PROBABILITY METHODS FOR ASSESSING FINANCIAL RISKS FOR ENTERPRISES

Vladimir Gorbunov[1],
Dmitry Denisov[2]

Abstract: The paper reviews methods for risk assessment which could be employed in the financial management of enterprises. The set of methods proposed renders it possible to assess the impact which different risk factors upon the efficiency of implemented projects and the effect of anti-risk measures on the financial performance of companies and thus identify the most efficient measures according to the criterion selected for project evaluation.

Key words: financial risk; risk assessment methods; risk optimization; business process; business projects; anti-risk measures.
JEL: D78, G32.

In a market economy, risk is inherent to the activity of any business entity due to the highly uncertain environment in which businesses operate. In most cases, the main objective of the operation of contemporary enterprises is to maximize their revenue and to increase the market value of the company. Financial risks are therefore considered to be the most significant ones in terms of

---

[1]Doctor of Technical Science, International Institute of Economics and Law 'Moscow University of Technology', Russia.
[2]Candidate of Economic Science, International Institute of Economics and Law 'Moscow University of Technology', Russia.

the impact which they might produce on the performance of companies.

In order to efficiently manage financial risks, it is necessary to accurately assess them in the first place. According to the underlying principle of risk management, it is possible to manage only those processes and phenomena that can be measured quantitatively. That principle was formulated by Norton and Kaplan who claimed that no economic process could be managed unless it was identified and adequately measured.

Since risk is a probability category, it is possible to employ probabilistic estimates when assessing uncertainty or measuring risk quantitatively. The major indicator used to measure the financial risk for an enterprise is the level of that risk. It has the most powerful effect on the return on the financial operations of an entity. Those two indicators are closely related and establish the 'risk-return' system.

The risk-return ratio is a major concept of financial risk-management, according to which the level of return on financial transactions, all other things being equal, is always accompanied by an increase in the level of the risk for these transactions and vice versa. The level of financial risk is also a major indicator in assessing the level of financial security of an enterprise, i.e. the degree to which the financial activity of a company is protected from external and internal threats. Therefore determining the risk level is an essential element of the decision-making process related to the financial management of any enterprise.

The level of financial risk refers to the probability of the occurrence of that risk under the influence of a given risk factor (or a group of factors) and the potential financial losses which an entity will suffer. Taking into account this definition, a set of relevant methods and tools is established to address different financial management issues. We will now review some major indicators employed in financial risk assessment:

Financial risk level (RL) is calculated with the formula:

$$RL = RP * FL$$

in which RP is the risk probability, i.e. the probability of financial risk occurrence and FL is the amount of financial losses which an entity will suffer should the financial risk materialize.

When employing this algorithm to assess the financial risk level, financial losses are usually expressed in absolute terms, while the probability of financial risk occurrence is expressed as a coefficient used to measure that probability (i.e. a coefficient of variation, a beta-coefficient, etc.). Hence, the level of financial risk will be expressed in absolute terms when employing this algorithm and is therefore less comparable to the values calculated by employing alternative options.

Dispersion refers to the degree in which the analysed indicator (in this case - the revenue expected from a particular financial transaction) may deviate from its mean value. The greater the deviation, the higher the risk will be. Dispersion is calculated with the formula:

$$\sigma^2 = \sum_{i=1}^{n} (R_i - \overline{R})^2 * P_i,$$

where σ^2 is the dispersion; R_i is the specific value of the returns which may be expected from a particular financial operation; $\overline{R}$ is the value of the average returns expected from the financial transactions; P_i is possible frequency (probability) of deviation from the returns expected from the financial transaction; n is the number of observations.

Dispersion cannot provide an exhaustive idea about the deviation $\Delta X = X - \overline{R}$, which is more indicative when assessing financial risk. Nevertheless, by calculating the variance it is possible to identify the relation between linear and quadratic deviations by employing Chebyshev inequality.

The probability that a random variable X will deviate from the mean value further than the specified tolerance ε> 0 does not exceed the value of its dispersion divided by ε2, i.e.

$$P(|\ X - \overline{R}\,| > \varepsilon\,) \leq \frac{D}{\varepsilon^2}.$$

Hence the conclusion that a low risk for the variance deviation corresponds to a low risk in terms of linear deviations and X data points will most likely be within the ε-range of the values expected for $\overline{\boldsymbol{R}}$.

Standard deviation is one of the measures which are used most commonly to assess the level of individual financial risk, just as dispersion determines the degree of absolute variability. It is calculated with the formula:

$$\sigma = \sqrt{\sum_{i=1}^{n} (R_i - \overline{R})^2 * P_i}$$

Standard deviation σ is a quantitative value and is measured in the same units as the variable. The advantage of the standard deviation method is that when the observed distribution (for example, the distribution of investment income) is close to normal, this parameter can be used to determine the boundaries within which the values of a random variable could be expected to fluctuate at a given probability level.

The coefficient of variation, CV, makes it possible to determine the risk level when there are different values of the mean return which is expected from a financial transaction (Gorbunov, 2013). The coefficient of variation is calculated with the formula:

$$CV = \pm \frac{\sigma}{\overline{R}} * 100\% \,.$$

The coefficient of variation is a dimensionless value. It may even be employed to compare the volatility of features which are expressed through different measurement units. The values of the coefficient of variation may range from 0 to 100%. The higher the coefficient, the higher the extent of variability is. The different values of the coefficient are attributed the following qualitative assessments: up to 10% - low variability; 10 - 25% - moderate variability; more than 25% - high variability.

The beta coefficient is used to assess the systematic financial risk of a security or a portfolio compared to the overall market. This indicator is usually employed to assess the risk of investment in securities and is calculated with the formula:

$$\beta = \frac{K \times \sigma_{И}}{\sigma_p},$$

where β is the beta coefficient; K is the correlation between the returns of a security (or a portfolio) and the mean returns of the overall market; $\sigma_{И}$ is the standard deviation of returns for the different types of securities (or for their portfolio as a whole); σ_p is the standard deviation of returns on the stock market as a whole.

Assessing the financial risk for different securities is based on the following values of the beta coefficient: $\beta = 1$ implies an average risk level; $\beta > 1$ implies a high risk level; $\beta < 1$ implies a low risk level.

By employing a probabilistic method of assessment, it is possible to estimated not only the risk for a specific transaction, but also for an enterprise as a whole (after analysing the dynamics of its returns) for a specified period of time. The choice of a specific method of assessment will depend on available data base and the expertise of the management team.

In the previous decade, a new method for assessing financial risk was designed which was based on the value-at-risk (VAR) indicator.

The value-at-risk indicator is a statistical estimate in monetary terms of the maximum possible amount of financial losses which an entity may suffer. It is estimated for a specified probability distribution of the factors affecting the value of assets (instruments) and the probability of occurrence of these losses over a given period of time.

It is clear from the definition above that the calculation of the VAR indicator is based on three major components. The first one is *the type of probability distribution of risk factors* which affect the value of assets (instruments) or a portfolio. The probability distribution which is used by risk-managers may be normal distribution, the Laplace distribution, Student's t-distribution, etc. Therefore, in order to determine the type of probability distribution which will be employed, it is necessary to first study statistically the impact which a change in a risk factor will produce on the value of an individual asset or an entire portfolio. Based on the findings of the conducted statistical study, the function of asset (or portfolio) pricing must then be plotted according to the specific financial risk factor(s). When determining the value-at-risk indicator for a set of risk factors (for example, when assessing the overall systematic risk), it is necessary to identify the type and strength of the correlation between different risk factors. The accuracy of VAR values depends on properly establishing the type of probability distribution for the model.

One of the definitions of the VAR indicator is the level of probability that the maximum possible amount of financial losses will not exceed the estimated value of the indicator. In financial risk management, this probability is referred to as the confidence level. The specific value of the confidence level in calculating the VAR indicator is determined by risk managers based on their risk preferences. In contemporary financial risk management, the confidence level usually ranges from 95 to 99%.

Finally, the third element in the value-at-risk model is the time period for which the VAR indicator is calculated (i.e. the specific time horizon for which potential financial losses are estimated). This period of time is referred to as '*the holding period*' in financial risk management. In contemporary financial risk management, this period is usually determined by employing either of two criteria: the planned period of owning an asset (i.e. how long the asset will be held in the portfolio of the company) or the liquidity level (i.e. the time it will actually take an asset to convert into cash without losing its current market value).

Figure 1 presents graphically the three components of the value-at-risk model. The curve in fig.1 represents the normal probability distribution of profit and loss for a financial instrument over a specified period of time.

The area between the values -2σ and +3σ presents the selected confidence level (95% of the area below the curve), while the area between the values -3σ and -2σ presents possible losses which are beyond the confidence level (5%). The value-at-risk indicator in the graph is estimated at RUB 3,000, i.e. the maximum possible amount of financial losses the financial instrument could suffer over the specified time period at the confidence level set by the risk-managers.

The graph also presents the returns which are beyond the confidence interval (10%) for that value of the VAR indicator.

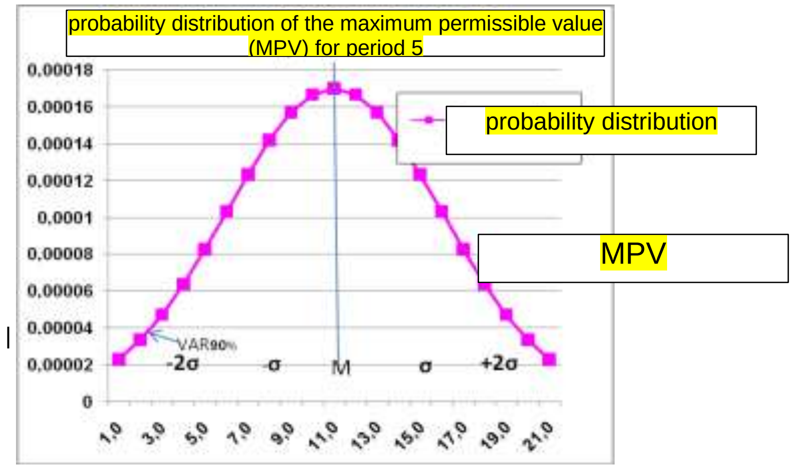

Fig 1. Graphical presentation of estimating the value-at-risk indicator (VAR)

In order to estimate risk comprehensively by employing the VAR model, it is necessary to set the probability (which should be low enough to consider the occurrence of an event 'nearly' impossible) or the confidence level of that value of probability. In most cases, a five-per-cent probability is set, which means that risk-managers determine a confidence level of 95% (100 - 5%) and obtained results are referred to as $VAR_{95\%}$ (which reads 'VAR at 95

%’). A 95% confidence level is contingent and risk-managers set the percentage according to their attitude to possible unlikely events and to their interpretation of what a ‘nearly’ impossible event is. Other levels of confidence, for example, 90% or 99% may also be employed (and then the estimated risk is for $VAR_{90\%}$ or $VAR_{99\%}$). Furthermore when risk managers estimate or calculate VAR, they also set a time horizon for the financial transaction. Therefore, they refer to risk as the minimum result which could be expected at a certain confidence level over a specified period of time.

Here is an example: an estimate that ‘the VAR assessment of the risk of a decline in returns over the next week is minus 2% at a confidence level of 95%’ or ‘weekly $VAR_{95\%} = -2\%$’ implies that:

- There is a 95% probability that the returns of the planned financial operation will be minimum -2% over a week;
- There is a 95% probability that the losses from the planned financial operation will not exceed 2% over a week;
- There is a 5% probability that the losses from the financial operation will exceed 2%.

Under normal distribution, there is a strict correlation between the two risk measures – dispersion and value-at-risk. Since normal distribution is determined by the two parameters M and σ, any value of this distribution (i.e. any quantile) will also be determined by the same parameters. Hence, for a normal probability distribution there is a clear correlation between dispersion and value-at-risk for any confidence level. This correlation may be expressed with the equation:

$VAR_i = M[X] - Z(1 - i)$,

where Z(1 - i) is a quantile in the range (1 - i) of standard normal distribution.

Here are three important formulas when expressing the values of quantiles in tables:

$$\begin{aligned} VAR_{90\%} &= M[X] - 1{,}283 * \sigma; \\ VAR_{95\%} &= M[X] - 1{,}645 * \sigma; \qquad (1) \\ VAR_{99\%} &= M[X] - 2{,}326 * \sigma. \end{aligned}$$

These formulas are of great practical significance. In the vast majority of cases, the probabilistic distribution of the results of economic operations is not known. However, it is often possible to estimate some values of an unknown distribution, for example, the expected result and the dispersion. We can then assume that the distribution will be very similar to normal distribution and we will be able to estimate VAR in terms of 1. Such an assumption holds true to operations on the financial market, since the prices of many important assets are determined by multiple different random factors whose impact is often inconsistent and in different directions. Even if the probability distribution of the results of each of these random factors is not normal, their joint probability distribution will tend to be normal. In order to design an analytical model of business processes, it is necessary to describe employed procedures and to specify the input parameters of these processes in analytical terms. What renders this approach more difficult is the analytical transformation of input parameters according to ongoing business processes. The process of analysis may be simplified by setting some limits on the input effects. For example, the E-Project (Gorbunov, 2013) programme employs only two values of M as input random parameters - mathematical expectation and standard deviation. Calculations for such variables are made similarly to calculations for random variables (Gorbunov, 2004):

- for any two random variables and the mathematical expectation of their sum M [X + Y]

$$M[X+Y] = M[X] + M[Y]\ ; \qquad (2)$$

- the variance of the sum of two random variables is equal to the sum of their variances plus the correlation coefficient K_{xy} multiplied by 2:

$$D[X+Y] = D[X] + D[Y] + 2K_{xy}\ ; \qquad (3)$$

- the mathematical expectation of the product of two random variables is equal to the product of their mathematical expectations plus the correlation coefficient K_{xy}:

$$M[XY] = M[X]M[Y] + K_{xy}\ ; \qquad (4)$$

- the variance of the product of independent random variables

$$D[XY] = D[X]D[Y] + m_x^2 D[Y] + m_y^2 D[X] \quad (5)$$

For regular business operations, most results are estimated through addition, subtraction, and multiplication as illustrated in equations (2-5).

The E-Project package assumes a normal distribution of output data. Such an assumption is possible in cases when a large number of random variables are involved in a business process and the final result is a complex combination of the impact of those input variables. We will estimate the difference in obtained results by applying the analytical model and the simulation method to business processes. For example, when input data varies according to Triang's law (Figure 2), the distribution of output data can be represented through normal distribution (Figure 3).

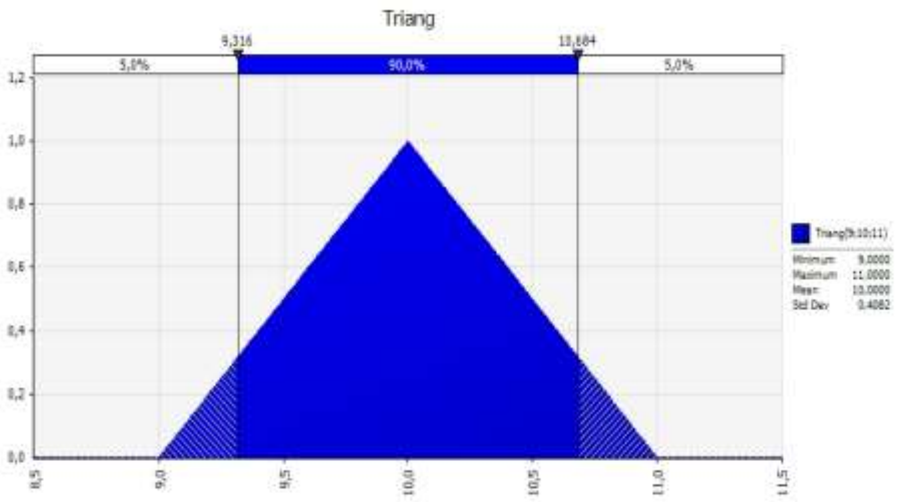

Figure 2. Probability distribution of the Sales input variable

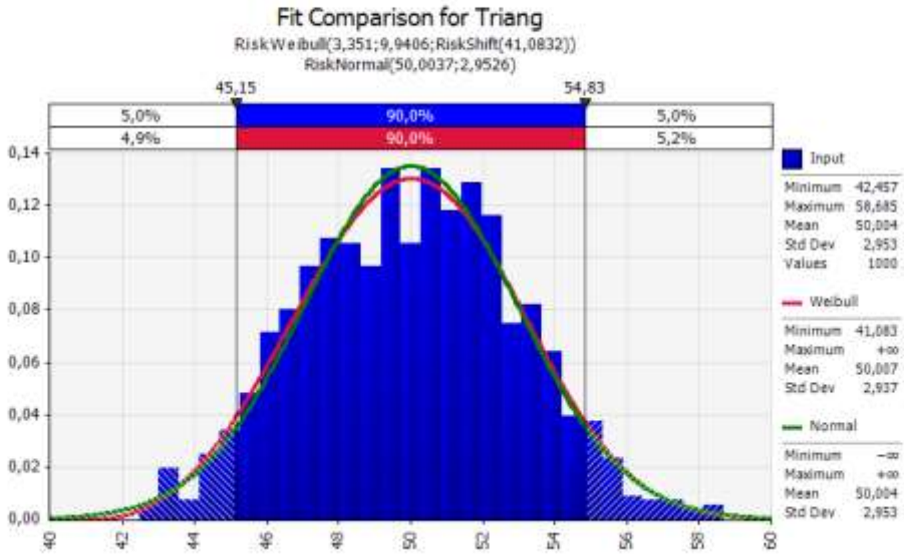

Figure 3. Probability distribution of output variables for a business process when input data are distributed according to the Triang dependency

The figure indicates that output values for regular business operations with different distributions of input parameters can be described through normal distribution. The example above shows normal distribution and the Weibull distribution. The difference in the standard deviation of all presented distributions is negligibly small. The higher the number of processes which have an impact on output variables, the more precise the probability distributions will be.

When input data are asymmetrically distributed, the results estimated through equations (2-5) will be less asymmetrically distributed compared to input variables. Figure 4 shows the result of a simulation with multiple input data, distributed according to 6 different laws. The probability distribution shows that the mathematical expectation and the standard deviation for normal distribution are the same as the output variables calculated through a simulation. The results of the simulation indicate that models of business projects can be based on analytical relationships (2-5), which will also make the analytical calculations and the modeling process easier . The output variables of business processes in analytical calculations largely depend on the accuracy of determined statistical values for the input variables.

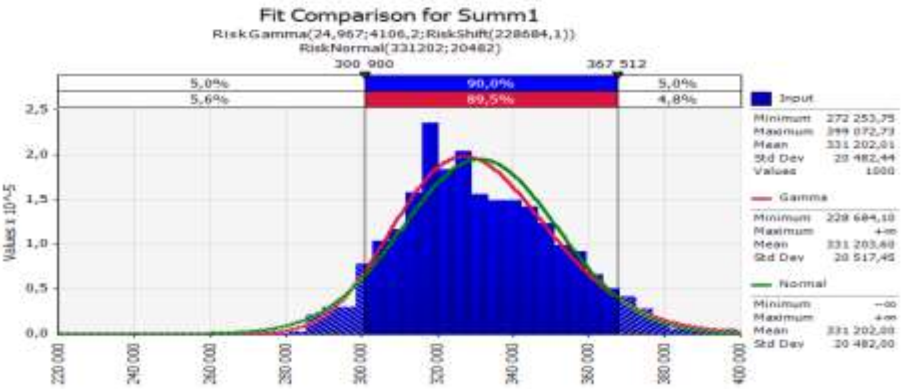

Figure 4. Distribution of output data for a business process as total sales increase with different distributions of input data.

An important stage in risk management is the optimization of costs to minimize losses. The characteristics of risk factors change when anti-risk measures are implemented. Risks can be optimised by comparatively evaluating the cost of anti-risk measures and predicted changes in the impact of risk factors in result of implementing anti-risk measures. As limited budgets make it impossible to implement all anti-risk measures, priority must be given to those anti-risk measures that will produce a marked positive effect.

To assess the impact of special risks, the E-Project program employs variables like the period of possible occurrence of a risk factor, the probability of occurrence of a risk situation P, the financial losses which will be incurred by the occurrence of a risk situation Q. In order to evaluate risks, they should be classified as technical, organizational, financial, environmental, technological, etc. The E-Project program provides measures to reduce the impact of risks. The program provides measures for reducing the impact of risks. The result of implementing these measures will change parameters P and Q to P_1 and Q_1. Anti-risk measures are recorded as ‘Investment measures’ and so is the cost of implementing them (Q_2) and the time period of their implementation. Table 1 presents a possible approach to risk assessment and anti-risk measures. The value of the logical variable K can be 0 or 1. When K = 1, an anti-risk measure is implemented and risk is estimated by multiplying P_1 by Q_1. When K = 0 no anti-risk measure is implemented and the parameters of estimated risk are P and Q.

Table 1.
Financial risks and anti-risk measures

№	Risk (Financial)	PQ	P_1Q_1	Anti-risk measure	Q_2	K
1	No increase in returns of investment.	10	4	Prepare a presentation and analytical tools to attract investment.	20	0
2	Production costs per unit of output remain high.	10	15	Introduce automated production to reduce production costs.	60	0
3	The average collection period of debts is not shortened.	20	6	Employ an automated system for collecting accounts receivable.	30	1
4	The net revenue from an individual contract does not increase.	60	12	Revise and update the contract.	30	1
5	The sales volume declines.	50	15	Launch a promotion campaign to boost sales.	10	1
6	Labour productivity declines.	30	20	Automate the assembly process.	60	0

The feasibility of these or other anti-risk measures is determined by conducting an integral evaluation of the financial results of the project for different values of the K parameter (Table 1). The E-Project program uses a special add-on which enables users to choose the optimum value of the K parameter for all risks depending on the criterion and the constraint which are set.

Anti-risk measures which are expected to be the most efficient are planned first. Figure 5 shows changes in financial losses after implementing 24 anti-risk measures and the costs of their implementation.

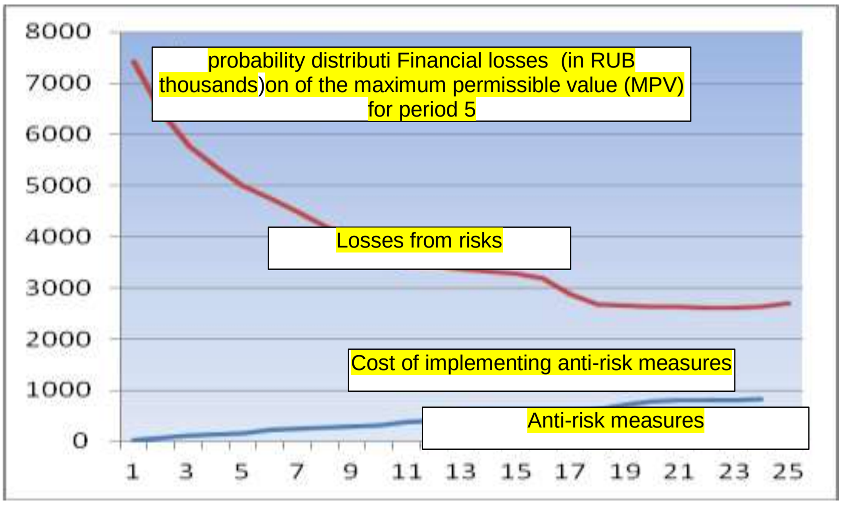

Figure 5. Losses incurred from risks and cost of anti-risk measures

A variety of algorithms can be run to automatically select appropriate anti-risk measures - for example, a range of measures which will not exceed the planned budget or measures which will exceed the established threshold. Figure 6 presents the result of a similar process of optimization, i.e. financial losses incurred from risks before and after implementing the anti-risk measures project.

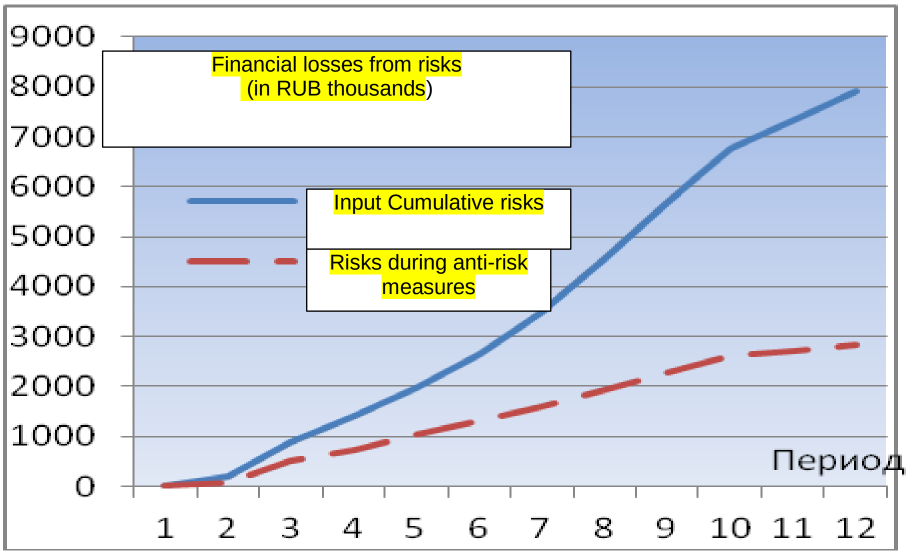

Figure 6. Losses incurred from risks before and after implementing anti-risk measures

The proposed methodology makes it possible to assess the impact which risk factors will have on the efficiency of a project; evaluate the impact of anti-risk measures on financial indicators and select the the most efficient measures in terms of the evaluation criterion selected for a project.

References

Gorbunov, V. L. (2004). *Baza dannykh 'AE-Project'*. Svidetel'stvo o registratsii No.2004629261/09.09.2004.

Gorbunov, V. L. (2007). Biznes-planirovaniye, otsenka effektivnosti innovatsionnogo proyekta M. *Finansy i yuridicheskoye pravo.*

Gorbunov, V. L. (2013). *Biznes-planirovaniye s otsenkoy riskov i effektivnosti proyektov:* Nauchno-prakticheskoye posobiye/V. L. Gorbunov. - M.: RIOR: Infra-M, 248 p.

Gorbunov, V. L. (2014). Uchet sbalansirovannykh pokazateley predpriyatiya v sisteme biznes-planirovaniya. *Sb. trudov mezhdunarodnaya konferentsiya 'Innovatsionnyye podkhody k resheniyu tekhniko-ekonomicheskikh problem'* M.MIET.

Roy L. Nersesian. (2013). *Energy Risk Modeling*. Palisade Corporation. NY USA

BUSINESS management

D. A. Tsenov Academy
of Economics, Svishtov

Year XXVIII * Book 2, 2018

CONTENTS

Submitted for publishinq on 13.06.2018, published on 19.06.2018, format 70x100/16, total print 40

ISSN 0861 - 6604

BUSINESS management

BUSINESS management 2/2018

PUBLISHED BY
D. A. TSENOV ACADEMY
OF ECONOMICS - SVISHTOV

2/2018

TO THE READERS AND AUTHORS OF "BUSINESS MANAGEMENT"

The journal of "Business Management" publishes research articles, methodological articles and studies, review articles, book reviews, commentaries and good practices reports.

1. Volume:

- Articles: between 12 – 20 pages;
- Other publications (review articles; book reviews, etc.): between 5 – 10 pages.

2. Submission of materials:

- On paper and electronically at one of the following e-mail addresses: bm@uni-svishtov.bg or zh.tananeeva@uni-svishtov.bg

3. Technical requirements (the article template is can be downloaded from the webpage of the journal):

- Format – Word for Windows 2003 (at least);
- Font – Times New Roman, size 14 pt, line spacing 1,5 lines;
- Page size – A4, 29–31 lines and 60–65 characters per line;
- Line spacing 1,5 lines (at least 22 pt);
- Margins – Top – 2.54 cm; Bottom – 2.54 cm; Left – 3.17 cm; Right – 3.17 cm;
- Page numbers – bottom right;
- Footnotes – size 10 pt;

4. Layout:

- Title of article title; name, scientific degree and scientific title of author – font: Times New Roman, 14 pt, capital letters, Bold – centered;

- Employer and address of place of employment; contact telephone(s) and e-mail – Times new Roman, 14 pt, capital letters, Bold – centered.

- Abstract – up to 30 lines; Key words – from three to five;

- **JEL** classification code for papers in Economics (http://ideas.repec.org/j/index.html);

- Introduction – it should be from half a page to a page long. It should state the main ideas and/or objectives of the study and justify the relevance of the discussed issue.

- The main body of the paper – it should contain discussion questions, an outline of the study and research findings/main conclusions; bibliographical citation and additional notes, explanations and comments written in the footnotes.

- Conclusion – it should provide a summary of the main research points supported by sufficient arguments.

- References – authors should list first references written in Cyrillic alphabet, then references written in Latin alphabet.

- Graphs and figures – Word 2003 or Power Point; the tables, graphs and figures must be embedded in the text (to facilitate language correction and English translation); Font for numbers and inside text – Times New Roman, 12 pt;

- Formulae must be created with Equation Editor;

5. Citation guidelines:

When citing sources, authors should observe the requirements of **APA Style**. More information can be found at: https://www.uni-svishtov.bg/default.asp?page=page&id=71#jan2017, or: http://owl.english.purdue.edu/owl/resource/560/01/

6. Contacts:

Editor in chief: tel.: (++359) 631-66-397
Co-editor in chief: tel.: (++359) 631-66-299
Proofreader: tel.: (++359) 631-66-335
E-mail: bm@uni-svishtov.bg; zh.tananeeva@uni-svishtov.bg;
Web: bm.uni-svishtov.bg
Address: "D. A. Tsenov" Academy of Economics, 2, Em. Chakarov Str., Svishtov, Bulgaria