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SIMULATION OF FOREIGN EXCHANGE RISKS MANAGEMENT IN CONDITIONS OF GLOBAL INSTABILITY

МОДЕЛЮВАННЯ УПРАВЛІННЯ ВАЛЮТНИМИ РИЗИКАМИ В УМОВАХ ГЛОБАЛЬНОЇ НЕСТАБІЛЬНОСТІ

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Abstract. The purpose of the work is to model exchange rate risk management under conditions of global instability. Due to the instability, unpredictability and uncertainty of global changes as a reaction to political and economic changes in the world, currency positions are not always open and clearly defined. This especially applies to currency operations under term currency schemes. In the banking sector, currency risk management consists in developing measures to ensure the bank's sensitivity to risk. It is necessary to clearly present the degree of possible harm and the ways to eliminate it by choosing appropriate strategies of operation. Mathematical justification of the use of financial tools for currency risk regulation during changes in market conditions caused by unpredictable global exchange rate fluctuations and adaptation of analytical criteria for assessing the quality of managerial decision-making in conditions of uncertainty and risk is presented. A description of the essence, advantages of use, limitations and features of management processes in the conditions of dynamic environmental influences on the functioning of open systems is given. The analysis is based on the methods of comparing the existing practice of responding to manifestations of fluctuations in the currency market, their protective and preventive measures in order to minimize losses during the execution of currency transactions, contractual obligations and financial calculations with the formalization of the essence of statistical quality criteria, recommendations and possible applications. The obtained results can be the basis for the development of a risk management model that will take into account costs, profits and probabilities of losses. The result of effective currency risk management is the reduction of losses due to changes in the exchange rates of world currencies. Effective use of currency regulation methods in combination with a rational foreign economic policy will reduce the negative impact of external factors.

Key words: currency risks; management; criteria; financial instruments; global changes; financial model; exchange rate; company.

Анотація. Ефективність управління валютними ризиками визначається використовуваними схемами управління, накопиченням інформації про ризики розробкою та впровадження запобіжних заходів. Метою роботи

є моделювання управління ризиками валютного курсу за умов глобальної нестабільності. У зв'язку з нестійкістю, непередбачуваністю та невизначеністю глобальних змін як реакції на політичні та економічні зміни, у світі, валютні позиції не завжди бувають відкритими та чітко визначеними. Особливо це стосується валютних операцій за терміновими валютними схемами. У банківському секторі управління валютним ризиком полягає у розробці заходів щодо забезпечення чутливості банку до ризику. Необхідно чітко представляти ступінь можливої шкоди та шляхи її виключення шляхом вибору відповідних стратегій функціонування. Подано математичне обґрунтування застосування фінансових інструментів регулювання валютного ризику при змінах кон'юнктури ринку, викликаних непередбачуваними глобальними коливаннями курсу валют та адаптації аналітичних критеріїв оцінки якості прийняття управлінських рішень в умовах невизначеності та ризику. Дається опис сутності, переваг використання, обмежень та особливостей процесів управління в умовах динамічних впливів довкілля на функціонування відкритих систем. В основу аналізу покладено методики порівняння існуючої практики реагування на прояви коливань ринку валют, їх захисних та запобіжних заходів з метою мінімізації втрат при виконанні валютних операцій, договірних зобов'язань та фінансових розрахунків з формалізацією сутності статистичних критеріїв якості, рекомендаціями та можливими застосуваннями. Отримані результати можуть бути основою розробкою моделі управління ризиками яка враховуватиме витрати, прибуток та ймовірності втрат. Результатом ефективного управління валютними ризиками є зменшення збитків за зміни курсів світових валют. Ефективне використання методів валютного регулювання у поєднанні із раціональною зовнішньоекономічною політикою дозволить знизити негативний вплив зовнішніх факторів.

Ключові слова: валютні ризики; управління; критерії; фінансові інструменти; глобальні зміни; фінансова модель; валютний курс; компанії.

STATEMENT OF THE PROBLEM

The internationalization of economic life, manifested in the free movement of capital, the expansion of the branch network of banks and operational activities, led to the fact that banks have to pay more and more attention to the currency component. The banking system's current functioning period is characterized by rapid variability of the financial and credit policy vector of the financial regulator. The foreign exchange market's volatility negatively affects the participants' activities in foreign economic activity. Uncertainty of changes in foreign exchange rates leads to currency risk. Considering the probabilistic component, the development of mathematical management models under uncertainty and risk must be a better-researched mathematical modelling problem and its practical applications.

ANALYSIS OF REMAINING RESEARCH AND PUBLICATIONS

One of the measures to manage currency risks in the banking sector and their possible neutralization is the introduction of various restrictions and limits on operations with counterparties and clients, losses, dealers, and foreign countries [1, 2]. Another equally important measure to reduce currency risks is the correct choice of currency in the contract. For the exporter, this currency should be a currency whose exchange rate increases during the agreement term; for the importer, on the contrary, a currency that decreases during the contract term is advantageous. These provisions are implemented by foreign economic contracts for many transactions for possible compensation of losses and simultaneous signing of contracts for export and import in the same currency with comparable payment terms [3, 4]. Fluctuations in the exchange rate, which create uncertainty in the currency

markets regarding the movement of exchange rates, have prompted interest in modelling currency risks [5]. Thus, in [6], based on the Monte Carlo method, when assessing the risks of equal and mixed-weighted portfolios of investment returns in five foreign currencies of Malaysia: US dollars, British pounds, EU euros, Japanese yen, and Singapore dollars, currency risk processes were modelled. Analysis of risk factors and consequences of exchange rate regimes in Sweden and Korea is presented in [1]. Currency risk modelling, taking into account national characteristics, is presented in several works performed in Pakistan [7], China [8], South Africa [9], Romania [10], and Ukraine [11, 12]. Currency risk modelling is an intergovernmental problem affecting countries' national interests in the currency market. The issue of modelling the foreign exchange market and criterion evaluations of its performance continues to be the focus of researchers from different countries.

The determining factor of any currency is the degree of trust in the currency both on the part of residents and on the part of residents. It is based on the following indicators:

- trust in the political regime,
- The country's openness to economic liberalization,
- Exchange rate regime,
- the balance of the country's payment bank,
- Basic macroeconomic indicators.

Currency risk factors:

- currency exchange rate fluctuations,
- inflation rate and interest rates,
- introduction of administrative restrictions and actions of state bodies.

Due to the instability, unpredictability and uncertainty of these indicators as a reaction to political and economic changes in the world, currency positions are not always

open and clearly defined. This is especially true for currency transactions from forward currency contracts, since the longer the contract term, the higher the probability of a change in the exchange rate.

In the banking sector, currency risk management consists in determining the bank's sensitivity to risk and accounting for factors that are dangerous for various divisions of the bank. It is necessary to clearly present the degree of possible harm and the possible ways to eliminate it by choosing appropriate strategies of operation.

SEPARATION OF PREVIOUSLY UNSOLVED PARTS OF THE GENERAL PROBLEM

Unsolved parts of the general problem of currency risk management include the need for a strict mathematical justification and criterion evaluations of financial regulation operations to develop preventive actions to eliminate or reduce currency risk.

PURPOSE OF THE RESEARCH

Objective of the work is to model the management of exchange rate risks in the face of global volatility.

To achieve this goal, the following tasks need to be addressed:

- perform an analysis of existing information on currency risk management in conditions of uncertainty;
- study the structure of financial instruments and functions of currency risk regulation;
- develop currency risk modeling and management schemes in conditions of global instability.

METHODS, OBJECT AND SUBJECT OF RESEARCH

Methods: statistical analysis, multi-criteria assessments, probabilistic representations.

Object of the study: the process of currency risk management in conditions of uncertainty

Subject of the study: statistical criteria of currency risk assessment, their essence and formalisation.

BASIC MATERIAL

Currency risk is the danger of currency losses due to changes in the price of the loan in the currency of payment in the period between signing the contract or credit agreement and making the payment. Currency risk management is identifying, measuring and reducing the risk of financial loss due to exchange rate fluctuations.

When settling with foreign counterparties, a significant amount of money can be lost due to exchange rate fluctuations. Individuals, companies, and banks are exposed to currency risk. The reason is changes in the exchange rate of the payment currency. Losses are caused to the exporter by a decrease in its value and an increase in the importer's price. Currency risk is particularly evident due to using several currencies in international agreements, notably when purchasing and selling foreign currency at different exchange rates. This is the risk that a financial instrument's fair value or future cash flows will

fluctuate due to changes in foreign exchange rates. Direct assessment of foreign exchange risk at the qualitative and quantitative levels and forecasting temporary trends in exchange rates are two main areas of foreign exchange risk analysis. Statistical and probabilistic methods with their quality criteria are used for their implementation.

The existing methods of assessing and regulating currency risk are based on a stable economy, while global economic changes most likely refer to random probabilistic processes for analyzing which monetary and financial indicators should be used and statistical implementations of a random process. Under these conditions, the statistical risk of losses from exchange rate fluctuations will be reduced to determining the probability of some undesirable event, including a crisis. The assessment of its consequences is combined into one more or less plausible result, combining probabilities of losses and profits.

Currency risk management in the banking sector under conditions of global change unpredictability belongs to the class of poorly structured and poorly formalized tasks and decision-making based on the construction of expert systems using appropriate criteria.

The relevance of the work is explained by the fact that the issue of currency risk management is the prerogative of banks' management bodies, which are based on decision-making based on assessments of foreign economic activity and currency transactions. The effectiveness of currency risk management is determined by the management schemes used, the accumulation of information about risks, and the development and implementation of preventive measures. Such a hierarchy of stages of currency risk reduction is based on the synchronization of operations accompanying the functioning of the banking sector on the domestic and foreign markets. There is no single methodology for currency risk management in the banking sector, so any steps in this direction are handy.

There are three types of currency risk that should be taken into account when making management decisions to reduce them:

- balance or translation, caused by discrepancies between the company's assets and liabilities, which are from different currencies. For a branch of a bank located in another country, assets come in the form of money, settlements with clients and other operations in the money of the head office, but there are no liabilities – fixed capital and profit;
- economic, related to the probability of the influence of the exchange rate on production indicators, such as a decrease in turnover, an increase in the cost of production while maintaining the price of finished products, belated actions of the government to stabilize the market;
- operational risk of receiving a benefit that is less than planned, causing losses from investments using foreign currency;

When making management decisions to reduce currency risks, these varieties are included as components of

preventive measures based on financial instruments and relevant strategies.

The structure of financial tools for currency risk regulation and the functions performed by them are presented in fig. 1.

The division of both categories of financial instruments into basic instruments and hedging instruments can be the basis for building foreign exchange risk management strategies. Managing foreign exchange risks with the help of underlying instruments involves a significant reduction in risk without significantly increasing hedging costs. This tool is the most effective for enterprises. Accounting for the cost of market hedging of currency risks for large companies can be expressed in an increase in the value of goods and services at nominal prices in a currency convenient for it. This will not require additional agreements and, accordingly, additional risks with small companies that form an inseparable financial complex, but will only be expressed in an increase in value.

Currency risk management strategies are based on decisions made on the basis of criterion-referenced assessments of the impending crisis situation. The emergence of a crisis situation is an unpredictable, uncertain or, in the language of mathematical statistics, a random variable with its realizations. Statistical solutions are based on the task of identification, which is to establish the probability

of a crisis situation as a result of processing statistical information about the state of the currency market and to take preventive measures as much as possible. The essence of statistical assessments of currency risk is to determine the probability of loss or profit on the basis of statistical data of past periods and to ensure the possibility of forecasting various options for the development of events.

With regard to the financial activity of a single company, statistical assessments of currency risk consist in the study of income and expenditure statistics, the establishment of probabilities of events and the determination of the magnitude of risks. The magnitude of the financial risk of causing losses or making a profit determines the probability of its occurrence under the influence of a specific factor or group of factors characterizing the probability of a crisis event. The level of profitability of financial operations is related to the risk of its achievement. Due to the uncertainty of situations caused by global changes, is used as the frequency or weight of the average expected value.

The main tools of the statistical method of risk calculation are:

- average value of the investigated quantity;
- dispersion;
- root mean square deviation;
- probability distribution of a random variable.

Currency risk management schemes are shown in fig. 2.

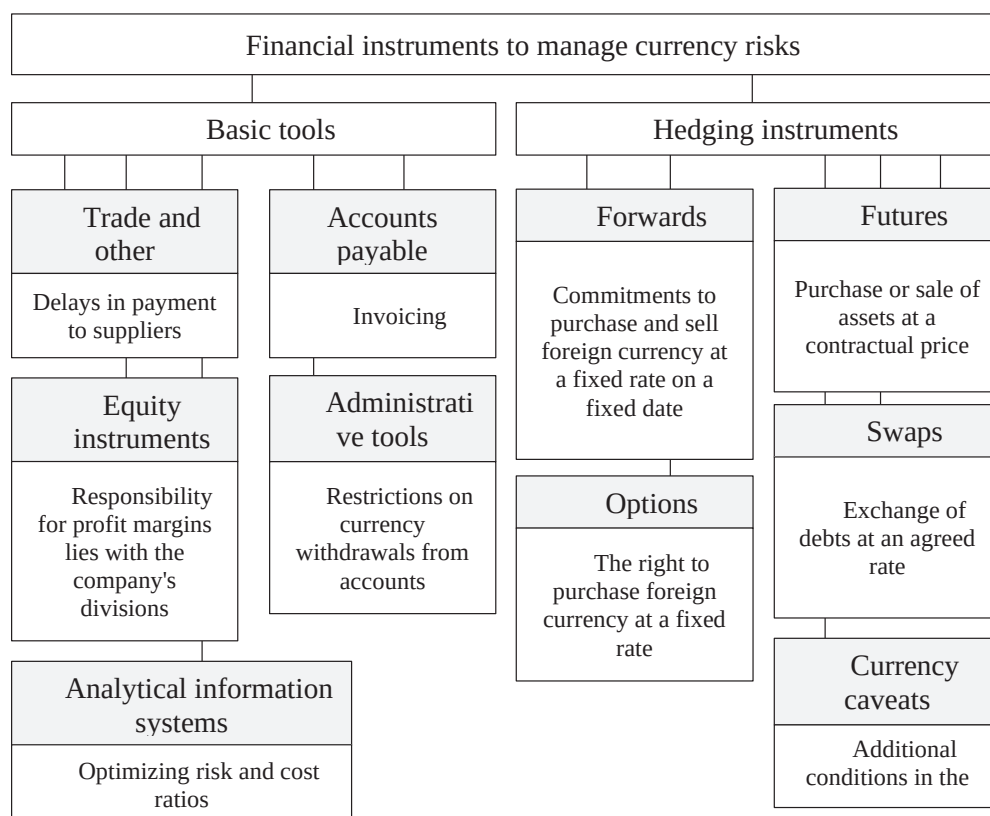


Fig. 1. Financial instruments and functions of currency risk management

CURRENCY RISK MANAGEMENT	
Use of basic instruments	Use of hedging instruments
– Currency breakdown of assets and liabilities – Revenues denominated in a convenient currency – Financing of one activity by another: imports from export proceeds – Use of foreign exchange earnings from one activity to pay off debts from another – nominated expenses and income, assets and liabilities in equal amounts in the same currency.	– Inclusion of market hedge values in revenue and expense contracts – a neutral attitude to risk when the volume of currency transactions is small and profits and losses are balanced – acceptance and increase of currency risk, earning income from speculation in the foreign exchange market – insurance of currency risk – refusal to engage in risky activities

Fig. 2. Currency risk management schemes

Effective currency risk management is crucial to maintaining a company's financial stability. Companies should regularly review their exposure to foreign currency risks and manage it. By implementing currency risk management schemes, companies can significantly mitigate the adverse effects of currency market fluctuations, protecting their market value and long-term competitiveness. By using foreign exchange market management strategies, companies can guarantee business stability. Based on the analysis of Figs. 1 and 2, the scheme of building mathematical models of currency risk management and the basic principles of modelling the management of open dynamic systems is presented in Fig. 3.

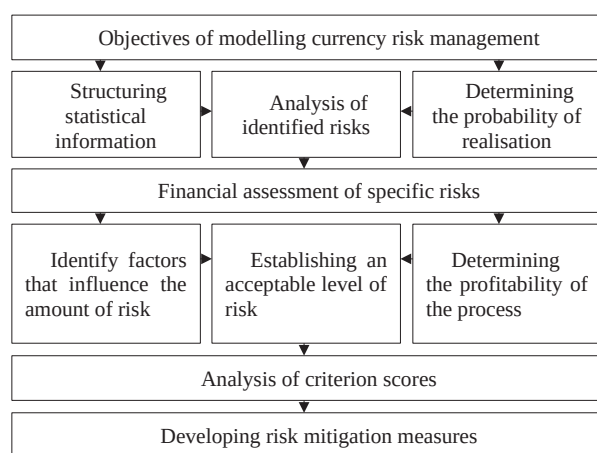


Fig. 3. Modelling of currency risk management

Modeling of currency risk assessments reduces the degree of uncertainty and substantiates management decision-making. The conducted research and generalization are the basis for building an information model designed to improve the currency risk management mechanism. The complex mechanism of currency risk management in the banking sector based on information technology and criterion evaluations allows to increase the efficiency of the banking system.

Uncertainty inherent in the functioning and development of the foreign exchange market leads to the

emergence of situations that have an unequivocal outcome. This circumstance applies to the decision-making process in conditions of uncertainty and determines the need to use appropriate methods and criteria that make it possible to obtain optimal managerial decisions acceptable for practice. It seems appropriate to dwell in more detail on the meaningful content of some criteria.

The consequences of evaluating exchange rate fluctuations in the conditions of global changes in the foreign exchange market in the direction of obtaining additional profit and causing damage are different, therefore the criteria for solving tasks in management and optimization, as well as financial instruments for their implementation, are different.

The ideal observer criterion considers the value of losses and gains caused by exchange rate fluctuations to be the same. Then the quantitative analysis of the process indicator G can be expressed by the equation.

$$G = 1 - (F + \beta)$$

where F – probability of damage; β – probability of additional profit.

According to this criterion, a minimum of total error in decision-making should be ensured. A mistake in obtaining a positive result, i.e. a profit, is considered a first-order error. A mistake in obtaining a loss from exchange rate fluctuations is considered a second type of error. They are manifested in the form of conditional probabilities.

The most cautious criterion is the minimum average risk criterion R_c assessing the impending crisis situation. Medium risk R_c is the mathematical expectation of losses associated with a decision.

Considering losses in the form of a discrete random variable that takes on the values C_{ij} with probabilities $P_{ij}(i, j = 0, 1)$ For medium risk we have

$$R_c = q(P_{00}C_{00} + P_{01}C_{01}) + P(P_{10}C_{10} + P_{11}C_{11})$$

where P and q – a priori probabilities of the presence and absence of crisis phenomena that cause changes in the exchange rate.

This criterion is used when large losses are expected in the event of sharp fluctuations in the exchange rate and it is necessary to develop preventive measures and insurance against expected possible losses.

The criterion of the normal distribution of states of the economic system requires statistical recognition of correct and incorrect estimates. The results are presented in the form of a set of observations, which are recorded in the form of a matrix

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{p1} & x_{p2} & \cdots & x_{pn} \end{bmatrix}$$

Each column of the matrix represents a vector of system states. In statistical decision theory, all types of

decision rules are based on the formation of a likelihood ratio L and comparing it to a certain threshold

$$L = \frac{f_n(x_1, \dots, x_n | a_2)}{f_n(x_1, \dots, x_n | a_1)} \geq c$$

where $f_n(x_1, \dots, x_n | a_j)$ – probability density of values $x_1, \dots, x_n$ provided they belong to a class a_j . The decisive rule for $k=2$ looks like

$$L = \frac{f(x_1, \dots, x_n | a_2) \geq \Pi_{12} - \Pi_{11}P(a_1)}{f(x_1, \dots, x_n | a_1) < \Pi_{21} - \Pi_{22}P(a_2)}$$

where $\Pi = \begin{bmatrix} \Pi_{11} & \Pi_{12} \\ \Pi_{21} & \Pi_{22} \end{bmatrix}$ – payment matrix, element Π_{ki} which quantifies the costs of a wrong decision.

Statistical methods of risk analysis are recommended to be used when there is a sufficient amount of analytical and statistical information on the states of the object of analysis. The advantages of these methods are the ability to analyse and evaluate various event scenarios and risk factors within a single approach. Difficulties in implementation lie in the need to apply probabilistic characteristics and select appropriate quality criteria.

DISCUSSION OF THE RESULTS OBTAINED

Both the countries where these fluctuations occur and neighbouring countries with economic ties are exposed to the risk caused by hard-to-predict currency fluctuations. In this situation, one of the ways to mitigate risks is diversification, i.e., the formation of assets from a set of different currencies to compensate for losses in one currency with profits from others. Such a set of currencies is a currency portfolio.

The following mathematical tools and theories of dynamic modelling are used in the process of modelling currency risk:

- stochastic programming,
- game theory,
- theory of fuzzy sets,
- modeling using neural networks.

Modeling the dynamics of the exchange rate requires an assessment of the risks associated with it [13]. The most common method of modeling the foreign exchange market of Ukraine and assessing foreign exchange risk is the Value-at-Risk method [14], which allows determining the maximum possible losses from exchange rate fluctuations with a given probability, i.e. perform statistical evaluation with a normal law of distribution of results.

However, the law of distribution of exchange rate changes does not always obey the normal law, especially during market volatility. In these conditions, in order to model future changes, it is necessary to collect information about changes in exchange rates in the depth of past periods, with their retrospective horizons, to perform their ranking, to determine confidence intervals and to make forecasts. However, the peculiarities of trends and causes of currency crises are not taken into account when implementing this modeling technique and cannot be repeated in the future.

In the practice of modeling management of currency risk fluctuations, regression models and their variants autoregression models, based on estimates of the squares of time series variances, have become widespread. The use of such mathematical models also has disadvantages related to the variability of the variance of the random error and the delayed reaction to emissions and jumps of the crisis situation.

An improvement of these mathematical models of currency risk management is the generalized GARCH model [15], which takes into account much fewer analyzed parameters than previous models. The advantage of the model is the speed of response to changes in the currency market. The advantage of such a generalized model of currency risk management is taking into account the dependence of the change in variance on the past positions of the company's currency portfolio. To find the defining parameters of the mathematical model of currency portfolio management, the method of maximum likelihood and its maximization by regulated parameters, which takes into account the asymmetry of the dispersion, is used [16].

A variety of mathematical models of currency risk management is their implementation as threshold, exponential and other mathematical models. When calculating value indicators as risk indicators, mean square deviations are used. Modeling of the amount of losses is carried out with the help of numerical approximation of their probability distributions. The use of these models shows a more realistic picture of possible potential losses. At the same time, it should be noted that for the management practice of modeling currency risk dynamics in conditions of global uncertainty, it is crucial not only to determine the moment of the crisis situation, but also to determine possible losses and necessary risk management strategies that reduce or neutralize. In the conditions of the uncertainty of global changes, it is necessary to improve the methods of managing currency risks and carry out management forecasting.

CONCLUSIONS

Based on the main methodological provisions specified in constructing the currency risk management modelling scheme, their manifestations in the most modern perspective management models are grouped and summarized. The performed analysis of promising, widely used world practice models, their semantic content, and distinguishing features made it possible to identify several features and shortcomings that restrain their practical implementation and defining directions of development.

It has been established that joint actions in modeling currency risk management obtain reliable and adequate information on risk identification and the scale of their effects on economic indicators.

Effective currency risk management reduces losses due to changes in the exchange rate of world currencies. Effective use of currency regulation methods in combination with a rational foreign economic policy allows to reduce the negative impact of external factors. By planning and organizing a currency risk management system in advance, investors can protect themselves from the impact of losses and minimize losses.

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