ECONOMIC PROCESSES MANAGEMENT
international scientific e-journal (ISSN 2311-6293)
epm.fem.sumdu.edu.ua
№2 – 2015

Prokopenko O. V. Modelling of the processes synchronized dealing with ecological safety within economic system [Internet source] / O. V. Prokopenko, V. Yu. Shkola, M. D. Domashenko, M. Yu. Troian // Economic Processes Management: International Scientific E-Journal. – 2015. – № 2. – Access mode: http://epm.fem.sumdu.edu.ua/download/2015_2/2015_2_24.pdf

Received 12.03.2015

УДК 330.131.5:502.17
JEL Classification: C 22, O12, O13, P41

MODELLING OF THE PROCESSES SYNCHRONIZED DEALING WITH ECOLOGICAL SAFETY WITHIN ECONOMIC SYSTEM*

Prokopenko Olha Volodymyrivna
Doctor of Economics, Prof., Dean of Economics and Management Faculty,
Chief of Economic Theory Department,
Sumy State University, Ukraine
Prof.,
Prof. of University of Economics and Humanities, Bielsko-Biala, Poland
Shkola Viktoriya Yuriyivna
PhD, Associate Professor, Associate Professor of Economic Theory Department,
Domashenko Maryna Dmytrivna
PhD, Associate Professor of Economic Theory Department,
Troian Mariia Yuriyivna
PhD, Associate Professor of Economic Theory Department,
Sumy State University, Ukraine

The synchronization as a scientific category is investigated. A set of indicators concerning economic system constituents at the enterprise and regional level is formed. A methodological approach to assessment of the processes synchronized dealing with ecological safety within economic system is proposed. A methodological approach to forecasting of economic system development dynamics mutually with the tools for the economic safety provision at the highest level is improved.

Keywords: *economic system, synchronization, ecological safety, a speed of the development synchronized, autonomous speed, efficacy, forecasting of system development.*

Introduction. The solution of the problem of extension the level of ecological safety underlies in the sphere of studying the mechanism of synchronization of

*The paper was written according to budget money from the Ministry of Education and Science of Ukraine, given to develop scientific-research topic № 53.15.01-01.15/17.3Ф «Methodology of forming mechanism of national economics innovative development based on alternative energy»

© O. V. Prokopenko, V. Yu. Shkola, M. D. Domashenko, M. Yu. Troian, 2015

business systems at different levels and processes that ensure its environmental safety.

Analysis of the recent research and publications. Theoretical and applied issues dealing with ecological safety management have been investigated by such academicians as V.P. Gorbylin, A.B. Kachynsky [4], B.M. Danylyshyn, A.V. Stepanenko [1], V.I. Danylov-Danylyan [10], S.I. Doroguntsov, A.M. Fedoryscheva, O.M. Ralchuk [2], A.M. Sunduk [5], O.M. Khimich [6], Ye.V. Khlobystov [7], V.M. Shmandiy [8] and others.

Previously unsettled problem constituent. At the same time, in spite of having been made profound and significant research contributions to the above mentioned problem solvement by such scientists, we must stress that the problem dealing with formation of the universal methodological approach to selection of the tools needed for the provision of ecological safety within the economic systems mutually with peculiarities of their development is still open to question. The solution of the problem will enhance the level of selection substantiation of the tools needed for ecological safety provision; to optimize the processes of ecological safety provision at the different levels, and also to avoid ineffective costs and enhance the level of ecological safety.

Main purpose of the article is development of scientific and methodological issues dealing with investigation and assessment of the processes synchronized concerning ecological safety within economic system.

Results and discussions. Synchronization, as a scientific phenomenon, possesses an enormous number of forms in nature, technology, economics, society, these factors make some difficulties in the general interpretation of this category. In [9, 11] it is defined as setting in motion two or more processes to their occurrence, it is a state, when a certain stages of distinct processes eventuating in the particular order, or simultaneously. This process leads up to the same meaning one or several objects with different variables. We suppose, that the most complete definition is given in the scientific work [3]. According to it, the process of synchronizations is regarded as quality of physical objects to formulate a single coexistence rhythm, despite of peculiarities of individual rhythms and possible extremely poor relationships.

It is established, that the effectiveness of tools, that ensure an environmental safety depends on the balanced state (or synchronization) of the development of the business system and appropriate processes, resulting from the application of z-th instrument. To calculate the process synchrony to provide ecological security of the economic system is to conduct on the basis of factors comparing, which characterize the system development and each investigated processes run, – speed of the system synchronous development ω and autonomic speed of the process to provide ecological security $\omega^{(z)}$, calculation formulas of which are suggested by authors.

It is proposed to determine the speed of the synchronous development of the system ω from the system of equations that describe its development.

$$\begin{cases} \dot{x}^{(s)} = X^{(s)}\left(x^{(s)}(t)\right), \\ \dot{y} = \varepsilon^{(z)^{\gamma}} \cdot Y\left(x^{(1)}, x^{(2)}, x^{(3)}, y(t)\right), \\ x^{(s)}(t) = \alpha^{(s)} \cdot \left[\theta^{(s)^{\beta}} \cdot \omega \cdot t + f^{(s)}\left(x_1^{(s)}, ..., x_i^{(s)}, ..., x_{n_s}^{(s)}, \delta^{(s)}, \omega, t\right)\right], \\ y(t) = \Lambda\left(y^{(1)}(t), ..., y^{(z)}(t), ..., y^{(k)}(t)\right), \\ y^{(z)}(t) = \alpha^{(z)} \cdot \left[\mu^{(z)^{\lambda}} \cdot \omega \cdot t + \varphi^{(z)^{m}} \cdot u^{(z)}\left(g^{(z)} \cdot y_1^{(z)}, y_2^{(z)}, \tau^{(z)}, \omega, t\right)\right], \\ s \in [1;3], \quad i \in [1; n_s], \quad z \in [1; k], \quad t \in [1; T], \end{cases} \tag{1}$$

where $x^{(s)}(t)$ – the function, that characterizes state of subsystem s , represented by the n_s-dimensional vector at the moment of time t; $x^{(1)}$, $x^{(2)}$, $x^{(3)}$ – functions, that characterizes the states of economic, ecological and social subsystems, accordingly; $y(t)$ – function, that describes the system of connections at the moment of time t; $x_i^{(s)}$ – index i, that characterizes the subsystem $x^{(s)}$; $\dot{x}^{(s)}$, $\dot{y}$ – derivatives of the function $X^{(s)}$, Y relatively; Y – k-th vector-function; $y^{(z)}(t)$ – k-th vector, that describes interrelations, arised in the system as a result of z-th process (tool) implementation; $\alpha^{(s)}$ – index of stability s-th subsystem; $\alpha^{(z)}$ – index of stability of the relations in the system with the influence of z-th process (tool); $\theta^{(s)^{\beta}}$ – coefficient of aggregation s-th subsystem with an environment (with amplifier nature of β =1 when it reduces to – -1); $\mu^{(z)^{\varepsilon}}$ – coefficient of aggregation z-th process (tool) with environment (with amplifier nature of τ=1 , when it reduces – -1); $\phi^{(z)^{m}}$ – dimensional coefficient of the efficiency z-th process (tool) (with amplifier nature of m=1, when it reduces – -1); $\varepsilon^{(z)^{\gamma}}$ – coefficient, that takes into account the synergism of social, economic and ecological effects in the results of introduction z-th process (tool) and the synergism, that occurred in the result of adding effects in each t-th period to the previous one (with amplifier nature of γ=1, when it reduces -1); $f^{(s)}$, $u^{(z)}$, Λ – mathematical functions; $\delta^{(s)}$ – the coefficient of cross-correlation component s-th subsystem; $g^{(z)}$ – coefficient of the potential speed of the outputs, that are going on the establishment of the z-th process (tool); $\tau^{(z)}$ – cross-correlation coefficient of the connections of z-th process (tool) of providing environmental safety with others; $y_1^{(z)}$, $y_2^{(z)}$ – constituents of the vector $y^{(z)}$; T – the duration of the investigated period; k – the amount of processes (tools) of providing environmental safety within an investigated system in the period t; s, z – sequence number of the subsystem and of the devising process (tool) of providing environmental safety; i – number of the indicator that describes subsystem $x^{(s)}$; n_s – quantity of indicators, that describe subsystem $x^{(s)}$.

It is needed to take into consideration, that an outputs, directed on the ensuring

of some result, and an expected effect not always can concur. Moreover, they can be stretched in time. It is also needed to take into consideration the speed of output of the investigated process through the time factor during the forecasting and valuing of the expected financial effusions. The existence of lag between the beginning of the process of providing environmental safety and getting the results conditions the necessity of introduction of the adjustment coefficient $g^{(z)}$. Its meaning is based on the definition of the process («fast» means that its results are seen in the short-term perspective, «slow» means process in which the results are observed only in the medium or long-term, «dot», resulting in a static variable, or "prolonged "its results are observed in the dynamics as relatively constant, evenly distributed over time) as well as current and potential environmental safety concept of the business system. There are designed a table of the value of the coefficient $g^{(z)}$ in order to simplify the use of index .It was introduced by the authors and based on a retrospective analysis of parameters , that correspond to the different processes and measures concerning the providing of environmental safety of the business system in accordance to the appropriate level. It was introduced in the terms of the actual concept, directed on the innovational ecological activity in different countries and regions.

The values of indicators $\alpha^{(s)}$, $\theta^{(s)}$, $\delta^{(s)}$, $\mu^{(z)}$, $\tau^{(z)}$ are determined by correlation-regressive analysis. The meanings of $\varphi^{(s)}$, $\varepsilon^{(z)}$, m, β, λ, γ are determined on the basis of the present experience or by the providing of an investigation. The second one is held only under the condition, that there are absence of the retrospective datum.

We shall consider ***the economic system*** as a set of economic, ecological and social subsystems.

The economic subsystem at the enterprise level are characterized by such indices: $x_1^{(1)}$ – index of physical volume of the production (pertaining to the previous period); $x_2^{(1)}$ – index of the goods turnover (pertaining to the previous period); $x_3^{(1)}$ – index of the rest of the production at the storehouses at the end of the investigated period (pertaining to the previous period); $x_4^{(1)}$ – index of profitability of production (pertaining to the previous period); $x_5^{(1)}$ – index of investments in the fixed assets (calculated as relation of the scope of investments in fixed assets in the investigated and previous periods); $x_6^{(1)}$ – index of providing with debts (calculated as the relation to the scope of received debts and the scope of goods realization of the business); $x_7^{(1)}$ – index of the prices on goods (pertaining to previous period); $x_8^{(1)}$ – index of financial supply of the business system on account of its own sources (calculated as a relation to the scope of incomes from all sources (profit of the business system) and the general sum of expenses during period *T)*; $x_9^{(1)}$ – the coefficient of deposits in the main funds; $x_{10}^{(1)}$ – the coefficient of renovation of the main funds; $x_{11}^{(1)}$ – the coefficient of the openness of the business system (the part of foreign trade scope in

the general goods); $x_{12}^{(1)}$ – the part of exported production; $x_{13}^{(1)}$ – the relation to the import and export; $x_{14}^{(1)}$ – the specific weight of the ecological taxes and payments in the structure of expenses; $x_{15}^{(1)}$ – the part of innovative production; $x_{16}^{(1)}$ – index of renovation the range of goods (pertaining to the previous period); $x_{17}^{(1)}$ – the part of expanses, that are spent on the research and development (R&D) in the general structure of expenses; $x_{18}^{(1)}$ – the part of income from the production and realization of the innovative production in the general structure of incomes.

An ecological subsystem at the enterprise level is characterized by such indices: $x_1^{(2)}$ – the part of ecological production in the general scope of the output in the business system; $x_2^{(2)}$ – the part of over the norm discharges in the environment, created in the result of trading of the investigated system; $x_3^{(2)}$ – the part of over the norm fault in the environment, caused by the industrial activity of the investigated system; $x_4^{(2)}$ – the part of the discharges частка (among those, that were created by the industrial activity of the investigated system), that were not ecological safely utilized during that period; $x_5^{(2)}$ – the part of cumulative discharges (from those, that were created in the result of previous periods), that were not ecological safely utilized during that period; $x_6^{(2)}$ – the part of the primarily raw materials, that are used for the production of goods; $x_7^{(2)}$ – index of economy of energy resources in the process of industrial production; $x_8^{(2)}$ – index of disease incidence among workers, that participate in the production. It is determined as a relation of the general number of morbidity accidents, that happened during the investigated period, to the average quantity of the workers, that occurred in the list of illness; $x_9^{(2)}$ – the part of workers, that have occupational diseases, received in the result of work on the investigated object; $x_{10}^{(2)}$ – the part of above the norm charges in the environment, that created at the objects of providing infrastructure of the investigated system; $x_{11}^{(2)}$ – the part of above the norm charges in the environment, occurred on the objects of providing infrastructure of the investigated system; $x_{12}^{(2)}$ – the part of the discharges (from those, that were created at the objects of providing infrastructure of the business system during the investigated period), that were not ecological safely utilized during that period; $x_{13}^{(2)}$ – the part of accumulated discharges (from those, that were created at the objects of providing infrastructure of the business system during the previous period), that were not ecological safely utilized during that period; $x_{14}^{(2)}$ – the part of initial raw materials, that are used at the objects of providing infrastructure; $x_{15}^{(2)}$ – index if economy of the energy resources at the objects of providing infrastructure; $x_{16}^{(2)}$ – index of disease incidence among workers, that participate at the objects of providing infrastructure. It is determined as a relation of the general number of morbidity accidents, that happened during the investigated period; $x_{17}^{(2)}$ – the part of workers,

that have an occupational diseases, that were received after the work at the objects of providing infrastructure; $x_{18}^{(2)}$ – index of internal danger of a risk situation (it is defined as a sum of losses, that appeared at the objects of the business system), correlated with the sum of general outputs of the business system in the investigated period; $x_{19}^{(2)}$ – index of external danger of a risk situation (it is defined as a sum of loss suffered of the result of a wreck, that appeared at the objects of investigated business system, to the other economy systems), correlated with the sum of general outputs of the investigated business system during the period *T*); $x_{19}^{(2)}$ – index of the general amount of damages or risk situations (in relation to the previous period); $x_{20}^{(2)}$ – index of the unprofitableness in a risk situations (calculated as a sum of losses, that occurred at the objects of the business system in the result of exigent condition during the period *T*, in relation to the previous period).

Social subsystem at the enterprise level is characterized by such indices: $x_1^{(3)}$ – demand and supply of the labour force; $x_2^{(3)}$ – the coefficient of fluctuation of the stuff; $x_3^{(3)}$ – the part of workers ,that are employed in the manufacturing process; $x_4^{(3)}$ – the part of disabled persons from the general number of workers; $x_5^{(3)}$ – the part of workers of the retirement age; $x_6^{(3)}$ – the correlation of an average salary of the worker, except administrative stuff and servicemen, and minimum subsistence level; $x_7^{(3)}$ – the part of outputs on social requirements of the workers in the general structure of outputs; $x_8^{(3)}$ – the correlation of the rates of increasing the work productivity and the increasing of the salary, except the administrative stuff and servicemen.

Economy subsystem at the regional level is characterized by such indices: $x_1^{(1)}$ – index of gross regional proceeds, calculated on the 1 person (pertaining to the previous period); $x_2^{(1)}$ – the part of production in GRP; $x_3^{(1)}$ –the part of agriculture in GRP; $x_4^{(1)}$ – index – deflator of the scope of GRP (pertaining to the previous period); $x_5^{(1)}$ – index of an industry (pertaining to the previous period); $x_6^{(1)}$ – index – deflator of industry (pertaining to the previous period); $x_7^{(1)}$ – index of agriculture (pertaining to the previous period); $x_8^{(1)}$ – index – deflator of the agriculture (pertaining to the previous period); $x_9^{(1)}$ – the turnover of the retail trade (pertaining to GRP); $x_{10}^{(1)}$ – index – deflator of the turnover of retail trade (pertaining to the previous period); $x_{11}^{(1)}$ – the turnover of a priced services, given by enterprises (establishments) of the region (in a comparison with the prices in relation to GRP); $x_{12}^{(1)}$ – index-deflator of the priced services (pertaining to the previous period); $x_{13}^{(1)}$ – investments in the main fund (pertaining to the GRP); $x_{14}^{(1)}$ – index of the physical turnover of the investments (pertaining to the previous period); $x_{15}^{(1)}$ – index – deflator of the investment

(pertaining to the previous period); $x_{16}^{(1)}$ – consumer price index on the end of the period (pertaining to the previous period); $x_{17}^{(1)}$ – index of the budgetary provision on account of proper sources of the incomes per capita (pertaining to the previous period); $x_{18}^{(1)}$ – the part of gross regional proceeds (GRP) per capita in the region of the gross domestic product (GDP) per capita in the country; $x_{19}^{(1)}$ – incomes of the reconciled budget (pertaining to GRP); $x_{20}^{(1)}$– cost – plus price off the reconciled budget (pertaining to GRP); $x_{21}^{(1)}$ – the proficit (+) and deficit (-) of the reconciled budget (pertaining to GRP); $x_{22}^{(1)}$ – the part of taxes in the GRP; $x_{23}^{(1)}$ – specific gravity of an ecological taxes and payments in GRP; $x_{24}^{(1)}$ – the part of added value in the general amount of the produced goods; $x_{25}^{(1)}$ – the relation of the volume of transfers from the regional budget to the gross added value; $x_{26}^{(1)}$ – index of providing the debts(calculated as the relation of the scopes of received debts and GRP); $x_{27}^{(1)}$ – the part of loss-making enterprise by the whole branches of industry of the economy of the region; $x_{28}^{(1)}$ – index of financial provision of the business system on account of proper sources (calculated as the relation of the scope of incomes from all sources (an incomes of the business system) and the general sum of outputs during the period *T*); $x_{29}^{(1)}$ – coefficient of the deposit of the main funds; $x_{30}^{(1)}$ – coefficient of the renovation of the main funds; $x_{31}^{(1)}$ – coefficient of the openness of the economy in the region (the part of the foreign trade scope in the gross added value); $x_{32}^{(1)}$ – the relation of the import to the export; $x_{33}^{(1)}$ – the part of an export in the gross added value in the region; $x_{34}^{(1)}$ – the part of import in the gross added value in the region; $x_{35}^{(1)}$ – expenses on the research and development (R&D) (pertaining to GRP); $x_{36}^{(1)}$ – the part of the income from the production and realization of the innovative production in the general structure of incomes.

An ecological subsystem at the regional level is characterized by such indices: $x_1^{(2)}$ – the part of ecological production in the general scope of production; $x_2^{(2)}$ – the part of ecological production in the general scope of retail trade; $x_3^{(2)}$ – the part of ecological production in the general import scope; $x_4^{(2)}$ – the part of over the norm discharges in the environment (pertaining to the general scope); $x_5^{(2)}$ – the part of over the norm faults in environment (pertaining to the general scope); $x_6^{(2)}$ – the part of waste products (from those, that were created during the investigated period), that were not safely utilized during that period; $x_7^{(2)}$ – the part of cumulative discharges from those, that were created during the investigated period), that were not safely utilized during that period; $x_8^{(2)}$ – the part of primarily raw materials, that are used for the production of goods; $x_9^{(2)}$ – the consumption of the initial fuel – and energy

sources (pertaining to the previous period); $x_{10}^{(2)}$ – an exploitation of the initial fuel- and energy sources at the operational and manufacturing demands (pertaining to the general scope of consumed energy resources of the current period); $x_{11}^{(2)}$ – an exploitation of the alternative sources of energy (pertaining to the general scope of consumed energy resources of the current period); $x_{12}^{(2)}$ – index of the development of the alternative energy in the region (pertaining to the previous period); $x_{13}^{(2)}$ – index of economy of energy resources in the process of manufacturing activity; $x_{14}^{(2)}$ – the part of infracted lands in the general area of available land; $x_{15}^{(2)}$ – the part of recultivated lands in the general area of the infracted one; $x_{16}^{(2)}$ – the amount of wild animals in the hunting grounds (pertaining to the previous period); $x_{17}^{(2)}$ – index of the animal reproduction (the relation to the areas of the planting, sowing and natural reproduction of the forests to the general area of deforestation); $x_{18}^{(2)}$ – index of sickness rate of the workers; $x_{19}^{(2)}$ – index of the workers, that have occupational diseases; $x_{20}^{(2)}$ – the part of the wastes (from those, that were created during the investigated period), that were not safely utilized during that period; $x_{21}^{(2)}$ – the part of cumulative discharges (from those, that were created during the investigated period), that were not safely utilized during that period; $x_{22}^{(2)}$ – the part of consumed energy resources by the population; $x_{23}^{(2)}$ – using of secondary energy resources by the population; $x_{24}^{(2)}$ – index of saving of the energy resources in the sphere of consumption (pertaining to the previous period); $x_{25}^{(2)}$ – index of increasing the amount of emergency situation, that caused by technological activities of people, according to the scale of its results (calculated as the relation between the general number of emergency situation to the general scope of the losses in the compared prices) (pertaining to the previous period); $x_{26}^{(2)}$ – index of increasing the amount of emergency situations, that have natural character, according to the scale of its results (calculated as the relation between the general number of the emergency situations, caused by technological activities of people to the general scope of losses in compared prices) (pertaining to the previous period); $x_{27}^{(2)}$ – index of increasing the amount of the emergency situations at the local level (pertaining to the previous period); $x_{28}^{(2)}$ – index of increasing the amount of the emergency situations at the object level (pertaining to the previous period); $x_{29}^{(2)}$ – the part of forest lands, suffered from the conflagrations, in the general scale of the forest; $x_{30}^{(2)}$ – losses, injured by the conflagrations (pertaining to the previous period); $x_{31}^{(2)}$ – the amount of traumatized people in the result of conflagration (pertaining to the previous period); $x_{32}^{(2)}$ – the amount of perished people in the result of conflagrations (pertaining to the previous period).

Social subsystem at the regional level is characterized by such indices: $x_1^{(3)}$ – demand and supply of the work force; $x_2^{(3)}$ – the level of unemployment in the region, according to the methodology of the International Labour Organization (ILO); $x_3^{(3)}$ – the level of concealed unemployment; $x_4^{(3)}$ – the part of persons of the retirement age, occupied in the labour activity; $x_5^{(3)}$ – the part of employable population in the general number of population the region; $x_6^{(3)}$ – the correlation of cash incomes and the expenses of the population; $x_7^{(3)}$ – the part of labour compensation in the structure of incomes of the population in the region; $x_8^{(3)}$ – the part of salary in the gross added value of the region; $x_9^{(3)}$ – correlation of an average salary of the workers , except administrative stuff and servicemen, and minimum for subsistence; $x_{10}^{(3)}$ – correlation of the increasing rate of work productivity and the of salary, except administrative stuff and servicemen; $x_{11}^{(3)}$ – correlation of an average salary of the workers and minimum for subsistence; $x_{12}^{(3)}$ – the part of population with an average explicit costs during the month, with a lower level of a minimum for subsistence; $x_{13}^{(3)}$ – the disruption between 10 % of prosperous and 10% of penurious population groups; $x_{14}^{(3)}$ – public assistance (pertaining to the previous period); $x_{15}^{(3)}$ – social transfers (pertaining to the previous period); $x_{16}^{(3)}$ – correlation of money income and expenses of the population; $x_{17}^{(3)}$ – coefficient of the depopulation; $x_{18}^{(3)}$ – the migration of inhabitants; $x_{19}^{(3)}$ – coefficient of birthrate; $x_{20}^{(3)}$ – coefficient of death rate; $x_{21}^{(3)}$ – coefficient of child mortality; $x_{22}^{(3)}$ – expected duration of life (at birth); $x_{23}^{(3)}$ – coefficient of ageing in the region; $x_{24}^{(3)}$ – expenses on the education (pertaining to GRP); $x_{25}^{(3)}$ – expenses on the culture (pertaining to GRP); $x_{26}^{(3)}$ – expenses on providing the health care (pertaining to GRP); $x_{27}^{(3)}$ – the amount of victims, suffered from injures during production.

It is proposed to use the system of equations, that represented by the formula (2), in order to predict the dynamics of the development of business system. It is based on the introduction of tools of the highest level Z^1.

$$\begin{cases} \dot{x}^{(s)} = X^{(s)}\left(x^{(s)}(t)\right), \\ \dot{y} = \varepsilon^{\left(zZ^1\right)^{\gamma}} Y\left(x^{(1)}, x^{(2)}, x^{(3)}, y(t)\right), \\ x^{(s)}(t) = \alpha^{(s)}\left[\theta^{(s)^{\beta}} \omega t + f^{(s)}\left(x_1^{(s)}, \ldots, x_i^{(s)}, \ldots, x_{n_s}^{(s)}, \delta^{(s)}, \omega, t\right)\right], \\ y(t) = \Lambda\left(y^{(1)}(t), \ldots, y^{(z)}(t), \ldots, y^{(k)}(t)\right), \\ y^{(zZ^1)}(t) = \alpha^{(zZ^I)}\left[\mu^{(z)^{\lambda}} \omega t + {}^{(z)^{m}} u^{(zZ^1)}\left(g^{(zZ^1)} y_1^{\left(zZ^I\right)}, y_2^{\left(zZ^I\right)}, \tau^{(z)}, \omega, t\right)\right], \\ s \in [1;3],\ i \in [1;n_s],\ z \in [1;k],\ t \in [1;T],\ Z^I \in [1;k^I], \end{cases} \tag{2}$$

where Z^I – sequence number of the introduced tool of providing environmental safety of the business system on the high level in a period t; k^J – the amount of introduced tools of providing environmental safety of the business system on the high level in a period t.

Formula (1) is proposed to be used for investigation of ecological safety processes flowing in the economic system and to be implemented at the government or lower levels omitting influence of the tools needed for higher levels; formula (2) – for investigation of economic systems at lower levels mutually with influence of the tools needed for higher levels.

Thus, having determined the indicator of the speed of the development synchronized within a system ω from formulas (1) and (2), we must compare it with indicator of the autonomous speed of the ecological safety process $\omega^{(z)}$, which is determined by z-th marketing tool implementation. Indicator $\omega^{(z)}$ is proposed to be calculated according to the formula

$$\omega^{(z)} = \frac{4T^{1/2} \quad \dot{y}^{(z)}(t)}{1 + y^{(z)}(t)}. \tag{3}$$

If $\omega^{(z)} = \omega$, then one may state that there is the complete synchronization of processes concerning providing ecology safety and development of economy system in general. Under this condition, economic system achieves the highest ecological and economic efficacy.

If $\omega^{(z)} < \omega$, then one may state that there is the interval synchronization of processes concerning providing ecology safety. That means the system has a significant development potential involving used measures, but some certain processes concerning providing ecology safety prevent its development due to disharmony with other processes. If there are changes of z-process parameters concerning providing ecology safety in future and if one can change the frequency of this process for reaching the complete synchronization of system processes in further periods of time, then one should correct some things. If some harmonization procedures of the process with other processes do not cause needed results or if performing any correcting measures requires a lot of resources, then one should consider the further development of the system involving stopping this process or its complete autonomy (that is the process is removed from system resources).

If $\omega^{(z)} > \omega$, then one may state that there is the impulse synchronization of the processes concerning providing ecology safety. It means there is a possibility to accelerate system development if the processes concerning providing ecology safety are optimized, which will increase the frequency of process synchronization leading to complete synchronization.

Conclusions and perspectives for further studies. The integral results of the

performed research improve the conceptual statements of the theory and method of investigation for synchronization of the processes concerning providing the ecology safety of economy system. The practical meaning of the obtained results consists in the possibility to increase the efficiency of controlling economy system for its constant development due to the offered scientific and methodological approach for estimating synchronization of the observed processes.

Thus, the issues being proposed by the authors, allow to move towards elaboration of the theoretical and methodological approaches to ecological safety management of the global economic system.

References

1. Danilishin, B.M., Stepanenko, A.V., Ralchuk, O.M. ta in. (2008). *Bezpeka regioniv Ukrayini i strategiya yiyi garantuvannya. Prirodno-tehnogenna (ekologichna) bezpeka [Safety Strategy of Ukraine's regions and its guarantee. Natural and man-made (environmental) safety]* (Vols. 1-2). Kyiv: Naukova dumka [in Ukrainian].
2. Doroguntsov, S.I., Fedorischeva, A.M., Ralchuk, O.M. (2004). *Bezpeka rozvitku I bezpeka stabilnosti – vidpovid na vikliki globalizatsiyi [Safety and safety of stability - the answer to the challenges of globalization]*. Kyiv: Znannya Ukraini [in Ukrainian].
3. Blehman, I.I. (1971). *Sinhronizatsiya dinamicheskih sistem [Synchronization of the dynamical systems]*. Moskva: Nauka [in Russian].
4. Gorbulin, V.P. (2009). *Zasadi natsionalnoyi bezpeki Ukraini [Fundamentals of the National safety of Ukraine]*. Kyiv: IntertehnologIya [in Ukrainian].
5. Sunduk, A.M. (2007). *Regionalniy vimir ekonomichnoyi bezpeki Ukrayini [Regional dimension of the economic safety of Ukraine]*. Kyiv: Logos [in Ukrainian].
6. Himich, O. (2002). Ekologichna bezpeka yak element natsionalnoyi bezpeki [The environmental safety as an element of the national safety]. *Pravo UkraYini – Law Ukraine*, 11, 44-48 [in Ukrainian].
7. Hlobistov, E. V. (2005). Problemi zabezpechennya ekologichnoyi bezpeki v umovah transformatsiyi ekonomiki Ukrayini [Problems of ecological safety in the economic transformation Ukraine]. *Extended abstract of Doctor's thesis.* Kyiv: Rada po vivch. produkt. sil UkraYini NAN UkraYini [in Ukrainian].
8. ShmandIy, V.M. (2004). UpravlInnya ekologIchnoyu bezpekoyu na regionalnomu rivni (teoretichnI ta praktichnI aspekti) [Management of ecological safety at regional level (theoretical and practical aspects)]. *Extended abstract of Doctor's thesis.* HarkIv: Ukr. nauk.-doslId. In-t ekol. probl. [in Ukrainian].
9. Shlyahtina, S. (2011). Sinhronizatsiya dannyih [Data synchronization]. *KompyuterPress – ComputerPress*, 7. Retrieved from http://mmi.fem.sumdu.edu.ua/sites/default/files/mmi2011_4_1_55_66.pdf [in Ukrainian].
10. Danilov-Danilyan, V.I. (Eds.). (1997). *Ekologiya, ohrana prirodyi i ekologicheskaya bezopasnost [Environment, Nature Conservation and Environmental Safety]*. Moskva: Izd-vo MNEPU [in Ukrainian].
11. Downey, Allen B. (2005). *The little book of semaphores.* [Електронний ресурс]. US: SoHoBooks. – Режим доступу: http://greenteapress.com/semaphores/

ECONOMIC PROCESSES MANAGEMENT
international scientific e-journal (ISSN 2311-6293)
epm.fem.sumdu.edu.ua
№2 – 2015

МОДЕЛЮВАННЯ СИНХРОННОСТІ ПРОЦЕСІВ ЗАБЕЗПЕЧЕННЯ ЕКОЛОГІЧНОЇ БЕЗПЕКИ ЕКОНОМІЧНОЇ СИСТЕМИ

Прокопенко Ольга Володимирівна,
д-р екон. наук, професор, завідувач кафедри економічної теорії,
Сумський державний університет, Україна
професор,
Вищої школи економіко-гуманітарної, м. Бельсько-Бяла, Польща;
Школа Вікторія Юріївна,
канд. екон. наук, доцент, доцент кафедри економічної теорії,
Домашенко Марина Дмитрівна,
канд. екон. наук, доцент кафедри економічної теорії,
Троян Марія Юріївна,
канд. екон. наук, доцент кафедри економічної теорії,
Сумський державний університет, Україна

Досліджено сутність синхронізації як наукової категорії. Сформовано комплекс показникі, що характеризують складові економічної системи на рівні підприємства та регіону. Запропоновано методичний підхід до оцінки синхронності процесів забезпечення екологічної безпеки економічної системи. Удосконалено методичний підхід до прогнозування динаміки розвитку економічної системи з урахуванням запровадження інструментів забезпечення економічної безпеки на вищому рівні.

***Ключові слова**: економічна система, синхронність, екологічна безпека, швидкість синхронного розвитку, автономна швидкість, ефективність, прогнозування розвитку системи.*

МОДЕЛИРОВАНИЕ СИНХРОНИЗАЦИИ ПРОЦЕССОВ ОБЕСПЕЧЕНИЯ ЭКОЛОГИЧЕСКОЙ БЕЗОПАСНОСТИ ЭКОНОМИЧЕСКОЙ СИСТЕМЫ

Прокопенко Ольга Владимировна
д-р экон. наук, профессор, заведующий кафедрой экономической теории,
Сумский государственный университет, Украина;
профессор,
Высшей школы экономико-гуманитарной, г. Бельско-Бяла, Польша
Школа Виктория Юрьевна
канд. экон. наук, доцент, доцент кафедры экономической теории,
Домашенко Марина Дмитриевна
канд. экон. наук, доцент кафедры экономической теории,
Троян Мария Юрьевна
канд. экон. наук, доцент кафедры экономической теории,
Сумский государственный университет, Украина

Исследована сущность синхронизации как научной категории. Сформирован комплекс показателей, характеризующих составляющие экономической системы на уровне предприятия и региона. Предложен методический подход к оценке синхронизации процессов обеспечения экологической безопасности экономической системы. Усовершенствован методический подход к прогнозированию динамики развития экономической системы с учетом введения инструментов обеспечения экономической безопасности на высшем уровне.

***Ключевые слова**: экономическая система, синхронность, экологическая безопасность, скорость синхронного развития, автономная скорость, эффективность, прогнозирование развития системы.*