in the system which would reduce the risk of activity results for activity planners and stimulate them to choose such alternatives whose results have the highest mathematical expectations. Thus, the insurance mechanism should help the manager of an activity to guarantee the income that is in conformity with the mathematical expectation of the activity result. The arrangement of such a mechanism brings about several problems (e. g. avoiding bluff) and is therefore complicated.[8]

Secondly. The problems cropping up are connected with ensuring the fidelity of stochastic co-ordination information.[9] For example, in case of interval co-ordination it is advantageous for activities to reserve bigger intervals for themselves; this, however, brings about additional expenditures for the centre (increase in stocks). For the co-ordination of such problems, additional mechanisms should be applied to prevent activities from planning excessively wide intervals.

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[7] *Эннусте Ю. А.* Принципы декомпозиционного анализа оптимального планирования. Таллин, 1976, 118.

[8] *Катышев П. К., Ротарь В. И.* Одна модель взаимного страхования. — Экономика и математические методы, 1983, вып. 6, 1042—1052.

[9] *Эннусте Ю. А.* Принципы декомпозиционного анализа, 118.

5. Conclusion

The decomposition of a macroeconomic two-stage and two-sphere stochastic optimum plan problem by activities yielded the following subproblems. Firstly, the subproblems of production activities, whose objective function is the mathematical expectation of the activity's profit at equilibrium prices, and whose constraint is expressed by limits of resources imposed on the activity and the direct activity constraints. The subproblems of production activities, in their turn, can be broken into the problems of the fixed plan of the first stage and these of the preliminary plan of the second stage.

Secondly, such a subproblem of the non-productive sphere can be formed, whose objective function is the sum of the expectations of the effects of non-productive activities, while its constraints are budgetary constraints, limits of resources and, finally, direct activity constraints. The budgetary constraint is the balance of the mathematical expectation of the difference between the incomes and expenditures of the non-productive sphere. At that the incomes consist of the difference between the inputs and outputs of the resources given to the system at equilibrium prices plus the profit of the production sphere. For a further decomposition of this subproblem, incomes should be allocated between non-productive activities.

The co-ordination parameters (prices and limits) are functions of the environmental state, being thus complicated and requiring simplifying treatments.

Complicated problems also arise in connection with harmonizing prescriptive and descriptive goals of the subproblems. To solve them, additional bonus and insurance mechanisms are required.

APPENDIX

Finding the first component of the saddle point when the second component is given

Let there be a strictly concave optimum problem

$$\max f(x)\} g_i(x) \geqslant b_i,\ x \geqslant X,\ i=1,\ \ldots,\ m; \tag{1}$$

whose solution is x^*.

The Langrangian function of problem (1) is

$$L(x, y) = f(x) + \sum_{i=1}^{m} y_i (g_i(x) - b_i),\ x \in X,\ y \geqslant 0, \tag{2}$$

whose saddle point is (x^*, y^*).

If y^* is given, x^* can be found from

$$\max [f(x) + \sum_{i=1}^{m} y_i^* (g_i(x) - b_i)];\ x \geqslant X. \tag{3}$$

Proposition. The following problem is equivalent to problem (3):

$$\max f(x)\} \sum_{i=1}^{m} y_i^* (g_i(x) - b_i) = 0,\ x \geqslant X. \tag{4}$$

Proof. Let the solution to problem (4) be x^0. Now, on the one hand, we know that

$$f(x^*)+\sum_{i=1}^{m} y_i^* (g_i(x^*)-b_i) \geqslant f(x^0)+\sum_{i=1}^{m} y_i^* (g_i(x^0)-b_i),$$

where due to the properties of the saddle point $\sum_{i=1}^{m} y_i^* (g_i(x^*)-b_i)=0$, and from problem (4) we know that $\sum_{i=1}^{m} y_i^* (g_i(x^0)-b_i)=0$ whence it follows that

$$f(x^*) \geqslant f(x^0).$$

On the other hand, the domain of the definition of x is larger in problem (4) than in problem (1). Hence it follows that

$$f(x^0) \geqslant f(x^*)$$

and consequently

$$f(x^*)=f(x^0).$$

From the latter equality and strict concavity of function $f(x)$ it follows that $x^*=x^0$.

Presented by K. Habicht

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Ülo ENNUSTE

TSENTRAALSELT KOORDINEERITAVATE OPTIMUMPLAANIDE STOHHASTILISEST TASAKAALUST

Artiklis on esitatud ühe makromajandusliku stohhastilise optimumplaani ülesande dekompositsioonanalüüs ja selle tulemuste majandusteaduslik tõlgendus. Lähteülesande eripära on kahe tegevussfääri kirjeldamine kahel staadiumil, kusjuures esimesel otsitakse kindelplaani ja teisel esialgset plaani.

Ülesanne on dekomponeeritud tegevuste lõikes ja osaülesandeid koordineeritud nii hindade kui ka limiitidega. Koordineerimine kujuneb äärmiselt keeruliseks, sest koordineerimisparameetrid on stohhastilise keskkonna seisundi funktsioonid. Lisaks sellele kerkivad probleemid, mis on seotud tegevuste preskriptiivsete ja deskriptiivsete eesmärkide seostamisega.

Eesti NSV Teaduste Akadeemia
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Toimetusse saabunud
1. VI 1984

Юло ЭННУСТЕ

О СТОХАСТИЧЕСКОМ РАВНОВЕСИИ ЦЕНТРАЛЬНО КООРДИНИРУЕМЫХ ОПТИМАЛЬНЫХ ПЛАНОВ

В статье представляется декомпозиционный анализ одной макроэкономической задачи стохастического оптимального планирования и дается экономическая интерпретация его результатов. Особенностью исходной задачи является описание двух сфер деятельности по двум этапам, причем первому из них отыскивается определенный план, другому — предварительный. Задача декомпонируется по видам деятельности, и подзадачи координируются как ценами, так и лимитами. Координацию крайне осложняют две причины: координирующие параметры представляют собой функции состояния стохастической окружающей среды, а также трудности взаимоувязки прескриптивных и дескриптивных целей деятельности.

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