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M. A. Gorbunov, A. V. Medvedev, P. N. Pobedash, E. S. Semenkin
Siberian State Aerospace University named after academician M. F. Reshetnev, Russia, Krasnoyarsk

THE MODELING OF THE WORLD SOCIO-ECONOMIC STRATEGY AS AN OPTIMAL CONTROL PROBLEM*

An approach to the modeling strategy of global social-economical development on the basis of the economic-mathematical optimum control model, considering interaction of the basic economic agents of the world social-economic system (WSES) – industrial, consumer, financial sectors, as well as the operating center (the world government) is described in this article. The task of optimizing the global social-economic development is formulated; the main principles of the analysis, restrictions and target criteria are analyzed.

Keywords: global economical crisis, sustainable development, mathematical models of optimal control.

Interest to the problems of human survival and the balanced development of the world socio-economic system is aroused under the conditions of the world socio-economic crisis. It is clear that such a kind of development requires the coordination of interests between business, consumer, and financial sectors. It also requires participation of a united control center (the world government). In this context the elaboration of the mathematical model of the global economy that will consider the balance of interests of required sectors is still relevant. Some mathematical models which describe the global development had been elaborated in the 1950s by scientists from The Club of Rome ([1] etc.). At the heart of these models is the system of usual first order differential equations. The analysis of such models showed the reality of crisis occurrences in world development. To these occurrences belong the greenhouse effect, over-population, the depletion of natural resources, etc. A necessity to fight them is confirmed by ratifying the Kyoto Protocol, which reduces emissions of greenhouse gases. It is important to note that the specified models don't solve the problem of optimal process control in global development and need a large amount of numeral experiments. These experiments do not always lead to optimal or quasi optimal development scenarios. Currently, the interest in investigating global development problems is aroused. This is connected with the series of world financial crises, which happened during the last years; which were caused by the imperfection of the world financial system, oriented on the dollar as the only world currency; and the domination through this, the geopolicy of one country. Let's mark works [2–4] as representative modern publications on this issue. An approach to solving the problem of global social-economic development management is based on solving the multicriterial, multistage linear optimal control problem.

It is necessary to note that for the management of global social-economic development, the operating agency of the WSES needs to accomplish several complicated and interconnected tasks: 1) socially-industrial (the maintenance of high production volumes with a solvent demand, employment, and high standards of living); 2) financial-industrial (first of all, the elimination of the financial system imbalance and production sector); 3) ecological (preserving a suitable living environment).

Let's consider the main elements of the prospective approach below. Let's formulate the following task, which will be called the main task of global social-economic development. We shall consider the available number of branches in the world's production sectors: food, clothes, housing, the articles of prime necessity etc. It is required to determine the amount of main production funds and the production volumes of the mentioned branches in set time moments, during which the total net present value of cash flows for industrial, social and financial sectors of world economy will be the greatest at a set planning horizon. The formulated task in our opinion can be considered as a global investment project (IP) of optimum WSES development management in a view of statutes to be mentioned. Let's suppose that in the global development model (GDM), the simultaneous economic agents aforementioned are the decision makers (DM), interested in a balanced development

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of global economy. The operating center (OC) defines the common "game rules" in the WSES in view of vital functioning conditions and the interests of all DM, directed to the observance of economic, ecological, social norms promoting the main goal of OC, and all the WSES in the whole to possibly survive for a long period, including extreme variants, when the time of IP is not limited.

Let's consider the possible goals of each DM. The goal of the production sector naturally, is to consider the maximization of discount sum for its own means (in monetary or material equivalent). The consumer sector is interested in having the certain minimal sum of means to provide itself with a minimal basket of goods: dwelling, clothes, food, medical and social service minimums. With a living wage exceeding these basics, provided by the OC or industrial sector in the form of grants or wages, the cumulative consumer – a worker of the industrial and financial institutions can provide himself with an individual share (nationalization, privatization) in real and financial actives of the WSES. The goal of the OC or the management quality criterion for the considered the WSES can consist of minimizing penalty sums for ecological and social-economic quotas (rules). Thus, without significant errors in the substantial sense, let's assume the performance of the following preconditions.

1. Each branch of the world industrial sector produces goods of one kind.

2. The labor compensation fund (LCF) for the world industrial sector labor force is some share of totals, proceeding from the realization of all the produced goods.

3. The manufacturing volume for each kind of production does not surpass forecast demand for this production at any moment on the time set interval, and the demand for a resource is defined as a product of norm for personal consumption of this resource in a population.

4. Monetary resources for every DM in a current time are nonnegative (i. e. this economical agent is solvent during the whole validity of IP).

5. The financial sector provides the industrial sector with credits during a current, for the period of functioning after finishing – the last one of them on a regular basis returns the sum of the credit and the percents.

Assumptions 1, 2, 5 are noted for the simplification of modeling; so they do not considerably influence the accuracy of the problem being solved. Assumption 3 limits from above the volume of produced goods by a potential demand, excepting the situation of overproduction entailing losses for the industrial sector the WSES and obviously, capable of driving the world into a crisis similar to that of overproduction, which occurred during the economic depression of the 1930s. Precondition 4 is an obligatory condition for the realizability of any IP as in the situation when the sum of means for any DM is close to null; in fact the crisis does not only refer to the DM, but to all the WSES. Emphasis on precondition 3 is essential as they are the coordinate interests of basic the WSES participants, allowing achieving the comprehensible compromise in their realization purposes during the first approximation, to basics of the following concern:

– satisfaction of a consumer sector demand;

– maintenance of industrial and financial sectors' profit (caused by a high level of production in a combination with solvent demand and promptly given and returned credits);

– timely and in due volume tax revenues in budget of the WSES (due to increase of profit and incomes of not only its industrial and financial, but also the consumer sectors);

– stability of WSES functioning (exception in the conditions of a crisis) within the limits of the selected "game rules".

It is necessary to note, that now the issue of financial crises' prevention, which can be looked upon as a problem of optimum control, in volumes of industrial and financial sector funds and their coordination with volumes of funds (material benefits) of the whole world system, obtains special urgency. Taking into account all preconditions resulted above, it is possible to consider the WSES as a self-adjusted operated system, automatically reacting to the externals of its influence, such as changes in the conjuncture of a supply and demand, investment activity in various fields, volumes of monetary weight, population, the level of pollution, or other parameters of the WSES. Then the corresponding acts by adjusting tax rates, the sums and key directions of grants, parity of the basic industrial and financial funds, quotas on the polluting substances' levels, and other parameters of system are possible to see as the control of the WSES.

Complex research of the specified problems demand the application of the system approach based on the solution for a multicriterial task of economical dynamics and the reception of values and interval ranges for model parameters in which WSES borders can balanced for as long as possible. To realize this approach we have offered to use a number of analysis principles – formulated below in the following component form for an economic-mathematical kernel.

Economic kernel.

1. As an efficiency criterion for every DM functioning, the use of net present value parameter NPV is selected.

2. Current money resources of each participant IP develop the balance of receipts and payments for the previous moment of time.

3. The general principle of risks consideration (management of risks) according to formula $r_i = r + i$ is used, where r_i, r are accordingly rates of discounting with and without taking risk into consideration, i is the inflation rate.

4. Criterion functions of DM have a general structure (the discounted balance of strategic incomes and charges in monetary streams).

Mathematical kernel.

1. Dependence on time from model variables (corresponds to realization of a substantial principle of monetary streams' time cost).

2. Linearity of model (substantially corresponds to the presence of strategic income linear calculation algorithm and charges of economic agents at abstraction from some insignificance; for the preliminary analysis of accounting and financial details).

3. Multicriterial models (substantially considers interrelation of all DM interests).

On the basis of the resulted economic-mathematical kernel components, we come to a conclusion, that for the task solution in view of optimum global social-economic development control it is expedient to use a class of

multicriterial, multistage tasks of linear programming that attracts an application opportunity of the effective analysis methods for the offered models based on the Bellman's principles: maximum, operational calculations (z-transformation).

The general balance equation of current money resources *of l*-th EA $Ds_l(t)$ $(l = 1, ..., N)$ during the moment t, participating in any global IP, formally looks like:

$$Ds_l(t+1) = Ds_l(t) + Ps_l(t+1) - \\ -Pl_l(t+1)\ (t = 0, ..., T-1), \quad (1)$$

where $Ps_l(t+1)$, $Pl_l(t+1)$ $(t = 0, ..., T-1)$ are accordingly receipts and payments *of l*-th DM, generated during realization of the given project. T is validity (horizon of planning) of IP, N is quantity of DM. It is necessary to state, that the dynamic equations of DM's own means contain monetary streams of receipts and the payments, providing their current functioning. As streams of receipts and payments, depending on DM, the profit, depreciation charges, investments into the basic and turnaround means, sale of actives, release of securities, a payment, taxes, payment of dividends, grants, social payments, the sums of basic duty, the percent for credits, etc. can be considered. For example, for world industrial sector realization of production, amortization, internal and external investments can be related to strategic receipts, and to payments – percent under credits, taxes (with the added cost on property, profit, womb using etc.), and penalties for infringement of ecological and social restrictions. The currency margin and receipts as a result of the market reference in secondary securities can be considered as receipts for the world financial sector (the currency market and the market of derivative securities), and as payments, – for example, some world tax increasing monetary weight. It is necessary to note, that during the initial moment of time $t = 0$ WSES has a fixed initial condition: $Ds_l(0) = Ds_l^0$ $(l = 1, ..., N)$, where Ds_l^0 is the initial sum of money *of l*-th DM.

For the performance of the solvency condition, according to the precondition 4, current money resources of any DM are considered non-negative during all IP action periods:

$$Ds_l(t) \geq 0 \left(t = 1, ..., T; l = 1, ..., N\right). \quad (2)$$

Infringement of a condition (2) can be treated so, that in the WSES *l*-th DM, during some moment t will not have enough financial resources for IP realization. The specified condition as it has been noted above is obligatory for IP realizability for any economic agent. Thus, if for any DM during some moment of time the specified inequality is not executed, i. e. $\exists l \in \{1,...,N\}, t \in \{1,...,T\}: Ds_l(t) < 0$, process of realization IP will be named a crisis.

Let's consider, what proceeds from the production realization of $R_k(t)$ *k*-th industrial branch MSES satisfy the following restrictions:

$$R_k(t) \leq \min\left(q_k(t), E_k(t)\right)\left(k = 1, ..., n\right), \quad (3)$$

where $q_k(t)$ is the demand for production of k-th kind in cost expression during the moment t, $E_k(t)$ is the maximal, defined by technical opportunities of industrial branches (a level of scientific and technical progress), volume production of *k*-th kind in cost expression during the moment t.

As target criterion DM it is expedient to choose the net present value (NPV) for the monetary streams representing a difference in its strategic incomes and expenses in the form of:

$$\mathrm{NPV}_l = \sum_{t=0}^{T} \frac{\text{ДП}_l(t)}{(1+r)^t} \ \left(l = 1, ..., N\right),$$

where $\text{ДП}_l(t)$ are monetary streams *of l*-th DM during the moment t; r are the rates of IP profitableness.

It is necessary to note, that in a constant, the reference to a micro- or meso-level in world WSES stocks for the majority of resources is essentially exhausting (hence limited). Therefore, for *k*-th industrial branch the conditions should be satisfied:

$$\sum_{t=0}^{T-1} \sum_{j=1}^{n} \bar{a}_{kj} y_j(t) \leq \overline{A_k} \left(k = 1, ..., m\right), \quad (4)$$

where $y_j(t)$ is volume of output *of j-th* kind during the moment t, $\overline{A_k}$ are known world reserves *of k*-th resource, $\bar{a}_{kj}$ is the charge norm *of k*-th product (resource) for product (resource) manufacturing *of j*-th kind (factors of Leontiev's matrix), m is the quantity of cores kinds considered in the model: economic (natural) resources (land, water, minerals, etc.). Conditions (3) and (4) are one of basic restrictions in WSES functioning and their neglect can considerably lower, than the value of any global model.

Taking to the account precondition 3 and condition (4) the forecast of such a social sector characteristic as population $N(t)$ becomes of basically important. Assuming, that it is described as a linear difference equation of the 1st order $N(t+1) = (1+\nu)N(t)$, $(t = 0 ..., T-1)$, it is easy to obtain the obvious formula $N(t) = N_0(1+\nu)^t$ $(t = 0, ..., T-1)$, where N_0 is the initial number during the moment $t = 0$, n is the population increase factor for one period. From the last formula it is visible, that at $\nu > 0$ $N(t)$ increases exponentially. It is obvious that for the social sector, the inequality similar to (4) takes place:

$$\bar{b}_k \sum_{t=0}^{T-1} N(t) \leq \overline{A_k} \left(k = 1, ..., n\right), \quad (5)$$

where $\bar{b}_k$ is the middleperson *of k*-th product charge norm. To consider a problem of optimum performance (survival) of the world social-economic system for as long as possible, term $T \to \max$; in conditions of stock and world resources limitation, and a growing population, the optimum value T^* can fall short. After term $T \leq T^*$, during the accomplishment of the aforementioned positions – the exhaustion of one resource can lead to world crisis. It makes us think seriously of how rationally are the resources spent, and what actions are necessary for a steady development of the world economic system for delaying the crisis. It is possible to offer the following variants of global development management: 1) population regulation (management in parameter ν); 2) rationalization of resources per capita (management in parameters $\bar{b}_k$ in conditions (5)); 3) rational wildlife management (management in parameters $\bar{a}_{kj}$ in conditions (4)); 4) regulation of the subsystem manufacturing balance – population (for example, according to conditions (3)), manufacturing – financial sector, the population – financial sector, etc.

The described approach based on the concept resulted above, and an economic-mathematical kernel is approved for the solution of following problems of large economic

system analysis: 1) management of regional social-economic system development in application to the analysis of regional industrial policy; 2) the coordination of the manufacturer, the investor and the supplier of the equipment contract (a problem of firm development); 3) the restructuralization of large enterprises in the machine-building branch; 4) development of investment analyst workplaces in the construction industry, and hypothecary crediting.

Now the package of applied programs [5], facilitating the multicriterial dynamic analysis and static linear problems of economic dynamics is developed. The use of a specified package increases the validity of decision-making in the global social-economic development management; including the interests of many persons for the reception of WSES parameter ranges and the optimum values of the operating variables. This provides stable development for as long as possible.

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K. V. Safonov
Siberian State Aerospace University named after academician M. F. Reshetnev, Russia, Krasnoyarsk

D. V. Lichargin
Siberian Federal University, Russia, Krasnoyarsk

ELABORATION OF A VECTOR BASED SEMANTIC CLASSIFICATION OVER THE WORDS AND NOTIONS OF THE NATURAL LANGUAGE

The problem of vector-based semantic classification over the words and notions of the natural language is discussed. A set of generative grammar rules is offered for generating the semantic classification vector. Examples of the classification application and a theorem of optional formal classification incompleteness are presented. The principles of assigning the meaningful phrases functions over the classification word groups are analyzed.

Keywords: natural language generation, natural language semantics.

One of the most important problems of the formal languages theory, a subdivision of theoretical computer science, is the problem of syntactic and semantic analysis of a given language sentences. Respecting the study of the natural and machine language structure, the foreground is the problem of generating the natural language i. e. grammatically and semantically meaningful phrases and texts of such languages, which satisfying definite meaningfulness criteria. For example, the Turing test. The importance of the matter is determined by the significance of such applied tasks as building natural-language interfaces, developing expert systems, electronic translators, electronic summarizing systems, e-learning systems, advertisement of user dialogue software provision, etc.

The principle purpose of this research is to offer a classification of natural language words and notions, allowing the generation performance for the meaningful speech and definition of meaningful speech criteria. The basic task is to determine the classification vector for natural speech words and notions, creating a dictionary for the classification of a set of the commonest English words. This make possible the algorithms of meaningful speech generation based on the given classification, proving the theorem of the optional formal classification incompleteness for the description of the differences in natural language word meanings.

The novelty of the work is reduced to the distinguishing particularities and the application efficiency of the generative grammar, described above, for the generation of the vector coordinates for the natural language word and notion classification and the particularities of using the classification for natural language generation.

A great number of researchers currently work on the problem of generating the meaningful subset of the language: