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ENVIRONMENTAL AND ECONOMIC RISKS IN THE IMPLEMENTATION OF THE SUSTAINABLE DEVELOPMENT MODEL FOR ENTERPRISES IN THE CONDITIONS OF ENERGY CHALLENGES

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Introduction. Scientists have been actively discussing ways to implement the model of sustainable energy development and ensure energy security at the global, national, regional, and local levels among the topical issues of the last decade. The main goal of the sustainable economy functioning is to provide fundamental values like the preservation of natural capital, public welfare, people's health, means of livelihood and survival, where energy resources play an increasingly important role. Politicians, scientists, practitioners, and society as a whole broadly discuss the issues of how to allocate limited or scarce resources among alternative, competing sustainable energy development goals; how the state of the ecosystem changes at the same time; how to achieve a balance between desirable economic development goals and limited natural resources; what risks arise during the implementation of environmental innovations; what strategy should be to build the eco-innovation system of the enterprise in the market conditions and their energy sustainability.

Analysis of recent research and publications. Modern science has a sufficiently developed toolkit for environmental and economic risk assessment and environmental management. However, these approaches often reflect the uncoordinated positions of different researchers (environmentalists or economists). Changing the regulatory framework for increasing the environmental tax under the EU model may cause environmental and economic risks in the implementation of the model of sustainable development of the enterprise [5]. The implementation of ecological innovations, which are aimed at preserving the ecological system, has no less influence on the effectiveness of the enterprises' functioning [6–8].

Energy challenges exert no less influence on the effectiveness of the enterprises' functioning. New aspects regarding the influence of energy security on the energy sustainability of enterprises in the conditions of the energy transition are important. [9]. For example, it is necessary to take into account the following new factors of the energy sustainability of the enterprise: the transformation of the energy system of the state and the transition to decentralized hybrid energy systems [10]; optimization of the environment of the national energy system [11]; introduction of hybrid energy systems in combination with energy storage technologies [12], etc.

The goals of the Energy Strategy of Ukraine for the period until 2050 (availability of clean energy, overcoming energy poverty, development of an innovative and decentralized energy system, full functioning of national energy markets and their integration into international ones) are important guidelines for building a model of sustainable energy development of enterprises [13]. The current state of Ukraine's energy security and the challenges the country faces during hostilities are complex [14]. Therefore, it is important to investigate

environmental and economic risks in the implementation of the sustainable development model for enterprises in the conditions of energy challenges.

Objectives of the article. The research objective is to propose a scientific and methodological approach to the assessment of environmental and economic risks in the implementation of the model of sustainable energy development of enterprises.

The implementation of the approach will make it possible to determine the ways of sustainable energy development of Ukrainian enterprises and their adaptation to new competitiveness conditions. This involves performing an economic-mathematical analysis of the amount of output of a given range of the enterprise's products in order to substantiate management decisions regarding the optimization of the production program for the future short-term period under the conditions of non-deterministic product and ensuring a certain level of income.

The main material of the study. Ukraine's integration into the European economic space actualizes the task of adaptation for Ukrainian enterprises and organizations regarding the emergence of new environmental and economic risks, including the uncertainty of the future market situation. One of the tasks of Ukraine as a candidate for EU membership is to introduce a system of relevant environmental norms and standards, to form its own position on their implementation and mechanisms of application taking into account the theory of value of natural capital, value of ecosystems and social value of specific products [1–4]. For example, the existing system of taxation of EU countries has established global values for the preservation of the environment (sustainable development goals). About 150 types of environmental taxes are applied in European countries. According to calculations of Ukrainian experts, an increase in the environmental tax on the example of the EU (excluding rent) in the total tax revenues to 5–6% will lead to an increase in their amount more than 10 times, and thus to an increase in the tax burden on enterprises, increase in the price of their products and decrease its competitiveness [5]. However, this can be avoided by simultaneously reducing corporate income taxation, which requires certain legislative changes in the field of environmental taxation. Such changes in the taxation system will significantly strengthen the stimulating environmental protection role of the environmental tax.

This situation is exacerbated by the state of Ukraine's energy complex in modern conditions. This requires the use of economic-mathematical methods and models in the procedures for justifying management decisions, in which uncontrollable parameters are random variables. The implementation of this approach will require a review of the value of specific types of products produced by Ukrainian enterprises in the system of new competitive requirements.

Therefore, the assessment of environmental and economic risks of the business model of enterprises in the conditions of the transition to European environmental standards and energy challenges makes it possible to predict changes in indicators of profitability of products, profitability of the enterprise, to assess changes in its competitiveness as a whole in the domestic and foreign markets. Thus, understanding, modeling, evaluating and managing the competitiveness of enterprises including the environmental component is extremely important, since the Ukrainian economy is not ready to compete in all European markets.

The relative value of individual types of enterprise products in the conditions of implementation of the sustainable development model is constantly changing. In order to maintain the level of income the enterprise needs to constantly change the amount of its output, that is, to reduce the quantity of products, relative value of which decreases, and to increase the quantity of products value of which increases. The total income can be significantly increased for the future short-term period by optimizing the production program, taking into account the statistical data for the previous periods. It is necessary to write down the resolution of the problem and to develop the economic-mathematical model for analysis of enterprise's output amount.

The enterprise can produce a certain range of products, known statistical data on prices and quantity of products in several periods. It is necessary to develop a production program for the enterprise, which will provide income at a given level in the future short-term period. This is a multi-criteria task with simultaneous optimization of several target functions on a given set of valid plans:

$$\left.\begin{array}{c} y_k = f_k(x) \to opt \\ x \in X \end{array}\right\} \quad (1)$$

where f_k – separate k-th function with criterion set $(k = \overline{1, p})$;
p – number of target functions to be optimized;
x – element of a set of valid plans X.

Under conditions of risk regarding the future level of prices for the company's products, the distribution of probabilities for a set of possible states of the environment or a set of possible consequences in the task of making managerial decisions is known or can be estimated. Therefore, the value of a unit of production in the future short-term period is a random variable with a known mathematical expectation and standard deviation.

In order to reduce the risk of a possible decrease in the level of income of enterprises due to unpredictable changes in the relative value of certain types of products, it is necessary to determine the optimal plan based on the criteria of maximizing expected income and minimizing its dispersion. To do this, we need to solve the following two-criterion problem:

$$\left.\begin{aligned} \bar{u} &= \sum_{j=1}^{n} w_j^1 \cdot y_j \to max \\ \sigma^2(u) &= \sum_{i=1}^{n}\sum_{j=1}^{n} \rho_{ij} \cdot \sigma_i \sigma_j \cdot y_i y_j \to min \\ \sum_{j-1}^{n} w_j^0 \cdot y_j &= u^0 \\ y_j &\geq 0, j = \overline{1,n} \end{aligned}\right\} \quad (2)$$

where u – expected future value of products (income);

$\sigma^2 u$ – income dispersion;

n – amount of production types;

i, j– numbers of production types (current and future);

w_j^0, w_j^1 – current and future relative value of a unit of the j-th product type;

y_i, y_j – current and future amount of one product type;

ρ_{ij} – correlation coefficient between w_j^0 and w_j^1 parameters;

σ_i, σ_j – standard deviation of one product type;

u^0 – the future value of products at current relative prices.

In the formula (2), the first target function influences the selection of those types of products that will provide the largest value of the expected income, and the second requires the selection of a range of products with the smallest dispersion of income. Limitations are the condition of equality of the total current value and the total value at current relative values and the condition of non-negativity of the number of products in the future period.

Therefore, from the set of effective plans of the two-criterion problem, the production program is optimal, in which the ratio of indicators corresponds and to the maximum of the generalized additive objective function on the set of admissible plans:

$$z = \frac{\bar{u}}{\bar{u}_{max} - \bar{u}_{min}} - \frac{\sigma^2(u)}{\sigma^2(u)_{max} - \sigma^2(u)_{min}} \quad (3)$$

where $[\bar{u}_{min}; \bar{u}_{max}], [\sigma^2(u)_{min}; \sigma^2(u)_{max}]$ – limits of variation (interval) of each of the target functions.

In order to test the economic-mathematical model, a production program for one future period (month) was developed for one division of the Poltava machine-building enterprise based on the data of 2021 and 2022. Initial data (current value and relative statistical data of product prices for the previous ten periods), as well as calculated forecast values (11th period) are shown in table 1.

The minimum and maximum value of each of the target functions (mathematical expectation and variance of income) were determined using the Microsoft Excel add-in "Search for a solution" (task 1 – task 4). Then the search for the maximum value of the generalized additive target function was performed according to formula 3. The obtained data are presented in table 2.

The results of calculations of the production program and mathematical expectation and dispersion of income are presented in tables 3 and 4. Thus, the output of the calculated number of products will provide the expected income within $\bar{u} \pm \sigma(u)$, i.e. [3542,61; 3559,99].

According to the results of calculations, the relative value of P2 products is expected to increase, so its output should be significantly increased. There is also a slight decrease in P3, but it has a maximum relative value, so its

Table 1

Relative Initial Data and Predicted Values

Period/ Production	P1	P2	P3	P4	Sum
1	0,1058	0,3194	0,3863	0,1885	1
2	0,1058	0,3194	0,3864	0,1884	1
3	0,1058	0,3194	0,3863	0,1885	1
4	0,1058	0,3194	0,3863	0,1885	1
5	0,1058	0,3195	0,3863	0,1885	1
6	0,1058	0,3195	0,3863	0,1885	1
7	0,1058	0,3195	0,3863	0,1885	1
8	0,1022	0,3301	0,3739	0,1939	1
9	0,1057	0,3195	0,3864	0,1884	1
10	0,1057	0,3195	0,3864	0,1884	1
11	0,1048	0,3223	0,3830	0,1899	1

Table 2

Additive Target Function

No	Target Function	Value
Task 5	General Target Function	53,31

Table 3

The Results of the Production Program Calculations

Production	P1	P2	P3	P4	Sum
Relative Value	0,1058	0,3194	0,3863	0,1885	1,00
Future Relative Value	0,1048	0,3223	0,3830	0,1899	1,00
Amount of Production	6500	2000	3300	5000	
Amount of Production for the future period	1168	5207	3145	2875	
Current Price	687,57	638,88	1274,75	942,46	3543,66
Price by the Current Relative Values	123,55	1663,32	1214,88	541,91	3543,66
Price for the Future Period	122,35	1678,44	1204,60	545,91	3551,30

Table 4

The Results of the Income Dispersion Calculations

σi*σj	**0,00113**	**0,00335**	**0,00393**	**0,00171**
0,00113	1,28E-06	3,80E-06	4,45E-06	1,93E-06
0,00335	3,80E-06	1,12E-05	1,32E-05	5,72E-06
0,00393	4,45E-06	1,32E-05	1,54E-05	6,69E-06
0,00171	1,93E-06	5,72E-06	6,69E-06	2,91E-06
ρij	1,0000	-0,9997	0,9992	-0,9990
	-0,9997	1,0000	-0,9999	0,9998
	0,9992	-0,9999	1,0000	-1,0000
	-0,9990	0,9998	-1,0000	1,0000
yi*yj	1168	5207	3145	2875
1168	1364224	6081776	3673360	3358000
5207	6081776	27112849	16376015	14970125
3145	3673360	16376015	9891025	9041875
2875	3358000	14970125	9041875	8265625
σi*σj*ρij*yi*yj	1,75	-23,09	16,32	-6,48
	-23,09	304,69	-215,45	85,55
	16,32	-215,45	152,38	-60,51
	-6,48	85,55	-60,51	24,03
	Income dispersion			75,53

output remains almost at the existing level. There is an insignificant increase for P4 products, and a slight decrease for P1 products, but also a low relative value, so their number should be slightly reduced in the future period. The total production value for the current period exceeds 2.5 million conditional monetary units. In the future period, income growth by several percent is predicted due to changes in the output of certain types of products.

Thus, in order to achieve in the future period of the planned income level of a certain range of products of the enterprise production program it is necessary to ensure the sale of products P2, as well as to increase the relative value of products P1 and P4.

Thus, the development of production program for the enterprise taking into account the change in value of products is a multi-criteria task with simultaneous optimization of several target functions on a given set of valid plans. Accordingly, the transformation of economic activity under modern conditions is related to the factors of randomness, vagueness, incompleteness of information (uncertainty), which creates environmental, economic, technological and other risks. Risk management is intended to provide an optimal ratio of future profit (increase of market value) and risk, its acceptable (allowable) level for the enterprise. A necessary condition for solving the risk problem is a clear understanding of the business entity's goals. Therefore, based on the specific goals of the organization and their likely changes, it is important to collect, process and analyze information about changes in the external and internal environment, the dynamics of internal indicators of financial, production, commercial activity in the past and in the current period, to make forecasts for the future. At the same time, it is the relative value of products that can act as one of the criteria for choosing a model and strategy for the sustainable development of enterprises in conditions of energy challenges.

Accordingly, the assessment of environmental and economic risks through the study of the factors of product value formation and their dynamic changes creates the basis for building a production program for the development of enterprises as innovative ecosystems.

In addition, the proposed scientific and methodological approach can be adapted to substantiate the model of energy resilience of the enterprise. In modern conditions, such a model should take into account new trends in the development of the energy market, the processes of decentralization of the energy grid, and the reconstruction of Ukraine's energy infrastructure under the influence of geopolitical factors.

Conclusions. In the light of new concepts of modern economic development of enterprises as innovative ecosystems, the search for new tools and mechanisms for the implementation of their adequate business models is now underway. They must ensure the stability of enterprises in the system of new requirements and take into account the created restrictions on the enterprises' functioning. Thus, the essential transformation of the economic category of value at the macro level through the implementation of the goals of sustainable development changes the modern context of the development of specific enterprises and the content of the value of specific products at the micro level.

The obtained results increase the scientific level of substantiation of the management decision regarding the optimization of the amount of the production program for the future short-term period under the conditions of non-deterministic market prices for products to ensure a certain level of income of the enterprise. The suggested economic-mathematical model can be used to develop a systematic approach to determine the needs for financial, material and labor resources for the implementation of the enterprise's production program, as well as increasing competitiveness and profits for future periods.

The further development of this approach will make it possible to increase the competitiveness of enterprises and justify the energy sustainability of their eco-business models.

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Olha Komelina, Doctor of Economic Sciences, Professor, Professor of the Department of Management and Logistics. **Yuriy Kharchenko**, Candidate of technical sciences, Associate Professor of the Department of Management and Logistics, National University "Yuri Kondratyuk Poltava Polytechnic". **Environmental and economic risks in the implementation of the sustainable development model for enterprises in the conditions of energy challenges.**

The article is devoted to the study of scientific and methodological foundations for assessing ecological and economic risks in the implementation of a model for sustainable development of enterprises under increasing energy challenges. It was determined that the development of a modern business model for enterprises should take into account changes in their competitive position, new trends in the development of the energy market, processes of decentralization of energy networks, and the reconstruction of Ukraine's energy infrastructure under the influence of geopolitical factors. The authors propose an economic-mathematical model for analyzing the volume of the company's products, taking into account the value of its products for the consumer. The implementation of this approach will make it possible to determine ways to achieve sustainable energy development of Ukrainian enterprises and their adaptation to new conditions of competitiveness and energy sustainability.

Key words: sustainability, global value, product value, environmental risk, economic risk, enterprise, energy challenges, energy sustainability.

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Комеліна Ольга Володимирівна, доктор економічних наук, професор, професор кафедри менеджменту і логістики, Національний університет «Полтавська політехніка імені Юрія Кондратюка». **Харченко Юрій Анатолійович**, кандидат технічних наук, доцент кафедри менеджменту і логістики, Національний університет «Полтавська політехніка імені Юрія Кондратюка». **Екологічно-економічні ризики при впровадженні моделі сталого розвитку підприємств в умовах енергетичних викликів**.

Стаття присвячена розробленню науково-методичних засад оцінки еколого-економічних ризиків, що виникають під час реалізації моделі сталого розвитку підприємств в умовах євроінтеграції України та впровадження відповідних екологічних та енергетичних стандартів. Виявлено вплив нових енергетичних викликів на розвиток українських підприємств, що пов'язані із системною трансформацією енергетичного ринку та його інфраструктури в умовах енергетичного переходу. Акцентовано увагу на дослідженні екологічної енергетичної стійкості підприємств як здатності відновлювати конкурентні позиції шляхом перебудови бізнес-моделі підприємства та впровадження інновацій. Обґрунтовано, що оцінка еколого-економічних ризиків та

енергетичних викликів для бізнес-моделі підприємств з урахуванням її цінності для споживача дає змогу прогнозувати динаміку результативності діяльності підприємства, а також оцінювати зміни конкурентоспроможності підприємства на внутрішньому та зовнішньому ринках. З'ясовано, що трансформація господарської діяльності підприємств за сучасних умов пов'язана з чинниками випадковості, невизначеності, неповноти інформації (невизначеності), що створює екологічні, економічні, технологічні та інші ризики. Управління ризиками покликане забезпечити оптимальне співвідношення майбутнього прибутку (приросту ринкової вартості) і ризику, його прийнятний (допустимий) рівень для підприємства. Запропонований науково-методичний підхід може бути адаптований для обґрунтування моделі енергетичної стійкості українських підприємств підприємства. У сучасних умовах така модель має враховувати нові тенденції розвитку енергетичного ринку, процеси децентралізації енергомережі, реконструкцію енергетичної інфраструктури України під впливом геополітичних факторів. Подальший розвиток цього підходу дасть змогу підвищити конкурентоспроможність підприємств та обґрунтувати їх екологічну та енергетичну стійкість як екосистем.

Ключові слова: стійкість, глобальна цінність, вартість продукту, екологічний ризик, економічний ризик, підприємство, енергетичні виклики, енергетична стійкість.