Subnational Public Financial Management in Ukraine: Designing and Implementing Fiscal Decision Support System

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Abstract

The article addresses theoretical and applicative issues concerning validation, design and implementation of mathematical economic models for forecasting of fiscal policy regional and national effects in an emerging economy (in case of Ukraine).

The theoretical framework integrates inductive and deductive epistemological bases. Proceeding from the emerging economy specifics and the mid-term forecasting purpose, a rationale is provided for using the System Dynamics modeling approach rather than AM or CGE in case of sub-nationally detailed economic modeling.

Information distortion challenges due to shadow economy and imperfect national statistics system have required to develop the relevant data adjustment tools, especially in taxation modeling.

The model set presented comprises real sector, financial sector, public sector and population. Particular models and causal chains are specified.

The overall decision support system developed is compliant with MTBF and top-down budgeting as these require accurate disaggregate mid-term fiscal forecasts and advanced policy analysis tools. It enables to create and update databases, to produce and to analyze mid-term scenarios facilitated with visual interface, and, finally, to assess the regional and nation-wide economic impact of various economic and financial regulators.

1. Introduction

Cost-effective and socially equitable fiscal policy is one of the key drivers of steady national development. However, current situation in Ukraine is the following: the state agencies that make decisions on economic legislature and policy change have no tools for calculating economic scenarios and for predicting at least the mid-term consequences of their actions. As the fiscal policies are up to hand control, their results misfit the expectations of the government and public and create the atmosphere of government institutions distrust. The existence of such an atmosphere was demonstrated by the wave of protests of small and middle business representatives that took place in the country in 2010 during the preparation and adoption of the Tax Code of Ukraine.

The scientific foresight of fiscal policies impact cannot be based only on the historic analysis of actual data and given tendencies. It demands the special tools like simulation models. Three classes of models are generally used to simulate the consequences of economic policies: accounting models (AM), computable general equilibrium models (CGE), and system dynamics models (SD). The AM-model examples are Financial Planning Framework (IMF) and Revised Minimum Standard Model-Extended (World Bank) (Model Building: RMSM-X Reference Guide, 1995). Examples of CGE-models are the "Dynamic Revenue Analysis for California"

(USA) (Dynamic Revenue Analysis for California, 2013) and "Russia: Centre - Federal District" (RF). The examples of SD-type of models are World3 (Meadows D.H. and Jorgen R., 2004), (Forrester J. W., 1970) and Threshold 21 (Bassia A.M. and others, 2009).

However the referenced models do not account for the regional specificity and (or) the institutional features of an emerging economy comprehensively. Thus it was crucial to design an information analysis system for sub-national fiscal decision making that would cover the specific features of the Ukrainian economy.

The system should include:

mathematical models of oblast (regional) economies,

databases for model building and checking,

software that facilitates user interface,

and overall system management orgware.

2. Idea of the system

The core idea of the Information analysis system for budget process support (IASBP) lies in creating a coherent set of databases and software for regional and nation-wide fiscal policy impact evaluation.

It is supposed that IASBP users (deputies of Verkhovna Rada, central and regional officials) will get an opportunity to design and analyze the scenarios of regional and national economy dynamics under selected parameters of regulators (e.g. under current and changed taxes, under current and new natural gas prices, etc.) (Figure 1). The system is supposed not to produce recommendations on target-setting and decision making, but to provide the information needed for this[2].

The basic modeling object in IASBP is an oblast economy (Figure 1). An oblast is the main administrative and territorial unit of Ukraine and the largest sub-national territorial unit of the budget system.

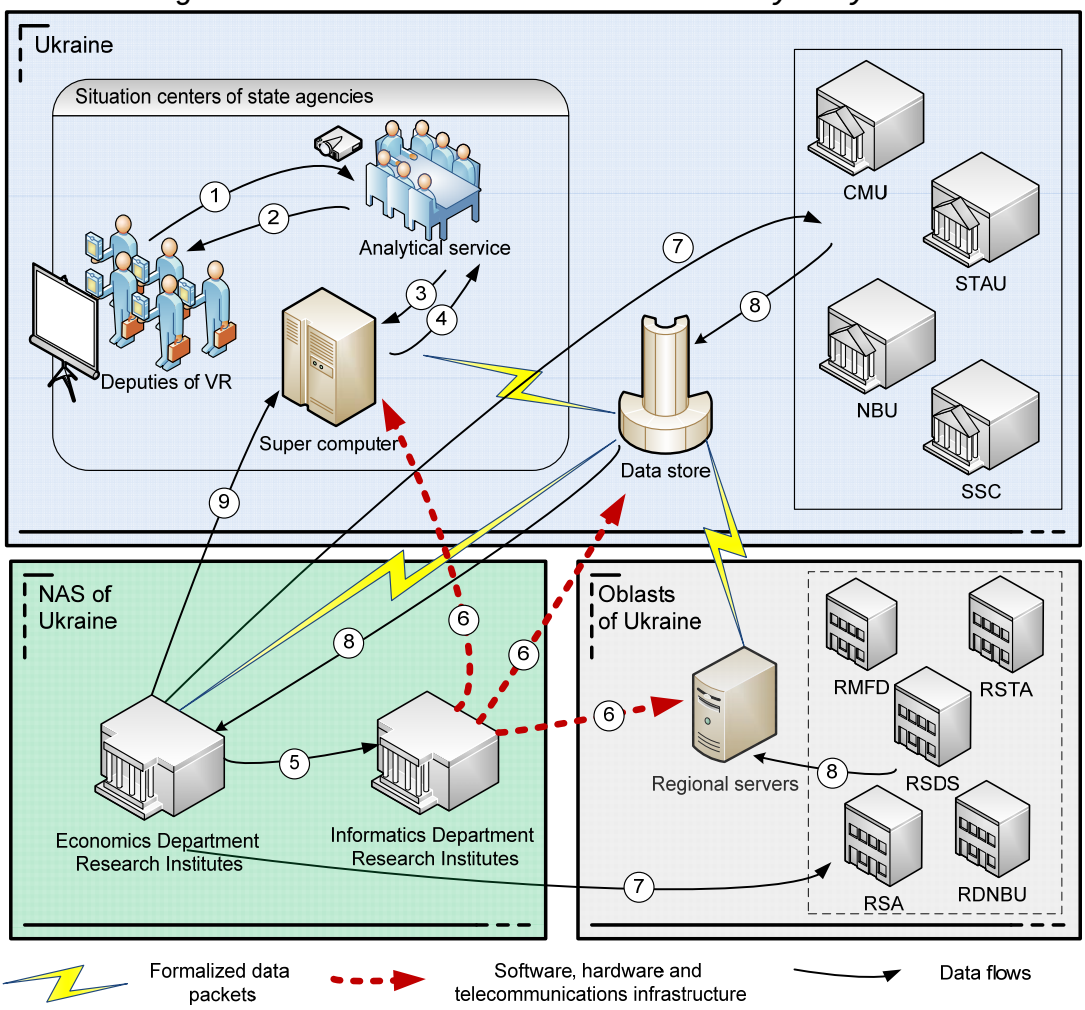
The economy of each oblast is a dynamic system that functions in specific Ukrainian institutional environment, which is characterized by persistent formal and informal rules (legal, social, political, etc). That is why taking into account the peculiarities of the system is a necessary condition for the adequate modeling of its behavior under fiscal policy impacts.

[2] As M. Allais says: "The aims can be revealed only by functioning of political system, in procedures that differ from country to country in one or another epoch. Meanwhile, the same problem is solved – the achieving of compromise between different citizens' aspirations, and as usual, the aspirations are contradictory.

As to an economist, he/she can answer only two questions: 1. Are the aims compatible with each other? 2. Are the used means the best to achieve the aims set? Economics does not define the choice; it only gives the scientific information according to which the reasonable choice of aims should be made.

It is a dangerous error to think that economics can help to work out scientific decisions. The models that are developed under operational research cannot give managers any ready-made solutions. They can just define the consequences of the decisions, given the assumptions accepted. The same is the case for the models that are developed by planning offices for their governments (Allais M., 1964)".

Figure 1. Structure of the information analysis system



Legend

1 – Request for forecast

2, 4 – Forecasts

3 – Scientific specification of inquiries

5 – Mathematical economic models

6 – Software, hardware, telecommunications infrastructure

7 – Primary data inquiry

8 – Primary data

9 – Models parameterization

CMU – Cabinet of Ministers of Ukraine

NBU – National Bank of Ukraine

SSC – State Statistics Committee

STAU – State Tax Administration of Ukraine

RMFD – Regional Main Financial Departments

RSTA – Regional State Tax Administrations

RSDS – Regional State Department of Statistics

RSA – Regional State Administrations

RDNBU – Regional Departments of NBU

In particular, it should be taken into consideration that:

1) Real sector enterprises are the backbone of Ukrainian oblast economies. They create the major part of the added value and make the major contribution to all budgets. In the case of Donetsk oblast, these are large metallurgical, machine building, coal mining and trade

enterprises. That is why the real sector models should make the core of the fiscal policy regional impact research program;

2) Ukraine is a market economy; however, in contrast to developed postindustrial countries, it is an emerging one, and has the relevant institutions in stage of formation, which cannot perform the set of functions typical for developed countries. Hence, inter alia, it makes no sense to model the stock market: the trading volume is not large, and it is not directly related to economic development financing (it is used, to a greater extent, as a property redistribution tool);

3) The economic agents' activities base on the settled informal standards of behavior (tax evasion, using corruption for business issues resolution, etc). In some cases, in addition to the usual transformation costs (resources spent to transform raw materials into finished products), the activities are associated with high transaction costs (intellectual property protection, contract enforcement, search of information, etc.);

4) Besides the formal economy, the results of which are reflected in accounting and financial reports, there exists a large shadow economy, the activities hidden from the state and out of state accounting and control.

3. Modeling methodology

Each method of dynamic systems modeling has its own scope and is used in such situations in which it can give an explanation (why something happens), or understanding (how it happens) of investigated phenomena. However, the scopes may overlap, and then the prerequisites for the synthesis of various methods emerge.

In the study of the forms of human behavior that determine the allocation of scarce resources to alternative purposes (the range of economic science according to L. Robbins, 1935), it is important to note that: "... a mode of existence of "goods" and the mechanisms of their "disposal" are institutional by nature" (Searle J. R., 2005), defined by the settled institutions' features).

Institutions are not something unalterable, given for the last time. They are changeable, inheritable and selectable as well. At the same time, in some economic sectors some social technologies are more developed, in others are less. In particular, it is well evident in transformation economies, where many elements of market system have not formed yet for various reasons.

If economic agents operate under streamlined stable socio-political practical procedures, "within the rules", their mode of behavior is easier (more economical) to simulate using hypothetical and deductive methodology, taking descriptively simplified neo-classical assumptions, including the rational behavior under the condition of full awareness (provided that the results of such modeling are empirically confirmed)[3].

[3] It is important to emphasize that the usual criticism of the neoclassical premises of rational behavior and full awareness of the economic agents, as unrealistic, is not always appropriate. Point is that "unrealistic" may be understood at least in two ways: as unexhaustive description of reality, and as erroneous, false one (Nagel E., [1963]). It is obvious that the above mentioned assumptions not always can be called false, because in certain circumstances, economic agents are really well informed and act rationally. Therefore, these conditions are to be considered incomplete in the sense that they abstract away from the complexity of the empirical world, for a more precise description of which additional conditions are usually required (Kanazawa S., [1988]). This incompleteness makes sense, since a theory is considered to be the more fruitful the fewer premises it uses. As noted by M. Friedman: "A hypothesis is important if it "explains" much by little, that is, if it abstracts the common and crucial elements from

If we consider a sphere of activity where any sustained procedure of social and political practices is absent, and there is the problem of "rules choice", then the best modeling approach is the experimental and inductive one, involving the search for patterns of behavior in the circumstances, that reflect economic realities, rather than some postulated rationality (under the mentioned condition of empirical confirmation)[4].

Again, relatively localized areas with variously developed institutions are present within an evolving oblast economic system. Whereas different research techniques are relevant to model the particular parts of a unified system, therefore different methods are possible and necessary to be used within a unified model of oblast economy. In this sense, the contradiction between the predominantly deductive neoclassicism and the mostly inductive institutionalism is losing its relevance. Therefore, the IASBP modeling of, for example, production output (when usual "industrial" problem of the best use of limited resource supply within the established production rules is solved) is based on aprioristic neoclassical production function; while the modeling of investment (when one needs to choose the avenues for future business development under the increased uncertainty in transformation economy) is based on inductive methods for posterior patterns detection from the primary "chaos" of statistic data.

Three classes of models are generally used to simulate the consequences of economic policies: accounting models (AM), computable general equilibrium models (CGE), and system dynamics models (SD). SD-modeling was used as a basis to develop IASBP. This choice stems from the purpose that is to assess not immediate but midterm (i.e., several years) impact of alternative decisions in fiscal policy. SD-models, as it follows even from their name, fit the purpose better than AM and CGE-models.

Second, whereas the IASBP simulation objects are particular oblast economies, which are obviously more open systems than a national economy (production and consumption are not confined within the regions), therefore the market equilibrium and market clearing assumptions of AM-and CGE-models are not realistic in this case.

Third, the problems of the economic agents' behavior variability and the damping of finite-difference equations have no fundamental significance for mid-term period.

Among the IASBP SD-models there are the models of objects and models of their behavior under the influence of economic and financial regulators.

4. General characteristics of the model set

IASBP model set is divided into two groups: 1) object models (mathematical analogs of objects and phenomena that make up an oblast economy) and 2) models of financial and economic regulators (mathematical equivalents of the regulation entities' actions that affect the social and economic processes in an oblast economy to achieve target parameters).

Object models, in turn, comprise the models of agents and models of markets (Figure 2).

Models of agents. There are four types of economic agents in IASBP: real sector enterprises (A1), financial sector institutions (A2), public sector organizations (A3) and population (A4).

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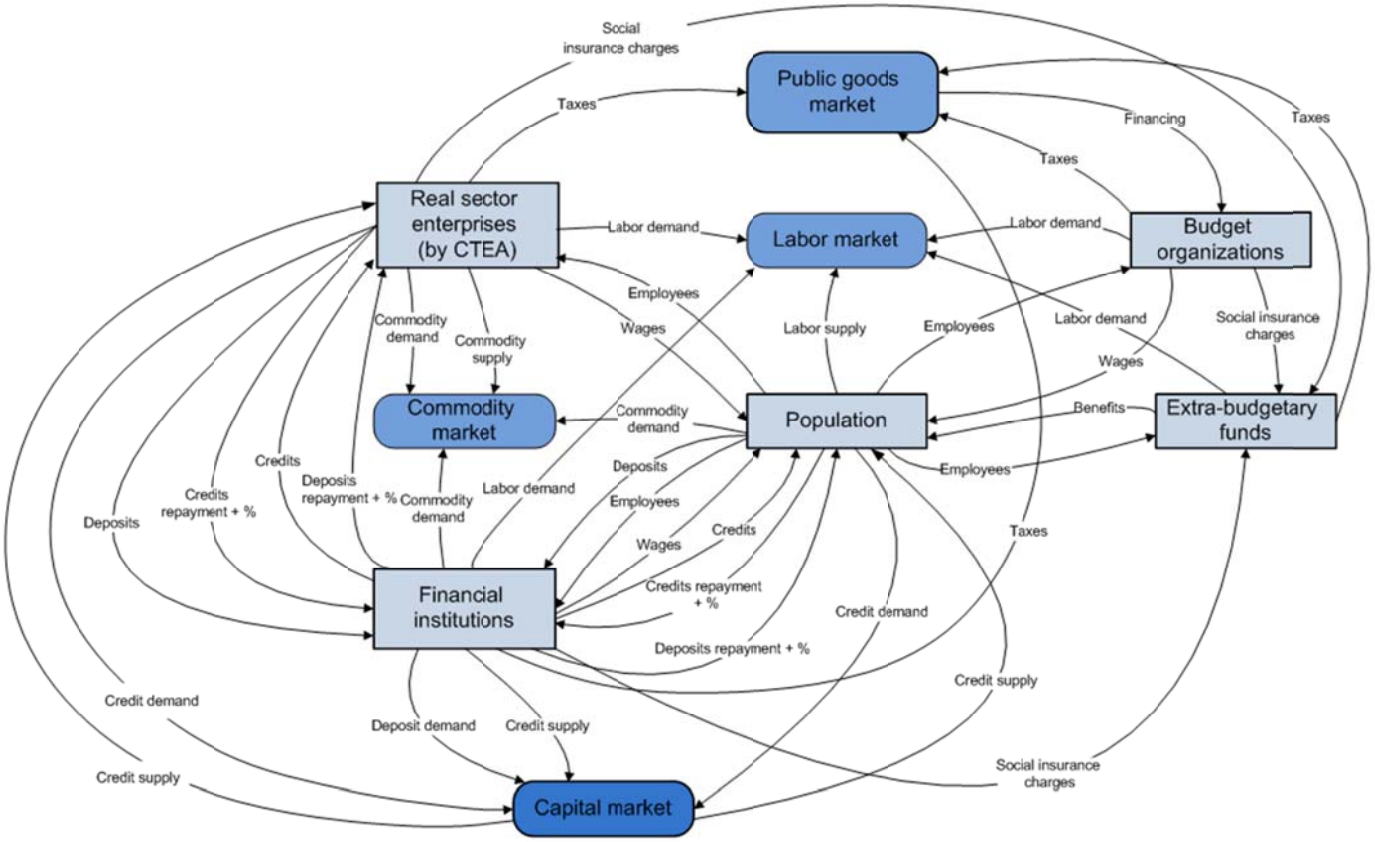
the mass of complex and detailed circumstances surrounding the phenomena to be explained and permits valid predictions on the basis of them alone" (Friedman M., 1953).

[4] For example, agent-based computational economics (using such key terms as bounded rationality, non-equilibrium dynamics, and direct inter-agent interactions) develops modern virtually inductive tools. Furthermore, with computer simulations, "... the properties of a system are derived from the recurrent interactions between simple objects, not from the requirements of rationality and equilibrium established by the modeler" (Fagiolo G., Roventini A., 2008).

(A1) *Real sector* is represented by a range of business entities of all forms of ownership engaged in production and service providing for profit, which are united in industries (according to the Classification of the Types of Economic Activities, CTEA)[5].

Each of the industries is an aggregate of the enterprises engaged in CTEA-defined specific economic activity and located in the oblast. These enterprises use the equipment and technology that are typical for the industry, produce and sell homogeneous products at the commodity market (reference oil, reference rolled metal product, etc.). Within the oblast, the enterprises engage labor in the labor market; buy credits from and sell deposits to financial intermediaries in the money market. A part of the sales profit arrives to the state and oblast budgets in the form of taxes. At budget expense, non-profit organizations provide public services that are necessary (inter alia) for the normal operation of commercial enterprises (law enforcement, education, health services, etc.).

Figure 2. Key economic inter-linkages in oblast economy object models



[5] According to the economic law, an industry is a set of productive statistical units that are engaged in mainly the same or similar economic activity. Further in this paper, the terms "industry" and "economic activity" are used interchangeably.

It is suggested that the industries within an oblast are not interconnected, and each industry's product has its own separate market. Therefore, there is no need to model input-output balance in this case[6].

The enterprises of each industry manufacture products, using capital and labor

$$
\begin{aligned}
&Y_{i\varepsilon} = \gamma_\varepsilon \left[k_\varepsilon^f (K_{i\varepsilon}^{fr})^{-\alpha_\varepsilon} + k_\varepsilon^v (K_{i\varepsilon}^{vr})^{-\alpha_\varepsilon} + k_\varepsilon^l (L_{i\varepsilon}^h)^{-\alpha_\varepsilon} \right]^{\frac{-\nu_\varepsilon}{\alpha_\varepsilon}} \zeta_i, \\
&K_{i\varepsilon}^{fr} > 0,\ K_{i\varepsilon}^{vr} > 0,\ L_{i\varepsilon}^h > 0, \\
&k_\varepsilon^f > 0, k_\varepsilon^v > 0, k_\varepsilon^l > 0, \quad k_\varepsilon^f + k_\varepsilon^v + k_\varepsilon^l = 1,
\end{aligned}
\tag{1}
$$

where $Y_{i\varepsilon}$ is the output of industry ε in period i (without VAT and excise duty, in compatible prices);

$K_{i\varepsilon}^f$ is the net fixed capital in industry ε in period i $(K_{i\varepsilon}^f > 0)$;

$K_{i\varepsilon}^v$ is the working capital in industry ε in period i $(K_{i\varepsilon}^v > 0)$;

$L_{i\varepsilon}^h$ is the labor input (measured in hours) in industry ε in period i;

i is the number of period;

γ_ε is the parameter of neutral technology effectiveness in industry ε;

k_ε^v is the working capital coefficient in industry ε;

k_ε^f is the fixed capital coefficient in industry ε;

k_ε^l is the labor intensity of industry ε;

ν_ε is the return to scale in industry ε (the degree of function's homogeneity) $\nu_\varepsilon > 0$;

$\sigma_\varepsilon = 1/(1+\alpha_\varepsilon)$ is the elasticity of resources substitution in industry ε;

ζ_i is the inflation rate in period *i*.[7]

The duration of a period (time step) is six months[8].

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[6] The exception is the manufacture of food products, beverages and tobacco that are intended primarily for consumption within the oblast, as well as trade, which provides services to sell these goods.

[7] For a forecast we take $\zeta_i = 1$, so the forecast is performed in the prices of the last reporting period. If, for example, the data for 2006-2010 are used for model set parameterization, then the forecast for 2011-2013 will be at the prices and terms of the second half of 2010. It is assumed that inflation does not distort the results of the parameterization, since the same effect will be on both the function value (output) and the argument value (production factors).

[8] The choice of such time step is because a half of a year is the shortest time interval for which the relatively reliable and comparable inter-annual accounting information on the performance of enterprises and organizations is available in Ukraine. As for the quarterly and monthly reported data, it often has significant variations, which are unexplainable in terms of mathematical modeling.

Commodity cost depends on depreciation, labor costs (wages with charges), resource costs and other costs related to production volume, energy prices (for end-consumers), land charge, and credit interest. It is defined by the formula

$$C_{i\varepsilon} = \beta_\varepsilon \left(k_\varepsilon{}^a K_{i\varepsilon}^{fr}\right)^{g_\varepsilon} \left(L_{i\varepsilon}^m (1+t_{i\varepsilon}^l)\right)^{r_\varepsilon} \left(Y_{i\varepsilon}\lambda_{i\varepsilon}^{im} \frac{k_i^c}{k_{i-1}^c} + Y_{i\varepsilon}(1-\lambda_{i\varepsilon}^{im})\right)^{\rho_\varepsilon} \left(\mathrm{E}_{i\varepsilon}\right)^{h_\varepsilon} \left(t_{i\varepsilon}^E\right)^{\pi_\varepsilon} \left(p_{i\varepsilon}^B\right)^{s_\varepsilon}, \tag{2}$$

where β_ε is the industry scale coefficient;

k_ε^a is the average depreciation rate (for one period) in industry ε;

$t_{i\varepsilon}^l$ and $t_{i\varepsilon}^E$ are the effective rates of wage charges (contributions to social insurance and social security funds) and land charge, respectively, in industry ε in period i;

$L_{i\varepsilon}^m$ is the labor costs in industry ε in period i;

λ_ε^{im} is the share of imported materials in the total supply for industry ε;

k_i^c is the exchange rate (to USD) in period i;

$\mathrm{E}_{i\varepsilon}$ is energy costs in industry ε in period i;

$p_{i,\varepsilon}^B$ is credit interest, $p_{i,\varepsilon}^B = \begin{cases} B_{i\varepsilon}^{vr} r_i^B & \Leftarrow B_{i\varepsilon}^{vr} > 0 \\ 1 & \Leftarrow B_{i\varepsilon}^{vr} \le 0 \end{cases}$;

$B_{i\varepsilon}^{vr}$ is the average remaining credit debt of the enterprises of industry ε in period i;

r_i^B is current credit interest rate in period i;

$g_\varepsilon, r_\varepsilon, \rho_\varepsilon, \tau_\varepsilon, \pi_\varepsilon, s_\varepsilon$ are industry intensity parameters.

The energy costs depend on particular energy prices (natural gas, oil products, coal, and electricity). In IASBP, this dependence is presented as a translog cost function (Christensen L., Greene W., [1976]). In this case, this function is

$$\begin{aligned} \ln(E_{i\varepsilon}) &= b_\varepsilon^0 + \ln(Y_{i\varepsilon}) + b_\varepsilon^{coal} \ln(p_{i\varepsilon}^{coal}) + b_\varepsilon^{gas} \ln(p_{i\varepsilon}^{gas}) + b_\varepsilon^{oil} \ln(p_{i\varepsilon}^{oil}) + b_\varepsilon^{el} \ln(p_{i\varepsilon}^{el}) + \\ &+ 0{,}5 b_\varepsilon^{coal} \ln(p_{i\varepsilon}^{coal})^2 + 0{,}5 b_\varepsilon^{gas} \ln(p_{i\varepsilon}^{gas})^2 + 0{,}5 b_\varepsilon^{oil} \ln(p_{i\varepsilon}^{oil})^2 + 0{,}5 b_\varepsilon^{el} \ln(p_{i\varepsilon}^{el})^2 + \\ &+ b_\varepsilon^{coal\_gas} \ln(p_{i\varepsilon}^{coal}) \ln(p_{i\varepsilon}^{gas}) + b_\varepsilon^{coal\_oil} \ln(p_{i\varepsilon}^{coal}) \ln(p_{i\varepsilon}^{oil}) + b_\varepsilon^{coal\_el} \ln(p_{i\varepsilon}^{coal}) \ln(p_{i\varepsilon}^{el}) + \\ &+ b_\varepsilon^{gas\_oil} \ln(p_{i\varepsilon}^{gas}) \ln(p_{i\varepsilon}^{oil}) + b_\varepsilon^{gas\_el} \ln(p_{i\varepsilon}^{gas}) \ln(p_{i\varepsilon}^{el}) + b_\varepsilon^{oil\_el} \ln(p_{i\varepsilon}^{oil}) \ln(p_{i\varepsilon}^{el}), \end{aligned} \tag{3}$$

where $p_{i\varepsilon}^{coal}$ is coal price for industry ε in period i;

$p_{i\varepsilon}^{gas}$ is natural gas price for industry ε in period i;

$p_{i\varepsilon}^{gas}$ is oil products price for industry ε in period i;

$p_{i\varepsilon}^{el}$ is electricity price for industry ε in period i;

$b_{\varepsilon}^{\cdots}$ are industry parameters.

Demand for products depends on the type of a market. Each industry's product has its market. The markets are classified into two types (table 1).

Table 1. Commodity markets in the model

Production of means of production (P1)		**Production of consumer goods (P_2)**	
Market equilibrium models			
$Y_{i\varepsilon}^{d} = Y_{i\varepsilon}^{I} + Y_{i\varepsilon}^{O}$ $Y_{i\varepsilon}^{r} \le Y_{i\varepsilon}^{d}$		$Y_{i\varepsilon}^{d} = Y_{i\varepsilon}^{I} + Y_{i\varepsilon}^{O}$ $Y_{i\varepsilon}^{r} \le Y_{i\varepsilon}^{d}$	
Demand determining factors			
Domestic market (P_{11})	**Foreign market (P_{12})**	**Domestic market (P_{21})**	**Foreign market (P_{22})**
$Y_{i\varepsilon}^{IA} = \varphi_{\varepsilon}(Y_{(i-1)\varepsilon}^{IA}, S_{i\varepsilon}^{d} \cdot T_{j}^{\mathrm{E}})$, $Y_{i\varepsilon}^{I} = (1 - \lambda_{i\varepsilon}^{imp}) Y_{i\varepsilon}^{IA}$	$Y_{i\varepsilon}^{O} = \varphi_{\varepsilon}(Y_{(i-1)\varepsilon}^{O}, S_{i\varepsilon}^{d} \cdot \overline{T}_{j\varepsilon}^{\ imp}) \psi_{i\varepsilon}$	$Y_{i\varepsilon}^{IA} = \varphi_{\varepsilon}(Y_{(i-1)\varepsilon}^{IA}, PS_{i}^{A}, S_{i\varepsilon}^{d} \cdot T_{j}^{\mathrm{E}})$, $Y_{i\varepsilon}^{I} = (1 - \lambda_{i\varepsilon}^{imp}) Y_{i\varepsilon}^{IA}$	$Y_{i\varepsilon}^{O} = \varphi_{\varepsilon}(Y_{(i-1)\varepsilon}^{O}, S_{i\varepsilon}^{d} \cdot \overline{T}_{j\varepsilon}^{\ imp}) \psi_{i\varepsilon}$

Legend

$Y_{i\varepsilon}^{d}$ is the total demand (in domestic and foreign markets) for the product of industry ε in period i

$Y_{i\varepsilon}^{I}$ is the domestic demand for the product of industry ε in period i, that is satisfied by domestic production

$Y_{i\varepsilon}^{O}$ is the foreign demand for the product of industry ε in period i

$Y_{i\varepsilon}^{IA}$ is the total domestic demand for the product of industry ε in period i, that is satisfied both by domestic production and import

$S_{i\varepsilon}^{d}$ is the demand seasonality index for industry ε in period i

T_{j}^{E} is the effective weight-average growth rate of the industries, that consume the commodities produced by industry ε, and therefore influence the demand for its products in year j ($i \in j$)

$\lambda_{i\varepsilon}^{imp} = f(k_{i}^{c}, \overline{T}_{i\varepsilon}^{M})$ is the part of the domestic demand for the products of industry ε in period i, which is satisfied by import

$\psi_{i\varepsilon}$ is the parameter of substitution of Ukrainian enterprises' products by third countries' products at foreign markets (default $\psi_{i\varepsilon} = 1$)

$\overline{T}_{j}^{\ imp}$ is the effective weight-average growth rate of foreign economies that import the products of industry ε in year j

PS_{i}^{A} is the growth rate of population's purchasing power in period i

Domestic demand can be met by domestic production and by imports; the ratio is determined by the available technology and depends on the exchange rate. A fall of UAH to USD exchange rate leads to a decrease in imports purchasing power of Ukrainian enterprises and citizens, and vice versa.

The equilibrium cost of products sold ($Y_{i\varepsilon}^{rz}$) is calculated as:

$$Y_{i\varepsilon}^{rz} = \min\left(Y_{i\varepsilon}^{d}; Y_{i\varepsilon}^{s}\right), \tag{4}$$

$$Y_{i\varepsilon}^{r} = Y_{i\varepsilon}^{rz}\lambda_{i\varepsilon}^{ex}\frac{k_i^c}{k_{i-1}^c} + Y_{i\varepsilon}^{rz}(1-\lambda_{i\varepsilon}^{ex}), \tag{5}$$

where $\lambda_{i\varepsilon}^{ex}$ is the share of the products exported by the industry in their total cost in period i, $\lambda_{i\varepsilon}^{ex} = f(\psi_{i\varepsilon})$;

k_i^c is the exchange rate (to USD) in period i.

The financial result of sales is profit or loss. Each industry can include both enterprises that profit, and ones operating at a loss.

(A2) *Financial sector* is represented by a number of commercial banks. The activities of the other types of financial intermediaries, particularly those that operate in the stock market, are not modeled specifically within IASBP. This is because the Ukrainian stock market is a major source neither of investment in real sector enterprises, nor of private income for a range of reasons (historical, institutional, etc.).

Commercial banks concentrate temporarily free funds from households and enterprises and distribute them on a fee basis among those clients (individuals and legal entities), that impose the effective demand for financial resources. The gross income of banks is formed as the difference between the interests received from debtors and paid to creditors. Other kinds of services that commercial banks usually provide to their customers and get extra-interest income from are not considered in this case.

Individual deposits. Given the large variety of deposits, which individuals have in banks (demand deposits, time deposits and combined ones, replenishable, partially withdrawable, multicurrency, compound deposits, etc.), the model uses a semiannual representative deposit (D_i^L):

$$D_i^L = f_w(\psi_i^L, W_i^A, T_i^G), \tag{5}$$

where ψ_i^L is the population's propensity to invest into bank deposits in period i;

W_i^A is the total regional net private income in period i;

T_i^G is the Ukrainian GDP growth rate in period i.

Taking into account the Ukrainian realities, the population's propensity to invest into deposits depends more on the economic growth rate (T_i^G), than on deposit interest rate[9] and can be described by the following logistic curve:

$$\psi_i^L = y = \frac{1}{\hat{\alpha}\hat{\beta}^{T_i^G} + \hat{\gamma}}, \tag{6}$$

where T_i^G is the intensity parameter in period i;

$\hat{\alpha}, \hat{\beta}, \hat{\gamma}$ are coefficients, $0 < \hat{\beta} < 1, \hat{\alpha} > 0, \hat{\gamma} > 0.$

The logistic curve is a typical S-form curve with asymptotes $\lim_{x\to\infty} y = \frac{1}{\hat{\gamma}}; \lim_{x\to-\infty} y = \frac{1}{\hat{\gamma}}.$

Corporate deposits, which are the legal entities' recourses borrowed by banks (demand deposits, time deposits) depend on their working assets in the previous period $(K_{i-1}^{vr} = \sum_{\varepsilon\in E} K_{(i-1)\varepsilon}^{vr})$ and are calculated by the formula

$$D_i^v = f_d(K_{i-1}^{vr}, T_j^G). \tag{7}$$

Financial intermediaries act as entrepreneurs who sell goods, money in this case. This means that, within available resources, they provide interest-bearing loans to enterprises of all industries and to population.

The following sequence of credit settlement is adopted in IASBP:

1) the funds borrowed by commercial banks (liabilities), that make their credit base, are decreased by legal reserve rate for active operations;

2) the credits are given to legal entities;

3) the credits are given to individuals;

4) the surplus is invested into financial capital (securities, interbank loans, etc.).

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[9] For a number of institutional reasons, the Ukrainian households do not actually have any other access to capital markets than through commercial banks. Yet, the real (inflation-adjusted) bank deposit interest rates may be negative. For example, in each month in 2006, average interest rates (annualized) on individual deposits did not exceed 11%, while the consumer price index (CPI) accounted to 111.6%. Only the individual time deposit interest rates were higher than the CPI. In 2007, weight-average interest rates on retail deposits in national currency did not exceed 14%, while the CPI (2006 = 100%) reached 16.6%. At the same time, the real (i.e. adjusted for GDP deflator) amount of retail deposits increased by 25%. In 2008, the weighted average interest rate on individual time deposits in national currency did not exceed 20%, while the CPI growth rate was 22.3%. A similar situation was observed in 2009-2010.

Thus, at first glance, there is a paradoxical situation: real interest rates are negative, but deposits are increasing.

In fact, there is nothing paradoxical in this. With no real investment alternatives, the households tend to minimize the inflation impact on savings and the risk of cash self-storage through depositing funds in commercial banks. The dominant impact on their decision comes not from the deposit interest rate, but from the availability of temporarily idle cash balances, which, in turn, is determined by the economic growth. The proposed functions of the propensity to invest reflect this fact.

(A3) *Public sector* is represented by a range of legal entities endowed with state or municipal property on operational management basis and performing non-commercial functions. These are budgetary organizations and extra-budgetary funds. All of them are grouped in accordance with the established functional classification of expenditure (CFCE).

They receive funding from the regional and state budgets (budget organizations) and from the payers of social contributions (extra-budgetary funds) to provide public administration, education, healthcare, welfare, etc. Other funding (self-financing and charitable contributions) is not specifically reviewed in this case and is considered to be quasi-permanent.

IASBP uses the approach, which is that, for modeling purposes, budget organizations are considered not as really functioning physical objects but as "black boxes" that input the affordable state funding from, and output public services provision. The internal structure of these «black boxes» (the condition of fixed and working capital, manufacturing process specificity, actual financial needs in terms of sustainable growth, etc.) is not investigated. This approach is technically easier to implement, and it better reflects the specifics of budget process organization in Ukraine, where the financing of budget organizations' costs is determined by not real, but the so-called "optimal" needs, that is, those that are a pragmatic compromise between the demands of organizations for their normal operation and development on the one hand, and the real possibilities of cost coverage from the budget on the other hand.

IASBP uses the second budget organizations modeling approach. In essence, this means modeling not the organizations themselves but their budget functions (purposes).

The degree of the functional disaggregation of the expenditure. IASBP models the basic functions performed by budget organizations. Further expenditure disaggregation of particular functions to sub-functions (e.g., for health care it would correspond to medical specialization) is not provided at the current stage of IASBP development.

A model forecasting the expenditure for item γ (budget expenditure function) can be formally represented as

$$^{-}X_{\gamma i} = f_X\left(^{-}L_{\gamma i}, ^{-}E_{\gamma i}, ^{-}O_{\gamma i}\right) + ^{-}F_{\gamma i}, \tag{8}$$

where $^{-}L_{\gamma i}$ is the general budget fund spending for labor payment with charges in period *i*;

$^{-}E_{\gamma i}$ is the general fund spending for utilities and energy in period *i;*

$^{-}O_{\gamma i}$ is other spending of budget general fund in period *i;*

$^{-}F_{\gamma i}$ is the special budget fund spending in period *i.*

Tax payments by legal entities and individuals are the major source of budget revenue. In accordance with the Budget Code of Ukraine, they are distributed between the state budget and local budgets. Such weighty national taxes, like VAT, profit tax, personal income tax, land charge, excise and customs duties (for import and export) are modeled particularly in IASBP. Some of them come to the State Budget of Ukraine fully or partially (VAT, profit tax, excise and custom duties), while the others get to oblast budget system (personal income tax and land charge). All the other taxes are not specified in IASBP, as being unimportant for public revenue generation.

(A4) *Population* links oblast economy into a whole. On the one hand, the residents of certain area are the source of labor for the real sector enterprises, financial institutions and public sector organizations. On the other hand, people receive income in the form of wages, interest, and

social benefits (pensions, welfare, etc.) that determine the real demand for consumer goods and the amount of savings that can be used to finance the extended reproduction of the economy.

IASBP represents the economically active population, i.e. people aged 15 to 70 years, who provide labor supply to produce goods and services (private and public) in oblast economy. The population consists of two groups: employed and unemployed.

An industry's labor demand is determined by capital maintenance needs

$$Q_{\varepsilon i}^{Ld} = f^{Q}(K_{i\varepsilon}). \tag{9}$$

As already noted, IASBP assumes that oblast labor supply sustainably exceeds the demand, and therefore the equilibrium number of employees is determined by the demand

$$\sum_{\varepsilon \in \mathrm{E}} Q_{\varepsilon i}^{Lr} = \sum_{\varepsilon \in \mathrm{E}} Q_{\varepsilon i}^{Ld}. \tag{10}$$

In turn, the total number of unemployed in period i is defined as

$$U_i = \max\left(U_{i-1} - \sum_{\varepsilon \in \mathrm{E}} \Delta Q_{\varepsilon i}^{Lr}; 0 \right), \tag{11}$$

where U_{i-1} is the number of unemployed in the previous period;

$\Delta Q_{\varepsilon i}^{Lr} = Q_{\varepsilon i}^{Lr} - Q_{\varepsilon (i-1)}^{Lr}$ is the aggregate change of labor requirement in industry ε in period i.

Aggregate average wage determines labor motivation and features the capacity for labor reproduction, professional and cultural development. It depends on the total payroll and the number of employed

$$w_{i\varepsilon} = f_l\left(L_{i\varepsilon}^{m}, Q^{L}{}_{i\varepsilon} \right), \tag{12}$$

where $Q^{L}{}_{i\varepsilon}$ is the number of employed in industry ε in period i.

Net total oblast household income (W_i^A) is defined by the formula

$$W_i^A = f_w\left(\sum_{\varepsilon} (L_{i\varepsilon}^{m} - \Xi_{i\varepsilon}^{w})\right). \tag{13}$$

Consumer purchasing ability growth rate is defined as

$$PS_i^A = \frac{W_i^A}{W_{i-1}^A} \frac{M_i^{pens}}{M_{i-1}^{pens}} \frac{t_{ib}^V}{t_i^V} \frac{t_{ib}^A}{t_i^A} \frac{k_i^c}{k_{ib}^c}, \tag{14}$$

where ib is the ordinal number of the period previous to tax rate change.

5. Models of economic and financial regulators

The state, represented by legislative and executive agencies, influences regional social and economic processes with regulators, by which we will understand the market intervention instruments applied to the commodity, capital, labor and public service markets.

The regulators are divided into economic and financial ones. IASBP includes the following economic regulators:

minimum wage;

energy prices (gas, oil products, coal, electricity).

Among the financial regulators there are:

national currency exchange rate (UAH/USD);

tax rates (including social taxes).

Tax impact on the public service quasi-market. Taxes directly affect the supply (budget revenue) through the changing of compulsory payments bases and rates. On the demand side (expenses by functional classification), tax impact is both direct (wage charges paid by the employees of public institutions), and indirect, through oblast economic growth that depends on the tax impact in commodity markets.

As follows from the above, the tax effects on the behavior of companies that operate in commodity markets are of the key importance. Therefore, they are discussed in more detail further.

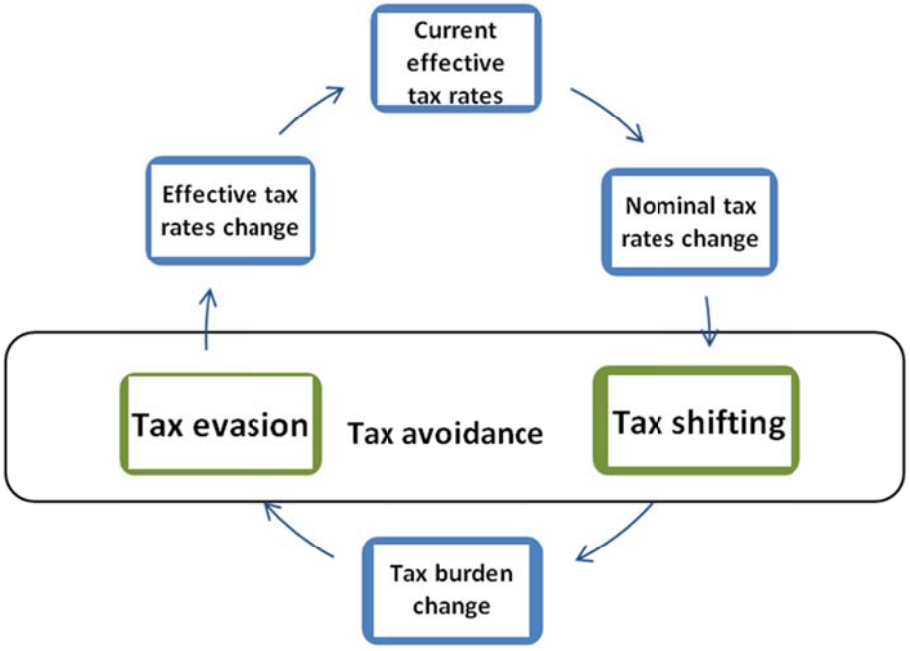
Taxes affect the behavior of corporate taxpayers[10] through the forced nonequivalent seizure of a part of their revenue for public purposes. Therefore, if there were no tax evasion costs, the companies would not pay taxes at all. However, as far there are such costs, so far the rational and fully informed economic agents (as it is considered in neoclassical economic theory) partially pay taxes and partially evade them, having compared the marginal benefits and marginal costs of tax evasion. Institutional and evolutionary theories assume that economic agents are not completely rational and informed. Therefore, the rules (institutions) that prevail in a given place at a given time define the "official payments/corrupt payments/covert tax base" proportion. The rules reflect the "path dependence," i.e. the current events depend on the past circumstances as well as on the current ones.

In any case, the change of the nominal (statutory) rate of any tax runs the chain of economic processes, the sequence of which is presented in Figure 3.

In the initial situation, an enterprise calculates the income tax liability by the rates specified in tax returns (single one as in the case of profit tax, or several returns as in the case of excise duty or customs duty). However, the actual tax payments may be less (due to tax reliefs, credits, exemptions, underpayments) or more (due to the advances, penalties, overpayments) than the rated value. The ratio of the amount actually paid to the declared (legal) tax base is the actual legal average tax rate j ($\tilde{t}_j^n$).

[10] IASBP assumes that all taxes are paid by enterprises, including the personal income tax, which is charged from the source of payment.

Figure 3. Nominal tax rates impact on effective tax rates



At the same time, a total tax base typically includes both declared (legal) and undeclared (illegal, unreported) components. This means that actual total average tax rate $(\tilde{t}_j^r)$ is calculated as the ratio of actual tax payment *j* to the total tax base and is different from the legal average $(\tilde{t}_j^r \neq \tilde{t}_j^n)$.

Ukrainian tax system comprises several different taxes, including the interrelated ones. Therefore, businesses are interested not in any single tax rate raise or reduction, but in the total tax burden change.

Overall tax ratio describes the total enterprise-borne tax burden, emerging from all statutory taxes.

Let the actual legal tax ratio $(\mathrm{T}_{i\varepsilon}^n)$ denote the ratio of the total amount of tax payments to the value-added declared by all the enterprises in industry ε in period *i*

$$\mathrm{T}_{i\varepsilon}^n = {}^{+}\Xi_{i\varepsilon}^{\mathrm{T}} / V_{i\varepsilon}^A, \tag{15}$$

and the actual total tax ratio $(\mathrm{T}_{i\varepsilon}^r)$ denote the ratio of the total tax payment to the total value-added (including the covert tax base) in industry ε in period *i*

$$\mathrm{T}_{i\varepsilon}^r = {}^{+}\Xi_{i\varepsilon}^{\mathrm{T}} / \bar{V}_{i\varepsilon}^A. \tag{16}$$

If the law provides, for example, an increase of some tax rate, then, at the given tax base, this leads to the planned increase of tax liabilities. These additional liabilities can either make an additional burden on an enterprise, and can be shifted (in whole or in part) to the resource suppliers or product buyers through the price mechanism. Such a shift, other things being equal, is the easiest and most economical way of avoiding taxes.

If tax shifting opportunities are limited, then at least a part of the additional tax burden falls on an enterprise resulting in the increase of planned total tax ratio and, consequently, planned legal tax ratio. We refer to it as "planned" because a rational (bounded rational) economic agent seeks to evade state-imposed additional liabilities using all available opportunities. Such actions reduce the increase of actual total tax ratio (which is the purpose of evasion), and, consequently, of actual legal tax ratio. The latter is important because shadow business income is not specified in IASBP models, and enterprises' reactions to the government's actions in the field of taxation are tracked through the legal tax ratio. The reverse reaction is expected from an enterprise if the planned total tax liabilities are reduced.

The composition of tax coefficients (ratios) is determined by IASBP specifics of economic processes modeling and depends on the type of tax. All taxes are divided into two types:

(H1) taxes that act as a product price surcharge (VAT and excise duties[11]);

(H2) taxes, which constitute a part of product price (corporate profit tax, wage charges, land charge, import customs duty[12]).

This distinction is important from the standpoint of the tax shifting modeling. Tax shifting varies across the particular commodity markets (see P_{11}, P_{12}, P_{21} and P_{22} in Table 1).

6. IASBP formation and maintenance technology

The practical implementation of IASBP model set has required:

1) establishment of the information support, i.e. to develop the methodical provisions and datasets of socioeconomic indices, that characterize the operation of oblast economy in retrospective;

2) parameterization of the models using these actual data, i.e. to calculate the numerical values of the variables and constants in the formulas that mathematically describe the processes simulated;

3) implementation of the developed mathematical models in system dynamics environment, to check their stability (the ability to maintain the current state in the presence of external influences) and adequacy (the ability to reproduce the main features of the system's behavior (Forrester J. W., [1970], Forrester J. W., [2007]);

4) development of IASBP software based on system dynamics principles;

5) development of the organizational support for IASBP.

Checking the model set for adequacy was performed by comparing the estimated values of the targets for the planning period (i = n+1) to their actual values (Table 2).

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[11] Export customs duty is a price surcharge too. However, in Ukraine it is applied to a limited range of goods and has a small share in the total amount of taxes. Thus, its influence on the behavior of economic agents is not considered in IASBP.

[12] Group H1 does not include personal income tax. This tax is neutral for enterprises: it reduces personal incomes of individuals, but does not apply to any costs or profits of legal entities. Of course, in practice, there are no completely neutral taxes at all, and personal income tax touches the economic interests of enterprises. The tax reduces the real wages of workers. This may lead to labor outflow if labor market situation is adverse to the employer, so he is forced to hold staff by incurring at least a part of personal income tax load. However, in this case, we do not take this into account, based on the realistic assumption that labor supply is excessive in Ukraine.

Table 2. Comparison of the estimated and actual values of Donetsk oblast economic indicators for the first half of 2010[13]

Real sector, UAH million						
CTEA	Y_i	$\hat{Y}_i$	Error	L_i^m	$\hat{L}_i^m$	Error
CA	13 573	13 239	2.5%	2838	2941	3.6%
CB	2259	2166	4.1%	244	240	1.6%
DA	7231	7131	1.4%	421	410	2.6%
DJ	65 009	66 840	2.8%	1647	1788	8.6%
DK, DL, DM	13 878	12 667	8.7%	884	871	1.5%
G	74 927	74 838	0.1%	762	662	13.1%
I	9747	9707	0.4%	1428	1578	10.5%
X	38 885	38 729	0.4%	3082	3801	23.3%
Total	**225 509**	**225 317**	**0.1%**	**11 306**	**12 291**	**8.7%**
Financial sector, UAH million						
	D_i	$\hat{D}_i$	Error	B_i	$\hat{B}_i$	Error
Individuals	21 267	20 203	5.0%	14 089	16 219	15.1%
Legal entities	11 539	12 654	9.7%	35 033	37 630	7.4%
Total	**32 806**	**32 857**	**0.2%**	**49 122**	**53 849**	**9.6%**

Public sector, UAH million							
Revenue section of the oblast budget				**Expenditure section of the oblast budget**			
Revenue items	${}^{+}\Xi_i$	${}^{+}\hat{\Xi}_i$	Error	CTEA	${}^{-}X_i$	${}^{-}\hat{X}_i$	Error
${}^{+}\Xi_i^w$	2647	2648	0.0%	${}^{-}X_{01,i}$	253	253	0.2%
${}^{+}\Xi_i^E$	492	492	0.0%	${}^{-}X_{07,i}$	1840	1978	7.5%
${}^{+}\Xi_i^{\mathrm{T}}$	3386	3686	9.0%	${}^{-}X_{08,i}$	1557	1550	0.4%
				${}^{-}X_{09,i}$	182	189	3.8%
Official transfers	2440	2422	0.6%	${}^{-}X_{10,i}$	193	288	48.7%
				${}^{-}X_{11,i} + {}^{-}X_{13,i}$	283	282	0.3%
Total revenue	**3911**	**3911**	**0.0%**	**Total expenditure**	**6031**	**6048**	**0.3%**

***Legend*:** $\hat{Y}_i, \hat{L}_i^m, \hat{D}_i, \hat{B}_i, {}^{+}\hat{\Xi}_i, {}^{-}\hat{X}_i$ are the estimated values of indicators; $Y_i, L_i^m, D_i, B_i, {}^{+}\Xi_i, {}^{-}X_i,$ are the actual values of indicators.

[13] The variables and constants used to calculate the predicted values of the indicators for the second half of 2010 had been parameterized with 1HY 2006 to 2 HY 2009 dataset.

The IASBP model set's ability to reproduce the trends of the regional economic dynamics is illustrated in Fig. 4.

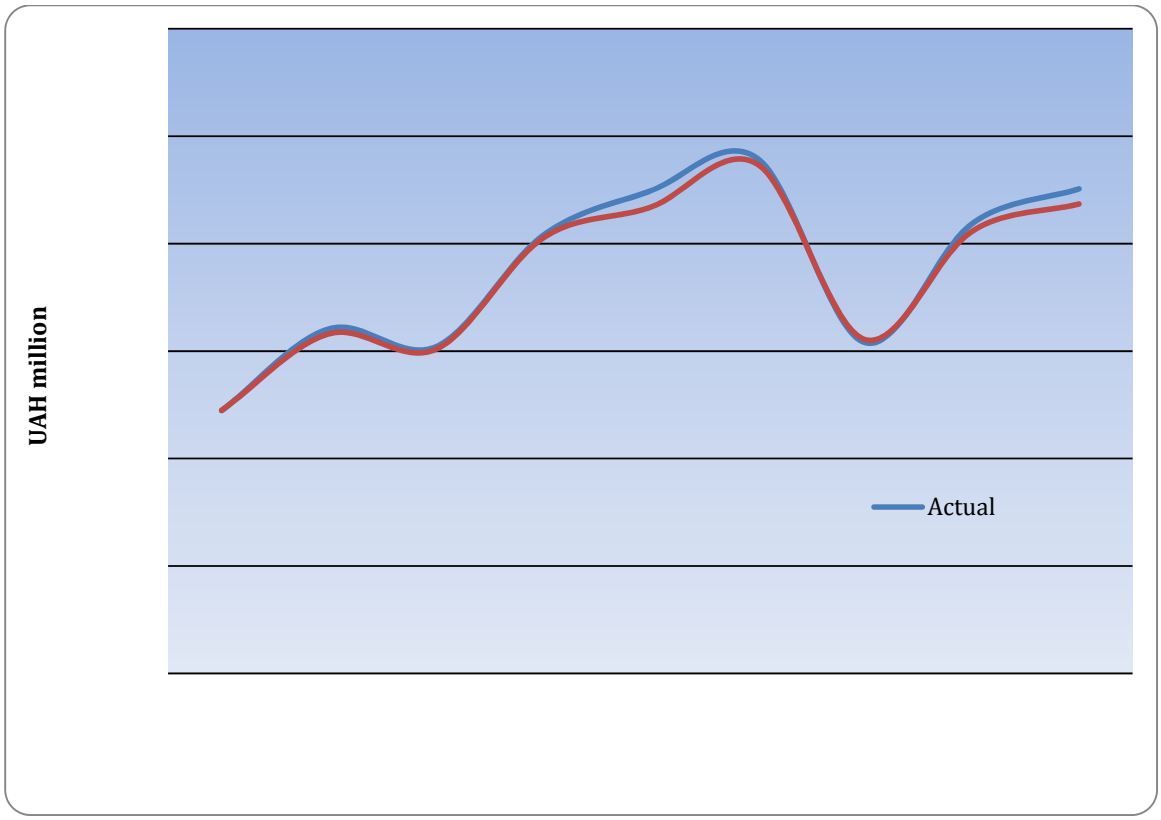
As follows from the figure, the estimated sales trend matches the actual one well. As far as many other key economic indicators depend on sales, so far the test for adequacy can be considered as passed.

Checking the stability of the model set. The stability in this case refers to the ability of the models to maintain their properties under the influence of changing the values of input variables. The following algorithm is used: 1) select the input variables; 2) set a rule of their values change (random variable distribution function); 3) select the current value of a variable within the tolerance region[14] using random number generator; 4) calculate the targets of a model; 5) repeat steps 3 and 4 several times. When the procedure is complete, the parameter spread analysis leads to a conclusion about the model set stability.

Economic and financial regulators, i.e. minimum wage, energy prices, tax rates, UAH to USD exchange rate, were used as the input variables. The model has demonstrated a sufficient stability after 1000 experiments: the main targets' deviation from their initial values (commodity sales and labor costs in the cost) does not exceed 25%.

IASBP is implemented as a software tool based on information technology. It belongs to the class of decision support systems, the subclass of situation centers. The purpose of a situation center is to support the real time analysis of actually occurring and hypothetical situations and forecasting their evolution under the planned management actions.

Figure 4. Actual and estimated aggregate sales revenue trends in Donetsk oblast



[14] It is set by experts with regard to realistic considerations (e.g., profit tax rate cannot exceed 50%, annual economic growth rate does not exceed 20%, etc.).

The following basic tools are used in IASBP software:

Microsoft Excel application package applied for raw data processing and model parameterization;

PowerSim system dynamics environment, for the implementation and configuration of the mathematical economic model set;

Microsoft Visual Basic.NET programming environment, which integrates Basic syntax and the elements of object-oriented and component-oriented programming languages, is used to create the user interface and to arrange the data access;

Microsoft SQL Server database management system is used for storage and structuring of, and to provide a reliable and secure access to IASBP data stores;

database query language of TRANSACT-SQL programming environment, which implements ANSI/ISO standard is used to perform structured queries with extensions.

The main elements of IASPB software are:

database, the statistical data about the activities within the real, financial and public sectors and population, regulatory and reference information, model estimates;

import utility to input statistical data from Microsoft Excel templates into the database;

interpretative program for Powersim SD models presentation in IASBP;

IASBP user interface implemented in Microsoft Visual Basic.NET programming environment.

7. Conclusion

When the primary problem of IASBP creation was set, there were serious concerns that it would not be solved. But this was neither because the authors were skeptical about the feasibility of mathematical models and information technology in economics (although the "presumption of guilt" in mathematical formalism has a right to exist) nor because ones do not have a sufficient experience in solving complex scientific problems. There was another reason, namely that the simulation object is very complex and, just as important, only partially open to observation: shadow economy accounts for, according to various estimates, 40-50% of GDP in Ukraine.

It turns out that the behavior of the object must be judged only by the behavior of its explicit part. If we draw a physical analogy, we have to predict the movement of an iceberg by the observations of the above-water part. Physicists by some indications can identify the shape and weight of iceberg's underwater part, and, accordingly, make scientific predictions (verifiable statements) about the direction and speed of the whole body's movement by the forces of wind and water. In the case of an economic system, as the experience of IASBP creation shows, reliable scientific predictions of development trends are theoretically possible. However, the usual tools based on the assumption of agents' rationality (bounded rationality) alone are insufficient. This is not because agents behave irrationally (unpredictably), but because the actual rationale for their behavior is hidden from the observer.

The solution of this difficult problem is partly facilitated with the 'inside' knowledge of the situation and understanding of the fact that human behavior is usually not arbitrary but framed by the institutional rules prevailing in a given place and at a given time. In view of this circumstance, one cannot expect a drastic transformation of economic system to occur in a small time interval (while the existing institutions remain). The way to solve the problem of scientific predictions based on incomplete information proposed and tested in IASBP is to construct an

inductive analogue of such rules in the form of relatively stable relationships identified between the official economic indicators, which indirectly reflect the "underwater" part of the economy.

In practice, this tool really works. In conjunction with other economic, mathematical and information processing tools, it enabled us to develop and practice IASBP buildup and support technology. It allows for creating and updating the databases describing the economic processes in oblast and national economy; producing and analyzing various scenarios for their mid-term dynamics; performing computational simulations aimed to assess the extent of various economic and financial regulators' impact on particular oblast economies and the overall economy of Ukraine.

But, of course, this does not mean that all major problems have been solved.

First, in order to properly delineate the scope of IASBP and understand when it predicts correctly, and when it already begins to make mistakes, one should know the country-specific "half life" of the dominant rules. Obviously, in our case it is more than a year (during this time new rules can appear, but it is difficult to distribute them across the region or country), but less than twenty years (two decades ago, Ukraine was a quite different socialist country inhabited by people with moral norms and rules of economic behavior, that are distinct from modern ones). So a three-year forecast period, adopted in IASBP, in principle, can be considered as one of the acceptable options.

Secondly, it is not enough to identify the period; we must also know the general trends of rule change. For this, it should be noted that behavior patterns, varying in time and space, are not only determined by external forces (e.g., punishments and rewards), but depend on the internal biological nature of man as well, "External signals and ontogenesis of each person interact with genetic predisposition in each specific situation, creating myriads of complex patterns of behavior" (Palmer J., Palmer L, 2002). It means that the complete research program for the problem should include the methods of evolutionary economics, aimed at identifying the long-term trends of economic populations' development. This is a school of economic thought, which emerged rapidly in recent decades (Stoelhorst J.W., 2008), but its scientific principles have not yet been fully exploited in the design of the IASBP presented here.

Thirdly, we need a mechanism to anchor the mid-term forecast parameterization to the vector of long-term evolutionary trends.

Obviously, these will be very difficult things to do. The work in this area is ongoing.

8. References

1. Allais M. Abondance ou misere. Propositions heterogenes pour le redressement de 1'economie francaise. Editions politiques, economiques et sociales, Paris, 1964.
2. Bassia A.M., Yudkenc J.S., Ruthd M. (2009) Climate policy impacts on the competitiveness of energy-intensive manufacturing sectors. Energy Policy Volume 37, Issue 8, pp. 3052-3060.
3. California Department of Finance (1996). Dynamic Revenue Analysis for California. [ONLINE] Available at: http://www.dof.ca.gov/html/fs_data/dyna-rev/dynrev.htm. [Last Accessed 25 September 13].
4. CGE модель социально-экономической системы России со встроенными нейронными сетями . http:.data.cemi.rssi.ru/GRAF/center/models/cge/cge7. htm.
5. Christensen L, Greene W (1976) Economies of Scale in U.S. Electric Power Generation. The Journal of Political Economy, Vol 84, No 4, Part 1, pp 655-676.
6. Fagiolo G., Roventini A. On the scientific status of economic policy: a tale of alternative paradigms. Working paper № 47. Universita di Verona, Dipartimento di Scienze economiche. 2008.
7. Forrester, Jay W. (1970) World Dynamics. Portland, Oregon: Productivity Press.
8. Forrester, Jay W. (2007) System dynamics – a personal view of the first fifty years // System Dynamics Review, 23, 345-358.
9. Friedman M. Essays in Positive Economics. Chicago: University of Chicago Press, 1953, p.3–43.
10. Kanazawa S. In Defense of Unrealistic Assumptions. Sociological Theory, 1988, Vol. 16, № 2, pp. 193-204.
11. Meadows D.H., Jorgen R., Meadows D.L. The limits to growth: the 30-year update. – Vermont: Chelsea Green Publishing Company, 2004. – 338 p.
12. Model Building: RMSM-X Reference Guide. – Washington, DC: World Bank, Development Data Group, Development Economics, 1995.
13. Nagel E. Assumption in Economic Theory . American Economic Review, 1963, Vol. 53, № 2, pp. 211-219.
14. Palmer J., Palmer L. Evolutionary Psychology: The Ultimate Origins of Human Behavior. 2002. Pearson. 304 pp.
15. Robbins L. An Essay on the Nature and Significance of Economic Science. 2nd ed. London: Macmillan, 1935, ch.1, p.1–23.
16. Searle J. R. What is an Institution? Journal of Institutional Economics. 2005. Vol. 1. № 1. P. 1 – 22.
17. Stoelhorst J.W. The Explanatory Logic and Ontological Commitments of Generalized Darwinism . Journal of Economic Methodology, 2008, vol. 15, № 4, pp. 343-363.