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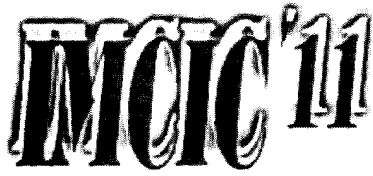
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# Stratification of Socio-economic Systems Based on the Principles of the Multi-modeling in a Heterogeneous Information-analytical Environment

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## ABSTRACT

The article considers the model complex of national economy of Russian Federation based on principles of multi-modeling. It describes the general structure of model complex and its realization based on methods of system dynamics, agent-based modeling and other modern technologies of simulation modeling.

**Keywords:** stratification, simulation modeling, socio-economic systems, complex systems, multi-modeling, hierarchical structure.

## INTRODUCTION

The developing informatization processes and introducing E-government at all the levels of public administration set the following tasks: increasing efficiency of management in regions on the basis of system approach to information support of authorities' activity and management functions fulfillment, forming the common information space and providing information and analytical support of solving operational and strategic tasks of regions' socio-economic development.

Further integration of management processes and informatization in the social sphere, industry and management makes it necessary to establish Situational centers of management and Decision Support Systems (DSS) which help organize data accumulation and analytical processing and contain tools for regions' socio-economic development and decision-making processes system modeling.

## THE MODEL COMPLEX OF THE NATIONAL ECONOMY

The model of the national economy is a complex of computer models of the major spheres of Russian life, the main project and prognostic tool for developing a national strategy, it forms the skeleton of a system-dynamic model used for development and justification of national projects and scenarios.

An integrated multi-model system for federal, regional and municipal government consists of the following simulation models: "Social sphere", "Housing and Utilities sphere", "Health Care", "Pension system of the Russian Federation", "Natural Resources", "Ecology", "Generalized dynamic model of the region", "Model of an agricultural region", "Model of the urban system", a model of particular economic sectors (fuel and energy complex, transport system, etc.), models of consumer and financial markets, system-dynamic model of social economic development of Russian Federation.

Model complex "Social sphere" consists of system models that are implemented based on the methods of system dynamics, describing relationship of socio-economic development of the region and social sphere and focused on forecasting pro-social development of the region based on scenarios of governmental economic management based on the territorial aspect.

Simulation model "Housing and Utilities sphere" provides:

- analyzing housing stock condition and performance of housing and communal utilities and supporting infrastructure;
- planning budget expenditures of the city including housing stock maintenance, renewal and

construction in order to improve population provision with dwelling;

- analyzing business activity of construction and maintenance enterprises and investment processes when constructing housing stock and infrastructure;
- analyzing condition of land resources of urban territories, validating town-planning programs.

System dynamic model "Health Care" provides:

- analyzing demographic tendencies, morbidity dynamics and population living standards;
- analyzing social, territorial, ecological and other risk factors;
- analyzing and forecasting financial condition of compulsory health insurance system;
- strategic planning of material, financial and staffing needs of health care system;
- reorganizing network of prevention and treatment facilities;
- analyzing and forecasting population provision with health care services.

Model complex "Pension system of the Russian Federation" provides:

- analysis of financial sustainability of the Pension Fund;
- government regulation of pension schemes;
- analysis and forecasting of the dynamics of average size of pensions;
- scenario modeling of arrangements of pension savings between the segments of financial markets and forecasting changes of profitability of the overall investment portfolio due to changes in its structure;
- analysis of dynamics of pension savings;
- analysis of the impact of the financial market on the profitability of the investment portfolio and pension savings.

"Model of an agricultural region" provides:

- forecasting condition of land and other natural resources of the region taking into account their bioclimatic potential and planning their further use; environmental regulation;
- analyzing and forecasting the region's economic condition; forecasting agricultural production volume;
- scenario analysis of possible strategies of the region's socio-economic development.

"Model of the urban system" provides:

- analysis of demographic tendencies, morbidity dynamics and population living standards;
- analyzing social, territorial, ecological and other risk factors;
- analyzing and forecasting of financial condition of compulsory health insurance system;

- strategic planning of material, financial and staffing needs of health care system; reorganization of prevention and treatment facilities network;
- analysis and forecasting of population provision with health care services;
- analysis of housing stock condition and performance of housing and communal utilities and supporting infrastructure;
- planning of the city budget expenditures including housing stock maintenance, renewal and construction in order to improve population provision with dwelling;
- analysis of business activity of construction and maintenance enterprises and investment processes when constructing housing stock and infrastructure;
- analysis of land resources condition in urban territories, validation of town-planning programs;
- forecasting of land and other natural resources condition in the region taking into account their bioclimatic potential and planning their further use; environmental regulation;
- analysis and forecasting of the region's economic condition; forecasting of agricultural production volume;
- scenario analysis of possible strategies of the region's socio-economic development;
- situation analysis when reorganizing industrial districts of the town based on the simulation model;
- town-planning policy and allocation of various functional objects on the territory using territorial maps and multiagent simulation models.

The model complex can be used independently or as part of decision support systems by local, regional and federal authorities.

Model complex provides:

- working out programs of socio-economic development of territories;
- developing effective policies in the field of economics, social welfare of the population, reforming of housing and utilities services and health care, pensions, considering the actual population trends, environmental and medical-demographic situation, the state of financial, human and other resources in the region;
- conducting of a comprehensive assessment of level and quality of life, basic socio-economic indicators of regional and industrial systems.

## **PRINCIPLES OF MULTI-MODELING**

Dynamic simulation models are the backbone of the process of decision-making. They allow us to study complex poorly formalized socio-economic system in the dynamics, considering uncertainty of information and a great number of stochastic factors, run a large number of alternatives, scenarios and strategies. Particular tasks and models of socio-economic systems implemented within a single model may reflect the

different types of relationships or aspects of the activity.

When modeling economic systems, you will have to deal with the hierarchical structure of the economy. Detailed below are key levels of modern mathematical models:

- external sector that encompasses the world trade and international capital flows, price formation on commodity and financial markets, behaviour of international commercial and financial organizations and so on;
- macroeconomic level that models key sectors of the economy such as households, companies, public sector (budget), monetary system and inflation;
- meso-economic level that encompasses models of regions and industries (input-output model).

Construction of a generalized model of the region is based on a complex of related simulation and mathematical models that have dynamic and informational links at all levels. Also generalized model is supported by a stratified description, made using CASE-tools at the top level representation of the simulated system. Stratification is a general principle of system simulation, which is used in the analysis and synthesis of complex systems based on computer modeling method. Stratification of complex systems considers construction of databases and knowledge bases processed to solve local problems in system analysis. Stratified model description of the complex creates the basis for the development of appropriate computer technology in the DSS and forms the foundation of databases and knowledge bases.

Implementation of models of different classes means the fundamental heterogeneity of information and analysis environment that is used for development of model of national economy, which combine different types of models - mathematical, structural, system-dynamic, agent, etc. Simulation modeling in such environment is a backbone method in developing of a generalized model of socio-economic system.

For this purpose means of describing the various classes of models (diagrams, flowcharts, functional dependencies, etc.) are needed in a single model environment. Such an environment also supports the processing of a broad frame of statistical data, expert knowledge, based on which model complex operates.

Information interaction goes between models, and in the decision-making process. For example, the results of scenario calculations for the simulation models can be input data for the balance models. At the same time expert procedures, mathematical models, etc can be used in the circuit of dynamic simulation model. Such interaction of models of different types and varying nature of computing are possible due to stratification of

the description of the system and modular construction of the generalized model.

Modular construction of a model complex makes it possible to form scenarios of the socio-economic system based on its morphological model. Morphological model is a table in which each of the subsystems mention the various options for its implementation, is formed by a set of configurations of the socio-economic system and the scenarios of its development. For example, possible scenarios for reforming of pension system are: changing the formula for calculating pensions, changing system preferences, changing of retirement age, extending the list of approved financial assets for investing of pension funds, transferring of savings element of the pension system from mandatory to voluntary, etc. For each configuration, targets are calculated - a balanced budget of the Pension Fund Russian Federation, the average pension, replacement ratio, etc. The simulation results are stored in a data warehouse and available for further comparative analysis for working out a consolidated scenario of the development of socio-economic system.

#### MULTI-MODELING SOFTWARE IN DSS

To construct an integrated model complex it is necessary to have tools embedding in DSS and allowing to create a stratified description of the model complex of socio-economic system and to develop particular models, implemented in the framework of the generalized model. Basic requirements to the means of forming of model complexes based on the principles of multi-modeling:

- supporting a common information space, an integrated, service-oriented information architecture;
- building a data warehouse based on a hierarchy of qualitative and quantitative socio-economic indicators;
- description of models of various types within a single notation and approaches, and the modeling language must be focused not on the programmers and mathematicians but analysts and managers;
- developed tools of scenario studies;
- interface oriented on decision-makers, rather than mathematicians.

When modeling a number of levels simultaneously – in parallel, you will have to face a variety of challenges. First of all, robust methods and extensive amounts of statistical data need to be applied to a large number of modeled variables and calibrated parameters. Another challenge is consistency of parameter and forecast estimates made for variables of disparate levels. To solve this problem, you should apply constraint equations to mathematical models that do not allow you to use traditional estimation methods such as OLS and forecast estimates.

The scale of the problem will lead to much higher levels of software complexity. To demonstrate the truth of this assertion, we'll refer to the PROGNOZ Platform. To model objects of disparate levels, different approaches are normally applied, so tools should support models such as system dynamics, general equilibrium, simulation, econometric, neural network and input-output models. This set of mathematical models will allow users to solve a variety of tasks:

- to process series, users can apply methods for seasonal adjustment (Census I/II, TRAMO), gap filling, smoothing (exponential, moving average) and filters (Hodrick Prescott, Baxter King, LRX);
- to carry out research, users can apply regression models, dynamic models (VAR, ECM), diagnostic tests, cause and effect tests and others;
- to perform short-term forecasting, trend (linear/ non-linear) models, ARIMA, Grey models and others are implemented;
- to perform situational analysis, the toolkit provides users with tools to build models visually, analyze cycles and build systems of equations;
- to enable strategic planning, linear/non-linear optimization methods, optimal management methods (genetic algorithms) are implemented;
- to analyze external threats, users can leverage forward-looking, concurrent and lagging indicators and binary regressions to build aggregate indices.

As a result, we have formulated the following key requirements to the structure of a software product:

- integration with external sources of social and economic statistics and own warehouse of parameters and model's description, scenario parameters and calculation results;
- tools to create and maintain so-called "libraries of models";
- built-in tools to calibrate model's parameters;
- powerful tools that are based on numerical methods and used to solve extensive systems of non-linear equations on the fly;
- visual tools to create and edit models, analyze results of scenario calculations;
- system to analyze and represent results (via Web as well).

The visualization subsystem will allow users to represent calculation results as tables and graphs, compare outcomes of different managerial impacts, analyze changes in obtained results and structures of indicators. The subsystem will enable several remote groups of analysts to export files. These capabilities will also allow users to edit models even if software installed on their computers does not provide any specialized tools. XML is used for uploading and loading models.

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