

Samorodov B. V.

*Doctor of Economics, Professor,
Kharkiv Educational-Scientific Institute
of SHEI «Banking University», Ukraine;
e-mail: bsamorodov@gmail.com; ORCID ID: 0000-0002-5267-1178*

Sosnovska O. O.

*Ph. D. in Economics,
Associate Professor of the Department of Finance and Economics,
Kiev Boris Grinchenko University, Ukraine;
e-mail: sosnovska.oo@gmail.com; ORCID ID: 0000-0002-2177-0691*

Zhytar M. O.

*Ph. D. in Economics,
Associate Professor of the Department of Finance named after L. L. Tarangul,
University of State Fiscal Service of Ukraine;
e-mail: zhytarmaksym@gmail.com; ORCID ID: 0000-0003-3614-0788*

Ananieva J. V.

*Ph. D. in Economics,
Associate Professor of the Department of Finance named after L. L. Tarangul,
University of State Fiscal Service of Ukraine;
e-mail: Yuliya_3103@yahoo.com*

METHODICAL APPROACH TO THE QUANTIFICATION OF ENTERPRISE FINANCIAL SECURITY LEVEL

Abstract. The method of evaluation of the level of an enterprise financial security as a priority criterion of its economic activity is proposed in the article. It is established that the calculation of indices for evaluation the financial security of a company is mainly based on the financial statements. According to these financial documents, one or another factor is determined, from the ratio of which the indices of an enterprise financial condition are formed as the information basis for the quantification of the level of its financial security

It is proved that in the process of quantitative evaluation of an enterprise financial security level, it is necessary to use the methods of big data analysis. It is proposed to use the Monte Carlo simulation method as the most adaptive to such problems and common among the methods of quantitative estimation of economic processes, the model of which is based on the generation of values consisting of random variables, over which a series of experiments are conducted in order to detect the influence of the initial data on the dependent variables. It is substantiated that the use of the Monte Carlo method allows not only to determine the probability of a future level of an enterprise financial security, but also to obtain the assessment of the deviation risk of certain indices of the financial condition from the established limits of normative values and to identify possible threats to the financial security of an enterprise.

It is proved that the analysis of the results of quantitative evaluation of an enterprise financial security level is the basis for making sound management decisions on optimization its financial risks and achievement the financial stability of an enterprise.

Keywords: enterprise, financial security, financial stability, factor analysis methods, simulation modeling, Monte Carlo method.

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Самородов Б. В.

*доктор економічних наук, професор,
Харківський навчально-науковий інститут
ДВНЗ «Університет банківської справи», Україна;
e-mail: bsamorodov@gmail.com; ORCID ID: 0000-0002-5267-1178*

Сосновська О. О.

*кандидат економічних наук, доцент кафедри фінансів та економіки
Київського університету імені Бориса Грінченка, Україна;
e-mail: sosnovska.oo@gmail.com; ORCID ID: 0000-0002-2177-0691*

Житар М. О.

*кандидат економічних наук, доцент кафедри фінансів імені Л. Л. Тарангул,
Університет державної фіскальної служби України;
e-mail: zhytarmaksym@gmail.com; ORCID ID: 0000-0003-3614-0788*

Ананьєва Ю. В.

*кандидат економічних наук, доцент кафедри фінансів імені Л. Л. Тарангул,
Університет державної фіскальної служби України;
e-mail: Yuliya_3103@yahoo.com*

МЕТОДИЧНИЙ ПІДХІД ДО КВАНТИФІКАЦІЇ РІВНЯ ФІНАНСОВОЇ БЕЗПЕКИ ПІДПРИЄМСТВА

Анотація. На основі інструментарію імітаційного моделювання запропоновано методіку оцінки рівня фінансової безпеки підприємства як пріоритетного критерію їхньої економічної безпеки. Установлено, що розрахунок показників для оцінки фінансової безпеки підприємства переважно здійснюється на основі фінансової звітності. За фінансовими документами визначається той чи інший фактор, із співвідношення яких будуються показники, що характеризують фінансовий стан підприємства як інформаційний базис для квантифікації рівня його фінансової безпеки.

Доведено, що у процесі кількісної оцінки рівня фінансової безпеки підприємства потрібно використовувати методи аналізу великих даних. Запропоновано використання методу імітаційного моделювання Монте-Карло як найбільш адаптивного до таких задач і розповсюдженого серед методів кількісної оцінки економічних процесів, модель якого ґрунтується на генерації значень, що складається з випадкових величин, над якими проводиться серія експериментів з метою виявлення впливу вихідних даних на залежні від них змінні. Обґрунтовано, що використання методу Монте-Карло дозволяє не тільки встановити ймовірність того чи іншого майбутнього рівня фінансової безпеки підприємства, а й отримати оцінку ризику відхилення окремих показників оцінки фінансового стану від установлених меж нормативних значень і визначити можливі загрози фінансовій безпеці підприємства.

Доведено, що аналіз результатів кількісної оцінки рівня фінансової безпеки підприємства є основою для прийняття обґрунтованих управлінських рішень щодо ухвалення оптимізації його фінансових ризиків і досягнення фінансової стійкості.

Ключові слова: підприємство, фінансова безпека, фінансова стійкість, методи факторного аналізу, імітаційне моделювання, метод Монте-Карло.

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Самородов Б. В.

*доктор економічних наук, професор,
Харьківський учебно-научний институт,
ГВУЗ «Університет банківського дела», Україна;
e-mail: bsamorodov@gmail.com; ORCID ID: 0000-0002-5267-1178*

Сосновская О. А.

*кандидат економічних наук, доцент кафедри фінансів і економіки,
Київський університет імені Бориса Грінченка, Україна;
e-mail: sosnovska.oo@gmail.com; ORCID ID: 0000-0002-2177-0691*

Житар М. О.

*кандидат економічних наук, доцент кафедри фінансів ім. Л. Л. Тарангул,
Університет державної фіскальної служби України;
e-mail: zhytarmaksym@gmail.com; ORCID ID: 0000-0003-3614-0788*

Ананьева Ю. В.
кандидат экономических наук, доцент кафедры финансов им. Л. Л. Тарангул,
Университет государственной фискальной службы Украины;
e-mail: Yuliya_3103@yahoo.com

МЕТОДИЧЕСКИЙ ПОДХОД КВАНТИФИКАЦИИ УРОВНЯ ФИНАНСОВОЙ БЕЗОПАСНОСТИ ПРЕДПРИЯТИЯ

Аннотация. На основе инструментария имитационного моделирования предложена методика оценки уровня финансовой безопасности предприятия как приоритетного критерия их экономической безопасности. Установлено, что расчет показателей для оценки финансовой безопасности предприятия преимущественно осуществляется на основе финансовой отчетности. По финансовым документам определяется тот или иной фактор, из соотношения которых определяются показатели финансового состояния предприятия как информационный базис для квантификации уровня его финансовой безопасности.

Доказано, что в процессе количественной оценки уровня финансовой безопасности предприятия необходимо использовать методы анализа больших данных. Предложено метод имитационного моделирования Монте-Карло как наиболее адаптивного к таким задачам и распространенного среди методов количественной оценки экономических процессов, модель которого основана на генерации значений, состоящих из случайных величин, над которыми проводится серия экспериментов с целью выявления влияния исходных данных на зависимые от них переменные. Обосновано, что использование метода Монте-Карло позволяет не только установить вероятность того или иного будущего уровня финансовой безопасности предприятия, но и оценить риск отклонения отдельных показателей финансового состояния предприятия от установленных границ их нормативных значений и определить возможные угрозы его финансовой безопасности.

Доказано, что анализ результатов количественной оценки уровня финансовой безопасности предприятия является основой для принятия обоснованных управленческих решений относительно оптимизации его финансовых рисков и достижения финансовой устойчивости.

Ключевые слова: предприятие, финансовая безопасность, финансовая устойчивость, методы факторного анализа, имитационное моделирование, метод Монте-Карло.

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Introduction. Nowadays, the urgent task of a stable performance of enterprises is to achieve the target level of financial security as a priority structural subsystem of their economic security, which is primarily caused by high dynamism, increasing competition and the growth of the cost of an error in making management decisions. Under these conditions, the ability of enterprises to implement the measures of antisipative or countervailing nature, which are aimed at counteraction adverse influences and threats, depends on the availability of necessary financial resources, the optimal formation and rational use of which is a necessary basis for the financially secure operation of any enterprise and for achieving the proper level of its financial stability in the changing economic environment. In this respect, the effectiveness of an enterprise available financial resources management depends on the development and implementation of risk assessment tools and the methods of quantification of an enterprises financial security level, which are universal and feasible.

Analysis Research results. Research and statement of the problem. In the scientific environment, the problem of the evaluation of enterprises financial security was researched by such economists as OM Amosov, OI Baranovsky, I.A. Blank, Z.S. Varnaliy, VM Geyets, K.S. Goryacheva, OV Grivkivska, V.V. Dergachova, OA Epifanov, E.E. Yermoshenko, I.M. Zelisko, S.M. Plyashenko, MO Kizim, TS Klebanova, D. Van Horn, T. Allison, G. Foster, J. Schumpeter [1—3; 5; 7—12; 16], as well as other domestic and foreign scientists, who generally agree that this process is difficult for most modern businesses to put it into practice due to the lack of a qualitative

informational and methodological support. Therefore, in spite of the high degree of coverage of these issues in the scientific literature, it should be noted that there is no single approach to the evaluation of enterprises financial security level among the existing methodological approaches. Most of the techniques do not take into account the current risky enterprise operating environment, which brings this problem to a new level of urgency.

The purpose of the article. The purpose of the article is the development of the methodological approach to the quantification of an enterprise financial security level in order to make quality management decisions on the optimization of its financial risks, achievement the target level of its financial security and ensuring its financial stability in an uncertain economic environment.

Research results. Risks in the field of enterprises business activity determine the level of their financial security, which is presented in the scientific environment as the state of protection against threats, risks and dangers. It is proved that risks can act as both destructive and constructive factors in the enterprise management system. Under risks, business executives may choose quite a cautious risk-management strategy that will impede the development of an enterprise. At the same time, a risk can be seen as an additional reserve to push for making although risky but justified decisions. That is why it is so important to build up an enterprise risk management system that could be able to identify and evaluate risks, run a series of scenarios, and properly choose the next steps to develop the economic process and ensure effective management of both an enterprise itself and its financial security. We believe that the process of monitoring the universal aggregate of financial security indices allows to identify and prevent the transformation of potentially risky situations and conditions into real threats to an enterprise operation.

It should be noted that the methodology of enterprises financial risks evaluation that have an unconditional impact on the level of their financial security, can be carried out by using the analysis of the factors that affect the economic activity of an enterprise, which requires the use of factor analysis methods. The efficiency of their use is explained by the fact that the methods of factor analysis allow with some approximation to solve one of the most common problems of financial risk assessment, namely the task of classification and meaningful description of the phenomena studied, based on the processing of large data files.

The information about the object under study can be presented in the form of data tables (quantitative or qualitative). The rows of such tables may correspond to a series of observations of the phenomenon under study, and the columns may characterize the features and criteria of such phenomena. Appropriate research is most effectively carried out by using enterprises information bases. The integrated use of these data can be presented in the form of integral indices that make it possible to generalize them and to determine the dependance between the factors of influence on certain spheres of economic activity of an enterprise and response to such influences.

In economic science, it is customary to use several types of deterministic factor analysis models: additive, multiplicative, and multiple.

Additive models are an algebraic sum of indices and have the following form:

$$Y = \sum_{i=1}^n X_i = x_1 + x_2 + x_3 \dots + \dots X_n, \quad (1)$$

On the basis of such models it is accepted to calculate the costs value as the sum of elements of production costs, quality indices of the products manufactured by individual types and others.

Multiplicative models are based on the product of a certain sample of elements in order to determine certain coefficients:

$$Y = \prod_{i=1}^n X_i = x_1 * x_2 * x_3 \dots * \dots X_n, \quad (2)$$

Multiple models show the ratio of certain quantities, in order to detect changes in relative values

$$y = \frac{x_1}{x_2}, \quad (3)$$

Quite often they are used along with other models, by combining them.

In economic calculations, when carrying out the factor analysis for step-by-step study of each variable, the method of chain substitutions is used, the essence of which is to determine the intermediate values of a general index by replacing successively the baseline values of the factors to the reporting values. The difference between the baseline values and the reporting values is equal to the change in the general index, which can be changed due to quantitative change one of the factors.

Such a model can be represented in the following form [6, p. 14—15]:

$$\begin{aligned}
 y^0 &= f(x_1^0, x_2^0, \dots, x_i^0, \dots, x_n^0); \\
 y_1^* &= f(x_1^1, x_2^0, \dots, x_i^0, \dots, x_n^0); \\
 \Delta(y_{x_1}) &= y_{x_1}^{*} - y_0; \\
 y_2^* &= f(x_1^1, x_2^1, \dots, x_i^0, \dots, x_n^0); \\
 \Delta(y_{x_2}) &= y_{x_2}^{*} - y_1; \\
 &\dots \dots \dots \\
 y_i^* &= f(x_1^1, x_2^1, \dots, x_i^1, \dots, x_n^0); \\
 \Delta(y_{x_i}) &= y_i^{*} - y_{(i-1)}; \\
 &\dots \dots \dots \\
 y^1 &= f(x_1^1, x_2^1, \dots, x_i^1, \dots, x_n^1); \\
 \Delta(y_{x_n}) &= y_n^{*} - y_{(n-1)};
 \end{aligned} \quad (4)$$

where x^0 – are baseline indices that have been established in previous studies;

x^1 – reporting indices, that is, those that characterize the currently researched object;

y_1^* – the intermediate value of the result.

The total change in the result $\Delta = y_1 - y_0$ consists of the sum of the changes in the general index due to the change of each factor, if the value of other factors remains fixed:

$$\Delta y = \sum_i \Delta(y_{x_i}) \quad (5)$$

The advantages of the method of chain substitutions are that it can be applied universally, it provides an opportunity to analyze any types of models and it can be applied in machine learning. The disadvantages are that it should be applied when there is an exact dependence of the quantitative measure of a certain factor and the result of generalization that cannot always be achieved.

It should be noted that the absence of a single system in the specialized economic literature to identify and evaluate the factors that affect an enterprise financial security causes the availability of a large number of factors and indicators. In most of the approaches proposed, the prerequisite for the determining of an enterprise financial stability is the assessment of its financial state, which is based on the coefficient system, on the basis of which the conclusion is made about the degree of the financial stability of an entity. The reason for the existence of a large number of approaches to the determination and evaluation of financial stability is the use of different systems of an enterprise financial condition evaluation indices.

The calculation of indices for assessing an enterprise financial security is generally performed on the basis of the financial statements - the balance sheet and annexes to it. According to financial documents, one or another record (hereinafter referred to as a factor) is determined, and the factors (ratios of various factors) are used to form the indices characterizing the financial state of an enterprise.

To calculate key indices, the information of such forms of reporting as the Enterprise Balance Sheet (*Form 1*), the Financial Statement (*Form 2*), the Balance Sheet Supplement (*Form 5*) and others are used.

To calculate the above indices and to evaluate the risk for each of them it is advisable to use one of the simulation methods, namely Monte Carlo, which is quite common among quantitative evaluation methods, since it is used in constructing the models whose variables are random values [14]. When creating such models, any factor that is inherent in uncertainty is replaced by a range of values, that is, probability distribution. Then repetitive calculations of the results are carried out, using every time a different set of random values of probability functions. It is sometimes necessary to do tens of thousands of recalculations to complete the simulation, depending on the number of uncertainties and the ranges established for such uncertainties. Therefore, the Monte Carlo modeling method allows to receive the values distribution of possible consequences.

For example, it is necessary to define some value of a . To calculate it, such a random variable X is entered so that its mathematical expectation can be equal to the desired value of a :

$$X \rightarrow MX = a \quad (6)$$

The following number of N tests are carried out, as a result of which certain values of X_i are found. And as the evaluation of the uncertain value of a , the arithmetic average of the values of X_i is taken, that is, for the total population with the universal mean of a , N objects are sampled and the uncertain value of a is evaluated as the sample mean:

$$a \approx \bar{X} \quad (7)$$

If the general population has a normal distribution, then based on interval estimates, it is possible to determine a confidence interval that covers the uncertain a , with probability of P .

The probability that the calculated mean of \bar{x} , which is determined by defining a random variable, differs from the uncertain and desired value of a no more than by δ , is equal to γ .

$$P(|\bar{x} - a| < \delta) = \gamma \quad (8)$$

To determine random variables the random variable generations are used. However, their computer modeling depends on the algorithm for generating such a random number.

Much attention has been paid to the practical implementation of the Monte Carlo method. Thus, while analysing the risks of the duration of their investment-construction project, the researchers N. Urazova and O. Martyniuk used the Monte Carlo method to determine the risk-free time for a number of construction works, which allowed to optimize the construction process in the process of designing it [15]. A. Kravets used the Monte Carlo method to assess risks when evaluating the effectiveness of business plans. This made it possible to develop an optimal decision-making strategy on investment [13]. The use of the Monte Carlo method in estimating the risks of the oil and gas sector by scientists E. Boldyrev and I. Burenina, allowed to establish the need to use its own funds for the company they were researching, since the results showed a significant credit dependency in the future [4].

It is worth noting that the practical value of the Monte Carlo method for businesses is in its simplicity and its ability to be used in machine learning to process large data files. In fact, the most optimal for defining the quantitative evaluation of an enterprise risks are the analytical methods of simulation modeling, which are widely used in practice; the models that can be calculated by using a large amount of data, that allows to increase the accuracy of the evaluation of the onset of a hazardous situation, ie the probability of a threat. In addition, given the uncertainty of the external and internal environment of modern enterprises, it is advisable to use expert methods. In this case, the number of experts, the accuracy of the questions they are asked, and the competence of such experts will determine the effectiveness of the evaluation. The peer assessment method has a considerable degree of certainty in the literature and is often used in practice. Therefore, the effectiveness of risk minimization depends on making sound management decisions that must be made on the basis of the calculations received, in expert, analytical and other ways.

For calculations, the 90 percent confidence interval (CI) can be used, and the normal (Gaussian) distribution curve is used as a form of the distribution curve, which is commonly used in the case of the confidence interval selected.

The Monte Carlo method involves the use of the random number generator for each value interval, which is the basis for generating a large number of scenarios.

Let us use the Excel formula:

$$=NORM.INV(\text{probability, mean, standard_dev}), \quad (9)$$

where probability – A probability from the normal distribution
 mean (median) – The arithmetic mean of the normal distribution
 standard_dev – The standard deviation of the normal distribution.

So,

$$\text{Mean} = \frac{(\text{upper limit CI} + \text{lower limit CI})}{2}, \quad (10)$$

$$\text{Standard deviation} = \frac{(\text{upper limit CI} + \text{lower limit CI})}{3}, \quad (11)$$

where VM is the upper limit of the 90% confidence interval;

NM is the lower limit of the 90% confidence interval.

It should be noted that the calculation of the above indices and the analysis of the results obtained form some idea of the financial stability of an enterprise, but it is due to the synthesis of most of these indices into a single system, ie an integral index, that the level of financial security can be determined.

It is proposed to use the universal aggregate of the indices of financial stability, which are given in *Table 1*, as an integral index of an enterprise financial security. The table also specifies the normative values for each index, on the basis of which the integral index of financial security will be calculated.

Table 1

Financial stability indices and their normative values

	Indices	Normative value
1	Absolute liquidity ratio	0,1 - 0,2
2	Current liquidity ratio	1 - 3
3	The ratio of working capital to cover inventories and expenses	> 0,5
4	Debt ratio	> 0,1
5	Equity to total assets ratio	0,4 - 0,6
6	Loan capital structure ratio	is considered in dynamics > 3
7	Borrowed and own funds ratio	the lower the better, it is considered in dynamics < 0,2
8	Ratio of capital turnover in calculations (in turnovers)	the higher the better > 1,05
9	Return on sales ratio	the more the better > 1,2
10	Return on equity ratio	the more the better > 0,08

Thus, the formula of the calculation of the integral index of an enterprise financial security (FS) has the following form:

$$FS = \sum_{i=1}^n V_i, \quad (12)$$

where V_i — the value of the contribution of each of the indices of financial stability to the calculation of the integral index of financial security;

i — the number of the financial stability index, $i = 1..10$.

Thus, to calculate the integral index of an enterprise financial stability the value V_i , which can be equal to 1, 0 or 0.5, and is determined by the following formula is used:

$$V_i = \begin{cases} 1, & \text{if } N_{i1} \leq P_i \leq N_{i2}; \\ 0.5, & \text{if } P_i > N_{i2}; \\ 0. & \end{cases} \quad (13)$$

or for the indices that only have one limit:

$$V_i = \begin{cases} 1, & \text{if } P_i > N_{i1}, (P_i < N_{i2}); \\ 0. & \end{cases} \quad (14)$$

where P_i — the value of the i -th index of financial stability;
 N_{i1} — the lower limit of the normative value for the i -th index;
 N_{i2} — the upper limit of the regulatory value for the i -th index;
 i — the number of the financial strength index, $i = 1..10$.

It should be noted that the maximum possible value of the integral index of an enterprise financial security is 10, which is an ideal situation, the minimum level is 0, which corresponds to the catastrophic level of an enterprise financial security (*Table 2*).

Table 2

Correlation table of the value of the integral index and the level of an enterprise financial security

№	Financial security integral index evaluation	The level of the financial security of the enterprise
1	0-2,5	catastrophic level of FB
2	2,5-5	low FB
3	5-7,5	normal FB level
4	7,5-10	high level of FB

Thus, each value of the integral index value corresponds to a certain level of an enterprise financial security. The general guidelines for each level can be:

- the catastrophic and low level of financial security implies immediate introduction of anti-crisis mechanisms, creation of an expert commission, development and implementation of the measures to restore the normative values of an enterprise financial stability indices;
- the normal level of financial security indicates that there may be financial resources management deficiencies, but this may also be related to the current market situation and is a temporary phenomenon that depends on the specific situation and on those indices of the financial condition that have received a non-maximum assessment, that is, they are beyond normative values;
- the high level of financial security is an ideal situation and can be defined as a target level of the financial security of an enterprise within a certain period of time.

Conclusions. Thus, the proposed methodological approach to the quantification of the level of the financial security of enterprises as a priority criterion for their economic security, allows to identify and assess step-by-step the main risks and threats, relying on the system of controlled indices to diagnose the level of the financial security of an entity, to develop sound management solutions to ensure a continued operation of an enterprise in an uncertain economic environment. The use of simulation modeling tools, namely the Monte Carlo method, allows not only to determine the probability of the future level of an enterprise financial security, but also to obtain the assessment of the deviation risk of certain indices of the financial condition from the established limits of normative values, to identify possible threats to the financial security of an enterprise based on the analysis and assessment of the probability of their occurrence.

Література

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