

Laboratory Work 1. Statistical Method for Risk Assessment

Risk management means a proper understanding of the degree of risk that constantly threatens people, property, and the financial results of economic activity.

It is important for any entrepreneur to know the true cost of the risk to which their activity is exposed. The cost of risk should be understood as the entrepreneur's actual losses, the costs of reducing the magnitude of these losses, or the costs of compensating for such losses and their consequences. A correct assessment of the true cost of risk by a financial manager allows them to objectively represent the volume of possible losses and outline ways to prevent or reduce them, or, if prevention is impossible, to ensure their compensation.

Risk assessment is the stage of risk analysis aimed at determining its quantitative characteristics: the probability of unfavorable events occurring and the potential size of the damage.

The following main methods for assessing risk for specific processes can be distinguished:

1. Analysis of statistical data on unfavorable events that occurred in the past.
2. Theoretical analysis of the structure of cause-and-effect relationships of processes.

Using available statistical data, it is possible to assess the probability of unfavorable events occurring and the size of the losses. This method is suitable for frequent and homogeneous events.

Methods that provide a separate assessment of the risk level include variance, which is the weighted average of the squares of the deviations of the actual results of risky actions (for example, investments, deposits, projects) from the average expected results.

Variance characterizes the absolute fluctuation of the risk frequency, while the coefficient of variation shows the relative degree of fluctuation. The coefficient of variation can range from 1 to 100%. The higher the coefficient of variation, the stronger the fluctuation.

The following qualitative assessment has been established for different values of the coefficient of variation:

- Up to 10%: weak risk fluctuation.
- 10–25%: average, moderate risk fluctuation.
- More than 25%: high risk fluctuation.

When using variance and variation, it is considered that risk has a mathematically defined probability of obtaining a result. This possibility, in turn, can be determined subjectively by expert means or objectively based on mathematical calculations of the frequency of the degree of risk.

Variance and standard deviation serve as measures of absolute dispersion and are measured in the same physical units as the varying characteristic. The coefficient of variation is a relative value. Therefore, it can be used to compare the fluctuations of characteristics expressed in different units of measurement.

Since the formation of the expected result (for example, the amount of profit) is influenced by a multitude of random factors, it is usually a random variable. One of the characteristics of a random variable is the law of distribution of its probabilities. The nature and type of distribution reflect the general conditions arising from the essence and nature of the phenomenon, as well as the features that affect the variation of the studied indicator (expected result).

Situations where losses are rare but their magnitude is significant arise from catastrophic circumstances, such as a factory explosion or an earthquake. Conversely, situations where losses occur frequently and their size is small are considered normal.

A significant number of organizations experience a large number of small-sized losses. For example, in large manufacturing companies, a large number of minor employee injuries occur annually. Situations like a fire or explosion at a factory don't happen as often. Between these two extremes are medium-sized losses, which may or may not occur, but with some probability.

Decision-making with a high level of risk depends on the risk appetite of the decision-makers. However, such decisions are only possible if the occurrence of an undesirable result will not lead to catastrophic events, such as bankruptcy or liquidation of the enterprise.

Normal Distribution in Risk Assessment

As practice shows, the so-called normal distribution is most often used to characterize the distribution of socio-economic phenomena. The assumption that most results of economic activity (income, profit, etc.), as random variables, follow a law close to the normal distribution is widely used in literature on the quantitative assessment of economic risk.

It is known that the normal distribution law is characteristic for the distribution of events when their result is the outcome of the combined influence of a large number of independent factors, and none of these factors has a predominant influence. In reality, the normal distribution of economic phenomena in its pure form is rare. However, if the homogeneity of the population is maintained, the actual distributions are often close to normal.

In practice, various goodness-of-fit criteria (between empirical and theoretical distributions) are used to check the validity of the adopted distribution, which allow for accepting or rejecting the hypothesis about the distribution law.

Statistical Method and Key Tools

Losses are characterized by the frequency (number) of losses and the severity (size) of losses. These concepts apply to all types of risks, both operational and financial/market risks of an organization.

The essence of the statistical method is to study the statistics of the occurrence of risky events that were identified by experts or the decision-maker within the framework of the study. For example, in financial and economic analysis, this is the assessment of costs and profits that occurred in this enterprise in previous periods (or in similar production, division,

etc.). Next, the magnitude and frequency of a certain result are established, and the most probable forecast for the future is compiled.

The use of statistical methods in the framework of financial and economic analysis boils down to determining the probability of events and selecting the best option from possible future events based on certain criteria approved by management.

The key tools used in statistical methods are the coefficient of variation, variance, and standard deviation.

Coefficient of Variation (v)

The coefficient of variation is a value that shows the change in quantitative indicators when moving from one variant to another and is determined by the formula:

$$v = \frac{\sigma}{x}$$

where:

- σ is the standard deviation.
- x is the weighted average value of the risky event.

The coefficient of variation is a relative value, and the absolute values of the studied indicators do not affect it, so it can be used to compare the change in different characteristics in different units of measurement. The coefficient of variation can take values from 0 to 100%. The larger this value, the stronger the change in the indicator.

It has been empirically established that:

- If the value is less than 10%, it means a weak change in the characteristic.
- If the value is from 10% to 25%, it is a moderate change in the characteristic.
- If the value is over 25%, it is a high change in the characteristic.

Weighted Average Value of a Risky Event (x)

The weighted average value of a risky event (average expected value of a risky event, mathematical expectation) is the weighted average value of all possible results, taking into account the probability of each result occurring, which can be calculated using the following formula:

$$\bar{x} = \sum_{i=1}^n x_i p_i$$

where:

- x_i is the absolute value of the i -th event or result.
- p_i is the probability of the i -th event or result occurring.

- n is the number of events result variants.

The average expected value measures the result that is expected on average. Despite being a quantitative characteristic, it does not allow for a decision to be made in favor of any variant during the study.

Variance (δ^2)

Variance is the deviation or dispersion of actual values from the average value of the characteristic under study. It can be calculated using the following formula:

$$\delta^2 = \sum_{i=1}^n (x_i - \bar{x})^2 = \sum_{i=1}^n p_i (x_i - \bar{x})^2$$

Although variance indicates the presence of risk, it does not determine the direction of the deviation from the set, i.e., expected, value. When studying the financial and economic performance indicators of an enterprise, it is important for decision-making to know exactly how the indicator will change—whether it will increase or decrease.

Standard Deviation (δ)

Standard deviation is calculated as the square root of the variance and is measured in the same units as the studied indicator:

$$\delta = \sqrt{\delta^2}$$

Example

An enterprise is considering options for investing its free funds in a project for one year. The profitability of this project depends on the possible change in electricity tariffs.

Based on expert estimates, the following scenarios are possible (on average over the year):

1. With a probability of 0.3, tariffs will increase by 30% (Event A1).
2. With a probability of 0.4, tariffs will increase by 20% (Event A2).
3. With a probability of 0.1, tariffs will increase by 10% (Event A3).
4. With a probability of 0.1, tariffs will remain at the former level (Event A4).
5. With a probability of 0.1, tariffs will decrease by 10% (Event A5).

According to these possible development options (on average over the year), the following receipts/payments are expected for every 1,000 UAH invested:

Event/Scenario	A1	A2	A3	A4	A5
Payment (UAH)	1500	1400	1200	1000	900

Task: Assess the profitability of the project under risk conditions.

Solution:

1. Determine the profitability (x_r) of each possible scenario. The initial investment is 1000 UAH.

$$x_r(A1) = \frac{1500 - 1000}{1000} = 0,5$$

$$x_r(A2) = \frac{1400 - 1000}{1000} = 0,4$$

$$x_r(A3) = \frac{1200 - 1000}{1000} = 0,2$$

$$x_r(A4) = \frac{1000 - 1000}{1000} = 0$$

$$x_r(A5) = \frac{900 - 1000}{1000} = -0,1$$

2. The random variable of profitability can then be defined by the following discrete probability distribution law:

Profitability (x_i)	0.5	0.4	0.2	0	-0.1
Probability (p_i)	0.3	0.4	0.1	0.1	0.1

3. Calculate the Mathematical Expectation of Profitability:

$$M(\tilde{x}_r) = 0,5 \times 0,3 + 0,4 \times 0,4 + 0,2 \times 0,1 + 0 \times 0,1 - 0,1 \times 0,1 = 0,32$$

4. Calculate the Variance (δ^2):

$$\delta^2 = \sum_{i=1}^n p_i (x_i - \bar{x})^2 = (0,5 - 0,32)^2 \times 0,3 + (0,4 - 0,32)^2 \times 0,4 + (0,2 - 0,32)^2 \times 0,1 + \\ + (0 - 0,32)^2 \times 0,1 + (-0,1 - 0,32)^2 \times 0,1 = 0,0416$$

5. Calculate the Standard Deviation (δ):

$$\delta = \sqrt{\delta^2} = 0,204$$

Conclusion: The average expected profitability for every 1,000 UAH is 32%. The risk (deviation of profitability) is 20.4%.

Assignments

Variant 1

There are 2 options for investing capital in Event A and Event B.

- Event A is expected to yield a profit of 15 thousand UAH with a probability of 0.1.
- Event B is expected to yield a profit of 18 thousand UAH with a probability of 0.9.

Task: Determine the expected profit for events A and B, as well as the total expected profit.

Variant 2

When investing capital in Event A (out of 120 cases):

- A profit of

15 thousand UAH can be obtained in 48 cases.

- 18 thousand UAH in 36 cases.
- 30 thousand UAH in 36 cases.

When investing capital in Event B (out of 100 cases):

- A profit of 15 thousand UAH can be obtained in 30 cases.
- 30 thousand UAH in 50 cases.
- 20 thousand UAH in 20 cases.

Task: Determine the average expected profit from investment in Event A and Event B, the variance for Event A and Event B, the standard deviation for Event A and Event B, and the coefficient of variation for Event A and Event B.

Determine which event is more profitable to invest in: Event A or Event B?

Variant 3

The enterprise can produce two types of goods. According to market research, there are two equally probable incomes for the first type of goods:

- 200 thousand UAH in case of successful sales.
- 100 thousand UAH if sales are not successful.

The income from the sales of the second type of goods is expected to be

170 thousand UAH with a probability of 0.97 , and

66 thousand UAH with a probability of 0.03.

Task: Assess the risk and make a decision on the production of both sets of goods.

Variant 4

The enterprise sells products with payment due after a certain period. In 5% of cases, non-payment for the delivered goods is possible. The amount of losses in this case is 30 thousand UAH (the cost of the delivered batch of goods).

Currently, the enterprise supplies 1000 batches of goods annually. In case of refusal of post-payment (credit), the sales volume will decrease to 800 batches. The profit margin is 15%.

Task: Determine the amount of risk and the optimal strategy for the enterprise.

Variant 5

There are 2 options for investing capital in Event A and Event B.

- Event A is expected to yield a profit of 17 thousand UAH with a probability of 0.2.
- Event B is expected to yield a profit of 19 thousand UAH with a probability of 0.8.

Task: Determine the expected profit for events A and B, as well as the total expected profit.

Variant 6

When investing capital in Event A (out of 160 cases):

- A profit of 15 thousand UAH can be obtained in 88 cases.
- 18 thousand UAH in 36 cases.
- 30 thousand UAH in 36 cases.

When investing capital in Event B (out of 100 cases):

- A profit of 15 thousand UAH can be obtained in 30 cases.
- 35 thousand UAH in 50 cases.
- 25 thousand UAH in 20 cases.

Task: Determine the average expected profit from investment in Event A and Event B, the variance for Event A and Event B, the standard deviation for Event A and Event B, and the coefficient of variation for Event A and Event B.

Determine which event is more profitable to invest in: Event A or Event B?

Variant 7

The enterprise can produce two types of goods. According to market research, there are two equally probable incomes for the first type of goods:

- 250 thousand UAH in case of successful sales.

- 150 thousand UAH if sales are not successful.

The income from the sales of the second type of goods is expected to be 174 thousand UAH with a probability of 0.97 , and 68 thousand UAH with a probability of 0.03.

Task: Assess the risk and make a decision on the production of both sets of goods.

Variant 8

The enterprise sells products with payment due after a certain period. In 7% of cases, non-payment for the delivered goods is possible. The amount of losses in this case is 20 thousand UAH (the cost of the delivered batch of goods).

Currently, the enterprise supplies 1100 batches of goods annually. In case of refusal of post-payment (credit), the sales volume will decrease to 800 batches. The profit margin is 18%.

Task: Determine the amount of risk and the optimal strategy for the enterprise.

Variant 9

There are 2 options for investing capital in Event A and Event B.

- Event A is expected to yield a profit of 15 thousand UAH with a probability of 0.1.
- Event B is expected to yield a profit of 18 thousand UAH with a probability of 0.9.

Task: Determine the expected profit for events A and B, as well as the total expected profit.

Variant 10

When investing capital in Event A (out of 120 cases):

- A profit of 25 thousand UAH can be obtained in 48 cases.
- 28 thousand UAH in 36 cases.
- 30 thousand UAH in 36 cases.

When investing capital in Event B (out of 100 cases):

- A profit of 15 thousand UAH can be obtained in 30 cases.
- 30 thousand UAH in 50 cases.
- 20 thousand UAH in 20 cases.

Task: Determine the average expected profit from investment in Event A and Event B, the variance for Event A and Event B, the standard deviation for Event A and Event B, and the coefficient of variation for Event A and Event B.

Determine which event is more profitable to invest in: Event A or Event B?

Variant 11

The enterprise can produce two types of goods. According to market research, there are two equally probable incomes for the first type of goods:

- 200 thousand UAH in case of successful sales.
- 100 thousand UAH if sales are not successful.

The income from the sales of the second type of goods is expected to be 140 thousand UAH with a probability of 0.97 , and 76 thousand UAH with a probability of 0.03.

Task: Assess the risk and make a decision on the production of both sets of goods.

Variant 12

The enterprise sells products with payment due after a certain period. In 1% of cases, non-payment for the delivered goods is possible. The amount of losses in this case is 30 thousand UAH (the cost of the delivered batch of goods).

Currently, the enterprise supplies 1000 batches of goods annually. In case of refusal of post-payment (credit), the sales volume will decrease to 800 batches. The profit margin is 15%.

Task: Determine the amount of risk and the optimal strategy for the enterprise.

Variant 13

There are 2 options for investing capital in Event A and Event B.

- Event A is expected to yield a profit of 14 thousand UAH with a probability of 0.2.
- Event B is expected to yield a profit of 29 thousand UAH with a probability of 0.8.

Task: Determine the expected profit for events A and B, as well as the total expected profit.

Variant 14

When investing capital in Event A (out of 160 cases):

- A profit of 17 thousand UAH can be obtained in 88 cases.
- 18 thousand UAH in 36 cases.
- 30 thousand UAH in 36 cases.

When investing capital in Event B (out of 100 cases):

- A profit of 17 thousand UAH can be obtained in 30 cases.
- 30 thousand UAH in 50 cases.

- 25 thousand UAH in 20 cases.

Task: Determine the average expected profit from investment in Event A and Event B, the variance for Event A and Event B, the standard deviation for Event A and Event B, and the coefficient of variation for Event A and Event B.

Determine which event is more profitable to invest in: Event A or Event B?

Variant 15

The enterprise can produce two types of goods. According to market research, there are two equally probable incomes for the first type of goods:

- 250 thousand UAH in case of successful sales.
- 150 thousand UAH if sales are not successful.

The income from the sales of the second type of goods is expected to be 174 thousand UAH with a probability of 0.96 , and 64 thousand UAH with a probability of 0.04.

Task: Assess the risk and make a decision on the production of both sets of goods.

Variant 16

The enterprise sells products with payment due after a certain period. In 3.5% of cases, non-payment for the delivered goods is possible. The amount of losses in this case is 50 thousand UAH (the cost of the delivered batch of goods).

Currently, the enterprise supplies 1100 batches of goods annually. In case of refusal of post-payment (credit), the sales volume will decrease to 800 batches. The profit margin is 19%.

Task: Determine the amount of risk and the optimal strategy for the enterprise.

Variant 17

There are 2 options for investing capital in Event A and Event B.

- Event A is expected to yield a profit of 12 thousand UAH with a probability of 0.2.
- Event B is expected to yield a profit of 29 thousand UAH with a probability of 0.8.

Task: Determine the expected profit for events A and B, as well as the total expected profit.

Variant 18

When investing capital in Event A (out of 160 cases):

- A profit of 12 thousand UAH can be obtained in 88 cases.

- 28 thousand UAH in 36 cases.
- 20 thousand UAH in 36 cases.

When investing capital in Event B (out of 100 cases):

- A profit of 15 thousand UAH can be obtained in 30 cases.
- 35 thousand UAH in 50 cases.
- 25 thousand UAH in 20 cases.

Task: Determine the average expected profit from investment in Event A and Event B, the variance for Event A and Event B, the standard deviation for Event A and Event B, and the coefficient of variation for Event A and Event B.

Determine which event is more profitable to invest in: Event A or Event B?

Variant 19

The enterprise can produce two types of goods. According to market research, there are two equally probable incomes for the first type of goods:

- 220 thousand UAH in case of successful sales.
- 120 thousand UAH if sales are not successful.

The income from the sales of the second type of goods is expected to be 124 thousand UAH with a probability of 0.97, and 62 thousand UAH with a probability of 0.03.

Task: Assess the risk and make a decision on the production of both sets of goods.

Variant 20

The enterprise sells products with payment due after a certain period. In 3% of cases, non-payment for the delivered goods is possible. The amount of losses in this case is 22 thousand UAH (the cost of the delivered batch of goods).

Currently, the enterprise supplies 1100 batches of goods annually. In case of refusal of post-payment (credit), the sales volume will decrease to 800 batches. The profit margin is 28%.

Task: Determine the amount of risk and the optimal strategy for the enterprise.