Simulation modeling of regions` social and economic development in decision support systems

Natalia N. Lychkina
The State University of Management
99 Ryazansky Avenue, Moscow, Russia, 109542
Mobile Phone: +7 (495) 749 71 77 / Fax Number: +7 (495) 371 05 28
E-mail: lychkina@imis.ru lychkina@guu.ru
http://www.lichkina.guu

Dmitriy Shults
PROGNOZ JSC & Perm State University

Tel.: (342) 240-36-63; fax: (342) 240-37-70
shultz@prognoz.ru   http://www.prognoz.com

Abstract

In the report many methodological and technological approaches for creating Decision Support Systems for regional and federal authorities are presented. They are based on using new information technologies such as Data Warehousing, On-Line Analytical Processing, simulation modeling and others. The general structure of model complex for region social-economic development and its realization based on methods of system dynamics and modern technologies of simulation modeling are described. In the article there are same sample solutions: analysis and forecasting of the region's resource potential; natural resources; demography, labour resources; regional economy; agriculture; social sphere.

Key words: Decision Support System, social and economic development of the   region, simulation modeling, methods of system dynamics, stratification, description of model complex, system flow charts.

Decision Support Systems for Regional Authorities

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 which help organize data accumulation and analytical processing and contain tools for regions' socio-economic development and decision-making processes system modeling.

The key function of Decision Support Systems for federal, regional and municipal authorities is solving the following tasks set:

- monitoring of socio-economic and financial indicators to control and analyze the current socio-economic situation in the region;
- analysis of territorial information and detection of tendencies and laws in the cumulative data;
- forecasting industry-specific and regional complexes and detecting disparities in the markets and the corresponding growth points in the socio-economic system;
- analysis of various factors impact on the socio-economic situation in the regions;
- system modeling of regions' socio-economic development on the basis of interconnected simulation and optimization models;
- information and analytical support of administrative decision-making including conducting scenario and target multivariate calculations of regions' socio-economic development and evaluating consequences of decision-making processes.

Nowadays regions' socio-economic development is an important strategic component of municipal management alongside with administrative and legal regulation and budget (financial and investment) policy. In practice working out the socio-economic development strategy is connected with preparing long- and short-term plan of a territory's development. Socio-Economic Development Department performs:

- complex analysis and forecasting of a region's (territory) socio-economic development;
- forming the aggregated plan of a territory's development;
- socio-economic development management based on the complex research of the current socio-economic situation.

The developed strategy defines the contents of key directions of local authorities' activity:

- budget and finance management;
- economics and entrepreneurship management;
- property management and land use;
- external economic activity management;
- environmental protection, etc.

According to the region management system structure there are three levels of decision making in socio-economic development: upper, middle and lower.

At the upper level macro modeling of a region's socio-economic development, forming the region's development strategy and working out the development program are carried out. The strategy development is performed at the Moscow City Duma.

At the middle level working out particular management decisions on the market economic regulation is conducted. Municipalities' activity information and analytical support is realized at the level of the Moscow City Government, administrations and committees. Socio-Economic Development Department on the basis of complex research can prepare recommendations for the management board, Finance Administration, Economics Administration, Consumer Market and Service Administration, Capital Development and Housing and Communal Services Administration, Land Registration and Distribution Department, Architecture and urban Development Administration, Municipal Loans Administration, Environmental Protection Committee, Social Protection Committee, the City Occupation center and others.

The lower level from the point of view of modeling is information level. All the data from districts, authorities, committees and administrations are stored there. It is

important to mention that at this level monitoring, analysis and short-term forecasting of key socio-economic and financial indicators are performed. The basic methods of information processing at this level are selecting and aggregating data necessary for analysis from various information sources (autonomous databases, the Federal State Statistics Service, etc.) and analysis and forecasting of comparable indicators of socio-economic development on the basis of time series smoothing and factor analysis.

Methodological and Technological Approaches to Decision Support Systems Development

Methodological and technological approaches to decision support systems development are based on the fact that administrative decision-making process is characterized by high information value and difficulty of the set problems and the necessity of conducting system analysis and target analytical research for their solving. To solve problems it is necessary to coordinate the decisions with all the authorities and between the socio-economic development strategic goals and economic, social and administrative tasks of operational and tactical management. Thus decision-making is an iterative process including a range of key stages.

The first stage of decision-making is connected with detecting structural peculiarities in unstructured territorial data on socio-economic development, and economic indicators of sectoral and regional complexes from various sources – federal bodies of statistical reporting, departments, administrations, enterprises, etc. Technologically this stage is implemented on the basis of Data Warehousing which main advantage is that scattered data is integrated and become problem-oriented and structured in time. It allows conducting research of dynamic tendencies and implementing various analytical applications.

One of the most important moments in decision-making is detecting key problems of application environment and analysis of tendencies, comparisons and exceptions which are characteristics of data stored in the Data Warehouse. Besides it is also important to confirm and interpret the detected laws which stimulate searching for appropriate decisions. Information and analytical support at this stage is realized through the so called Data Mining tools. Their methods range, depending on the task, is quite wide: from the advanced statistical methods including regression, cluster analysis to smart technologies such as genetic algorithms, neuronet technologies, etc.

The found relations visualization by means of OLAP, forming multidimensional data presentation and random slice and dice with help of handy graphic frames increases a system analyst's activity efficiency at this stage.

Thus during the preliminary stages data is structured by application environment problems and converted into strategic information at the expense of tendencies search which prepares the basis for the decision-making key stage – modeling supported by the modern simulation modeling technologies. Dynamic simulation models serve as the backbone and most valuable link of decision-making process, allow researching complicated socio-economic systems in dynamics, in the context of information ambiguity and stochastic factors impact and play back various development alternatives, scenarios and strategies. Development of a region's aggregated model is carried out on the basis of a set of interconnected simulation and optimization models with advanced dynamic and information relations among all the levels of models and supported stratified description performed by CASE tools at the upper level of the modeled system presentation.

The final procedures of variants estimation or selecting by results of complicated informative experimental investigation held on the basis of simulation models set are characterized by an expert's direct participation in target model research and applying calculating procedures based on compensation combination of simulation modeling and various analytical methods: Data Mining (from statistical methods to expert and intelligence systems), balance methods, logistic approaches, iterative simulation and optimization calculating procedures, etc. it is necessary to mention that Data Mining methods are used at various iterations of decision-making: at simulation model input – during external environment analysis and internal structure specification, and at the output – during strategic planning and operational management at interpreting modeling results and selecting procedures.

The general architecture of Decision Support Systems for regional authorities is shown in Figure 1.
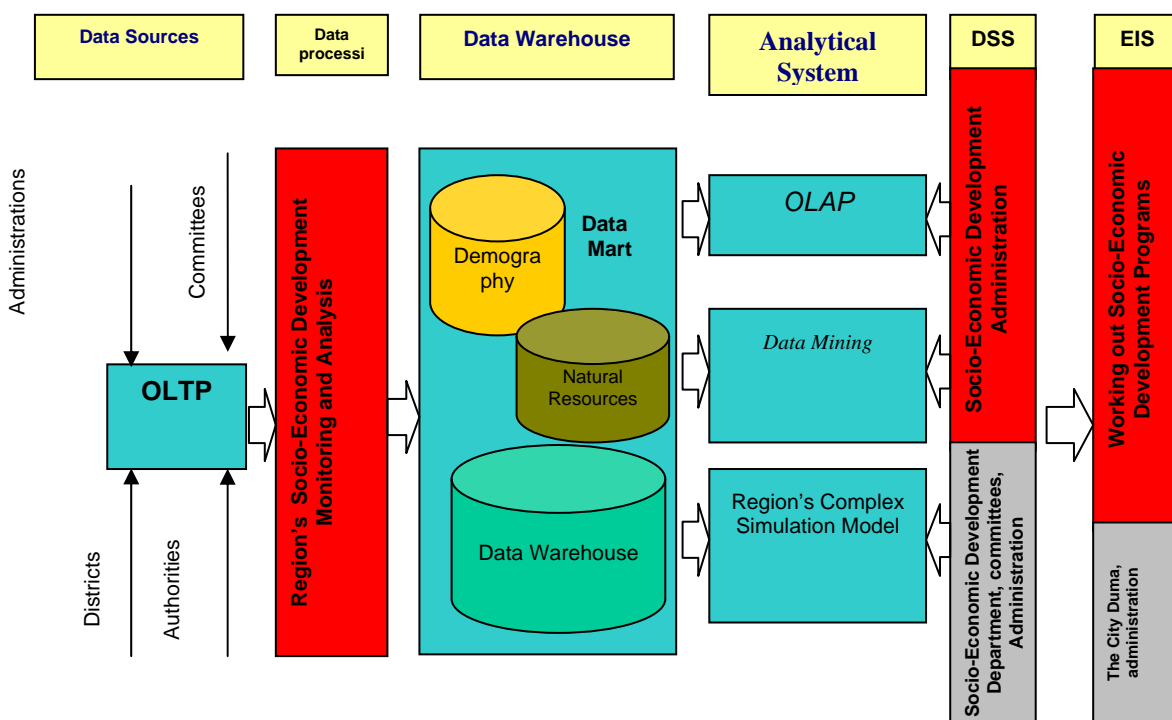

Fig.1. The general architecture of Decision Support Systems for regional authorities.

Decision Support Systems analytical basis is the region's aggregated simulation model and intelligence and expert systems accumulating the experience of solving management tasks and providing participation of experts interacting with the models set in a transparent way through dialogue interface while forming rational economic decision. For more information on working out the region's aggregated simulation model see sections 3 and 4.

Depending on the interface functional content there are EIS and DSS systems assigned respectively for those who make decisions and system analysts responsible for strategic planning.

For the time being in the Russian market there are many analytical systems oriented at applying modern information technologies in Decision Support Systems are presented, e.g. Hyperion Essbase OLAP-server, Oracle Discoverer, software solutions

by Cognos, Olap Services by Microsoft, DSS/OLAP by Business Objects. Among the systems providing integrative solutions for supporting all the levels of the above mentioned Decision Support Systems structure it is possible to single out application by SAS Institute and PROGNOZ (www.prognoz.com).

PROGNOZ experience in modeling solutions

The PROGNOZ company was founded on base of the Perm State University during Perestroika by professors of economics and mathematics. The main clients of young company were government and local authorities of the Soviet Union and then the Russian Federation. And the basic tasks the company had to solve were analysis, forecasting, planning of the national and regional economy and sectors.

There were different applications on the software market but all of them were created for solving very partial tasks, not so complicated and sophisticated ones.

Large government analytical centers accumulate statistical data on economies of different countries, regions and industries. These data arrays include information from many different data-providers and are calculated using different methodologies and algorithms.

In decision making process specialists implement a wide range of econometrical methods including smoothing, extrapolation, regression and factor analysis, multidimensional statistical analysis and so on. And the main requirement of modelers is simple interface (without coding).

Beside econometrical tools handling a single equations it is required to make systems of equations, dynamic system of equations (Vector autoregression and Error-correction model), to sort equations and to analyze cycles in them. Designing of large-scale models also requires users to specialize in determined sectors of economy and corresponding blocks of model.

Besides simple scenarios of forecasting and simulations, practical tasks need to have instruments for optimization and dynamic programming.

Summarizing all the above mentioned, we can conclude that application oriented to such tasks solving should:
1. be integrated with industrial databases and include tools for data validation
2. include many statistical and mathematical methods with user-friendly interface
3. include tools for handling large-scale mathematical models
4. have tools for forecasting and optimization
5. include multiuser working with modeling and administration tools
6. advanced decision making tools
7. include results of visualization tools.

System Modeling of Regional Processes

Methodological basis for modeling the socio-economic development in the region is system analysis. Its main procedure is building generalized (integrated) regional model reflecting all factors and relations of a real system.

The region as a modeling object is characterized by:
- weak theoretical knowledge, quality nature of knowledge about the system, no theory of city`s development;
- high uncertainty level of the source information. There is internal and external uncertainty. Internal uncertainty is a combination of factors which can not be

controlled by a decision-maker fully, but he/she may influence them (e.g., domestic socio-economic environment, risk factors, etc.). External uncertainty is defined by interaction with environment – these are the factors which can be slightly controlled by a decision-maker (ecological, demographic, foreign policy situation, resources supply to the region from the outside, etc.);

- as a consequence, the results are of quality nature and make it possible to judge about development directions of the dynamic processes, analyze stability of dynamic processes.

Socio-economic regional processes should be analyzed and modeled considering the following factors:

- a region is seen as a complicated semistructured system, which system modeling assumes revealing a great number of complex interrelated cause and effect links between factors described in the system and which result of influence is not always obviously seen (according to Forrester, territorial systems are contrintuitive), and the modeling object structure has a great share of expertise;

- regional systems are stochastic and should be studied in the conditions of uncertainty and ambiguity;

- a region is a social system, that is why natural and psychological factors (connected with people's interests, etc.). It is vital to consider long-term interests of the society while decision-making. Regional development level should provide conditions for human life reproduction;

- a region is a dynamic system. Research of reproduction processes demands study of the system`s development dynamics, growth processes analysis considering general life cycle of the region and its parts (population, enterprises, housing stock, etc.), adaptive evolution. The latter is connected with the fact that:

- a region is a self-regulating system. It is governed via intraorganizational processes and is based on changing the laws and methods of internal governing. Weak administrative measures, non-efficiency of target financing and other administrative programs which are not connected with activating economic regulators, were highlighted by Forrester [1]. Social programs result in shifts and disbalance;

- there is a conflict between targets of long-term planning and short-term decisions, that is why coordination at decision-making is needed;

- condition of normal development in the system is maintaining economic balance (achieving balance of resources use in the system).

The following main factors are active in this system: own resource potential of the region (labor, nature, production, finance) and attracted resources (as investments and centralized capital investment), and real production processes.

In decision-making, purposeful selection of administrative solutions and economic methods of management should define such proportions of social reproductions (achieving balance of resources use in the system), which to maximum extend satisfy population needs in the region and increasing its level of life. It is the main target of regional administration.

The socio-economic system in question has a complicated intra structure (fig.2) containing the following subsystems: population, production, non-production sphere, ecology, environment, finance, foreign economic sphere, is managed hierarchically and has separate active subsystems, where relations of elements are described considering influence of the external environment on intra structure.
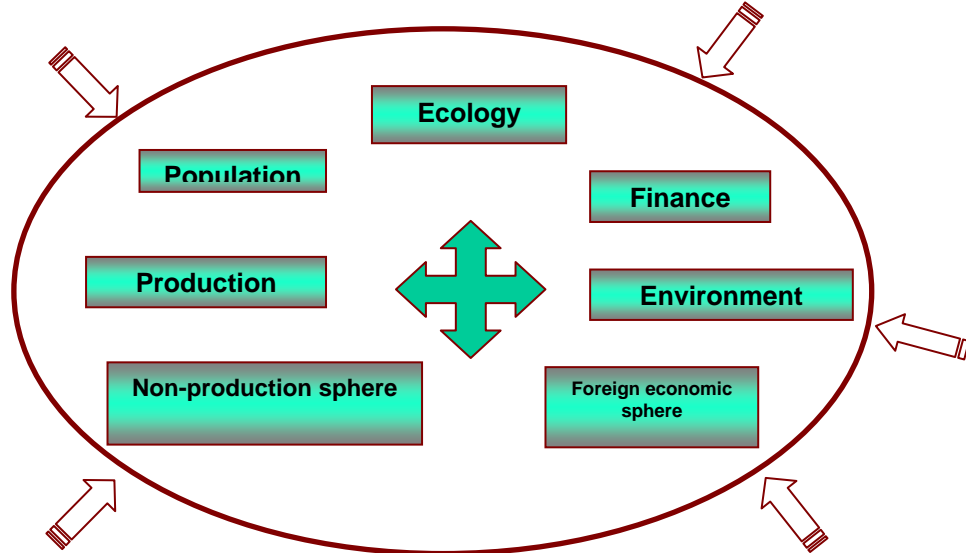
Fig.2. Socio-Economic System Structure

A region is presented as a purposeful and multi-target system with heterogeneous internal and external targets, independent subtargets of separate subsystems, system of targets measure indicators, various strategies to achieve them, etc.

General target of the system may be formed as a series of slightly formalized interconnected subtargets. When selecting this or that development variant it is vital to form an approved decision making it possible to find compromise between regional targets and federal targets, on the one hand, and aims of separate enterprises and economic entities, on the other hand.

Let us describe a system of socio-economic development indicators of a region. Socio-economic component plays a dual role: personality overall development, from the one side, and a certain way to satisfy people`s needs in social infrastructure services, from the other.

Provided we start from the personality overall development, then its indispensable conditions will be achieving a certain level of life (material aspect), and a set of forms and types in the people`s vital activity. Normal vital activity conditions are provided by satisfying material, social and cultural needs while using the welfare and services supplied by the social infrastructure enterprises in the region. The degree of satisfaction of these needs should be reflected by the corresponding system of indicators.

Generalized approach towards evaluation of development level makes it possible to make a hierarchical structure of indicators (fig.3), all socio-economic indicators of which are interconnected, and build aggregated indicators describing socio-economic development level of the region. System of socio-economic development indicators of the region is a complicated hierarchical structure with multiple separate indicators and which may depending on management task include criteria of social, economic, town planning and other effects of development variant.
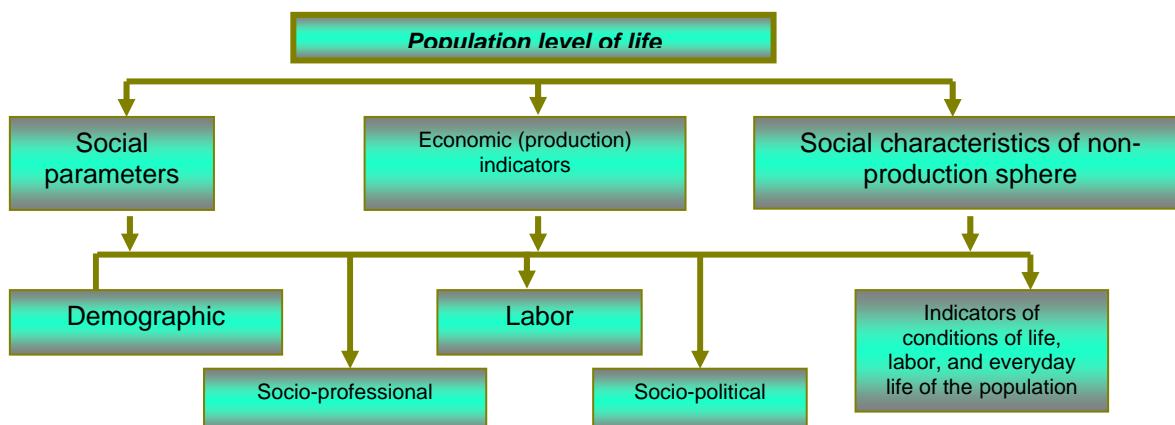

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In general case the system of indicators includes integrated criterion reflecting level of life of the population in the region (e.g., national income per capita). The top level of this hierarchical structure incorporates 3 groups of aggregated criteria, including:

- generalized estimation of social parameters in the region;
- indicators of object economic (production) conditions of the region;
- variables describing social characteristics of non-production sphere dependent on production development.

In turn, aggregated indicators provide general estimation of socio-economic structure and include demographic, socio-professional, labor and socio-political parameters, as well as parameters of level of life, labor and everyday life of the population.

The models contain basic types of regulators for territorial systems:

- administrative;
- normative;
- land;
- budget and taxation;
- organizational and legal;
- contractual.

Stratified Description of Generalized Model of a Region

Based on the system approach, the stratified description of the modeled complex of socio-economic development of the region is made. It is shown on fig.4, where the main levels are given:

- analysis and forecasting of resource potential of a region;
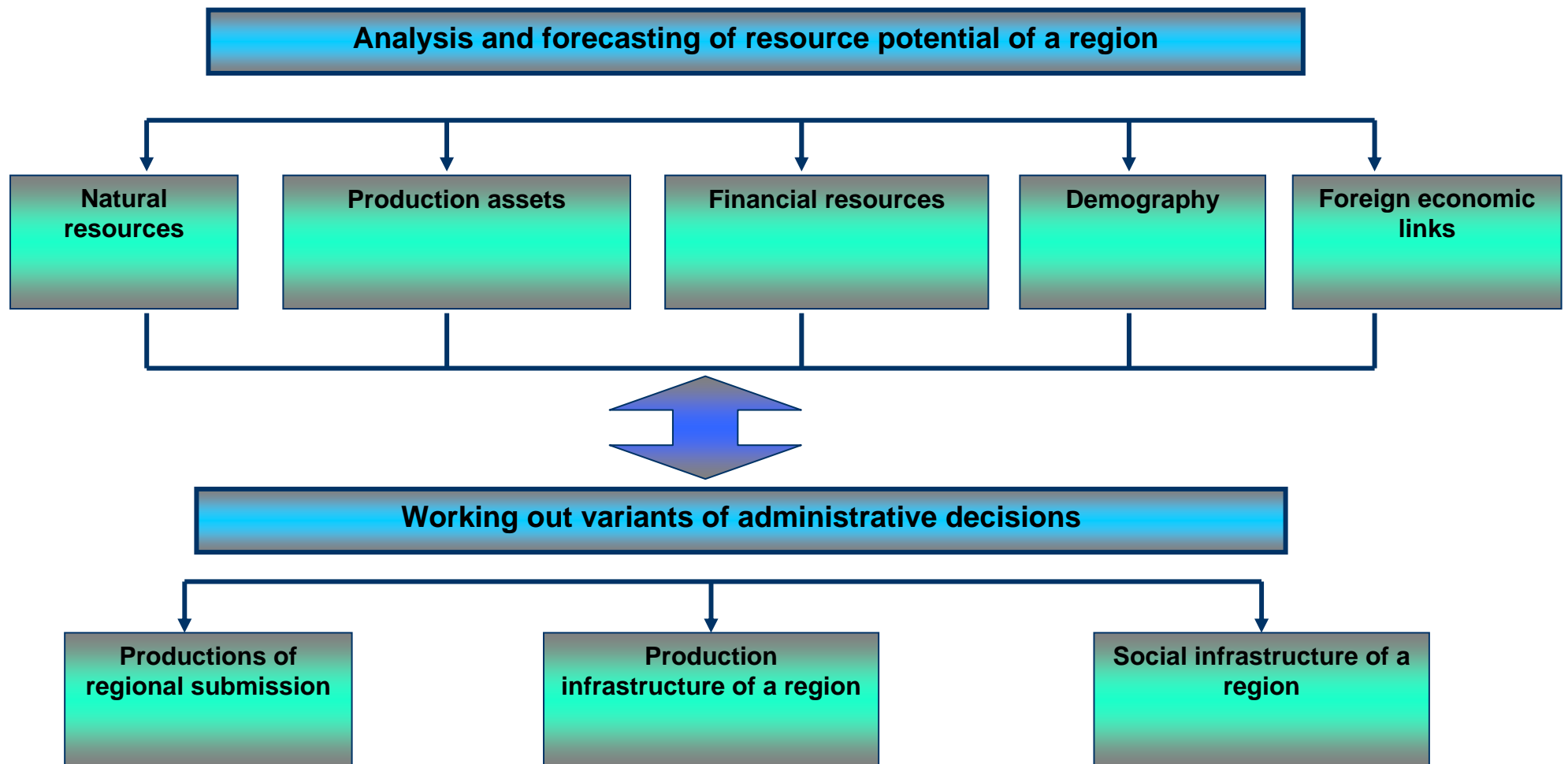- working out variants of administrative decisions.

Fig.4. Generalized model of socio-economic development of a region.

The first level has the following blocks: natural resources, production assets, demography, finance, foreign economic links, and some others.

In the *Natural resources* block the content is studied, natural resources consumption is estimated, resource saving issues are discussed and general ecological situation of the region is analyzed. Forecasting and economic and ecological regulation is carried out following the sustainable development concept. On the resource potential analysis in the model natural resources are detailed into renewable and nonrenewable. On higher levels there are models by basic types of natural resources: land (separately agricultural land and urbanized land), water, forestry, etc., reflecting specific character of consumption and reproduction of each resource type.

In the *Production assets* block the structure and efficiency of using regional production assets are studied considering science and technical progress, advanced technologies and other factors.

In the *Demography* block general demographic situation in the region and by separate age groups is analyzed, labor resources condition is forecast, and employment is estimated considering migration processes.

Modeling of budget process, analysis of credit and investment activity, conduct of the bank system reflects general condition of the financial resources in the region.

The analytical block *Foreign economic links* shows basic exogenous relations of the regional system with the environment: external trade and export and import transactions, structure of the government contractual work, credits and loans, etc.

Real strategic variants of regional development are elaborated in three main directions:

- productions of regional submission (depending on peculiarity of the region, it is possible to make a block of production of non-regional submission);
- production infrastructure of a region;
- social infrastructure of a region.

The *Production* block is responsible for general strategy of developing industry and business in the region, location of enterprises, comprehensive analysis of economic balance on regional markets and revealing disproportions in the development, property management, implementation and estimation of efficiency of the innovation projects introduced, etc.

The analytical block *Production infrastructure of a region* is responsible for decision support connected with the development of energy, construction, transport systems which provide facilities to develop production and social sphere.

In the direction *Social infrastructure of a region* services sphere is developed according to the revealed trends of consumption, housing, medical care, education, and social policy, etc.

Separate tasks and models of socio-economic systems implemented within the framework of one model may reflect different types of relations or aspects of the object functioning: balance relations, technological, behavioral, structural, ecological, demographic, exogenous, etc. System character of the research assumes dynamically formed, developed information relations between models of all striations while elaborating and making decisions. For instance, decisions about production development are connected with analysis of labor resources in the region, resources of production infrastructure, first of all energy and transport, and with solving of other problems. Feedback is seen in case with ecological system, analysis of financial outpayments (first of all taxes within the framework of local budget). In the output it is necessary to analyze if the social sphere is supported, as the main task of the territorial department is whether the city is able to provide itself.

In practice, the generalized model may be implemented via interrelated mathematical models and simulation models with complicated information and developed dynamic links between models of all levels. Stratified description of the model set makes the implementation easier and formal methods such as G. Clear concept or CASE tools or other means of models integration may be used (nested, hierarchical structure), supported by modern modeling system. Stratification is a general principle of system modeling. It is used for analysis and synthesis of complex systems based on computer modeling. Stratification of complex systems means generating databases and knowledge for which there are calculation processes to solve local tasks of system analysis. Stratified description of the model suite is the basis for computer technology and decision support systems, databases and knowledge.

Simulation Modeling of Socio-Economic Processes

The main system forming method in regional socio-economic development tasks is simulation modeling which:

- makes it possible to form generalized model of the system based on single data frame;
- has iterative character of model development, step by step detailing of modeled subsystems, which increase completeness of estimating the decisions made while revealing new problems and acquiring new information;
- provides new methodological basis for scientific research – the experiment on simulation model (and it is possible to estimate consequences of the decisions made not on the people, but on computer models). The main advantage of simulation modeling is that the expert is able to answer the question "What happens if…?", i.e. experimenting with model to work out development strategy;
- is widely used in decision support as it is possible to analyze multiple alternatives, strategies, make scenario calculations, study stochastic systems un uncertain conditions, etc.;
- makes it possible to study development dynamics of social systems.

Models and methods of system dynamics are used on macro level of the suite. System dynamics concept makes it possible to model dynamic processes on the high aggregation degree. It is based on the theory of the dynamic system functioning as a set of flows (cash, products, human, etc.). General structural scheme of system dynamics models is divided into two parts: flows network and information network.

Models of regions are models of a resource type: resources (labor, financial, natural, etc.) get exhausted, resources get replenished, and may be described as a network of heterogeneous flows. Condition of the regional economic system is described by variables (population of different categories, production assets, resources in use). External factors and administrative decisions define the pace (dynamics) of the modeled system (speed of supply and removal of resources).

Based on analysis of expert knowledge all factors of the system and cause and effect correlations between them are revealed. Using the latest modeling systems (such as Ithink, Vensim, Dynamo and others) the model is created on ideographic level. Visual designer makes models easily interpreted for joint expert revisions. System flow charts are a form of expert knowledge structure, in which information network there is disbalance by different types of resources demand and consumption.

In decision making blocks, control actions on different object types are shown based on this information. The latest modeling systems have enhanced tools for scenario calculations and analyzing modeling results.

System dynamics models are used with differential equations of equilibrium and together with principles and methods of logistics based on optimization, administration, integration of flows in complex systems. Perspective is using computer modeling with other decision support methods, business intelligence, expert procedures, intellectual and optimization calculations based on compensation approaches.

In conclusion it is worth to mention that traditional modeling methods may be used as well: analytical, forecasting, combination of expert estimation methods, etc.

General aspects of simulation modeling include the following:

- **methodological** connected with creation of new concepts of formalization and structuring the systems modeled, oriented at mathematical and information support of the whole modeling cycle: from setting the task and creating the concept model up to analyzing the results of calculation experiment and decision-making;
- **mathematical** connected with using statistical methods, mathematical methods of optimization and decision-making, machine intelligence;
- **technological** aspect.

Today simulation modeling becomes more and more mature computer technology. Below are improvement directions of modeling in brief:

- creation of problem oriented modeling systems in different research areas;
- user friendly and easily interpreted graphic interface, when blocks of discrete models and system flow charts of the continued ones are made on ideographic level, and parameters of models are defined by submenus;
- object-oriented modeling;
- use of 2- and 3D animation in real time;
- use of structural and functional approach, multilevel hierarchical, nested structures and other ways to present models on different description levels;
- improving tools for scenario calculations;
- information (access to databases) and mathematical support of input data analysis, analysis of sensitivity and a wide range of calculation procedures [2], connected with planning, organization and carrying out of a calculation experiment on simulation model;
- use of interactive distributed modeling, developments in interaction of simulation modeling with the world wide web, etc.

Business Intelligence System to Forecast Region's Socio-Economic Development

At the Department of Information Systems of the State University of Management in the framework of the project *Complex Integrated Automated Business Intelligence System of Administrative and Territorial and Municipal Management* Modeling of Region`s socio-Economic Development block is created. The core of the project is presented by the simulation models set based on the system dynamics methods and simulation modeling technologies. At the moment the following models sets are implemented at the level meeting the requirements of practical use:

- the region's aggregated simulation model allowing forecasting key indicators of a region's socio-economic development and financial and economic indicators, carrying out complex analysis of life standard and quality by territories for short and long term;
- *Regional Resource Potential Analysis and Forecasting* analytical module specified by basic natural resources: land (including land of urbanized territories), water, forest, mineral and other resources. The module allows analyzing region's natural resources utilization in terms of socio-economic development; it contains *Ecology* subsystem with specification of production and technical ecological relations in the modeled regional system;
- *Budget Process Modeling* module helping analyze income and plan expenditures of the local budget while performing complex evaluation of socio-economic development and key financial indicators for forming the region's financial policy;
- *Demography Tendencies Analysis* module on the basis of dynamic models including *Region's Human Resources* subsystem;
- *Economy* models set allowing forecasting of industry specific and regional complexes, conducting market balance analysis and detecting disparities and the corresponding growth points in the region's economic system;
- *Social Sphere* dynamic models set, in the framework of which the corresponding aggregated model and *Health Care*, *Housing* (adjusted to solving tasks in terms of the current reforms in these spheres) and *Education* model complexes are implemented;
- model complexes adjustment to regions' specific character – *Urbanized Territory*, *Russian Towns*, *Agricultural Districts*, etc.

Sample solutions

System and dynamic model of health care provides (fig.5,6)**:**
- 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.

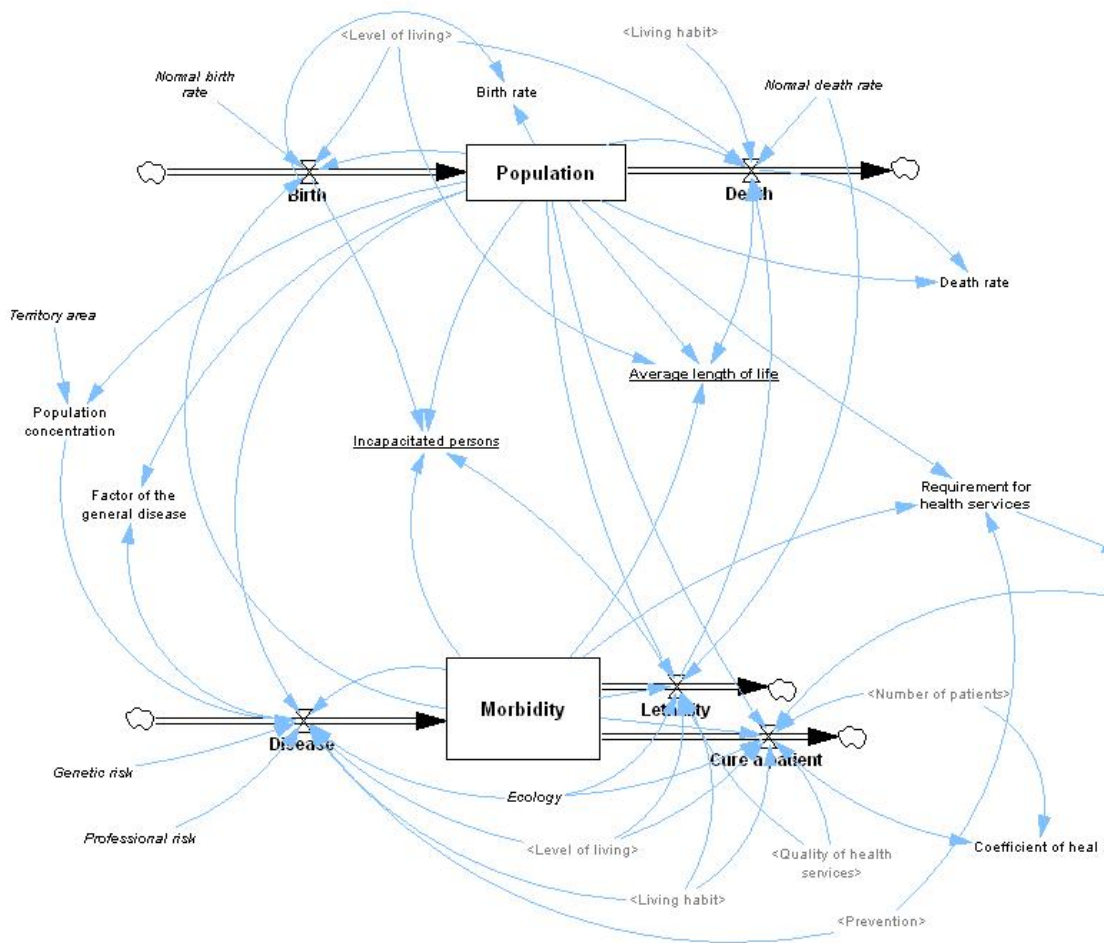**Fig 5.** System and dynamic model of health care. The fragment of flow diagram.
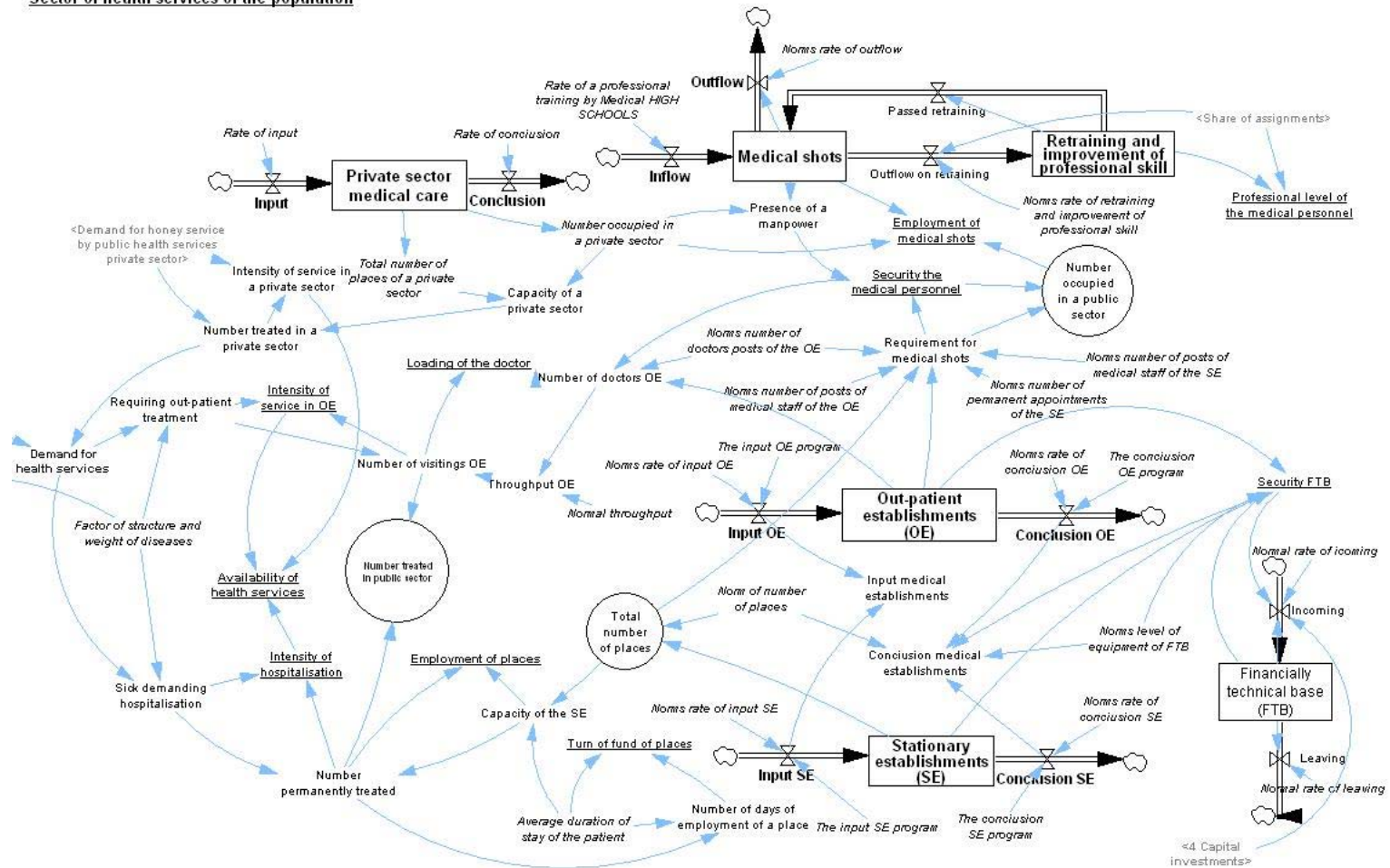
Fig 6. System and dynamic model of health care. The fragment of flow diagram

Simulation models for housing and communal utilities provide (fig.7) **:**

- 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.
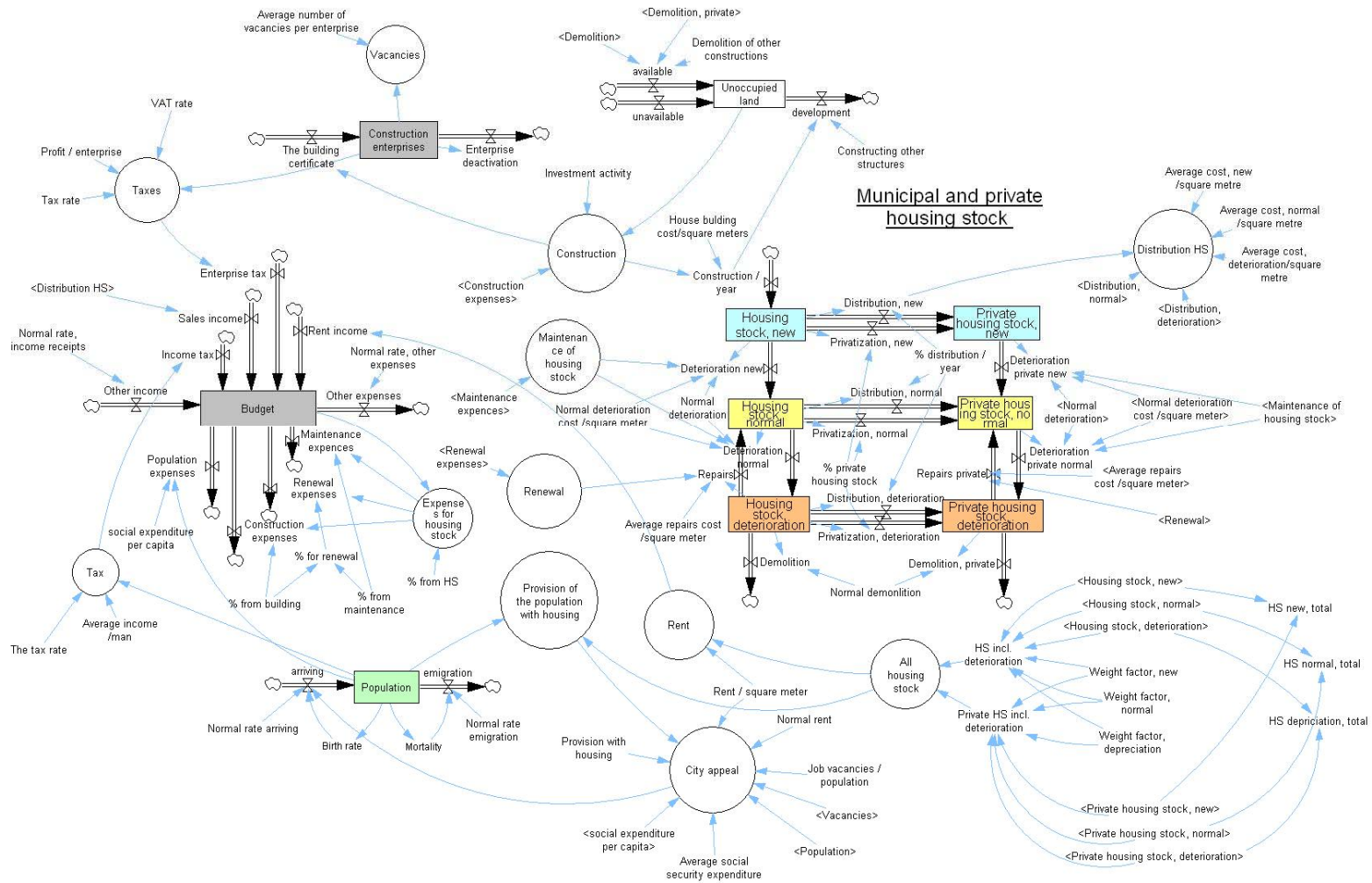
Fig 7. Simulation models for housing and communal utilities. The fragment of flow diagram .

Dynamic model of an agricultural region provides (fig.8)**:**

- 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;
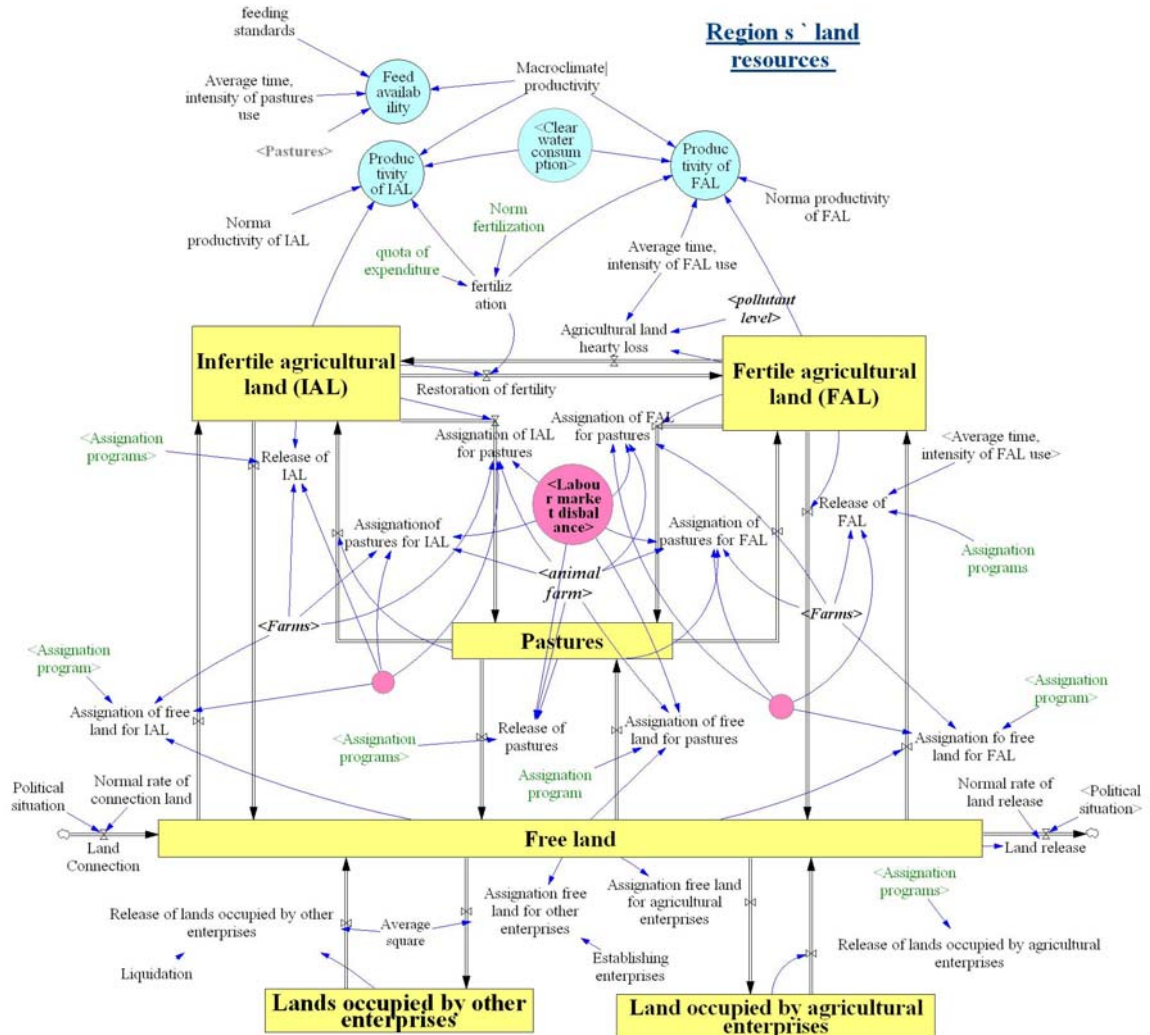- scenario analysis of possible strategies of the region's socio-economic development.

Fig 8. Dynamic model of an agricultural region. The fragment of flow diagram.

Solutions for municipal authorities include (fig 9):

- situation analysis when reorganizing industrial districts of the town based on the simulation model;
- town-planning policy and allocating various functional objects on the territory using territorial maps and multiagent simulation models.

Fig 9. Solutions for municipal authorities. Models` animation interface.

Solutions for federal, regional and municipal authorities

- Analysis of demographic tendencies, morbidity dynamics and population living standards; analyzing social, territorial, ecological and other risk factors.
- Analysis 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.

Macroeconomic forecasting applications

In general, macroeconomic models consist of the following blocks:
- households,
- real sector,
- balance of payment,
- government finance,
- bank and monetary sector;
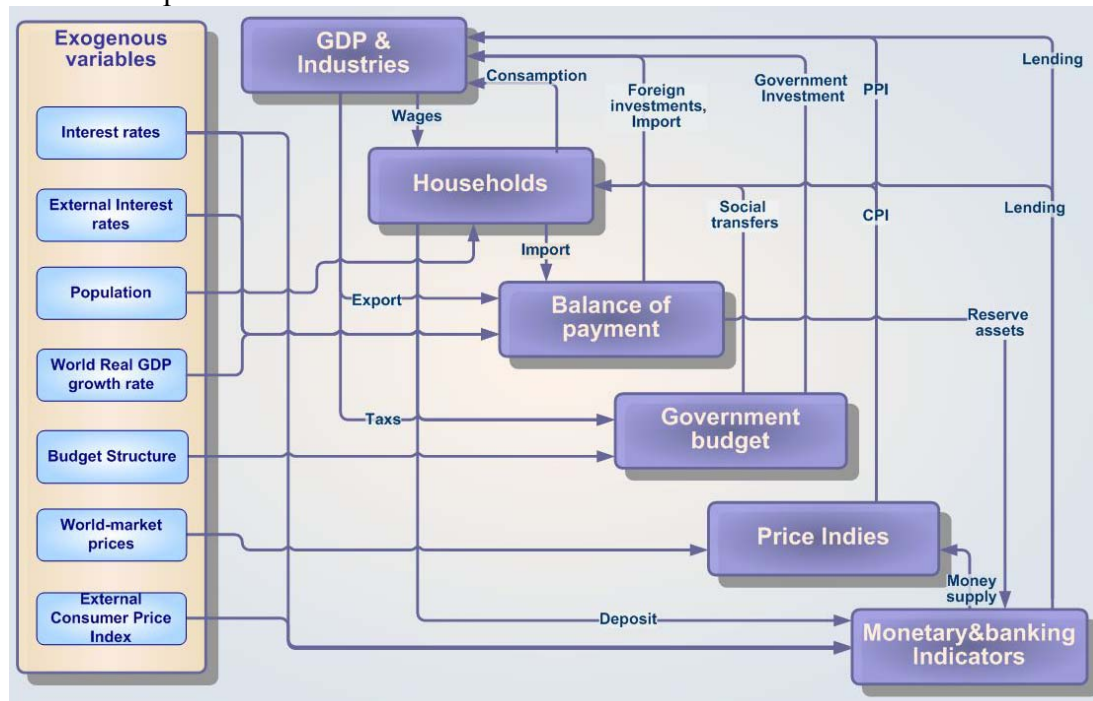- block of prices and inflation.

Fig.10. Example of macroeconomic model structure

Usually macroeconomic models use the following scenario (exogenous) variables:
- External Variables:
  o Foreign Direct Investment
  o Major export/import goods prices
  o Exchange Rate (for fixed exchange rate modes)
  o World and foreign countries inflation
  o World and foreign countries GDP growth
  o External interest rates
- Internal Variables:
  o Interest rates of monetary authorities:
  o Required Reserve Ratio
  o Tariffs and quotas
  o Tax rates and government expenditures
  o Population dynamics and migration

Besides the macroeconomic level, the model can include also industrial and input-output models, regional models and models of foreign countries. Such large-scale model can include some hundreds and even thousands of equations and modeling variable. This feature allows users to take into account not only direct linkages between variables but also indirect ones and feedbacks.

Sensitivity analysis allows users to estimate influence of different shocks on key macroeconomic variables and elasticities in dynamics.
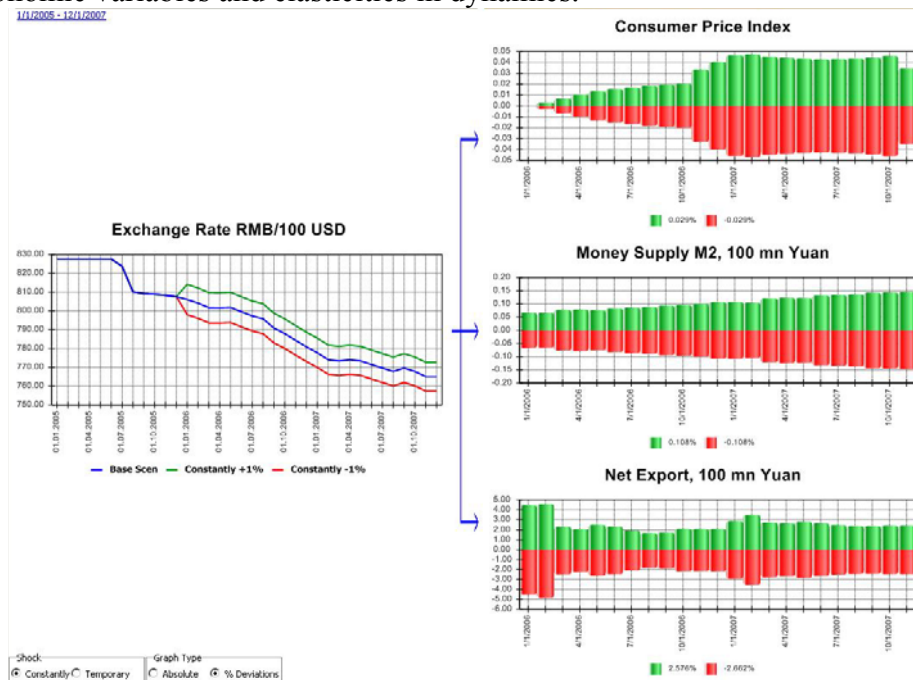

Fig.11. Sensitivity analysis examples

Scenarios approach in these models allows experts to determine threshold values of exogenous variables. Such kind of analysis is used to determine limit of oil price that can be offered by oil exporter countries.
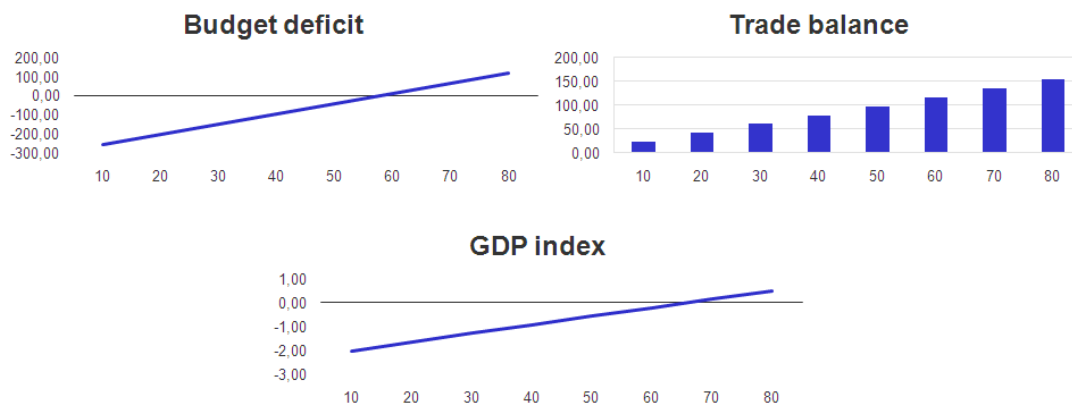

Fig.12. Determination of oil price threshold value

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