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Article

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Innovative Approaches to Improving the Process of Risk Management in the Context of Developing a Strategy for the Foreign Economic Activity of Enterprises

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Abstract: The article presents innovative approaches to improving the risk management process in the context of developing a strategy for foreign economic activity of enterprise. To identify risks and choose the optimal strategy for foreign economic activity of enterprises (FEA), economic and mathematical modelling was used using the risk matrix and the criteria of Bayes, Laplace, Wald, Savage, Hurwitz, Hodge-Lehman. To approbate the results of the study, enterprises of the pharmaceutical industry were selected. According to the theory of games, in order to improve the risk management process, elements of the payment matrix have been applied, which characterize the profit of pharmaceutical enterprises in foreign economic activity. The use of the Hurwitz criterion, which is a criterion of pessimism-optimism, made it possible to choose the optimal strategy for the selected enterprises. The developed matrix of risks of foreign economic activity (strategic, operational, financial and external) for the selection of the optimal strategy of foreign economic activity through the use of economic and mathematical modelling should be used to determine the risks of the greatest impact at different stages of foreign economic activity using the theory of games. The presented matrix of risks of foreign economic activity is built for domestic enterprises of the pharmaceutical industry and is aimed at improving the process of risk management of foreign economic activity, which will enable enterprises of the pharmaceutical industry to predict risks at the early stages of activity and take into account in the general concept of the strategy of foreign economic activity of enterprises. The pharmaceutical industry of Ukraine was chosen for research because it is the most popular in modern conditions, and, according to the results of the analytical review, very high-risk. That is why the use of economic and mathematical modelling for risk calculation allows to optimize the economic behaviour of domestic pharmaceutical enterprises, while providing a reliable basis for making sound strategic decisions in the process of risk management in the context of developing a strategy for foreign economic activity. The risk management process, consisting of 7 stages and 18 steps, has been improved, and innovative tools have been proposed that facilitate the implementation of risk management in the enterprise in the process of developing a foreign trade strategy. The use of economic and mathematical modelling in risk forecasting and the formation of a foreign economic activity strategy will help enterprise managers to significantly increase management efficiency, reduce risks at the stage of planning foreign economic activity. The article improves the risk management process, which consists of 7 stages and 18 steps, and offers innovative tools that facilitate the implementation of risk management in the enterprise in the process of developing a foreign trade strategy. The use of economic and mathematical modelling in risk forecasting and the formation of a foreign economic activity strategy will help enterprise managers to significantly increase management efficiency, reduce risks at the stage of planning foreign economic activity.

Keywords: strategic management; transfer pricing; innovation; risks; strategy; risk matrix; foreign economic activity; game theory.
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Introduction. In a globalized world, foreign economic activity (FEA) is attractive for enterprises seeking to expand their market presence and increase profitability. Foreign exchange increases the opportunity for growth, but it is accompanied by a large number of risks. Effective management of foreign exchange is an important condition and tool for preventing the occurrence or minimizing risks that can affect the financial stability and stability of the operation of an enterprise. Making systemic decisions that allow adequate responses to internal and external challenges is a complex process for which individual enterprises are often not ready. Therefore, in the process of developing a foreign exchange strategy, an important stage is the development of a risk management system. The study of this issue has attracted the attention of a large number of scientists, theoreticians and practitioners. The effectiveness of the risk management system will help increase the stability and productivity of enterprises and gain competitive advantages in foreign markets.

Traditional approaches to risk management usually consist of making a yes or no decision at certain points in time or periodically reviewing a stable business process. In the age of innovation, this approach is doomed to failure. Flexible development can mean that proposals are never fully completed but are in a state of constant development, making it impractical to commit at some point in time. Therefore, it is necessary to develop innovative approaches to improve the risk management process. There are real conditions of risk and uncertainty in the process of carrying out foreign economic activity. Therefore, mathematical risk analysis methods were used to include these risks in the variables to be analysed. The necessary tools are used to analyse variables under conditions of uncertainty. Despite the fact that the topic of risk management is not new, under the conditions of the external and internal challenges of globalization, the essence and structure of risks have changed significantly. Therefore, new business organizations and institutions have developed recommendations and regulatory documents and improved management methods by using new approaches and tools that help managers and leaders modify risk management practices. One effective means of such improvement is economic-mathematical modelling. In the works of the authors, the general risks of entrepreneurial activity are considered, classifications by types of risks are presented, and the characteristics of methods for measuring, managing, modelling, and reducing them are given. However, the risks of foreign economic activity are ignored. Risk assessment in the implementation of export operations by an enterprise is one of the most important stages of foreign economic activity because the study of the nature, sources, size and consequences of risks is necessary for making effective management decisions at the enterprise. In particular, there is a need to improve risk assessment to prevent enterprises from reaching the verge of bankruptcy in critical situations, with strict restrictions on financial resources in the context of foreign economic activity. To assess risks, mathematical modelling, which is a type of quantitative method, can be used. Mathematical modelling allows for improving the risk management process in the context of developing a strategy for the foreign economic activity of enterprises. Although basic risk management systems were established in Roman times, the concept is becoming increasingly important today. Depending on the activity carried out by the enterprise, the enterprise will be exposed to certain dangers. A risk assessment program can only be successful if it fully complies with the legal, social and ethical goals and rules for the use of the latest technologies. By using various technologies and ways to minimize and mitigate the impact of risks, a company will protect itself from uncertainty, reduce costs and increase the likelihood of business continuity and success. To reduce risk, companies need to apply constant monitoring and develop measures that will help reduce the impact of negative events while maximizing positive events. Only such a well-considered and consistent approach to risk management will contribute to the effective management of the enterprise. Risk management establishes a specific set of strategic processes that begin with enterprise objectives to identify risks and contribute to risk mitigation through best practices. The inclusion of risk management in the strategic planning of the FEA is important because it helps to anticipate and consider various problems and scenarios that may arise in the future and affect the operation and achievement of the company's goals. Thus, the strategic planning of FEA and risk management is a complex and permanent part of effective management at the enterprise. It is impossible to predict everything that will go wrong, but foresight when problems arise will undoubtedly improve the chances of success and provide a better perspective in the FEA process. In addition, the practice of risk prediction using economic-statistical planning will only encourage the enterprise to remain flexible and not be afraid to try new alternatives in the FEA process.

This paper is composed of six major sections. Subsequently, section 1 presents the introduction. Section 2 provides a literature review in which various approaches to improving and justifying the risk management process in the context of developing a strategy for the foreign economic activity of enterprises are justified. Additionally, the literature on the specifics of risk management in the context of developing a strategy for the foreign economic activity of enterprises was processed. Section 3 describes the methodology and research

methods. The main economic and mathematical methods used in the article are considered. Formulas used for constructing matrices based on various approaches of scientists are provided. Section 4 presents the results. Based on the selected pharmaceutical enterprises, the proposed methodology for the risk management process in the context of developing a strategy for the foreign economic activity of enterprises was tested. Finally, section 5 provides a discussion and conclusions.

1. Literature Review. Change in business management can be analysed as an episode with a beginning and an end, or it can be seen as a continuous organizational process with the possibility of reflecting external influences and social and historical backgrounds. Risk events that occur in a dynamic and uncertain environment, such as market volatility, geopolitical crises, economic changes, regulatory reforms and cyber threats, long-term patterns and others, constitute external influences that are increasingly emphasized in the organizational environment. Although the topic of risk and risk management is not new, the complexity of risk has changed, while guidelines and regulatory documents and statements from leading business organizations and institutions have emerged that require managers and executives to modify management practices to include and directly recognize them. Increased requirements for the creation of effective risk management systems ensure the emergence of new organizations, business consulting agencies and professional associations (IFAC, 2012) and even new fields of knowledge in universities (Tkachuk et al., 2022). The emergence of risk management as a new paradigm in strategic management provides an opportunity to rethink the role of managers and directors, but above all, risk management is a form of management and a new direction of research. The individual circumstances that require enterprises to adapt and adapt to a changing environment have been studied in detail in the scientific works of Andreeva & Ritala (2016), Hernandez & Dopico (2017), and Mischuk & Holiver (2015). Fernandez & Rodríguez (1997), Gerasimenko (2019), Calderon et al. (2006), and Chenhall (2008) examined changes in the administrative and operational systems and processes of enterprises, as well as in the production and commercial relations that arose under the influence of internal and external environmental risks. Gerasimenko (2019), Tkachuk et al. (2022), Wu & Olson (2009), Klymenko (2013), and Vasilieva et al. (2015) studied the problem of risk management by conceptualizing it as a process that supplements the accounting, economy or finance of the enterprise. From this point of view, Karlin et al. (2021) and Prymostka et al. (2024) outlined various aspects of the risk activities of enterprises, which can be considered the basis of a new paradigm of research on the risks of foreign exchange. Vasilieva et al. (2015) considered a traditional approach focused on the negative aspect of risk and considered risk management to be a function performed by management to protect the enterprise from adverse events, aimed at reducing losses; the science and art of recognizing the existence of threats by determining their consequences for resources; and the application and modification of cost factors to effectively contain adverse consequences within certain limits. In contrast to the above approach, IFAC (1999) defines risk management as the search for opportunities and actions that can minimize the possible losses of the enterprise through appropriate procedures and methods of coverage that avoid financial losses. According to this approach, risk management is considered a process, system, approach, practice, and a new form of strategic management that provides information guidance on the risks that may arise and allows for improved management performance. In 1990, H. Markowitz and V. Sharp were awarded the Nobel Prize for developing the theory of economic risk. Currently, there is no consensus among scientists and practitioners regarding the unequivocal understanding of the essence and role of risk management. For example, Riazanova (2022), the Committee of Sponsoring Organizations, COSO (2004), Gerasimenko (2019), and the Institute of Internal Auditors (IIA, 2009) believe that it contributes to the achievement of a company's goals. Among them, it is worth highlighting the definition presented COSO (2004): risk management is "a process carried out by the board of directors of an economic entity, its management and the rest of its personnel, applied to the determination of the enterprise's development strategy and intended to identify potential events that may affect the enterprise, manage it within the limits of the accepted risk and providing confidence in the achievement of goals". Similarly, from Miller's point of view, risk management is closely related to enterprise strategy, as it is "a standardized and formal process immersed in the dynamics of business cycles, the permeability and diffuse nature of business boundaries, and the various processes and hybrid practices through which uncertainty arises" (Miller et al., 2008). This argument is accepted in risk management systems COSO 2004 and ISO: 2009, Riazanova (2022), Tkachuk (2022), Gerasimenko (2019), Beasley et al. (2015) and the professional field Institute of Management Accountants.

Onopriienko et al. (2023) believe that risk management is a part of strategy because its formulation and implementation in the enterprise requires reviewing the changing environment by identifying the main influences and drivers of uncertainty changes. In this sense, according to Chenhall (2008), strategies must be

rethought in a continuous process of formation. That is, it is necessary for the enterprise to constantly assess its state in terms of the balance between potential productivity, acceptable risks and uncertainty. In addition, as he claims, IMA (Institute of Management Accountants),the strategy allows you to level risks within the limits and acceptable levels of variation of the risk strategy itself, implemented at the enterprise. Thus, strategy formulation is enhanced by corporate risk management, as risks and strategic alternatives are identified and evaluated according to the enterprise's risk appetite (Kulish et al., 2024). In addition, risk management contributes to the creation of value, as it is a system that is integrated into all practices, processes and operations of the enterprise in an appropriate, efficient and effective way and is part of the development strategy (Kuznyetsova et al., 2021). Organizational processes defined in the business development policy and strategic management of the enterprise, as well as in the review and change management processes, are supported by processes, technologies and knowledge to assess and manage the uncertainty faced by the enterprise in creating new value (IFAC (1998); ISO 3100 (2009); IMA (2011)). Therefore, risk management is interconnected not only with the company's strategy but also with internal control and effective management (IFAC, 2011). It is integrated as part of the administrative process to ensure the functioning and continuous monitoring of critical factors in the enterprise, as well as its control. Hernandez & Dopico (2017) believe that risk management is intertwined with operational activities and changes the functions of the entire management team and senior management, particularly the board, to enhance accountability and transparency. Finally, risk management is increasingly visible and certified to the public because of its role in defining the integrity and legitimacy of the enterprise. Power (2009), in response to the demands of various leading institutions in the field, actively promotes a new approach to management by providing specialized risk management services (Pricewaterhouse Coopers PWC, 2017; Deloitte, 2017). Garafonova et al. (2023a) determined the prospects for the functioning of Ukrainian organizations under the modern conditions of European integration and globalization of the economy studied. In summary, the literature on risk management can be divided into three groups:

- First, Tkachuk et al. (2022) and Popescul & Georgescu (2013) investigated the determinants of the implementation of the risk management process.
- Second, Tkachuk et al. (2022) and McShane et al. (2011) consider risk management a way to increase enterprise value.
- The third category includes those that examine the specific channels through which risk management adds value to the enterprise (Onopriienko et al., 2023).

These differences are due to various indicators of risk management effectiveness (Tobin's Q, return on assets or ROA, volatility of ROA/profitability, etc.), as well as differences in the applied risk measurement. Despite the large number of publications, the specifics of risk management of foreign exchange in the context of the development of the company's foreign exchange strategy remain insufficiently covered. Anisimova & Vitka (2011) see suspected dangerous events that occur in the context of foreign economic activity as a risk in the sphere of foreign economic activity. Vasylieva et al. (2015), speaking about the risk in the sphere of foreign economic activity, indicate the unpredictability of foreign economic operations and incomplete confidence in the effectiveness of operations that are planned and carried out in the process of carrying out foreign economic activity; the authors also include the threat of loss of resources, additional costs, and loss of profit by business entities. Tyulienieva (2016), investigating risks in the field of foreign economic activity, noted that they are possible adverse events that may occur, and as a result, losses and property losses of participants in foreign economic activity may arise. Podrieza (2010) believes that the risk of an enterprise – subject of foreign economic activity – is an economic category that reflects the result of the implementation of the chosen decision in the form of success, failure or deviation from the set goal during production and economics, including foreign economic activities, taking into account the influence of the internal and external environment. Hrigorieva & Kobrzhitsky (2015) define risks in the context of foreign economic activity as conditions that can cause or contribute to the manifestation of reasons for nonimplementation of a foreign economic transaction of an enterprise. Vitlinsky et al. (2014) believe that the assessment is a quantitative description of the identified risks, as a result of which their characteristics, such as the probability and size of possible damage, are determined. When conducting a risk assessment, it is necessary to create a list of scenarios for the development of adverse situations, and for various risks, construct functions for distributing the probability of occurrence depending on its size. At the same time, to ensure the maximum efficiency of the risk management of the enterprise's economic activities, this management should be carried out on the basis of detailed forecasting and planning. That is, first, the activity of managing foreign economic risks at the enterprise should be systematic, and therefore, it should be based on the developed strategy of this

management (Ilyashenko, 2004). It cannot be said that the above risk management tools are complete, and in principle, it is impossible to provide tools that will include the possibility of minimizing any possible risk. However, by taking as a basis and determining which of the presented main tools are best suited for dealing with enterprise risks and for which risks each specific method will be used, the enterprise can build an individual risk management strategy. The strategy of managing foreign economic risks in this case should be indicative. The action plan of the enterprise at all levels of its management ensures minimal riskiness of foreign economic activity. The development of a strategy for managing foreign economic risks at an enterprise should begin with the definition of the main goal of foreign economic activity because it is the strategic goal that will determine the boundaries of management actions for managing foreign economic risks (Mashina, 2003). The purpose of this research is to use methods of economic-mathematical modelling and game theory to assess risks, which will provide an opportunity to improve the process of risk management in the context of developing a strategy for the foreign economic activity of enterprises.

Methodology and research methods. Economic and mathematical modelling using game theory was used in the research process. Three enterprises in the pharmaceutical industry were selected. The main criteria for selecting these enterprises were implementation of foreign economic activity, exports to more than 6 foreign countries, at least 100 employees, availability of profit over the past year, and entry into the top 10 pharmaceutical companies in Ukraine. On the basis of the published financial reports of the investigated enterprises, the borrowers were singled out for the study. Using the methods of analysis and synthesis, the obtained results were systematized; risk matrices were constructed; the Maximax, Bayes, Laplace, Wald, Savage, Hurwitz, and Khoja-Lehmann criteria were used; and risk assessment was carried out. With the help of the Maximax criterion, which focuses on the most favourable state, that is, the criterion that describes an optimistic assessment of the situation (the criterion of extreme optimism), a decision is made to determine a strategy that ensures profit maximization for each state in which the enterprise operates. The solution that achieves maximum profit is recognized as the best. The maximax criterion is not the only decision-making strategy under uncertainty. It is advisable to use it when the possibility of risk and the probability of conditions in which these risks may arise are assumed, known or unknown. According to the Bayes criterion, optimal solutions (or a set of such optimal solutions) are those solutions for which the mathematical expectation of the evaluation functional reaches the highest possible value. It is best suited to a situation of multiple repetitions, when a better average result will lead to a better overall result. If the considered decision-making situation is often repeated under unchanged conditions, then choosing the best strategy according to the Bayes criterion seems to be the best. Under conditions of complete uncertainty, the Laplace rule is applied, according to which all probabilities are considered equal. According to Wald's rule (the rule of extreme pessimism), when considering a decision, it is assumed that, in fact, the situation is the worst, resulting in the smallest income. This criterion corresponds to a pessimistic decision-maker, for whom the fear of losing is much more important than the fear of winning. By choosing a strategy based on the Wald criterion, one can firmly rely on the result obtained in determining it, even under the worst circumstances. The Savage Minimum Risk Criterion recommends choosing as the optimal strategy the one in which the magnitude of the maximum risk is minimized under the worst conditions. The Savage criterion focuses on the most unfavorable conditions; That is, it describes a pessimistic assessment of the situation. When applying Savage's rule (minimum risk rule), a matrix of risks is analyzed, that is, states of inconsistency between various possible consequences of adopting certain strategies. Considering the decision made, it is assumed that, in fact, there is a situation of maximum risk.

Hurwitz's rule is used when choosing a solution that recommends being guided by some average result, which characterizes the state between extreme pessimism and unbridled optimism. The optimal strategy is considered to be one for which the relation, $max(s_i)$ – multiple states is fulfilled, where $si = ymin(aij) + (1 - y) \times max(aij)$. At y = 1, the Wald criterion will be obtained; With y = 0, an optimistic criterion (maximax) will be obtained. The Hurwitz criterion takes into account the possibility of both the worst and the best behavior. The worse the consequences of wrong decisions, the greater the desire to insure against mistakes (the closer y is to 1).

The article also uses the Hodge-Lehman criterion. The criterion is based on the minimax criterion and the Bayes-Laplace test, "which is characterized by the fact that the parameter expresses the degree of confidence in the probability distribution used. When V = 1, the criterion becomes the Bayes-Laplace test, and when V = 0, it becomes the minimax criterion" (Karyy et al., 2021). For each row, the criterion value is calculated using the following formula:

$$W_i = u\sum a_{ij}\, p_j + (1 - u)\, min(a_{ij}) \quad (1)$$

Another indicator used in the article is the generalized Hurwitz criterion. "This criterion is a certain generalization of the criteria of extreme pessimism and extreme optimism and is also a special case of the generalized Hurwitz criterion for wins under the following assumption" (Beregova et al. 2019):

$$\lambda_1 = 1 - \lambda. \lambda_2 = \lambda_3 = \cdots = \lambda_{n-1} = 0, \lambda_{n-1} = 0, \lambda_n = \lambda, \quad (2)$$

where $0 \leq \lambda \leq 1$

The Hurwitz strategy performance indicator is calculated using the formula:

$$G_i = (1 - \lambda) mina_{ij} + \lambda maxa_{ij} \quad (3)$$

The optimist's approach,, λ - G is chosen from the condition of a non-increasing average. An auxiliary matrix is built, obtained by placing profitability indicators in each row, and a strategy with the maximum value of the efficiency indicator is considered. The optimal strategy $A_{ij} + \lambda_{max} \times a_{ij} = (1 - \lambda)_{min} \times a_i G$ according to Hurwitz is as follows:

$$\lambda = \frac{b_1}{b_1 + b_4} \quad (4)$$

The maximin principle (Hermeyer's criterion) is applied to the resulting matrix. The maximin principle is the principle of optimal player behavior in game theory. It consists of striving to maximize the minimum profit. The principle is especially important in antagonistic games, in which it results in the first player gaining the value of the game. Following the maximin principle, players are often forced to use mixed strategies. Thus, the new matrix must be supplemented on the right by another column, in which the smallest values of the elements of each row must be entered. Then, you need to select the largest of the elements of the added column. The row in which it stands will be the optimal strategy (N). $N > 0_{ij}$, if $a_j/q_{ij}=a_{ij}e < 0_{ij}$, if $a_j q_{ij}=a_{ij}$.

The last indicator used in the article is the combined Bayes-Laplace and minimax criterion (BL(MM) criterion). The selection rule for this criterion is formulated as follows. The decision matrix is supplemented by three more columns:

- Mathematical expectation of each line.
- The difference between the reference value $e_{i0j0} = max_i \left(min > j(e_{ij})\right) min_j(e_{ij})$ and the smallest value of the corresponding line.
- The difference between the largest value $max_j(e_{ij})$ of each row and the largest value $\llbracket min_j(e_{i0j})$ of the row in which the value e_{i0j0} is located.

Those options are selected, the lines of which reflect the greatest mathematical expectation. Using these criteria, a graph was constructed that shows the riskiness of the risk assessment matrix, marked with colours according to their severity. On the basis of the obtained data, approaches to increasing the effectiveness of risk management were substantiated, which made it possible to improve the risk management process in the context of the development and implementation of the enterprise's risk management strategy. In the process of developing a foreign exchange strategy, an enterprise can protect itself from negative influences, which prevent it from charging for the supply of products or services and which are associated with a large number of risks accompanying foreign exchange, by implementing various approaches and methods. One of these methods is economic-mathematical modelling using game theory. Any economic activity can be interpreted as a game. In a broad sense, "nature" refers to a set of uncertain factors that influence the effectiveness of decisions made. The lack of difference between the game (win) and the possibility of management obtaining additional information about its state distinguishes the management game from the usual matrix game in which two conscious players participate. The structure of investment portfolios, consisting of two or more assets, is aimed at reducing the individual risk of each of the assets at foreign exchange. As a preliminary step to the general formulation of the problem for a portfolio consisting of an arbitrary number of assets, it is advisable to pay attention to the case when the portfolio consists of two assets. In this case, the portfolio consists of two assets A_1 and A_2 with expected returns μ_1 and μ_2, risks σ_{12} and σ_{22} and weights $w_1 = T$ and $w_2 = 1 - t$, respectively. Such a portfolio has minimal risk, so it will provide an opportunity to prove that the key information for performing the analysis is performed in terms of correlation ρ_1, ρ_2 (correlation coefficients) between both assets $A_1$and A_2.

Two cases are selected for the study: $-1 \leq \rho < 1$ and $\rho = 10 < \sigma_1 \leq \sigma_2\sigma_2$. Without loss of generality, we will further assume that. In both cases, the equations for the expected return μ and for the risk of the portfolio for the enterprise in the implementation of foreign exchange are as follows:

$$\mu = w_1\mu_1 + w_2\mu_2 \quad (5)$$

$$\sigma_2 = \mu_1 w_1^2\, \sigma_1^2 + w_2^2\, \sigma_2^2 + 2w_1w_2\, \rho\sigma_1\sigma_2 \quad (6)$$

Marking through $w_1=t$ and $w_2 = 1-t$, the above expressions μ and σ_2 are transposed as follows:

$$\mu = (\mu_1 - \mu_2)t + \mu_2 \quad (7)$$

$$\sigma_2 = (\sigma_1^2 + \sigma_2^2 - 2\rho\sigma_1\sigma_2)t_2 - 2\sigma_2(\sigma_2 - \rho\sigma_1)t + \sigma_{22} \quad (8)$$

Equation 1. The parametric equations of the expected return of foreign exchange (μ) and the risk of foreign exchange (σ_2) of the portfolio within the parameter t, which represents the weight W_1 =T of the asset A_1 of the portfolio: $-1 \leq \rho < 1$. Note that in this case, as $-1 \leq \rho < 1$ in $0 < \sigma_1 \leq \sigma_2$, the coefficients t_2 and σ_2 satisfy:

$$\sigma_1^2 + \sigma_2^2 - 2\rho\sigma_1\sigma_2 = (\sigma_1 - \sigma_2)^2 + 2\sigma_1\sigma_2(1 - \rho) > 0, \quad (9)$$

Equation 2. The sign of the coefficient t_2 is determined with σ_2 in equation 1. Therefore, $\sigma_2 = \sigma_2(t)$ is a quadratic function of the parameter t and represents a parametric equation, where t is a parameter of the expected return μ and the risk of the FER, and its graph is a "lying" parabola, open right. In the context of the study of the risk of financial portfolios of foreign exchange σ_2, it is marked on the abscissa axis, and μ is on the ordinate axis.

$$\sigma_{2min} = \frac{-2\sigma_2(\sigma_2-\rho\sigma_1)}{2(\sigma_1^2+\sigma_2^2-2\rho\sigma_1\sigma_2)} = \frac{\sigma_2(\sigma_2-\rho\sigma_1)}{\sigma_1^2+\sigma_2^2-2\rho\sigma_1\sigma_2} > 0 \quad (10)$$

Fig. 1 shows two possible locations of points $\sigma_2(\sigma_1^2,\mu_1)$ and (σ_2^2,μ_2) in the parametric equation of the parabola.

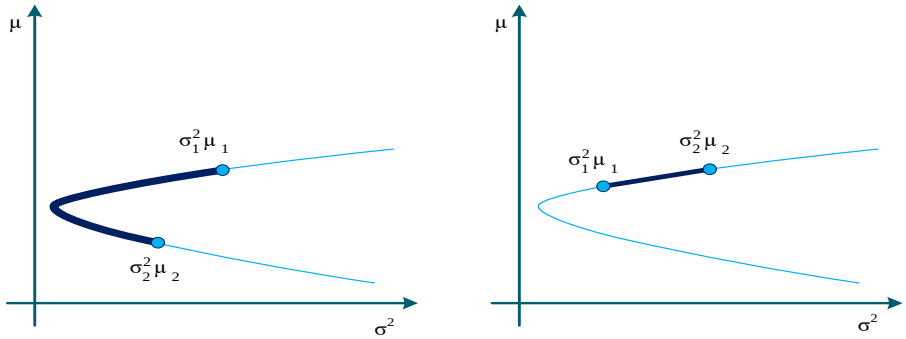

Figure 1. Representation of the risk of the FEA (σ_2) and the return of the FEA (μ) in two different cases
Sources: developed by the authors.

Equation 3. The expression of the weight t = w1 of the first asset that minimizes the risk of the FEP. The minimum risk for the FEP is determined. Without loss of generality $\sigma_2 0 < \sigma_1 \leq \sigma_2$, i.e., the asset A_1 is exposed to at least as little risk as the asset A_2. The given function $\sigma_2 = \sigma_2(t)$ is positive and, therefore, legitimizes the notation σ_2. In this context, the value t_{min} specified in formula (3) is correctly defined and is positive since the denominator is positive and since $-1 \leq \rho < 1$ and $0 < \sigma_1 \leq \sigma_2$, the condition $\sigma_2 - \rho\sigma_1 > 0$ is fulfilled; therefore, the numerator is also positive. The value t_{min} is obtained either using the formula for the vertex (or minimum) of a (convex) parabola or using differential calculus, where the result given in formula (2) is used in the second expression. After algebraic manipulation, the value of the minimum risk σ2 min is subtracted from the expression for calculating σ_2, the value of t_{min}.

The case is singled out when the assets in the foreign exchange have an ideal negative correlation ρ = -1 since the minimum possible risk for the portfolio is achieved—zero risk of the foreign exchange. For practical purposes, it is important that it is possible to achieve a minimum risk of foreign exchange without opening short positions in the portfolio. For this, it is necessary to determine under what conditions $w_i = t_{min} \in |0.1|$ and under what conditions $w_2 = 1 - t_{min} \in |0.1|$. The condition of minimum risk of foreign exchange without the need to make a short sale (short position). It was determined that the denominator is positive: $\sigma_1^2 + \sigma_2^2 - 2\rho\sigma_1 > 0$ and, in addition, $0 < \sigma_1 < \sigma_2$ and if $\rho < 1$, performing $\sigma_2 - \rho\sigma_1 > 0$; therefore, the numerator is also positive: $\sigma_2(\sigma_2 - \rho\sigma_1) > 0$. In addition, the minimum risk of FEA is zero, $\sigma_2 = 0$, if the correlation between both assets is perfect and negative, $\rho = -1$. Thus, let us assume that there are two assets (strategies) of FEA A_1 and A_2 with risks $\sigma_1 > 0$ and $\sigma_2 > 0$, respectively, so that $0 < \sigma_1 \leq \sigma_2$ and that the correlation coefficient ρ corresponds to $-1 \leq \rho < 1$. That is, if the assets do not have an ideal positive correlation (ρ = 1), then the total risk of the FEA portfolio can be minimized without short selling. The minimum risk can become zero in the (unlikely) case if the correlation between the two assets that make up the portfolio is perfect and negative (ρ = -1). Taking formula 1 into account, such a case leads to $\sigma_{2min} = \sigma_1^2 = \sigma_2^2$, and any value of w_t minimizes the risk of FEA. To avoid the risk of not selling at FEA, one can use $t \in [0]$. Let us assume that the portfolio of foreign exchange, described in Table 1, is $0 < \sigma_1 \leq \sigma_2$ and is $\rho = \rho_1$, $\rho \in [-1,1]$ by and its statistical correlation.

Table 1. Characteristics of FEA portfolio assets

Assets of the ZED portfolio	Expected return on assets	Risk assets	Active weight	Correlation of assets
A_1	μ_1	$\sigma_1^2>0$	$w_1=t>0$	
A_2	μ_2	$\sigma_2^2>0$	$w_2=1-t$	$\rho\in$ [-1, 1]

Sources: developed by the authors.

Therefore, for a portfolio of foreign exchange funds consisting of two financial assets A_1 and A_2 with individual risks σ_1^2 and σ_2^2, accordingly, provided that there is a correlation between them $p_{i,2} = p$, only if $-1 \leq \sigma\frac{\rho_1}{\rho_2} < 1$ and $0 < \sigma_1 \leq \sigma_2$ is the total risk of the foreign exchange portfolio minimized (this risk is lower than the individual risks of foreign exchange σ_1^2 and σ_2^2) without the need to carry out test sales (the asset of FEA with the greatest risk A_2). The risk of the FEP can become zero in the case (very unlikely in practice) when ρ = -1. The risk of the FEP can be minimized (or even zero) in other cases, which is unlikely in practice. Therefore, it is important to use economic-mathematical modelling in the process of developing a foreign exchange strategy for risk assessment. As an example of the application of economic and mathematical modelling, enterprises in the pharmaceutical industry were considered.

2. Results. FEA is the process by which a company expands its operations beyond national borders to establish a presence in other markets and expand its global reach. This activity involves bringing products or services to other countries and adapting the foreign trade strategy to the conditions and requirements of the foreign market. For the correct and optimal FEA, the company is suggested to take the following steps, built using the Canva online graphic design platform (Fig. 2). FEA can provoke the emergence of a number of risks and problems for businesses. There are different ways of classifying the risks of foreign exchange. On the one hand, these are those that fundamentally depend on the business and its efficiency:

- operating rooms related to the internal management of the enterprise and operations carried out with clients;
- legal, which provides compliance with current norms and commercial practices;
- production and conformity of goods: in cases where the enterprise works as an exporter;
- documentary: preparation and receipt of documents necessary for international commercial activities.

On the other hand, there are a number of risks inherent in foreign exchange, which the company cannot control. These include:

- country risk: combines a set of alarm signals derived from the country's geopolitical context;
- monetary policy risk: a consequence of the convertibility and volatility of the currency exchange rate, as well as the interest rate;
- commercial and credit risks arise from possible nonpayment of products in the process of foreign exchange.

Before agreeing to international contractual relations, the enterprise must assess the risks and determine the threshold of their admissibility. There are certain triggers for adopting an internal risk and credit policy

and factors to consider in evaluating each business opportunity that arises. Exchange rate fluctuations can seriously affect exporters who provide credit to their customers. In addition to purely internal methods, such as price adjustments or risk sharing with a foreign party, there are a number of external hedging instruments, including currency insurance, currency options and structured products. Therefore, the company needs to choose the optimal payment method. Money orders and documentary letters of credit are mechanisms that guarantee that commercial transactions will be completed by customers. The enterprise may also consider credit insurance to be a fundamental tool for reducing risks in export activities. These mechanisms will help mitigate the threats associated with political and commercial risks.

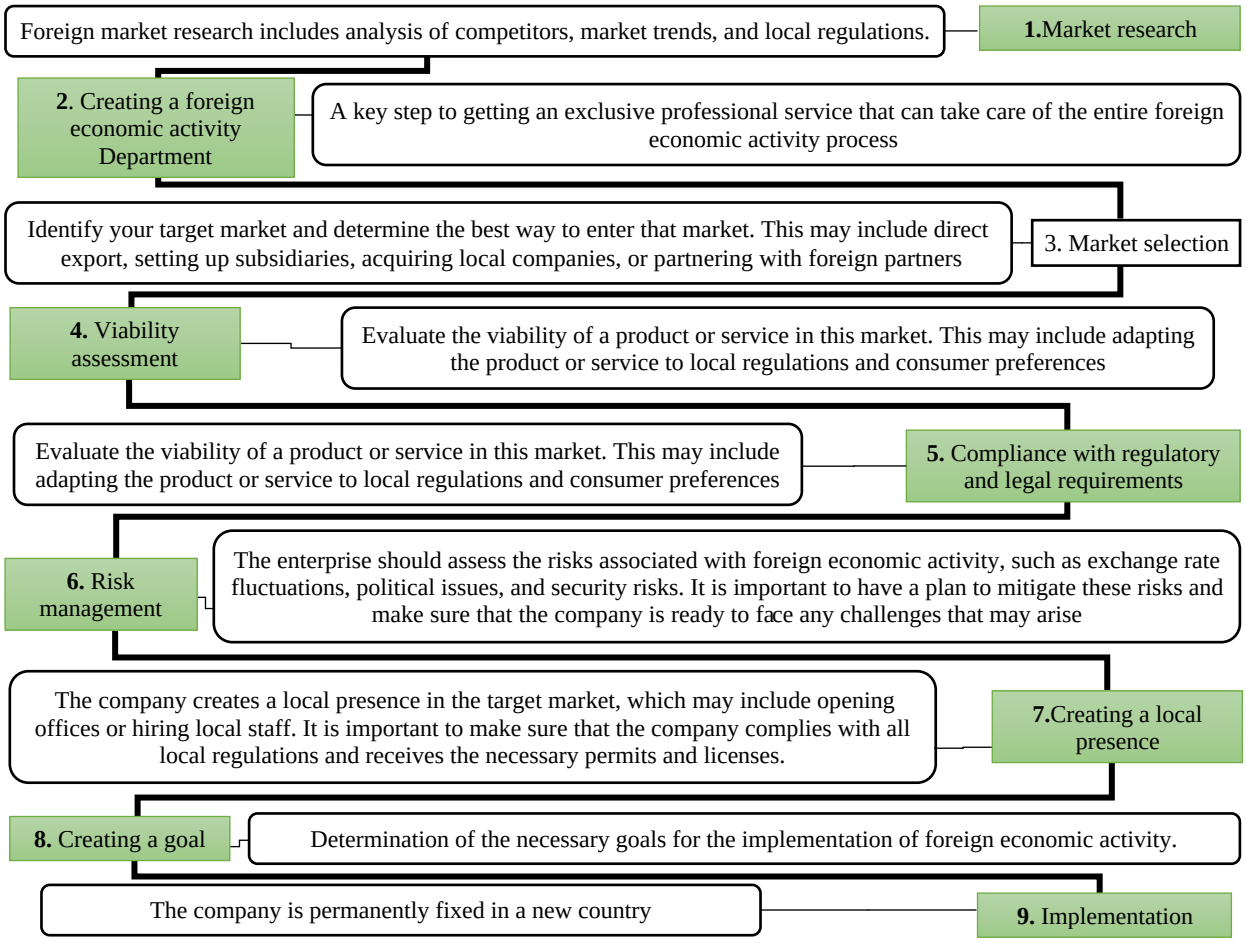

Figure 2. The role of risk management in the process of developing a foreign exchange strategy
Sources: developed by the authors.

At the end of July 2022, the Government of Ukraine made the decision to include the pharmaceutical industry in the direction of the production of drugs and medical products among the priority areas of the economy. Thus, the Ministry of Health of Ukraine introduced a number of changes regarding the procedures for state registration/reregistration of medicinal products and their circulation during the period of martial law. As an example of an almost immediate result, the pharmaceutical company PRJSC "Pharmaceutical Firm Darnytsia (further in the text – PRJSC Darnytsia), in cooperation with the Ministry of Health of Ukraine and the National Security and Defense Council of Ukraine (NSDC) in May of this year, registered a drug to protect the population from radioactive iodine and provided 5.25 million doses for the needs of the Ministry of Health of Ukraine for free. Garafonova et al. (2023b) emphasize that institutional support for pharmaceutical production does not require direct subsidies. The Ukrainian pharmaceutical industry is fully self-sufficient, accounting for 4.1% of the manufacturing industry's GDP. Its products are popular in many countries worldwide, and over the past 5 years, the export of medicinal products from Ukraine has increased by 64%. To investigate the correctness of the use of economic-mathematical modelling, the enterprises of the pharmaceutical industry JSC Farmak, PRJSC Darnytsia, and LLC Arterium LTD (further – LLC Arterium)

were selected, whose general characteristics and input data for conducting economic-mathematical modelling are presented in Fig. 3 and Table 2.

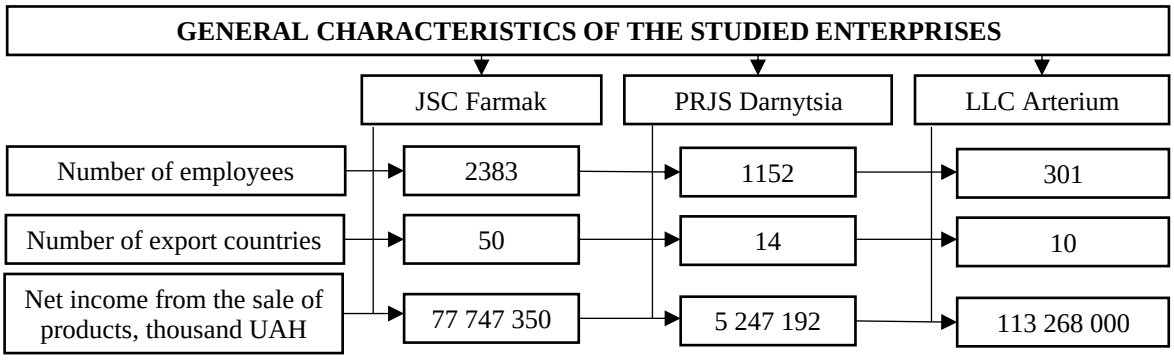

Figure 3. General characteristics of the studied enterprises
Sources: developed by the authors.

Table 2. Input data for calculating the risks of foreign exchange for enterprises in the pharmaceutical industry

Strategies,	JSC Farmak				PRJSC Darnytsia				LLC Arterium			
UAH thousand	**N1**	**N2**	**N3**	**N4**	**N1**	**N2**	**N3**	**N4**	**N1**	**N2**	**N3**	**N4**
Gross profit	3628370	4280211	5164712	4659721	609629	814994	2835522	3587183	530233	557602	484090	499733
Goods	14964	12528	34740	40944	2009	6160	20091	29855	309133	122271	258145	241054

Note: N1, N2, N3, N4 – strategies according to gross profit and goods.
Sources: developed by the authors.

Since it is necessary to minimize costs, we modify the matrix by multiplying all its elements by (-1) and then adding them to the maximum element of the matrix (5164712, 3587183) so that the matrix does not contain negative elements. Thus, the condition for finding the maximum function was established (Table 3).

Table 3. Adjusted matrix for calculating the risks of foreign exchange for enterprises in the pharmaceutical industry

Strategies,	JSC Farmak				PRJSC Darnytsia				LLC Arterium			
UAH thousand												
Gross profit	1536342	884501	2977554	2772189	751661	0	0	504991	27369	0	73512	57869
Goods	5149748	5152184	3585174	3581023	3567092	3557328	5129972	5123768	248469	435331	299457	316548

Sources: developed by the authors.

With the help of the risk matrix, we will check the use of the Maximax, Bayes, Laplace, Wald, Savage, Hurwitz, and Khoja-Lehmann criteria for risk assessment and we will the substantiation of approaches to increasing the effectiveness of risk management were verified, which will provide an opportunity to improve the risk management process in the context of the development and implementation of an enterprise's E&P strategy. To begin with, let's consider the Maximax criterion, which focuses on the most favourable state and describes an optimistic assessment of the situation. For clarity of the method, Table 4 is built, which displays the alternatives of the strategies and the indicators in which they are implemented.

Table 4. Alternative strategies and indicators that they implement for enterprises

	JSC Farmak					PRJSC Darnytsia					LLC Arterium				
A_i	**P_1**	**P_2**	**P_3**	**P_4**	**max(a_{ij})**	**P_1**	**P_2**	**P_3**	**P_4**	**max(a_{ij})**	**P_1**	**P_2**	**P_3**	**P_4**	**max(a_{ij})**
A_1	1536342	884501	0	504991	1536342	2977554	2772189	751661	0	2977554	27369	0	73512	57869	73512
A_2	5149748	5152184	5129972	5123768	5152184	3585174	3581023	3567092	3557328	3585174	248469	435331	299457	316548	435331

Notes: A_i – the i-th solution option; P_i – the state probability; max(a_{ij}) – the option for which the largest value is reached A_i.
Sources: developed by the authors.

For JSC FARMAK, the maximum element max = 5152184 is chosen from (1536342; 5152184). Conclusion: We choose the N=1 strategy. PRJSC Darnytsia: We select the maximum element max = 3585174 from (2977554; 3585174). Conclusion: We choose the N=1 strategy. LLC Arterium: select the maximum element max = 435331 from (73512; 435331). Conclusion: We choose the N=2 strategy. Next, the use of

other criteria for risk assessment in the context of the development and implementation of the enterprise's environmental protection strategy was verified.

Bayes criterion A_i = 3. According to the Bayes criterion, the strategy (pure) that maximizes the average profit *a* or minimizes the average risk $r > j$ is considered optimal A_i. The calculations for determining the optimal strategy according to the Bayes criterion are given in Table 5.

Table 5. Calculation of the optimal strategy according to the Bayes criterion for enterprises in the pharmaceutical industry

	JSC Farmak					PRJSC Darnytsia					LLC Arterium				
A_i	**P_1**	**P_2**	**P_3**	**P_4**	**$\sum(a_{ij}p_i)$**	**P1**	**P_2**	**P_3**	**P_4**	**$\sum(a_{ij}p_i)$**	**P_1**	**P_2**	**P_3**	**P_4**	**$\sum(a_{ij}p_i)$**
A_1	384085.5	221125.25	0	126247.75	731458.5	744388.5	693047.25	187915.25	0	1625351	6842.25	0	18378	14467.25	39687.5
A_2	1287437	1288046	1282493	1280942	5138918	896293.5	895255.75	891773	889	3323572654.25	62117.25	108832.75	74864.25	79137	324951.25
p_i	0.25	0.25	0.25	0.25		0.25	0.25	0.25	0.25		0.25	0.25	0.25	0.25	

Notes: A_i – the i-th solution option; P_i – the state probability; max(a_{ij}) – the option for which the largest value is reached A_i
Sources: developed by the authors.

For JSC FARMAK, strategy N=2 with (731458.5; 5138918), maximum element max = 5138918 is selected. PRJSC Darnytsiawith (1625351; 3572654.25) maximum element max = 3572654.25 and strategy N=1 is chosen. For the LLC Arteriumwith (39687.5; 324951.25), the maximum element max = 324951.25, and the strategy N=2 is chosen.

Wald criterion <a_i = 3>. According to the Wald criterion, a pure strategy that guarantees the maximum profit under the worst conditions is considered optimal, i.e., a = max (min (a_{ij})). The calculations of the optimal strategy according to the Wald criterion are given in Table 6.

Table 6. Calculation of the optimal strategy according to the Wald criterion for enterprises in the pharmaceutical industry

	JSC Farmak					PRJSC Darnytsia					LLC Arterium				
A_i	**P_1**	**P_2**	**P_3**	**P_4**	**min(a_{ij})**	**P_1**	**P_2**	**P_3**	**P_4**	**min(a_{ij})**	**P1**	**P2**	**P3**	**P4**	**min(a_{ij})**
A_1	1536342	884501	0	504991	0	29775	542772189	751661	0	0	27369	0	73512	57869	0
A_2	5149748	5152184	5129972	5123768	5123768	3585174	3581023	3567092	3557328	3557328	248469	435331	299457	316548	248469

Notes: A_i – the i-th solution option; P_i – the state probability; max(a_{ij}) – the variant for which the largest value is achieved.
Sources: developed by the authors.

For JSC Farmak with (0; 5123768), the maximum element max = 5123768; strategy N=3 is chosen. For the PRJSC Darnytsia, with (0; 3557328) maximum element max = 3557328, strategy N=2 is chosen. For the LLC Arterium, from (0; 248469), the maximum element max = 248469 is selected with the strategy N=1.

According to the Savage Minimum Risk Criterion, we investigate the condition under which a = min (max(r_{ij})). We will form a matrix of risks (states of inconsistency between various possible consequences of adopting certain strategies). The maximum profit in the jth column b_j = max (a_{ij}) characterizes a favourable state" (Beregova et al. 2019). The calculation results are given in Table 7.

Table 7. Savage Minimum Risk Criterion for the pharmaceutical industry

Strategies	**JSC Farmak**					**PRJSC Darnytsia**					**LLC Arterium**				
	N1	**N2**	**N3**	**N4**	**max(a_{ij})**	**N1**	**N2**	**N3**	**N4**	**max(a_{ij})**	**N1**	**N2**	**N3**	**N4**	**max(a_{ij})**
A_i	**P_1**	**P_2**	**P_3**	**P_4**		**P_1**	**P_2**	**P_3**	**P_4**		**P_1**	**P_2**	**P_3**	**P_4**	
A_1	3613406	4267683	5129972	4618777	5129972	607620	808834	2815431	3557328	3557328	221100	435331	225945	258679	435331
A_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Notes: A_i is the i-th decision option, P_i is the state probability, and max(a_{ij}) is the option for which the largest value is reached.
Sources: developed by the authors.

For JSC Farmak with (5129972; 0), the minimum element *min* = 0; strategy N=3 is chosen. For PRJSC Darnytsia with (3557328; 0), the minimum element *min* = 0, and the strategy N=4 is selected. For the LLC Arteriumwith (435331; 0), the minimum element *min* = 0, and the N=2 strategy is selected. Let's apply the Hurwitz criterion to calculate the optimal strategy and calculate si. The results are shown in Table 8.

For JSC Farmakwith 768171; 5137976 maximum element *max* = 5137976, the N=2 strategy is chosen. For PRJSC Darnytsia from 1488777; 3571251 maximum element *max* = 3571251, the selected strategy is N=2. For the LLC Arteriumis selected from 36756; 341900 maximum element *max* = 341900; and strategy N=2 is chosen.

Table 8. Hurwitz criterion based on the pessimism-optimism criterion for the pharmaceutical industry

A_i	P_1	P_2	P_3	P_4	$\min(a_{ij})$	$\max(a_{ij})$	$y\min(a_{ij}) + (1-y)*\max(a_{ij})$, a>1
				JSC Farmak			
A_1	1536342	884501	0	504991	0	1536342	768171
A_2	5149748	5152184	5129972	5123768	5123768	5152184	5137976
				PRJSC Darnytsia			
A_1	2977554	2772189	751661	0	0	2977554	1488777
A_2	3585174	3581023	3567092	3557328	3557328	3585174	3571251
				LLC Arterium			
A_1	27369	0	73512	57869	0	73512	36756
A_2	248469	435331	299457	316548	248469	435331	341900

Notes: Ai is the ith decision option, P_i is the state probability, and $\max(a_{ij})$ is the option for which the largest value is reached.
Sources: developed by the authors.

Results of Hodge-Lehman criterion calculation are given in Table 9.

Table 9. Calculation of the Khoja-Lehman criteria for the enterprise pharmaceutical industry

	P_1	P_2	P_3	P_4	$\sum(a_{ij}p_j)$	W_i
				JSC Farmak		
A_1	384085.5	221125.25	0	26247.75	731458.5	365729.25
A_2	1287437	1288046	1282493	1280942	5138918	5131343
	0.25	0.25	0.25	0.25		
				PRJSC Darnytsia		
A_1	744388.5	693047.25	87915.25	0	1625351	812675.5
A_2	896293.5	895255.75	891773	889332	3572654.25	3564991.125
	0.25	0.25	0.25	0.25		
				LLC Arterium		
A_1	6842.25	0	18378	14467.25	39687.5	19843.75
A_2	62117.25	108832.75	74864.25	79137	324951.25	286710.125
	0.25	0.25	0.25	0.25		

Notes: A_i is the i-th decision option, P_i is the state probability, $\max(a_j)$ is the option for which the largest value is reached, W_i-Khoja-Lehman criterion.
Sources: developed by the authors.

For JSC Farmak with 365,729.25; 5131343 maximum element *max* = 5131343, strategy N=2 is chosen. For PRJSC Darnytsiawith 812675.5; 3564991.13 maximum element *max* = 3564991.13, the selected strategy is N=2. For the LLC Arterium, with 19843.75 and 286710.13 maximum elements and a maximum of 286710.13, strategy N=2 is chosen. The next step is calculation of the generalized Hurwitz criterion $\lambda_1$according to formula (2), as well as the effectiveness of the strategy according to Hurwitz $G_i$by formula (3) and the optimal strategy A_{ij} by formula (4). The results are presented in Table 10.

Table 10. Matrix of the generalized Hurwitz criterion for the pharmaceutical industry

A_i	P_1	P_2	P_3	P_4	$\min(a_j)$	$\max(a_j)$	A pessimist's approach
				JSC Farmak			
A_1	0	504991	884501	1536342	0	1536342	869929.53374611
A_2	5123768	5129972	5149748	5152184	5123768	5152184	5139858.1138099
				PRJSC Darnytsia			
A_1	0	751661	2772189	2977554	0	2977554	1930906.0154719
A_2	3557328	3567092	3581023	3585174	3557328	3585174	3575385.7779301
				LLC Arterium			
A_1	0	27369	57869	73512	0	73512	49393.204671258
A_2	248469	299457	316548	435331	248469	435331	374022.82809991

Sources: developed by the authors.

For JSC Farmak with 869929.534; 5139858.114 maximum element *max* = 5139858.11, strategy N=2 is selected. For PRJSC Darnytsia from 1930906.015; 3575385.778 maximum element *max* = 3575385.78, strategy N=2 is selected. For LLC Arterium: from 49393.205; 374022.828 maximum element *max* = 374022.83; strategy N=2 is chosen. Further, to the matrix obtained in Table 10, we apply the maximin principle (Hermeyer's method). The transform the matrix according to the Hermeyer's method and the results of the calculations are shown in Table 11.

For JSC Farmak from 0; 20495072 maximum element *max* = 20495072, selected strategy N=2. For PRJSC Darnytsiafrom 0, the maximum number of elements is 14229312, the maximum number of elements is

14229312, and the selected strategy is N=2. For LLC Arterium from 0; 993876 maximum element *max* = 993876, selected strategy N=2.

Table 11. Transformed matrix according to Hermeyer's method for enterprises in the pharmaceutical industry

Ai	***P₁***	***P₂***	***P₃***	***P₄***	***min(e_{ij})***
Strategies	**N1**	**N2**	**N3**	**N4**	
			JSC Farmak		
A_1	6145368	3538004	0	2019964	0
A_2	20598992	20608736	20519888	20495072	20495072
p_i	0.25	0.25	0.25	0.25	
			PRJSC Darnytsia		
A_1	11910216	11088756	3006644	0	0
A_2	14340696	14324092	14268368	14229312	14229312
p_i	0.25	0.25	0.25	0.25	
			LLC Arterium		
A_1	109476	0	294048	231476	0
A_2	993876	1741324	1197828	1266192	993876
p_i	0.25	0.25	0.25	0.25	

Notes: A_i is the i-th decision option, P_i is the state probability, and min(e_{ij}) is the option for which the smallest value is reached.
Sources: developed by the authors.

The study applied the combined Bayes-Laplace and minimax criterion (BL(MM) criterion) to the matrix of the obtained solutions (Table 11) and we will choose the options that reflect the greatest mathematical expectation:

$$\sum(a_{i,j}p_j) < a_i = 36 > \sum(a_{1j}, p_j) = 1536342 * 0.25 + 884501 * 0.25 + 0 * 0.25 + 504991 * 0.25 = 731458.5.$$

$$\sum(a_{2,j}\, p_j) = 5149748 * 0.25 + 5152184 * 0.25 + 5129972 * 0.25 + 5123768 * 0.25 = 51389182 = 5123768$$

The max-max$_2$ condition is fulfilled for the rows of Table 11 (marked A_1 and A_2). The maximum mathematical wait time is selected from these lines, which is >5123768 min. Thus, as a result of consideration of various options with different criteria, strategy 2 was most often recommended for JSC Farmak, for PRJSC Darnytsia, strategy 2, and for LLC Arterium, strategy 1. Therefore, graphically, the criteria for optimization when choosing a strategy of FEA, x → max, y → min, for enterprises are as follows (Fig. 4):

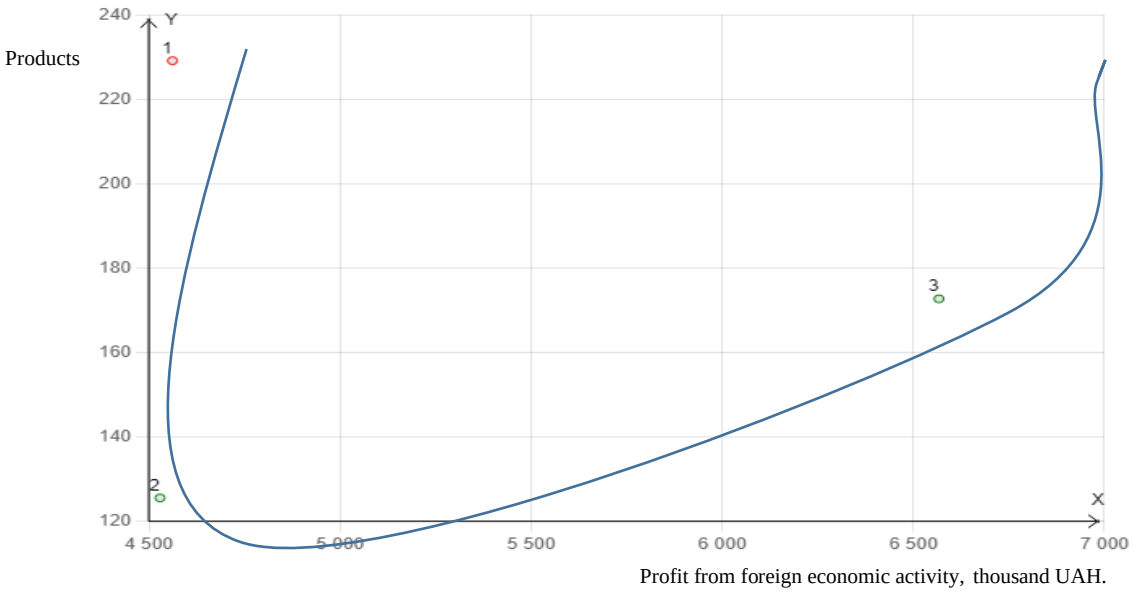

Figure 4. Optimization criteria of the FEA: x → max, y → min
Notes: Above: 1, 2, 3 - strategies
Sources: developed by the authors.

On the basis of mathematical modelling, a risk matrix of foreign exchange (strategic, operational, financial and external) was developed. The FEA risk assessment matrix displays different levels of risk, which are color-coded according to their severity: high risks are red, moderate risks are yellow, and low risks are green. Figure 6 also graphically displays the results of economic-mathematical modelling (maximax and maximin curves).

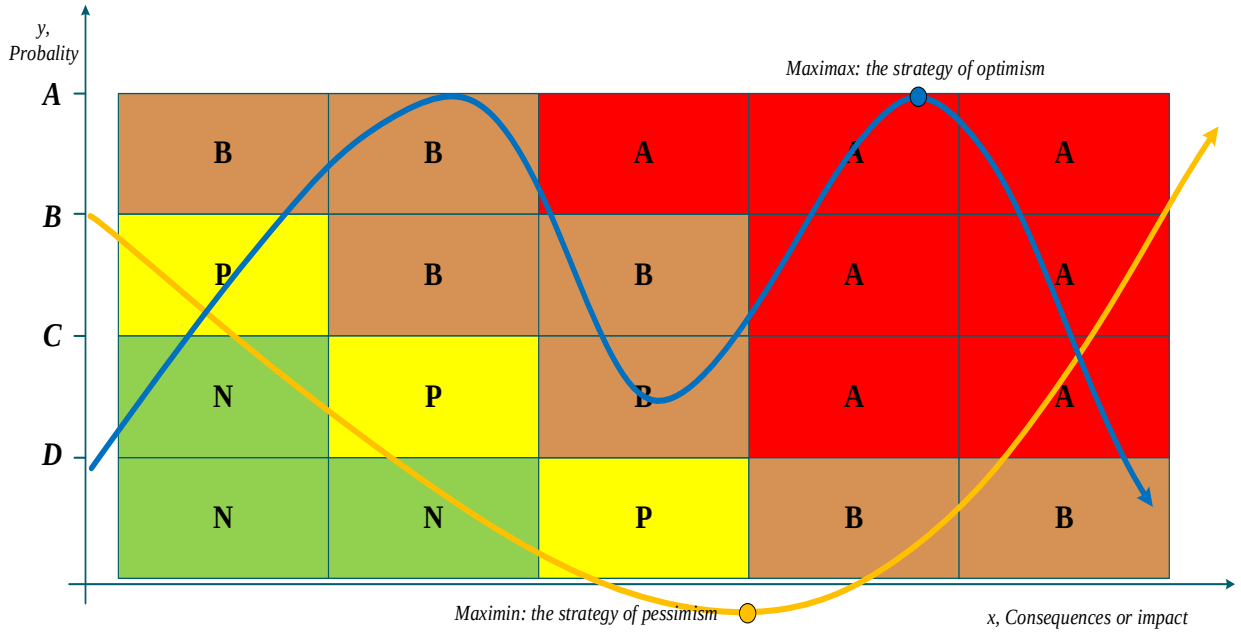

Figure 5. Matrix of risk analysis of FEA enterprises in the pharmaceutical industry
Notes: Above: A: Extreme risk - requires immediate action; B: High risk - requires top management attention; P: Moderate risk - requires indication of managerial responsibility; N: Low risk is implemented through corrective administrative procedures. A (unavoidable), B (very likely), C (average probability), D (impossible). (Source: Developed by the author)
Sources: developed by the authors.

The risk matrix has two axes: one measuring probability and one measuring impact. The probability of occurrence of risky events can range from 61% to 90%, while very unlikely events are extremely rare, with a probability of occurrence of less than 10%. Depending on the country of the FEA and the risk appetite, a minor impact may cause a small amount of loss, while a catastrophic impact may result in significant losses. By estimating the probability and impact of a risk event, the risk matrix provides a quick snapshot of the threat landscape at the FEA. By visualizing the threat landscape in this way, professionals can more easily predict and determine how to minimize events that may have a significant impact on an enterprise that carries out FEA. Once the risks are classified according to the risk analysis matrix of the FEA, they will require means of control and preventive actions to be taken for each risk, which will allow the enterprise to make the best decision at each stage of the FEA in the process of forming the FEA strategy. Therefore, for enterprises in the pharmaceutical industry, it is proposed to improve the risk management process, which consists of 7 stages and 18 steps, which most closely correspond to the resulting matrices, which will be obtained as a result of economic and mathematical modelling. The special advantages of using the proposed approach are as follows:

1. Economic and mathematical modelling can be applied at the enterprise level to improve the risk management process.
2. Communication surveys and consultations with interested parties.
3. Determination of the mechanisms of identification of risks of foreign exchange.
4. Quantitative–qualitative scale of probabilities and consequences of the risks of foreign exchange.
5. Levels of tolerance to the risk of FEA on a qualitative and quantitative scale.
6. Use of computer tools for risk management of foreign exchange.
7. The use of a questionnaire to assess the growth of the enterprise's competitiveness due to the improvement of the process of risk management of foreign exchange.

Below is a description of the stages of the proposed approach with an indication of the main elements that must be developed at various stages of its formation (Fig. 6). The stages offer a set of tools that facilitate the implementation of risk management in the enterprise in the process of forming the company's foreign

exchange strategy. In the same way, information and technical support are offered, which helps to simplify the process of implementing and monitoring the risks of foreign exchange. In this way, a comprehensive proposal for the implementation of FEA is formed, which contributes to the transfer of best practices and consolidates the accumulated knowledge for employees.

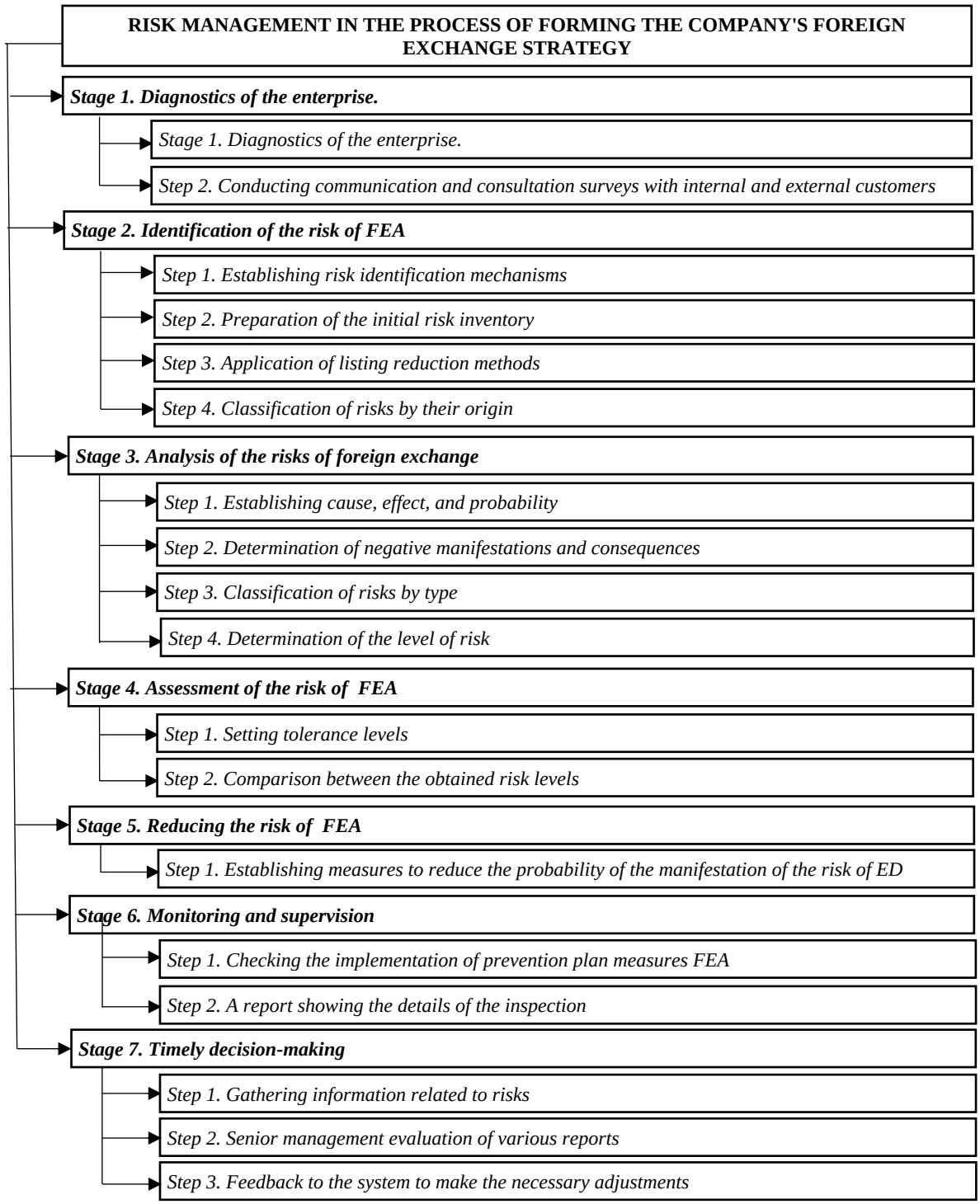

Figure 6. Sequence process risk management in the process of forming a company's foreign exchange strategy
Sources: developed by the authors.

The developed approach is useful for the systematic evaluation of the risk management of FEA risks in enterprises due to the opportunities it provides to management to monitor the results regarding the prevention of FEA risks.

3. Discussion. The above proposals demonstrate a set of tools that facilitate the process of implementing risk management at enterprises. The proposal fully corresponds to the references recorded in the literature. An economic-mathematical toolkit is also offered, which helps to simplify the process of implementing and monitoring risk management in the context of developing a strategy for foreign exchange. In this way, a single offer for the provision of services is achieved, which facilitates the transfer of best practices and consolidates accumulated knowledge for enterprises. To improve the risk management of foreign economic activity at enterprises, one can offer a set of risk management tools and use them during all stages and stages of a foreign economic transaction, which will allow one to more flexibly manage and master the risks of foreign economic activity. Vitlinsky & Velikoivanenko (2004) developed an algorithm for managing enterprise risks that arise in the context of a global crisis as a result of foreign economic activity. It covers the following stages: risk identification; risk identification; assessment of the degree of risk impact on the enterprise; identification of risk management methods and tools; elimination of risk or reduction of its impact; and monitoring and control. In the study by Babailov & Kurdenko (2022), risk management was divided into three professionally oriented parts: risk economics, risk engineering and risk administration. In other words, the management of economic, engineering and administrative risks must be performed separately by relevant specialists. However, further deepening of the authors' understanding of risks led to doubts and the question of the legality of using the phrase "risk management" in the literature and special management practice. Ozel (2020) addresses risk management (in this context, the non-identity of management and management can be ignored): "risk management is the process of making decisions and implementing measures aimed at changing risk. The authors Dergachova & Rudnitskaya (2020) consider, on the one hand, the very existence of "process" risk management; on the other hand, the actual opposite is stated: "It is impossible to eliminate risks in the activities of business entities, since they represent an element of objective reality". Zelinska et al. (2021), from the problems of risk of foreign economic activity, proposed building a classification system for these risks and various approaches to solving this problem. In contrast to existing methodological approaches, the sequence of the risk management process was developed in the process of forming the company's foreign exchange strategy. is a useful tool for the systematic assessment of risk management. Its transformation into a composite index would be very useful for use as a management tool due to the opportunities it provides for management to monitor performance.

4. Conclusions. The study improved the process of risk management in the context of the development of a foreign exchange strategy. The approach presented in the article can be implemented at enterprises of any type. The success of the proposed approach is supported by the practical experience of approbation and the guarantee of compliance with the requirements of the legal framework of the country in which enterprises operate and carry out FEA. The FEA risk matrix created with the help of economic and mathematical modelling makes it possible to determine the greatest impact risks at various stages of the FEA using game theory. The application of economic-mathematical modelling at enterprises will contribute to the implementation of risk management procedures at various enterprises and in various sectors of the economy and to the adoption of effective decisions for the implementation of goals related to the leadership and competitiveness of enterprises in foreign markets. A procedure for assessing and managing risks in the context of developing a foreign exchange strategy that can be implemented at any type of enterprise is presented. The proposal is based on taking into account theoretical research, practical experience, and the results of successful application at the enterprise. At the same time, the proposals allow the enterprise greater flexibility, better management and the implementation of new results regarding the improvement of the risk management process in the context of the development of the FEA strategy. However, the adaptation of this testing method was conducted only at enterprises in the pharmaceutical industry. Thus, it is necessary to conduct further research on the use of the risk management process in the context of developing a strategy for the foreign economic activity of enterprises in other industries and with other countries to obtain broader conclusions. Future research may also cover different industries using more enterprise metrics.

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Інноваційні підходи до удосконалення процесу управління ризиками в контексті розроблення стратегії зовнішньоекономічної діяльності підприємств

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У статті представлені інноваційні підходи до удосконалення процесу управління ризиками в контексті розроблення стратегії зовнішньоекономічної діяльності підприємства. Для ідентифікації ризиків та вибору оптимальної стратегії зовнішньоекономічної діяльності підприємств (ЗЕД) використано економіко-математичне моделювання з використанням матриці ризиків та критеріїв Байєса, Лапласа, Вальда, Севіджа, Гурвіца, Ходжа-Лемана. Для апробації результатів дослідження були вибрані підприємства фармацевтичної галузі. Відповідно до теорії ігор, для удосконалення процесу управління ризиками застосовано елементи платіжної матриці, що характеризують прибуток підприємств фармацевтичної галузі при ЗЕД. Використання критерію Гурвіца**,** що є критерієм песимізму–оптимізму, дозволило вибрати оптимальну стратегію для обраних підприємств.

Розроблену матрицю ризиків ЗЕД (стратегічних, операційних, фінансових та зовнішніх) для вибору оптимальної стратегії ЗЕД за допомогою застосування економіко-математичного моделювання варто використовувати для визначення ризиків найбільшого впливу на різних етапах ЗЕД з використанням теорії ігор. Наведена матриця ризиків ЗЕД побудована для вітчизняних підприємств фармацевтичної галузі і спрямована для удосконалення процесу управління ризиками ЗЕД, що дасть можливість підприємствам фармацевтичної галузі прогнозувати ризики на ранніх стадіях діяльності та врахування у загальній концепції стратегії зовнішньоекономічної діяльності підприємств. Фармацевтична галузь України обрана для дослідження тому, що вона є найбільш затребуваною в сучасних умовах, і, з результатів аналітичного огляду, дуже високоризикованою. Саме тому застосування економіко-математичного моделювання для розрахунку ризиків дозволяє оптимізувати економічну поведінку вітчизняних фармацевтичних підприємств, забезпечуючи при цьому надійну основу для прийняття обґрунтованих стратегічних рішень в процесі управління ризиками в контексті розроблення стратегії зовнішньоекономічної діяльності. У статті удосконалено процес управління ризиками, що складається з 7 етапів і 18 кроків, та запропоновано інноваційні інструменти, які полегшують впровадження управління ризиками на підприємстві в процесі розробки стратегії ЗЕД. Використання економіко-математичного моделювання при прогнозуванні ризиків та формуванні стратегії ЗЕД допоможе керівникам підприємств суттєво підвищити ефективність менеджменту, знизити ризики на етапі планування зовнішньоекономічної діяльності.

Ключові слова: стратегічне управління, трансфертне ціноутворення, інновації, ризики, стратегія, ризик-матриця, зовнішньоекономічна діяльність, теорія ігор.