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USE OF DIFFERENT METHODS FOR SCENARIO FORECASTING OF ECONOMIC AND MATHEMATICAL ANALYSIS ON THE EASTERN EUROPE EXAMPLE

O. Tarasova
Kyiv National Taras Shevchenko University
prosp. Akademika Glushkova, 4d, Kyiv, 03680, Ukraine. E-mail: olga_ta@bigmir.net

This paper attempts usage mathematical tools to investigate some scenarios of the development of market economic relations between Ukraine and Hungary. Formation of new economic structures and aggregation of markets in certain countries require additional tools for analysis and forecasting of economic processes on more global level. The possibilities and prospects of economic cooperation between the EU and the post-soviet countries can be explored in miniature by example of these two countries. The object of the investigation is the mathematical models of functioning and interaction of economic agents of market economic sphere in Hungary and Ukraine. Similar models can be used for analytical and prognostic research of market economy in separate regions and the whole country.

Key words: mathematical modeling, economic models, prediction.

ЗАСТОСУВАННЯ РІЗНИХ МЕТОДІВ СЦЕНАРНОГО ПРОГНОЗУВАННЯ ДЛЯ ЕКОНОМІКО-МАТЕМАТИЧНОГО АНАЛІЗУ НА ПРИКЛАДІ КРАЇН СХІДНОЇ ЄВРОПИ

О. В. Тарасова
Київський національний університет імені Тараса Шевченка
просп. Академіка Глушкова, 4д, м. Київ, 03680, Україна. E-mail: olga_ta@bigmir.net

Зроблено спробу застосувати математичний апарат для дослідження деяких сценаріїв розвитку ринкових економічних відносин між Україною та Угорщиною. Формування нових економічних структур і агрегація ринків у деяких країнах вимагає додаткових інструментів для аналізу і прогнозування економічних процесів на більш глобальному рівні. Можливості та перспективи економічного співробітництва ЄС і пострадянських країн можуть бути вивчені в мініатюрі на прикладі цих двох країн. Об'єктом дослідження є математичні моделі функціонування та взаємодії економічних агентів ринкової економіки Угорщини та України. Подібні моделі можуть бути використані для аналітичної та прогностичної досліджень ринкової економіки в окремих регіонах й у країні в цілому.

Ключові слова: математичне моделювання, економічні моделі, прогнозування.

PROBLEM STATEMENT. The history of development of market economy in Ukraine and Hungary is similar because of the common Soviet past. Both states in their economic development have passed a stage of state regulation that has been gradually changing into open-type market relations. But in time, the rate of this economic transition in the Hungarian case was noticeably faster compared to Ukraine. Neighboring and the similar historical past as well as similar systems of resources point to the importance of experience exchange for Ukraine concerning the formation of economic mechanisms and tools which are characteristic of market economies. Let us look at these two countries separately.

Hungary. After overcoming the soviet period, Hungarian economy started a new stage of economic development and, not without difficulties, came out of the crisis. Reformation of the country's economy entailed growth of unemployment and inflation, temporary recession of the level of life of great masses of population. Planned socialistic economy was replaced by the market system. After 1989, the Hungarian foreign policy had fundamentally changed. Joining the process of European integration and particularly aiming for the membership in NATO and EU had become its highest priorities. In 2004 Hungary had already joined the EU. A long period of transition from planned economy of soviet type to market economy entered a new stage of switching to market economy of European type [1–3]. Other European countries have also had such experience [2, 4, 5].

New stage means new priorities. More and more attention is given to foundation and development of small and medium-sized enterprises, which was enabled only by market economy [6].

Hungary takes active steps towards involving Ukraine into cooperation within the project "Ukraine–Vyshegrad Group of Four–EU". It aims to establish a close interaction between the "V–4" countries and Ukraine in the issue of upgrading the border between Ukraine and its western neighbors, which became outer boundary of EU.

In order to remove obstacles in trade, measures have been taken to adjust with Hungarian part trade limits on import of single Ukrainian products to Hungary. After consulting at the level of experts of Emergency Ministry of Hungary and Ministry of Economy of Ukraine, the Hungarian part has cancelled the limits on import of several products from Ukraine.

Ukraine. The period of planned economy lasted much longer than in Hungary, Poland, Romania or Slovakia. Its foundations take much deeper roots and require much more time for transformation. Nowadays Ukraine, as any other post-soviet country, is characterized by high level of monopolization, discrepancy between technologies that were created before and new conditions of management, lack of approved mechanisms of market self-regulation, which were being formed for decades in the countries with market economy. It leaves a mark, particularly, on the course of many macroeconomic processes, well-studied in other conditions [7].

Let us consider, for example, inflation. It is obvious that in conditions of monopolized economy, a monopolist can react on the decrease of demand by considerably increasing the price and forward decrease of supply. As a result, inflation, and specifically stagflation (a combination of inflation and recession) will be intensified along with the decrease of nominal monetary aggregate and income of end consumers. But these very measures underlie any recommendations on anti-inflation policy, designed and tested in conditions of developed market economy. Thus even the theses, used as axioms by economists, should be tested in conditions of transition economies by special investigation, including the application of quantitative methods and economic-mathematical modeling.

EXPERIMENTAL PART AND RESULTS OBTAINED. As an economic agent we choose a mathematically formalized functional unit working in its own interests in some conditions. Some of the economic agents were stated and described by Hungarian, Ukrainian and Russian scientists [7–10]: population, producers, traders, banks, the administration and the market sphere. It is considered that the aforementioned economic agents work independently in their own interests, not taking into account the interests of other agents, and their common activity characterizes the state of national economy.

The analysis of the two countries' economy allows drawing the following conclusions:

– Both countries go through the stage of transition economy of different types. It assumes the same set of economic agents for modelling with a different structure of parameters.

– The economic structure of Hungary is more stable, than that of Ukraine, which reflects in macro showings of the model.

– In order to describe the structure of interaction of agents the "producer" can be aggregated to macro level, as interchange of goods and services is more important for the two countries than common production.

– The political strategy of a country towards a partner country may set value of dirigible showings of the government (export tax, import tax, etc.).

The East-European scientific research in the field of economic modelling is dedicated to detailed study of classical and modern mechanisms of developing and functioning of market economy [8, 9]. In these works [11, 12] the approach of linguistic unification of the concepts base, used by economists of different fields, is analyzed. It is worth mentioning that the implementation of such approach may become a bridge between economists and experts in applied mathematics. The unification of concepts in different fields of economy can contribute to mathematical formalization of economic processes and phenomena, which is especially important for mathematical investigation of complex intersectoral economic systems.

East-European scientists pay great attention to solving applied problems that occur in practice [1, 13, 14]. Particularly, it refers to research of economic processes concerned with small and medium enterprises [1, 13, 14]. For the post-soviet countries it is an important issue, which hasn't been developed enough. It is small and medium businesses that enable overcoming total monopolization of planned economy and form the basis of market relations structure.

In Russia, the problem of economic modeling has been studied since 1990s. Detailed analysis of economic structure transformation was carried out using mathematical apparatus of the research on mathematical analysis, methods of investigating operations, system analysis, decision-making theory, multicriteria linear and non-linear optimization, game theory, probability theory. The result of research of transition period by the scientists in Moscow is described in [15, 16].

In Ukraine, investigations started with modeling of inflation dynamics during the transition period [7]. The impact of monopolized price formation in single sectors on prices and overall volume of production was studied. Models of intersectoral balance are an effective tool to study such effects. Considering this, a model was designed that can be regarded as a summary of well-known web-like schemes of price calculation. Besides, forecasting probable sudden monopoly price changes and their consequences, this model allowed discovering the inner sources of expenses as well. Calculations by this model determined ways of the maximum increase of end consumption by decreasing production expenses. A whole class of Ukrainian mathematical models is underlied by the modified Leontyev model. Modifying the classical model of intersectoral balance by differentiation of old and new technologies enabled reaching successful results in transitional economies modelling [16]. The Leontyev model modified in such a way is especially convenient for practical work with statistics of the post-soviet countries.

Works of mathematicians and economists of North and South America are important for understanding the results obtained by East-European scientists. Particularly, Latin America, while going through similar processes, had experience in mathematical modelling and forecasting of economical processes of structure transformation and transition from one type of economy to another. The mathematical model which allows analysis of macroeconomic indicators in the period of structural reforms of the economic system was created within the research [17]. The research published in the *Journal of International Economics* give a detached view on the dynamics of developments in Eastern Europe and The Soviet Union and their impact on the world economy in general [2]. Such works are important for deeper understanding of the processes that take place in the countries of Eastern Europe in the global context.

The optimization theory, numeral methods, mathematical modelling and theory of dynamic systems are also used in the work as mathematical tools, necessary for modelling of economic processes and for analysis of obtained equations sets [8, 18–22].

Our economic system consists of the following economic agents: production and management, population, government, and the banking system. Regulation by the government is possible due to the adjustment of tax rate

and interest rate. System of two-commodity model is described in detail in [23]. Our model consists of four submodels which describe the economic agents (the producer, population, the Government, the banking system), the financial balance equations (for the producer, for the workers and for the proprietors as the parts of population, for the Government, for the banking system), three subsystems that describe markets (product market, capital market and labor market) and subsystem of macro indexes (demand for imported inputs of the tradables and non-tradables sectors, aggregated demand, import, export, general price level, nominal exchange rate, actual inflation rate). The model has 39 equations including four balance equations.

The producer. In this model the producers realize products without any assistance; therefore the agent "trader" is absent. The price p also is the product index in the market. Manufactures, the population groups, and the Government are the product buyers. Parameter n_p is the income tax rate for manufactures. Supplies of products are supposed to be counted from a constant level of an operational stock, which is necessary for the uninterrupted market functioning. In this case the stock may have negative value.

$$
\begin{aligned}
&Y = Mf(x);\\
&Y^s(p,s) = Mf(x);\\
&R^d(p,s) = xM;\\
&\frac{dM}{dt} = I - \mu M;\\
&\Phi^I = \widehat{O}^I = pbL; J = bI;\\
&\Phi = \Phi^I + \Phi^L + \Phi^O + \Phi^G;\\
&\frac{dQ}{dt} = Y - \frac{\widehat{O}}{p};\\
&x = \frac{R^L}{M};
\end{aligned}
$$

where R^L – amount of labour used in production; $f(x)$ – neoclassic production function; M – total production capacity; s – rate of wages; p – product price; Y^s – product supply; R^d – producer's demand for labour; $I(t)$ – long-term management of investments; Φ^I – stream of investments; J – stream of product which forms the basic assets; μ – rate of amortization; b – rate of capital intensity of a product; Φ^O, Φ^L – expenses of the population groups for products purchases, Φ^G – expenses of the government for products purchases; Q – product stocks.

Population. The agent can be described by such indicators: ω – level of material consumption; P – number of workers; P^A – number of able-bodied persons; $\lambda_p > 0$ – fixed rate of demographic growth; R^s – offer of a labour; $U(\omega) > 0$ – limited for all ω function; Φ^O – part of profit which is spent for consumption; η_0 – part of cost of gross national product which proprietors consume; r_2 – interest rate for deposits; p – product price; Y – volume of the made product.

$$
\begin{aligned}
&\omega = \frac{\widehat{O}^L}{pP};\\
&R^s = P^A U(\omega);\\
&P = P_0 \exp(\lambda_p t);\\
&P^A = P^A{}_0 \exp(\lambda_p t);\\
&\Phi^O = \eta_0(r_2) pY.
\end{aligned}
$$

The Government. Variables π, r_G (interest rate of bonds), n_P, n_L, n_O (tax rates) are the classical set of parameters of state regulation of market economy.

$$\Phi^G = \pi \cdot pY,$$

where p – product price; Y – volume of the made product; Φ^G – expenses for the government consumption; π – parameter.

Banking system. The banking system is supposed to consist of a great number of banks which operate with certain interest rates of deposits r_2 and credits r_1. Interest rates are formed as a result of interaction of the total deposits supply and credits demand in the market of the capital. Legislatively, in order to avoid uncontrollable inflationary rise in prices, banks should reserve the obligations. One way of reservation is bank investment in the state bonds. It is repaid for banks by the interest rate r_G.

$$L^G = \xi^* \cdot D^O,$$

where L^G – bank reserve; ξ^* – legal reserve rate; D^O – the size of proprietors' deposits in bank system.

The system of the balances equations. The financial balances equations for the producer:

$$
\begin{aligned}
&0 = (1 - n_p)\Phi + \Phi_K^P - \Phi^L - sR^L - H^P - d^P,\\
&\frac{dL^P}{dt} = \widehat{O}_K^P - H^P + r_1 L^P,
\end{aligned}
$$

where Φ_K^P – bank credits.

The financial balances equation for the workers

$$0 = (1 - n_1)sR^L - \Phi^L.$$

The financial balances equations for the proprietors:

$$
\begin{aligned}
&0 = (1 - n_O)(d^P + d^B) - B^O - \Phi^O;\\
&\frac{dD^O}{dt} = B^O + r_2 D^O.
\end{aligned}
$$

The financial balances equations for the Government:

$$
\begin{aligned}
&0 = n_O(d^P + d^B) + n_L sR^L + n_p\Phi + \Phi_K^G - \Phi^G - H^G,\\
&\frac{dL^G}{dt} = \widehat{O}_K^G - H^G + r_G L^G,
\end{aligned}
$$

where Φ_K^G – the government loans.

The financial balances equations for the banking system:

$$0 = H^P + H^G - \Phi_K^P - \Phi_K^G + B - d^B;$$
$$L^R + L^G = D^O.$$

The equation for bank dividends:

$$d^B = r_L L^P + r_G L^G - r_2 D^O.$$

The product market:

$$\frac{dp}{dt} = -\alpha \frac{Q}{M} p,$$

where $\alpha > 0$ – time constant, M – total producing capacity; s - the rate of wages; p – product price; Q – product stocks. The product price is supposed to vary depending on the market stocks Q.

The market of labour.

$$\frac{ds}{dt} = \frac{s}{\Delta_s} \max\left\{0, \frac{R^d - R^s}{R^s}\right\},$$
$$R^L = \min\left\{R^d, R^s\right\},$$

where R^L – total labour which is used by manufacture in fact; s – the rate of wages; R^d – labour demand of manufacture; R^s – worker's labour supply; $\Delta_s > 0$ – time constant.

The capital market:

$$\Phi^I = \Phi_K^P;$$
$$H^P = (r_1 + \mu^*) L^P;$$
$$\hat{O}^I = \frac{1-\xi^*}{\xi^* + (1-\xi^*) n_p} \{(1-n_p)\hat{O}^G -$$
$$-[n_O (d^P + d^B) + n_p \hat{O}^O] -$$
$$-[n_L + (1-n_L) n_p] s R^L + (\mu^* + r_G) L^P\};$$
$$\frac{d^P}{L^P} = \frac{d^B}{L^B} = \beta r_2.$$

Φ^I – flow of investment; Φ_K^P – bank credits; H^P – producer credits payments; r_1 – credit interest rate; μ – amortization rate; L^P – producer credit volume; ξ^* – legal reserve rate, d^P – dividends of proprietors of manufactures; d^B – dividends of banks proprietors; L^G – state credits; β – parameter.

The system of macro equations is given in detail in [24]. We show only key equations, which are crucial for description of interaction.

Demand for imported inputs of the tradables sector:

$$ztd = \frac{p_4 p_2 wr^{p_3} kt^{p_5} yts^{p_1} (1 + p_6 ir)}{pz^{(1-p_4)}},$$

where yts – real supply of tradables, wr – real wage rate, kt – real capital stock in the tradables sector, ir – real interest rate, pz – domestic relative price of import.

Demand for imported inputs by the non-tradable sector:

$$znd = p_9 yns,$$

where yns – real supply of non-tradables.

Aggregated demand:

$$yyd = ypd + ged,$$

where ypd – real domestic private expenditure, ged – real government expenditure.

Export:

$$xt = yts - ytd + zt,$$

where ytd – real demand for tradables, zt – total real imports.

Import:

$$zt = ztd + znd + zrd,$$

where ztd – real demand for imported inputs by the tradables sector, znd – real demand for imported inputs by the non-tradables sector, zrd – other imported goods.

General price level:

$$P = PT^{p_{43}} PN^{(1-p_{43})},$$

where PT – price index of tradables, PN – price index of non-tradables.

Nominal exchange rate:

$$\frac{ER_t}{ER_{t-1}} = \left(\frac{P_t}{P_{t-1}}\right)^{p_{27}}.$$

Actual inflation rate:

$$ri_t = \frac{P_t - P_{t-1}}{P_{t-1}}.$$

Realization of the model. Scenario 1 (Ukraine). Let the state be going through the stage of transition from planned to market economy. The population is divided into proprietors and workers. Workers are interested in getting higher income in the form of wages. Proprietors aim at increasing income of production and commercial banks. Banks give credits for production development and hold deposits with set interest. The quantity of able-bodied population is decreasing due to working migrations and natural processes. Indexes of state regulation remain constant. The result is shown in the figures 1–11.

The increase in production often depends on the increase in the use of labor force, partially due to improvement of technologies. Unsatisfied demand for labor resources on the inner market will use outer resources. Wages will grow until they reach the upper bound. However, production capacity will gradually fall. As a result, it will be more profitable for the country to buy foreign goods and to export a part of its own products (particularly, as raw material.) Due to lower price for foreign goods, own price also gradually decreases. At the same time, inflation rate will grow in proportion to demand for foreign goods, and exchange rate will gradually fall in proportion to the third currency ($). It is the situation that is now observed in Ukraine.

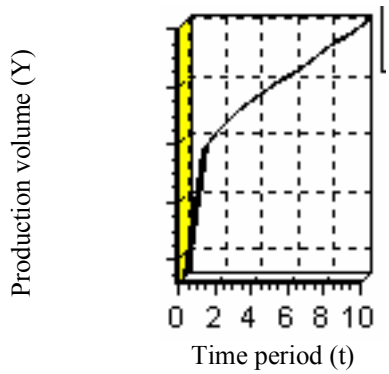

Figure 1 – Dynamics of the model predictive values of production volume

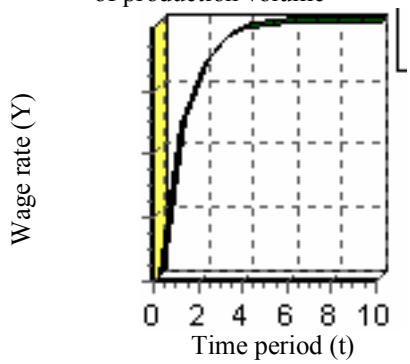

Figure 2 – Dynamics of the model predictive values of wage rate

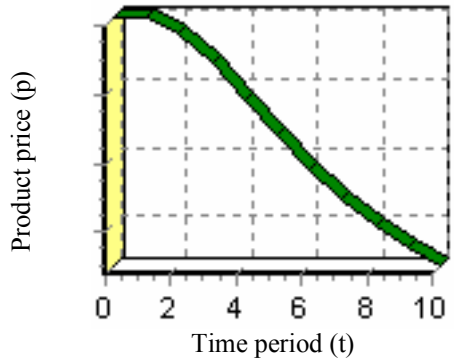

Figure 3 – Dynamics of the model predictive values of product price

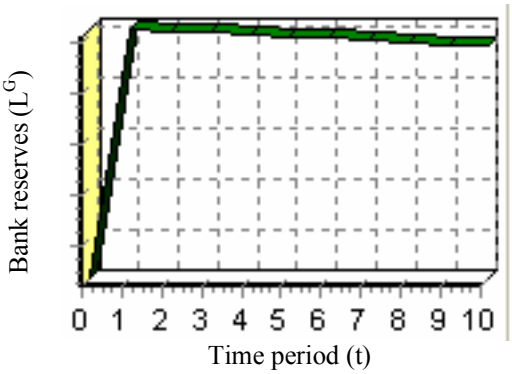

Figure 4 – Dynamics of the model predictive values of bank reserves

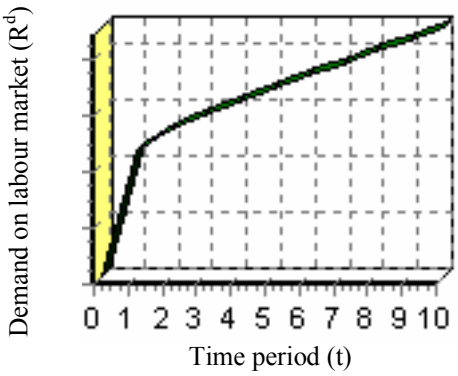

Figure 5 – Dynamics of demand on labour market

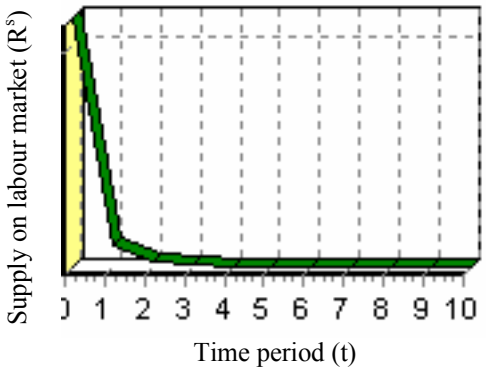

Figure 6 – Dynamics of the model predictive values of supply on labour market

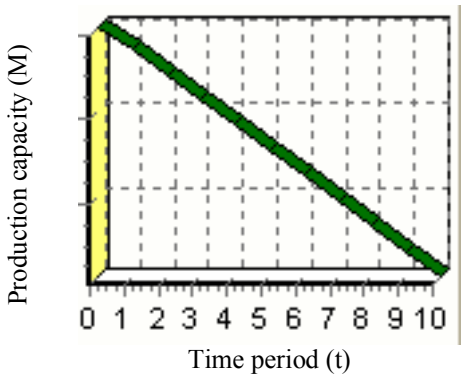

Figure 7 – Dynamics of the model predictive values of production capacity

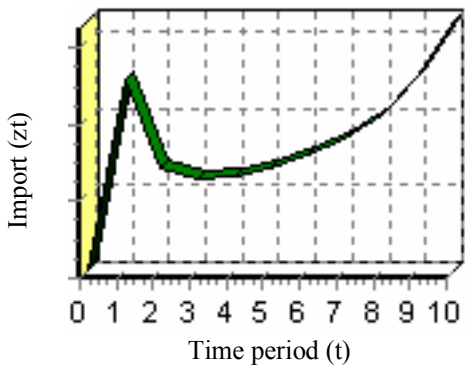

Figure 8 – Dynamics of the model predictive values of import

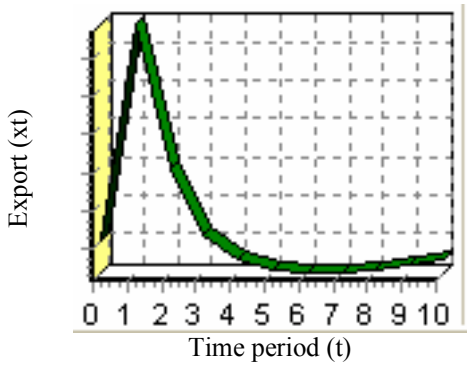

Figure 9 – Dynamics of export

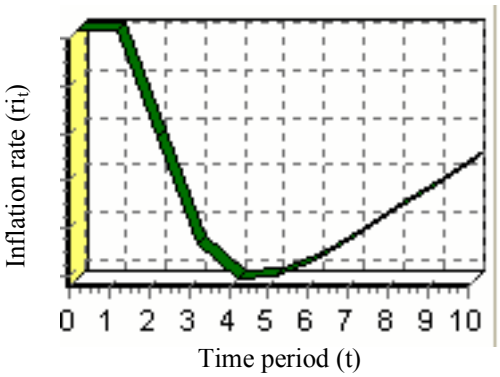

Figure 10 – Dynamics of the model predictive values of inflation rate

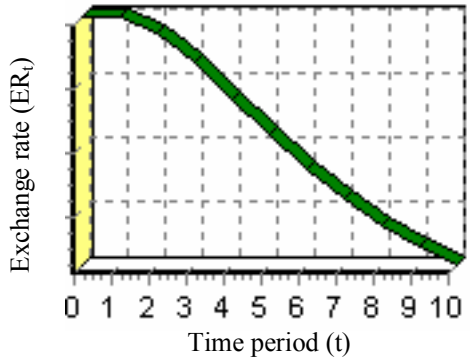

Figure 11 – Dynamics of the model predictive values of exchange rate

Scenario 2 (Hungary). Let the state be going through the stage of market economy transformation. The structure of economic agents remains similar to the model given above, but the system is more stable. The indices of state regulation remain stable.

As shown in the figures 12–22, in such conditions production volume will increase according to the law of exponential growth until it reaches the upper bound of satiation. Production capacity will increase, but the price of the product will decrease. As long as wages will grow rapidly along with increasing demand and supply on the labour market, the product will become cheaper due to:

– reduction of price for production technology;
– reduction of price for raw materials imported from a neighbour country.

Demand for foreign wages and supply for export are stabilized gradually. Bank interest rate also becomes stable in time, which makes credits for investments into production more accessible, and enhances people's confidence in deposits.

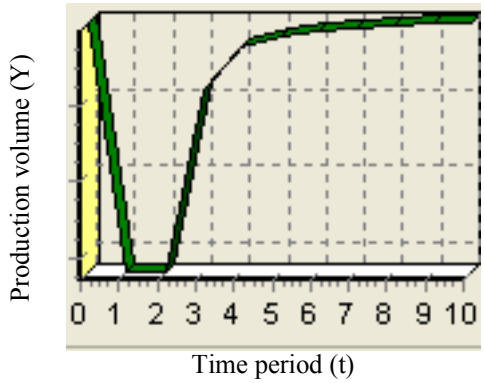

Figure 12 – Dynamics of the model predictive values of production volume

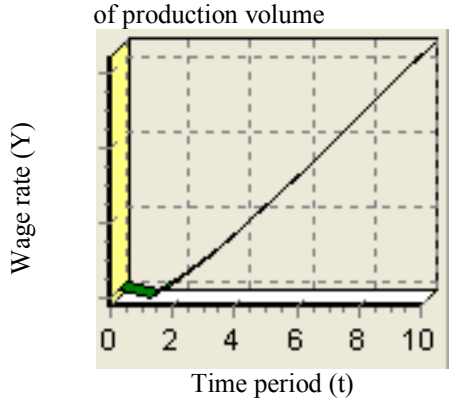

Figure 13 – Dynamics of the model predictive values of wage rate

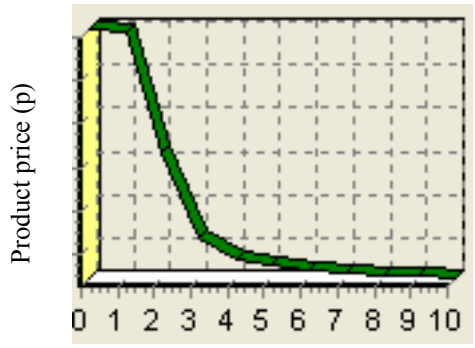

Figure 14 – Dynamics of the model predictive values of product price

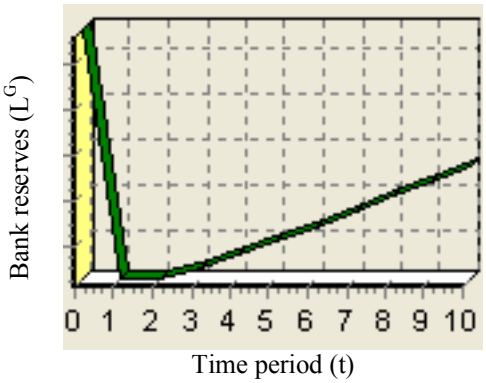

Figure 15 – Dynamics of the model predictive values of bank reserves

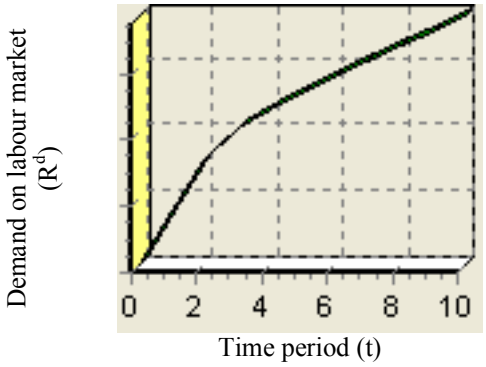

Figure 16 – Dynamics of the model predictive values of demand on labour market

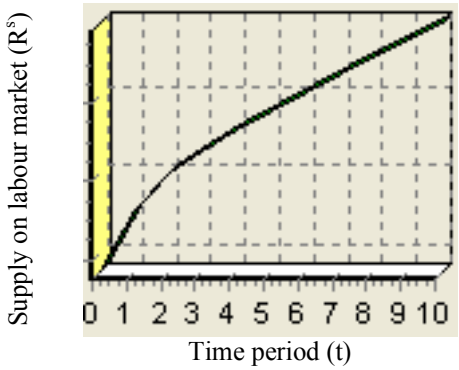

Figure 17 – Dynamics of the model predictive values of supply on labour market

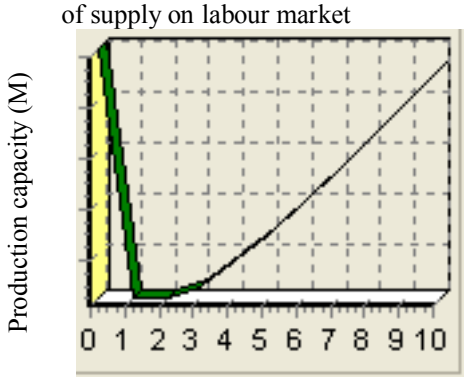

Figure 18 – Dynamics of the model predictive values of production capacity

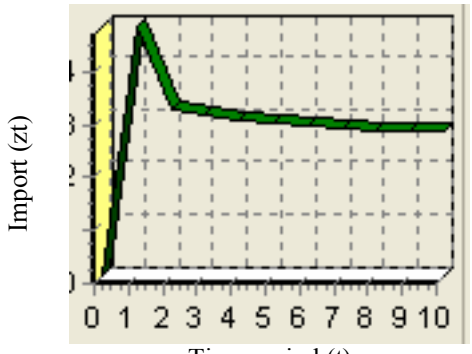

Figure 19 – Dynamics of the model predictive values of import

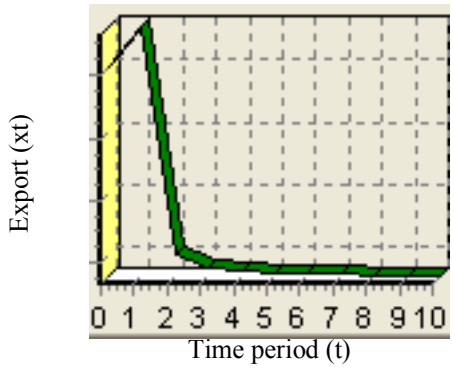

Figure 20 – Dynamics of the model predictive values of export

As for the macro indexes: inflation rate is stabilized gradually, according to the exponential growth of economy. At the same time local currency is strengthened. Presumably initial fluctuations on the diagrams are connected with probable lack of coordination of the initial data.

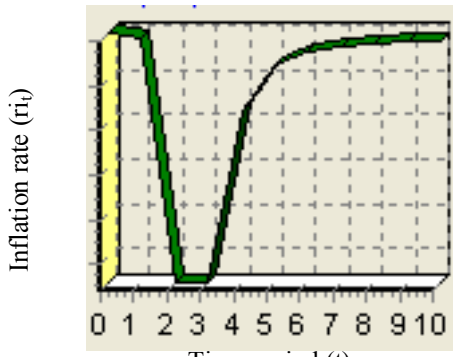

Figure 21 – Dynamics of the model predictive values of inflation rate

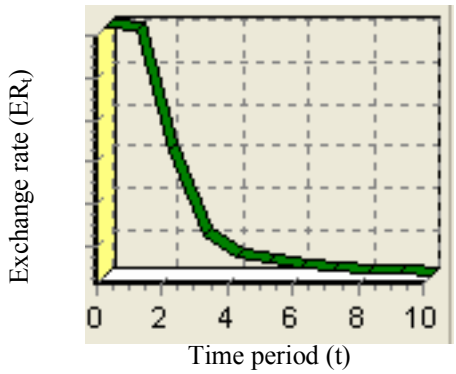

Figure 22 – Dynamics of the model predictive values of exchange rate

Borland Delphi 7.0 was used for this model. The analysis is zeroed in on general trends in dynamics of economic processes in the countries. The dynamics is traced during a term of 10 conventional periods. For identifying the parameters of the model the gradient method of parameters identification was used [25].

CONCLUSIONS. The constructed model enables analyzing the main trends of economic interaction of the two countries with different types of development of their economies. At the same time the model's structure allows tracing impact of a certain interaction type on every economic agent. The given example represents an unregulated system with constant parameters of state regulation. However, every state can regulate customs

rates for export and import, tax rates for inner economic agents, interest rate. Thus, every state is able to regulate the dynamics of interaction and type of inner economic structure. The constructed model allows analyzing possible results of different regulation scenarios by setting and correction of the state regulation parameters.

The model also allows finding optimal parameters of state regulation for a given strategy, which is described by the dynamics of indices values. For this possibility the technique of optimization theory was used.

Thereby, the constructed model can be used for specific data of the two countries – Ukraine and Hungary, or for other two countries of Eastern Europe after prior attuning of the model's parameters. It can be used for prognostic and analytic investigation of each country's development in course of interaction, for improving the dynamics of certain indices by finding optimal state regulation, as well as to choose the optimal strategy of cooperation by coordinated choice of optimal regulation for the two countries.

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REFERENCES

1. Berg, A., Sachs, J. (1992), "Structural adjustment and international trade in Eastern Europe: the case of Poland", *Economic policy*, no. 14, pp. 17–73.

2. Collins, S., Rodrik, D. (1991) "Eastern Europe and The Soviet Union in the world economy", *Journal of International Economics*, vol. 32, issue 3–4, pp. 389–392.

3. Gal, M. (2007), *Venture capital as financial source for SMEs in transitive economy of Slovakia and Hungary*, Miskolc, Hungary.

4. Siebert, H. (1991), "German unification: the economics of transition", *Economic policy*, no. 13, pp. 287–340.

5. Sorlescu, M. (2008), "The rural development in Romania in the post-accession period", *International conference on economics, low and management, Section 3: Economics*, Torgu Muree, Romania, pp. 71–80.

6. Vojtoviy, S., Gal, M. (2004), "Small and medium enterprises in the condition of European integration", *Yearbook from the international scientific conference "European integration: local and global consequences"*, Brno, Czech Republic. pp. 36–45.

7. Sergienko, I., Mykhalevych, M. (2002), "Economic cybernetics: problems of development and prospects of use", *Bulletin of National Academy of Ukraine*, no. 2, pp. 13–20.

8. Burda, M. (1988), "Wait unemployment in Europe", *Economic Policy*, no. 7, pp. 391–426.

9. Burda, M., Wyplosz, Ch. (1993), *Macroeconomics. A European text*, Oxford University Press, UK.

10. Petrov, A.A., Pospelov, I.G., Shananin, A.A. (1996), *The experience of mathematical modelling of economy,* Energoatom, Moscow, Russia.

11. Menyhort, E. (2006), *A critical evaluation of rhetorical economics*, Miskolc, Hungary.

12.Menyhort, E. (2005), "Introduction to rhetorical economics", *European integration studies*, Miskolc university press, Vol. 4, no. 1, pp. 109–114.

13. Monostori, L., Erdxs, G., Kadar, B., Kis, T., Kovacs, A., Pfeiffer, A., Vancza, J. (2010), "Digital enterprise solution for integrated production planning and control", *Computers in Industry*, no. 61(2), pp. 112–126.

14. Pence, N.E., Morrell, J.S. (2008), "Algorithm and theorem for optimizing the clean-up function of a vector of products", *International conference on economics, low and management, Section 5: Information and decision system mathematical modelling and statistics*, Torgu Muree, Romania, pp. 27–39.

15. Avtukhovich, E.V., Guriev, S.M., Olenev, N.N., Petrov, A.A., Pospelov, I.G., Shananin, A.A., Chukanov, S.V. (1993), *A Mathematical Model of the Transition Economy*, Dorodnicyn Computing Centre of the Russian Academy of Sciences, Russia.

16. Ryaboshlyk, V. (2006), "A Dynamic Input-Output Model with Explicit New and Old Technologies: an application to the UK", *Economic Systems Research*, no. 18(2), pp. 183–203.

17. Wang, B., Klein, E., Rao Gouranga, U.L. (1995), "Inflation and stabilization in Argentina", *Economic Modelling*, vol. 12, no. 4, pp. 391–413.

18. Ortega, J.M., Rheinboldt, W.C. (1970), *Iterative solution of nonlinear equations in several variables*, Academic Press, London and New York.

19. Gill, P.E., Murray, W. (1977), *Numerical method for constrained optimization*, Academic Press, London and New York.

20. Gill, P.E., Murray, W., Wright, M.H. (1981), *Practical optimization*, Academic Press, Stanford University, California, USA.

21. Polya, G. (1954), *Mathematics and plausible reasoning*, Princeton university press, Princeton, New Jersey, USA.

22. Szabolcs, Lxrincz (2005), "Persistence effects in a dynamic discrete choice model. Application to low-end computer servers", *KTI/IE Discussion papers,* Hungary, 29 p.

23. Tarasova, O. (2008), "The analysis of market economy agents' activity by "Mathematical model complex", *International scientific conference microCAD 2008, Section G: Mathematics and computer science*, Miskolc, Hungary, pp. 79–83.

24. Nazaraga, I., Tarasova, O. (2008), "The mathematical models of Eastern Europe countries economy", *International conference on economics, low and management, Section 5: Information and decision system mathematical modeling and statistics*, Torgu Muree, Romania, pp. 53–65.

25. Beyko, I. (1997), "An Unified Theory of Optimal Modeling and Simulation", *Proc. 15th IMACS World Congress (IMACS'97)*, Berlin, pp. 687–693.

ИСПОЛЬЗОВАНИЕ РАЗЛИЧНЫХ МЕТОДОВ СЦЕНАРНОГО ПРОГНОЗИРОВАНИЯ ДЛЯ ЭКОНОМИКО-МАТЕМАТИЧЕСКОГО АНАЛИЗА НА ПРИМЕРЕ СТРАН ВОСТОЧНОЙ ЕВРОПЫ

О. В. Тарасова

Киевский национальный университет имени Тараса Шевченко

просп. Академика Глушкова, 4д, г. Киев, 03680, Украина. E-mail: olga_ta@bigmir.net

В статье представлен вариант использования математического аппарата для исследования некоторых сценариев развития экономических отношений между Украиной и Венгрией. Формирование новых экономических структур и агрегация рынков в некоторых странах требует дополнительных инструментов для анализа и прогнозирования экономических процессов на более глобальном уровне. Возможности и перспективы экономического сотрудничества ЕС и постсоветских стран может быть исследовано на примере этих двух стран. В работе исследуются математические модели функционирования и взаимодействия экономических агентов рыночной экономики Венгрии и Украины. Подобные модели могут быть использованы для аналитических и прогностических исследований рыночной экономики в отдельных регионах и в стране в целом.

Ключевые слова: математическое моделирование, экономические модели, прогнозирование.

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