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THE THEORY AND METHODS FOR INVESTIGATION OF THE PROCESSES SYNCHRONIZED DEALING WITH ECOLOGICAL SAFETY WITHIN ECONOMIC SYSTEM

The synchronization as a scientific category is investigated in the article. A set of indicators concerning economic system constituents at the enterprise and at regional level is formed. A methodological approach to assessment of the processes which 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, speed of synchronized development, autonomous speed, efficacy, forecasting of system development.

Problem statement. The solution of the problem of extension the level of ecological safety underlies in the sphere of studying the mechanism of synchronization of business systems at different levels and processes that ensure its environmental safety.

Analysis of the recent researches 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. At the same time, in spite of having been made profound and significant research contributions to the problem solvement above mentioned 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 which are in need for ecological safety provision; to optimize the processes of ecological safety provision at the different levels; to avoid ineffective costs; to enhance the level of ecological safety.

The object of the article is the development of scientific and methodological issues dealing with investigation and assessment of the processes which synchronize ecological safety within economic system.

The main results. Synchronization as a scientific phenomenon, possesses an enormous number of forms in nature, technology, economics, society. These factors make some difficulty in 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 synchronization 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:

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

where $x^{(s)}(t)$ – function that characterizes the state of subsystem *s*, represented by n_s-dimensional vector at the moment of time *t*; $x^{(1)}$, $x^{(2)}$, $x^{(3)}$ – functions that characterize the state 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 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 $\gamma = 1$, 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 – duration of the investigated period; k – the amount of processes (tools) 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 should take into consideration that 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 appropriate to take into consideration the speed of output of the investigated process through time factorin terms of 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 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. The table of the value of the coefficient $g^{(z)}$ in order to simplify the use of index is designed. It was introduced by the authors basing on a retrospective analysis of parameters that correspond to different processes and measures concerning providing of environmental safety of business system at the appropriate level. It was introduced in the conditions of 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 experience or investigation. The second one is held only under the condition that retrospective data is absent.

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

Economic subsystem at the enterprise level is 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 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 business system openness (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 is 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).

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 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 (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 of 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 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 risky situation (it is defined as a sum of losses that appeared at the objects of business system), correlated with the sum of general outputs of business system in the investigated period; $x_{19}^{(2)}$ – index of external danger of a risky 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*); $x_{20}^{(2)}$ – index of general amount of damages or risky situations (in relation to the previous period); $x_{21}^{(2)}$ – 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.

Economic subsystem at the regional level is characterized by such indices: $x_1^{(1)}$ – index of gross regional proceeds, calculated for one 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 paid services, given by enterprises(establishments) of the region (in a comparison with the prices in relation to GRP); $x_{12}^{(1)}$ – index-deflator of paid services (pertaining to the previous period); $x_{13}^{(1)}$ – investments in 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 at 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 (incomes of 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 renovation of the main funds; $x_{31}^{(1)}$ – coefficient of economy openness 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.

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 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 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 population; $x_{23}^{(2)}$ – using of secondary energy resources by the population; $x_{24}^{(2)}$ – index of energy resources saving 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 which are suffered from the conflagrations, in general scale of the forest; $x_{30}^{(2)}$ – losses which are injured by 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 which are occupied in the labour activity; $x_5^{(3)}$ – the part of employable population in the general number of population in 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 added gross 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 which are suffered from injures during production.

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

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

where Z^I – sequence number of the introduced tool of providing environmental safety of the business system at the high level in a period t; k^I – 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 which are in need at higher levels; formula (2) – for investigation of economic systems at lower levels mutually with influence of the tools which are in need at 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 the desired 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.

We should mention that the proposed theoretical and methodical approach to the evaluation of the processes synchronized dealing with ecological safety within economic system, which takes into account its ecological safety changeability, tools implementation costs, synergy of the ties among the above mentioned tools, subsystems and systems of the different levels, and provides flexibility when forming the most optimal set of tools which are in need for ecological safety within differently ranked economic systems performance. Its implementation at the enterprise, government or local authorities allows us to optimize the processes of ecololgical safety provision at the different levels, and also to avoid ineffective costs.

Conclusions and perspectives for further researches. 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 obtained results consists in the possibility to increase the efficiency of controlling economic system for its constant development due to offered scientific and methodological approach for estimating synchronization of observed processes.

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

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Теорія та методика дослідження синхронності процесів забезпечення екологічної безпеки економічної системи

Досліджено сутність синхронізації як наукової категорії. Сформовано комплекс показників, 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.

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Теория и методика исследования синхронизации процессов обеспечения экологической безопасности экономической системы

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.

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