Chapter

Risk Analysis in Engineering Projects

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Abstract

Modern business processes are characterized by a large number of random factors that can affect the characteristics of internal and external processes. The created models use the method of calculating output parameters as an operation with random characteristics of factors that affect the final results. The processes and factors of the project are divided into permanent and random. Random processes are characterized by individual distributions and characteristics. The mathematical model of a business project is formed by a program that performs operations with the characteristics of random factors and risk factors that form the business project. The generated model allows you to calculate financial flows and balances at all stages of the project implementation, and determines various indicators of its effectiveness. To optimize these indicators, it is planned to introduce anti-risk measures. The model allows you to optimize the number of such activities, taking into account their cost and the degree of impact on the project performance indicators. Using the proposed method of analyzing business projects allows you to take into account possible random factors and risk factors and make the most optimal management decisions.

Keywords: risk assessment, discount rate, Probabilistic, simulation, distribution

1. Introduction

Innovative business projects require a thorough analysis of their implementation. For this analysis, a business plan is drawn up, the most important element of which is the financial model of the project. Typically, a business plan uses deterministic characteristics of the project's processes and objects. However, it is impossible to accurately predict the values of these processes, since they relate to the future time and are subject to market influences. By their nature, they refer to random processes with their individual characteristics and distributions. Just as random are the potential risks that may occur during the implementation of the project. The peculiarity of the considered method of constructing a financial model of the project is that all the initial data of the project components are recorded as random variables, if they are such. To quantify the characteristics of random variables, the program uses the ModelRisk add-in. The implemented program allows you to learn the output characteristics of a business project as random variables with their distribution law. This form of results allows you to more accurately determine the risks of project implementation.

2. A functional model of a business process

The financial plan of the project involves the construction of business models, which shows all the actions performed with reflection used material values, labor cost, duration of execution of all intermediate operations.

IDEF0 refers to functional project presentation techniques that treat an organization as a set of functions that transform an incoming flow of information into an output one. The process of converting information consumes certain resources. The main difference from the object methodology is the clear separation of functions (data processing methods) from the data itself.

To build such models using special modeling languages, e.g. UML (Unified Modeling Language) [1]. Remedies such language describes the simple components of the procedure of a business process and reveals the relationship between the internal sub-processes and external data streams. Example view model of the company's activities (IDEF0 methodology), planning the development of a training course and sell it through the online shop shown in **Figure 1**.

The main part of the methodology is given in the diagram. The main conceptual principle of the IDEF0 methodology is the representation of any system under study as a set of interacting and interrelated blocks that reflect the processes, operations, and actions occurring in the system under study. In IDEF0, everything that happens in the system and its elements is usually called functions. Each function is assigned a block.

Function blocks in diagrams are represented by rectangles representing named processes, functions, actions, or operations that occur over time and have recognizable results. Each block contains its own name and number. The block name must be an active verb, a verbal phrase, or a verbal noun denoting an action.

The blocks in IDEF0 are arranged in order of importance, as the author of the diagram understands. This relative order is called dominance. Dominance is

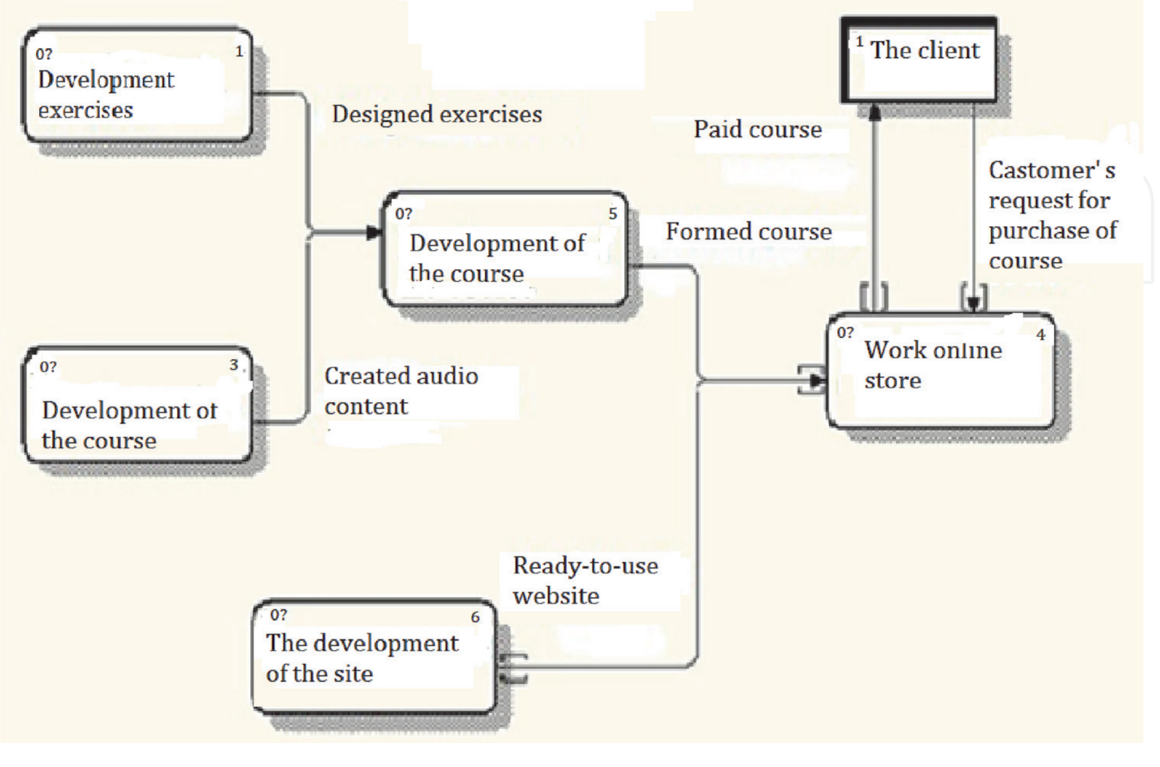

Figure 1.
IDEF0 business model.

understood as the effect that one block has on the other blocks in the chart. The most dominant block is usually located in the upper-left corner of the chart, and the least dominant block is located in the right corner.

The interfaces through which the block interacts with other blocks or with the external environment of the simulated system are represented by arrows entering or exiting the block. Each side of the functional unit has a default value from the point of view of when the block arrows [2, 3].

IDEF0 distinguishes five types of arrows:

1. input data - the material or information that is used or transformed by the function block to obtain the result (output). It is assumed that the job may not have any entry arrows.

2. Governance - the rules, strategies, procedures, or standards that govern a business unit. The control acts on the block, but is not transformed by it.

3. Output-the material or information that is produced by the block. A block without a result does not make sense and should not be modeled.

4. the mechanism of the resources that perform the block, for example, the staff of the plant, machinery, equipment, etc. At the analyst's discretion, the mechanism arrows may not be displayed in the model.

5. Call - a special arrow pointing to a different work model. The call arrow is used to indicate that some work is being done outside of the simulated system.

The model includes three types of documents (graphical charts, Glossary, text), which refer to each other. In the graphical diagrams with blocks and arrows, and their connections displays information about the system. The blocks represent the basic functions of the model elements. These functions can be broken down (decomposed) into its component parts and presented in the form of more detailed charts. The decomposition process continues until the subject is described at the level of detail necessary to achieve the objectives of a specific project. The Glossary is created and maintained by a set of definitions, key words, explanations for each element of the chart and describes the essence of each element. The text gives additional description of the operation of the system.

The model of the business process allows the financial models to determine cost characteristics of the processes, their interaction in time.

The financial plan of the project should reflect all costs associated with its preparation, take into account the cost of manufactured goods or services and determine income from the sale of the goods or services. The projects differ by the time interval during which there is a formation of business, its development and completion. During the project the prices of goods, raw materials, debt capital can change and in financial terms, these changes must be taken into account.

Many characteristics and parameters of the processes included in the project cannot be defined by constant values. This is due to the dependence of these parameters on the set of internal processes that form these parameters. Many of these processes are random in nature. The business plan and financial model of the project are drawn up for the coming period. In the period of market relations, it is possible to predict the indicators of economic and technological processes only as indicators of random processes. At the same time, in many cases it is possible to determine the characteristics of random processes that are included as components in the analyzed business process. For example, when drawing up projects related to the production of agricultural products, accumulated statistical characteristics can be used that link the effectiveness of production with climatic conditions.

For an analytical model of business processes, it is necessary to describe the procedures used and set the input parameters of the process in an analytical form. The complexity of this approach lies in the analytical transformation of input parameters in accordance with the ongoing business processes.

When using the Monte Carlo method in a model, as a rule, the most influential parameters of the model found during the sensitivity analysis are involved. Within the framework of modeling, a large number of model implementations are carried out with a joint random change of the selected parameters. The determination of the distribution law is based, if possible, on historical data of the selected value. The user sets the number of implementations of the method, and for each selected parameter, the limits of its change and the distribution law of the corresponding random variable. If the selected parameters depend on each other, then you must set the correlation coefficient between them.

The Monte Carlo algorithm is associated with a sequence of operations:

- Select a set of variable parameters (risk factors).
- Set the boundaries of change and the distribution laws of each of the factors.
- Refine the correlation matrix for the factors that depend on each other.
- Run the output parameter calculation for the desired number of experiments (usually at least 1000). Form statistical characteristics of the output distribution.

Monte Carlo analysis allows you to understand the degree of uncertainty of the analyzed final value (characterized, for example, by setting a 90% confidence interval). Also, the user can focus only on the values that interest him, setting them when determining the interval instead of the % probability. In the results table, information is usually displayed in percentiles. The percentile is the percentage or

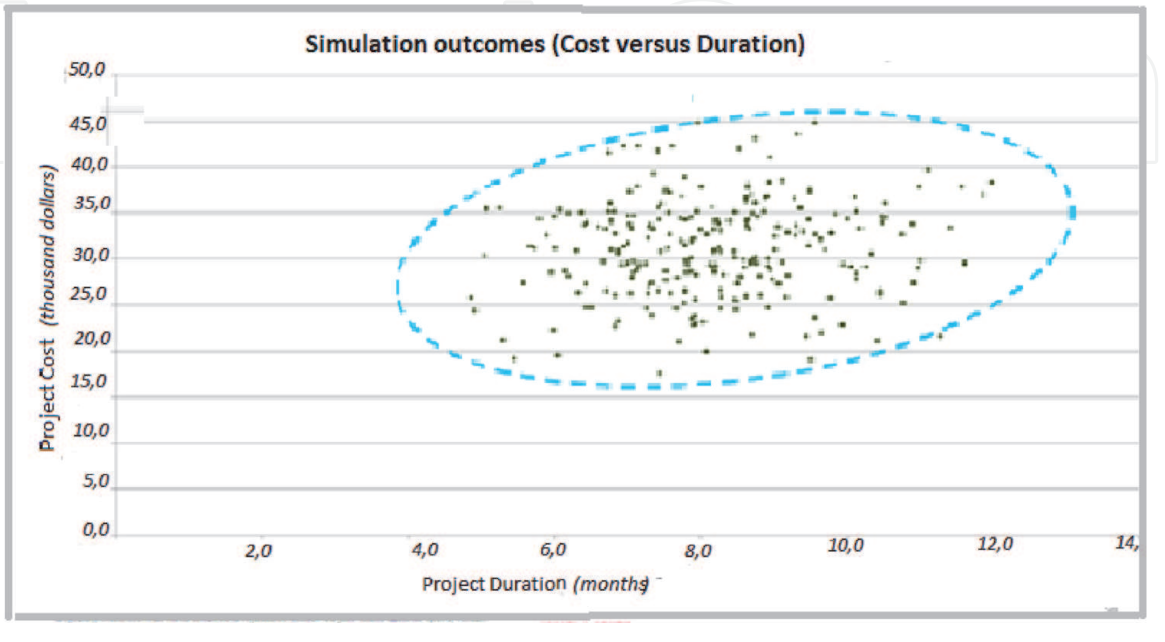

Figure 2.
Distribution of simulation results.

probability that the forecast value will be less than or equal to the value for a given parameter.

The Monte Carlo algorithm can become a necessary tool for all analysts, and their reports will contain not just General arguments about "potential risks", but also a separate section with a discussion of the results of the Monte Carlo analysis.

In many projects, the risks are determined not only by financial losses, but also by the failure of project deadlines. In such cases, risks can be assessed on a two-dimensional plane: cost, time of implementation.

When using Monte Carlo simulation on this plane, a set of results is formed, determined by the distribution laws of random input variables (**Figure 2**). the distribution Density of these calculations determines the probability of obtaining results corresponding to the coordinates on the plane under consideration.

All results can be divided into areas related to successful and unsuccessful project implementation.

3. Market and specific risks, feature of their account

A financial plan is an important document containing detailed information about cash flow on current operations as well as investment and financing activities of the enterprise. Properly plan the Manager may obtain information:

- about the source of funds and directions of their use;
- about the excess cash in the accounts of the enterprise, about the extent to which the enterprise extension is provided at the expense of own and borrowed funds;
- does enterprise in additional borrowing.

When making a report on cash flows for previous periods the entrepreneur uses the actual data available in the accounting records. The preparation of the forecast for the coming period requires more detailed analysis of the current situation and trends of its change. Often entrepreneurs are planning the distribution of funds to the best and worst case and also for the most real situation.

When planning the activities of small enterprises can be taken into account the probabilistic nature of the factors influencing its activity. In this case, the calculation of the indicators for the future period is not reduced to the calculation of the three moments of development, and to the calculation of a single process, which mathematically defines the probability of achieving the possible result of activity of the enterprise depending on the identified characteristics of the involved processes. Such forecasting will enable the entrepreneur to choose the right development strategy of the enterprise, ensuring the timely payment accepted debt.

Such figures as the price of the traded goods or services, the cost of materials or components, labor cost, etc., are connected with mathematical dependencies with the performance of the company. The variation of the initial indicators requires to re-produce the calculations. In this regard, there is a need for automated means of calculation that established procedures to instantly output when the source data changes.

To help developers to speed up the preparation of the business plan, to provide the necessary for the investor the level of quality of design documents, the entrepreneur offers specialized programs for financial planning. Traditionally, such systems are developed versions of the document templates. Most popular systems provide capabilities very far removed from the program Excel, and all of their value for the user lies in a well-chosen list of topics, filling it out, he will get more or less acceptable financial plan. As an example, the most popular system of this group is the program for Business Plan Pro with hundreds of thousands of users.

In connection with acceleration of rates of economic development, of particular importance is the ability of some of the programs on financial planning to take into account the risk factors. Such programmers can be placed on the program "E Project" [4, 5]. The program has the following features:

- the program incorporates a probabilistic calculation of the business processes;
- the program uses a widespread and reliable software packages;
- openness of the program provides the ability to navigate freely in calculation methodology, adapted to specific user requests by creating their own forms of source data and calculation algorithms;
- ability to enter data in the form of arbitrary shapes, and the results of calculations in the form of required reports. There are good editors for the formation of forms and reports;
- performed advanced analysis of the creditworthiness of the project, i.e. the dependence of results of calculation and changes in loan terms;
- a probabilistic calculation of the financial risk of the project depending on the probability characteristics of the source data;
- the results of the calculations are formed in the form of tables and diagrams.
- has the ability to convert data in HTML format.

The software package "E-Project" consists of two related programs: program of the calculation of economic indicators, realized in the program Excel, and textual blanks business plan that is implemented in Word.

In the analysis module using an input form, enter all of the source digital data for the project, it calculates the results, determine the course of economic processes associated with the implementation of the project.

Working with a design file starts with the opening title page of the project, where the author writes the project name, author name, choose project start date, the interval calculation of the project (month, quarter) and the duration of the calculated period. In this form, you select the currency format, in which to engage in financial calculations (RUB, thousand RUB, USD, thousand USD, etc.).

After filling in and confirming the passport data, the program displays a main form, consisting of ten control buttons (**Figure 3**).

The first eight control buttons provide a data input on the project.

The data input forms will be used to determine the financial flows required to support the production of products or provision of services to chart and plan-schedule of works for project implementation, for the computation of the aggregate depreciation at any point in your project.

A form of "Investment costs" it is designed to estimate all costs associated with the organization of projects. It is a list of all activities that must be performed to implement the project. For each of these events the data is entered at its cost (discusses options for average, minimum and maximum value), data at the

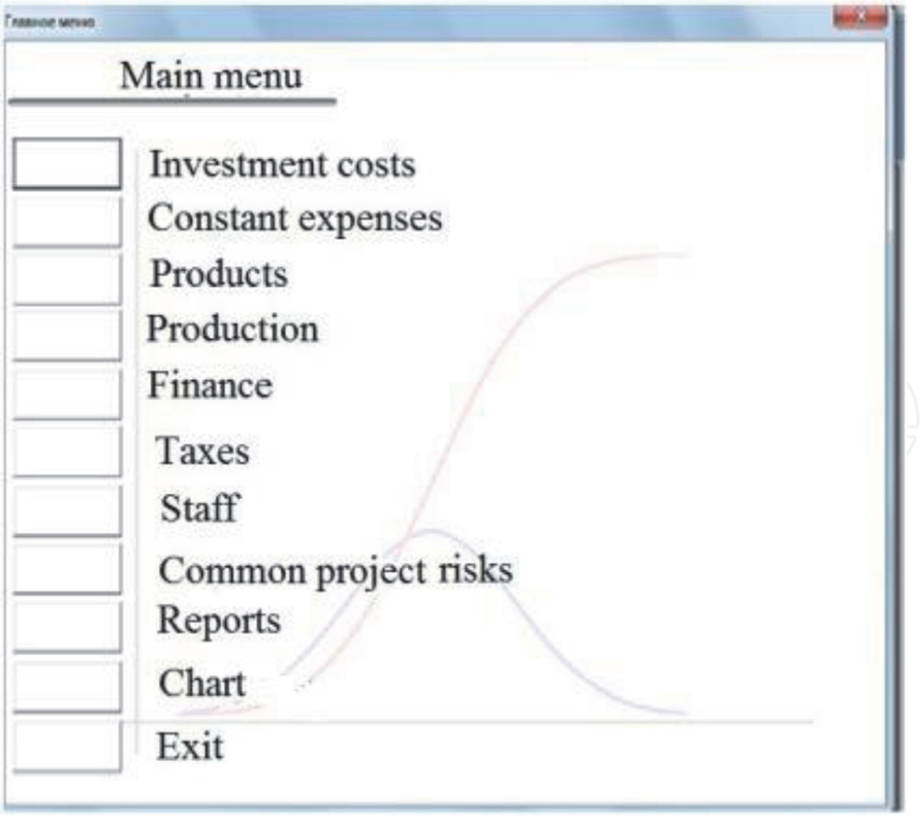

Figure 3.
The main menu of the project.

beginning of the activity and its duration, availability of plant and equipment associated with the event and the rate of depreciation for each fixed asset group.

To estimate fixed costs that are not related to the costs of producing the main products, use the form "Constant expenses". Such expenses include costs associated with building maintenance, payment for utilities, communications, transportation, security, etc.

Form "Products" associated with the data describing income and expenses for each planned type of product or service. It includes all the costs associated with the release of each type of product. The form provides for entering values for material and labor resources. The values of the tax and time delays for the preparation of production, for the production and for the sale of the product are determined.

Form "Production" is the total spent for marketing researches and answers the question, how much and when will be implemented the manufactured products listed in the form of "Products ". Since sales in the future period are random data, they are entered with the characteristics of this random process. To more accurately determine the process characteristics, use the ModelRisk add-in. The sales in this form shall be submitted in the number of products, the characteristics of which are presented in the form of "Products".

For enter initial data on the financial activities and considers such indicators as equity, loans, repayment of loans, interest on loans, grants and government funding, the payment of dividends used Form "Finance".

The procedure of payment and the amount of taxes depends on the legal form of the enterprise, accepted the forms of accounting and tax reporting. Input form "Taxes" specifies the source data for the calculation of the tax planning. In this form, the authors of the draft introduce the adopted tax rate for the primary taxable base indicators: payroll, income, imputed income, profit, property.

To determine the financial flows associated with staff wages, receiving a set salary, is a "Staff". In this form indicates the period during which the employee will work in the project, his position and set salary. You can plan rates without names when you do not know the names of the professionals who will be involved in the project.

The financial model allows us to assess the impact of the considered risk factors, taking into account the possible impact on the business process, taking into account the activation time of the risk factor. To calculate the impact of risks the software uses the input form of the "Common project risks". All risks of the project can be divided into two categories: market and special. Market risks due to fluctuations in price parameters, the instability of the market. These indicators can change from its average value both upwards and downwards. Such risks must be characterized by the standard parameters for random distributions (expectation, variance), which are determined by the entered data, reviewed the input forms. The second type (special risks) associated with the specific situation in the project, which can with some probability to occur and this will cause the appropriate financial changes.

№	Risk (Finance)	PQ	P_1Q_1	Event	Q_2	K
1	Revenue from employee training will not increase	10	4	Prepare present information and analytical materials for training staff	20	0
2	Support high production costs per unit of output	10	15	To Introduce the automation system to reduce cost of production	60	0
3	Will Not decrease the average collection time of accounts receivable	20	6	To Automate SIS theme collection of receivables	30	1
4	Will Not increase the net income of the main contract	60	12	Change mane contract	30	1
5	Reduced advertising agency sales growth	50	15	To Perform a range of promotion to increase sales	10	1
6	Administrative costs will increase	30	20	To Introduce the machine to the area	60	0

Table 1.
Risks and measures for compensation of financial risks.

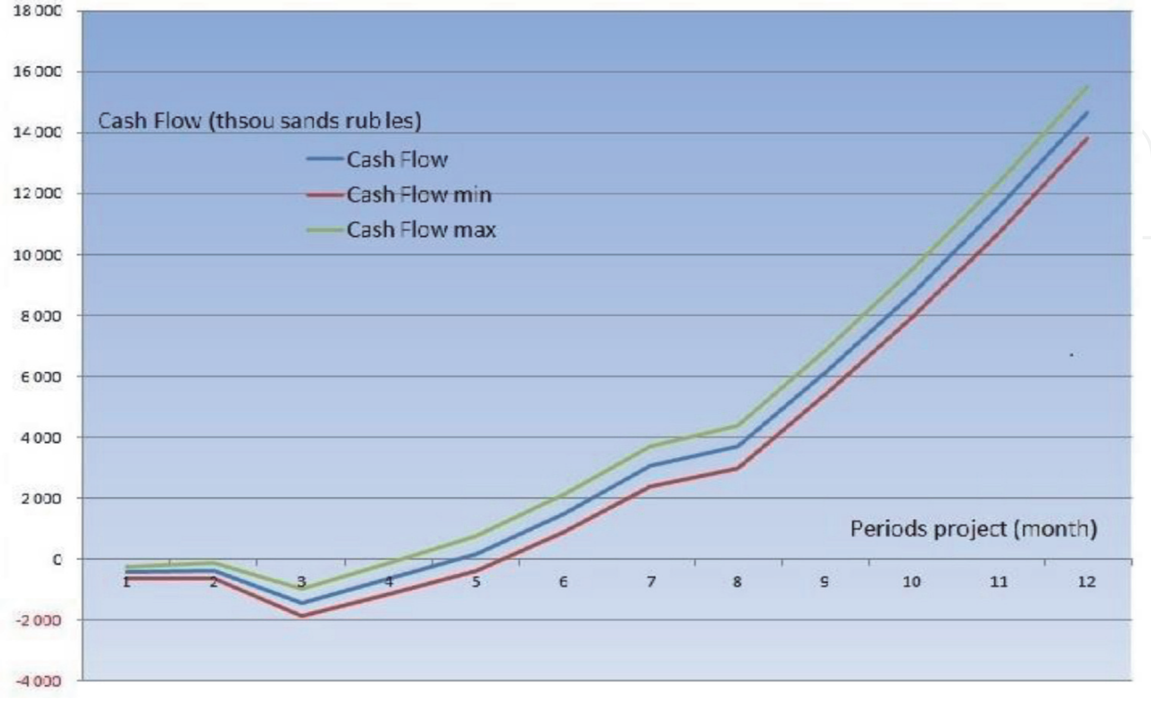

Figure 4.
Example of chart "The Cash flow project".

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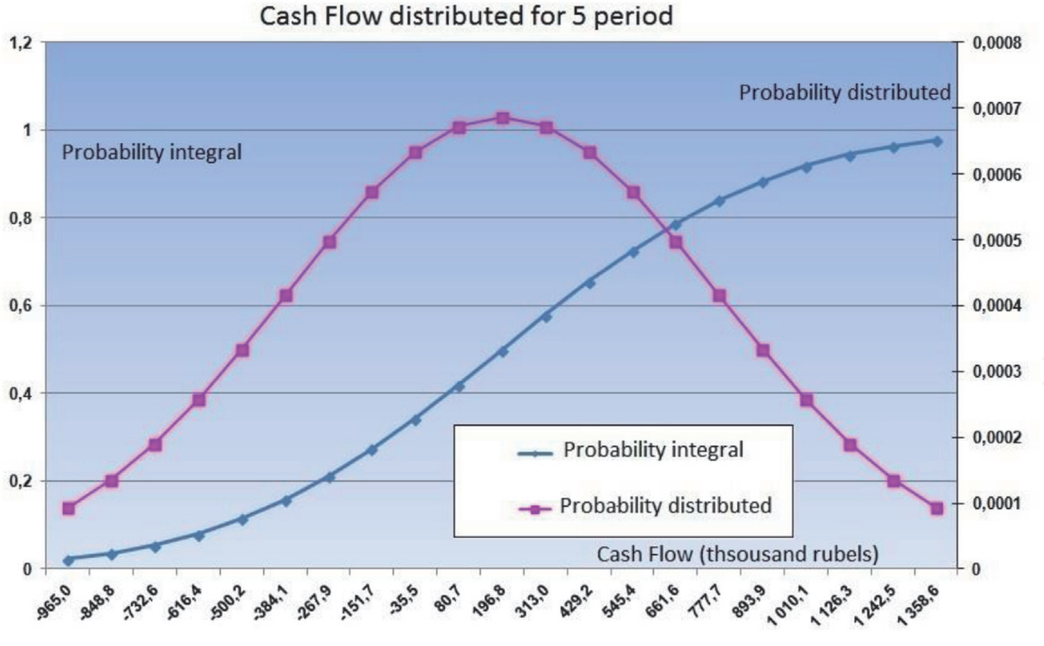

Figure 5.
Example of chart "Cash Flow Distribution".

To assess the impact of the special risks are considered characteristics such as the period of manifestation of this risk factor, the probability of a risk situation R, the financial cost upon the occurrence of a risk situation Q. For the construction of rose risks should be allocated considering the risk factor to one of the accepted categories: technical, organizational, financial, environmental, technological, etc. The Program includes measures to reduce the impact of risks. The effect of these events will change the parameters P and Q on P1 and Q1. Those events are recorded in the form of Investment measures the cost of these activities Q2 and their execution time. **Table 1** reflects the approach to risk assessment and events. A Boolean variable K can take the value 0 or 1. When K = 1 is performed event risks are characterized by the product of P1Q1, K = 0 event fails, and the risk perceived with the parameters R Q.

Introduction data in the form ends with the formation of the financial model of the project. The results for the generated models can be observed on the output reports that are in accordance with the selected algorithm and the results are given in tables (button on the main menu "Reports") or graphics (click main menu "Chart"). An example of the output graph shown in **Figures 4** and **5**.

4. Measurement of risk using the discount rate, expert assessments, indicators of sensitivity

Discount rate is widespread to account for the risk through the introduction of special allowances to the risk-free discount rate.

Calculation formula for discount rate is:

$$NPV = \sum_{t=1}^{T} \frac{CF_t}{(1+i)^t} + \frac{CF_{(T+1)}}{i-g} * \frac{1}{(1+i)^T}, \tag{1}$$

NPV — net present value of future cash flows; T is the number of settlement periods within the planning horizon; CT_t — cash flow over the t- period; $CF_{(T+1)}$ cash flow terminal of the first period; i — the value of the discount rate, g is the growth rate of cash flow in the post-planning period (percent per annum) [6].

To build value models of the company and its elements may be used in the simplified model developed by the magazine Business Valuation Review [7] for emerging markets. This model is based on the assumption that the yield on government Eurobonds reflects the risks associated with investing in the share capital of “ideal companies”, i.e. companies with no flaws. Disadvantages of a real company are equal to the risks specific to the company and the specific business. These flaws are marked as premium to the discount rate due to these risk factors. For the practical application of this model for risk management must be expanded given the types of risk into its components, to establish the relationship of these elements with the parameters and determine the total value of the allowances.

Method of expert estimations consists in the possibility of using the experience of experts in the analysis process of the project and considering the influence of diverse qualitative factors.

Formal peer-review process often comes down to the following. The management of the project (firm) develops the list of evaluation criteria in the form of the expert (polling) sheets containing the questions. For each criterion are assigned (at least - are calculated) and the corresponding weighting coefficients, which were not disclosed to the experts. Then for each criterion, the compiled answers, the weight of which is not known to the experts. The experts should have full information about the evaluation project and, through the examination to analyze the questions and mark the chosen answer. Next, the completed expert sheets are processed accordingly (on the basis of well-known computer packages for the processing of statistical information) and the output or results of the examination.

Not all risk factors can be digitally assessed. The reason for this may be the lack of experience with such factors. In these cases, the risk assessment can be carried out by experts using relatively rough estimates. Important to comparative analysis, which experts use to assess the occurrence of risk events simplified scale of gradations. For example, place each of the events on the graph in the axes of “impact” is “probability”. The diagram consists of 9 cells, each of which corresponds to a single set of estimates (**Figure 6**). For example, the event characterized by the estimated “low impact, low probability” should be displayed in the lower left cell of the chart, and event assessments “low impact, high likelihood” should be displayed in the lower right cell, etc.

The whole chart is divided into 3 approximately equal parts. Three cells of the diagram located at the bottom left, is an area of insignificant risk. Three cells of the diagram in its upper right part, is an area of significant risk. The remaining part of the diagram (3 cells), it is an area of medium risk. Thus, the risk associated with event A is insignificant, the risk events B - average, risk events C is substantial. The resulting diagram, which, in accordance with expert assessments applied to all risk events, called risk maps. This map shows what risk events can take place, what is the correlation between different types of risks and how risks should be given maximum attention (in this example, risk events C). This approach is widespread in the practice of risk management companies in the real business. Risk managers typically use 3 or 5 (rarely 7) grades for probability of exposure and materiality.

		The probability		
		Low	*Medium*	*High*
The Impact	*Strong*			Event C
	Average	Event A	Event B	
	Weak			

Figure 6.
The risk maps.

Described card r is a convenient way to visualize risk. In practice, there are other ways of visualization, such as using a circular or a color chart.

Sensitivity analysis and scenario analysis is the sequential steps in quantitative risk analysis, the latter allows to get rid of some of the shortcomings of sensitivity analysis. However, the scenario method is most effective can be applied when the number of possible values for NPV of course. However, as a rule, when carrying out a risk analysis of the investment project, the expert is faced with an unlimited number of different scenarios. The actual method of assessing individual risk of the project help to solve this problem (simulation), the basis of this method is the probabilistic assessment of the occurrence of various circumstances.

By using specialized software packages for the calculation of economic efficiency of projects evaluation of impact of risks is obtained in the form of output tables and graphs reflecting the impact of risk factors on project output.

5. Digital risk assessment in entrepreneurship

Risk- category probability, so in the process of assessing uncertainty and quantifying risk it is possible to use probabilistic calculations. The most important indicator of the measure of financial risk of enterprise is its level.

In entrepreneurship, financial success is often associated with innovative solutions in projects. But any innovative solution is based on new approaches, on the use of new technologies or organizational structures. The success of the use of the original solutions in projects is not guaranteed. A huge number of new projects do not achieve financial success due to the fact that the solutions used in them did not take into account the peculiarities of market mechanisms, the demand for new solutions is not always confirmed by the market, and unplanned factors that prevent its implementation are encountered on the way to project implementation. In projects that are funded by venture capital, which are characterized by increased risk, there is one successful project for ten projects, the profit from which covers the costs of the nine remaining projects. And four out of ten projects are unprofitable. This ratio is a consequence of the impact of risks that were not taken into account during the initial organization of projects.

Financial risks of projects consist of a combination of internal and external risk factors that affect the planned business process. Many of these factors are random and cannot be predicted in the initial planning. Some random factors have formed statistics of their manifestation and can be taken into account in the project through known statistical indicators. Accounting for risks through digital indicators allows you to build a more accurate business process model. To form such a digital estimate, a certain number of indicators are used:

The level of financial risk Ur. is defined as the product of the probability of occurrence of this financial risk Pl by the amount of possible financial losses in the implementation of the considered risk Fl:

$$Ur = Pl * Fl$$

The complexity of determining losses from this relationship is often reduced to the complexity of determining the probabilistic characteristics of risk factors. Often, the probability of occurrence of a risk factor depends on a set of external factors and is characterized by a certain law of distribution of its occurrence. The law of distribution of risk factors can be characterized by a number of indicators.

In practice this algorithm makes the size of possible financial losses usually expressed by an absolute amount and the probability of occurrence of financial risk

– one of the coefficients the measurement of this probability (the coefficient of variation, beta coefficient, etc.). Accordingly, the level of financial risk when it is calculated according to the following algorithm will be expressed absolute indicator, which significantly reduces its basis of comparison when considering alternative options.

The variance σ^2 characterizes the degree of variability of the studied indicator (in this case the expected income from realization of financial operations) with respect to its average value. Then the fluctuations grow, the greater the risk. The variance is calculated according to the following formula:

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

Ri – specific value of the possible variants of the expected income for the financial transactions; $\hat{R}$ - the average expected value of income under financial transactions; P_i – potential frequency (probability) of obtaining separate variants of the expected income on financial transactions; n is the number of observations.

Dispersion does not give a complete picture of the deviations $\Delta X = X - \hat{R}$, more pronounced for the risk evaluation. However, the job dispersion allows establishing a link between linear and quadratic deviations using the well-known Chebyshev inequality.

The probability that a random variable X deviates from its expectation by more than a given tolerance $\varepsilon > 0$, does not exceed its variance, divided by ε^2, i.e.

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

This shows that a small risk of dispersion deviation corresponds to a small risk according to a linear deviation of point X are likely to be within ε – neighborhood of the expected values.

A more common estimate of probabilistic processes is the standard deviation. This characteristic of a random process has the same dimension as the random variable. For example, if the profit is measured in dollars, then the standard deviation is measured in the same values. Just like the variance, the standard deviation characterizes the spread of random parameters and is determined by the following dependence:

The root mean square (standard) deviation is one of the most common in assessing the level of individual financial risk as the variance determines the degree of absolute variability and is calculated by the following formula.

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

The advantage of standard deviation is that when you reach the observed distribution (e.g., distribution of investment income) to normal this parameter can be used to determine the boundaries in which with a given probability, one should expect the value of a random variable.

The coefficient of variation CV lets you define the level of risk if the average expected income from financial operations differ [6]. The calculation of the coefficient of variation is carried out according to the following formula:

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

For the characteristics of random processes, the coefficient of variation CV is used. The peculiarity of this indicator is that it is a dimensionless quantity. With it, you can even compare the fluctuation of features expressed in different units of measurement. The coefficient of variation varies from 0 to 100%. The larger the coefficient, the greater the fluctuation (the spread of values of a random variable). The following qualitative assessment of various values of the coefficient of variation is established: up to 10% - weak fluctuation, 10–25% - moderate fluctuation, over 25% - high fluctuation.

The coefficient of variation CV – a dimensionless quantity. With it, you can even compare the variability of traits, expressed in different units of measurement. The coefficient of variation varies from 0 to 100%. The greater the ratio, the greater the variability. Established the following qualitative assessment of the different values of the coefficient of variation: 10% - weak variability, 10–25% moderate variability, over 25% - high variability.

The beta coefficient (β) is a parameter that allows you to assess the systematic financial risk of an individual project in relation to the level of risk of the financial market as a whole. This indicator is usually used to assess the risks of investing in individual securities and is calculated using the formula.

The beta coefficient (β) allows you to evaluate individual or portfolio systematic financial risk in relation to the risk level of the financial market as a whole. This indicator usually used to assess the risk of investing in individual securities and is computed by the formula

$$\beta = \frac{K \times \sigma i}{\sigma_p},$$

where β is the beta coefficient; K – the degree of correlation between the level of profitability on individual type of securities (or their portfolio) and the average level of profitability of the group equity instruments at the market as a whole; σi– standard deviation of return on the individual securities (or on their portfolio as a whole); σ_p – standard deviation of return on the stock market as a whole.

The level of financial risk for individual securities is based on the following values of beta coefficients: β = 1 – average; β > 1 – high level; β < 1 is low level.

Of particular interest for the assessment of entrepreneurship are methods that allow using the probabilistic method to assess the risk not only of a particular transaction, but also of the project as a whole, analyzing the dynamics of its income over a certain period of time. The choice of specific methods for evaluating long-term projects is determined by the availability of the necessary information base and the level of qualification of management personnel.

Using the probabilistic evaluation method can be assess the risk not only of a particular transaction, but also the business of the company as a whole (analyzing the dynamics of its income) for a certain period of time. The choice of specific assessment methods is determined by the availability of necessary information base and skill level of management personnel.

In the last decade has been the development of a new methodology for evaluating measures of financial risk through the use of the indicator "cost of risk" or "var" (Value-at-risk, VAR).

Value at risk is a measure of the statistical estimation expressed in the monetary form the largest possible size of financial losses in the prescribed form of the probability distribution of the factors influencing the value of the assets (tools) and a given level of the probability of occurrence of these losses over the estimated period of time.

From the above definition it is clear that the methodology of the calculation of VAR consists of three main elements. One of these elements is set by the risk Manager species a probability distribution of risk factors affecting the value of the assets (tools) or their total portfolio. Such can be the normal distribution, Laplace distribution, t-test etc. One of the definitions of VAR is set the risk-Manager level of probability that maximum possible size of financial losses will not exceed the estimated value of this indicator. In the terminology of financial risk management this specified probability is characterized by the term the confidence level. The specific value of the confidence level for the model of calculation of VAR is chosen by the risk Manager based on his risk preferences. In the modern practice of financial risk management this level is usually in the range of 90–99%.

A visual representation of the formation of a VAR gives the plot shown in **Figure 7**.

As can be seen from the graph in **Figure 7**, revenue curve illustrates the normal probability profit distribution on the financial instrument in a predetermined billing period of time. The field inside this graph between the -2σ and + 3σ corresponds to the chosen confidence level (90% of the area under the curve), and the between -3σ and-2σ — characterizes the value of possible losses beyond the confidence level (10%). On the chart, the VAR determined in the amount of −732,6 thousand rubles. This corresponds to a maximum size of possible financial losses on the financial instrument under the given confidence level and estimated valuation period, the value of VAR in the diagram separates the value of income beyond the limits of the confidence interval (10%).

To use the VAR measure to assess project risks, you need to specify the probability (small enough to consider an event "almost" impossible) for which the value of a random variable is determined. This value of the variable corresponds to the boundary value of the variable that is characteristic of the given probability of the process. Most often, in practice, they set a probability of 5%, respectively, they talk about a confidence level of 95% (100–5%) and denote the result in the form of VAR95% (pronounced "VAR at the level of 95%"). The 95% level is quite conditional, each individual sets this level based on their own attitude to possible unlikely

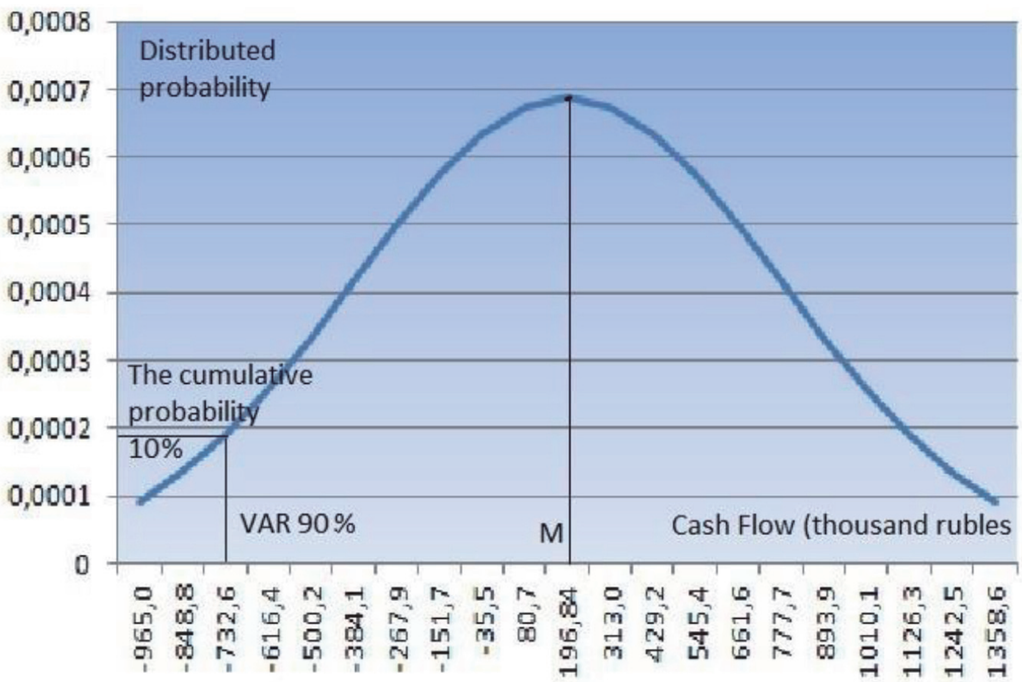

Figure 7.
Graphic method of determining the value indicator "value at risk" [VAR].

events and their understanding of what is considered an "almost" impossible event. Other confidence levels can also be used, such as 90% or 99% (then we talk about VAR90% or VAR99%).

When evaluating or calculating VAR, in practice, the time horizon of the project (financial transaction) is set. Therefore, the risk is referred to as the minimum result that will be obtained with a certain confidence probability within a specified period of time.

Here is an example. The phrase "evaluation of the VAR of the risk of lower returns during the next weeks is minus 3% at a confidence level of 95%" or briefly "a week VAR95% = - 3%" means that:

- weekly loss of over 3% is possible with a probability of 5%;
- with a probability of 95% loss for the week will not exceed 3%;
- with a probability of 95%, the yield of the planned operation will be at least −3% for the week.

Different distributions of random processes have certain relations with the VAR parameters. The normal distribution is defined by two parameters M and σ, and any characteristic of this distribution (in particular, any quantile) is also defined by these two parameters. This means that for a normal probability distribution, the relationship between variance and VAR at any confidence level is unambiguous and has the form:

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

where Z(1 - i) - quantile of order (1 - i) standard normal distribution.

The values of the tabulated quantiles, we present several important special cases:

$$\begin{gathered} VAR\ 90\% = M[X] - 1,283 * \sigma \\ VAR95\% = M[X] - 1,645 * \sigma \\ \mathrm{VAR}\ 99\% = \mathrm{M[X]} - 2,326 * \sigma. \end{gathered} \tag{2}$$

These ratios can be effectively used to evaluate complex business processes. Complex processes are a set of procedures that are different in nature, and the distribution of such complex processes is likely to approach the normal distribution.

This assumption is close to the truth for games in the financial markets, since the prices of many important assets are determined by a variety of random factors, often acting in an inconsistent and multidirectional way. Even if the probability distribution of the results of each of these random factors is not normal, their combined distribution will tend to be normal.

The input data of business processes are characterized by individual distribution laws. The complexity of using this characteristic in the information model lies in the analytical representation of the input parameters in accordance with the ongoing business processes. By accepting some restrictions on input effects, you can simplify the analytical analysis procedure.

By adopting some limitations on input actions, it is possible to simplify the analytical analysis. For example, in the E-Project [2] as the parameters of the random input signals are used only two characteristics of M – mathematical expectation and D - standard deviation. Operations such variables are performed according to the rules of operations with random variables [3]:

- for any two random variables and the expectation of their sum M(X + Y).

$$M\ (X+Y)=M(X)+M(Y) \tag{3}$$

- the variance of sum of two random variables is equal to the sum of their variances plus twice the correlation time of the *K*xy:

$$D(X+Y)=D(X)+D(Y)+2Kxy \tag{4}$$

- the mathematical expectation of the product of two random variables is equal to the product of their mathematical expectations plus the correlation time of the *Kxy*:

$$M(XY)=M(X)*M(Y)+Kxy \tag{5}$$

- the variance of independent random variables.

$$D(XY)=D(X)*D(Y)+M(X)2*D(Y)+M(Y)2*D(X) \tag{6}$$

Most of the results of typical business processes are built on the combination of operations of addition, subtraction, and multiplication can be defined by Eqs. (3)–(6).

Typically, a business process involves a large number of random variables, and the final result is a complex combination of these inputs. For such processes, the output results tend to be distributed according to the normal law. In the "E-Project" program, an assumption is made about the distribution of total values in accordance with the normal law. Rate the difference between the results of modeling the business process using the analytical model and method of simulation. For example, for changing the law Trian input data (**Figure 8**), the distribution of the output can be represented by a distribution by a normal distribution (**Figure 9**) [8, 9].

From this figure it is seen that model business processes at various distributions of the input parameters allow the output process to describe the distribution of the normal law. The standard deviation of all the distributions differs by a negligible amount. An approximation to these distributions will be more accurate the more processes will affect the output parameters.

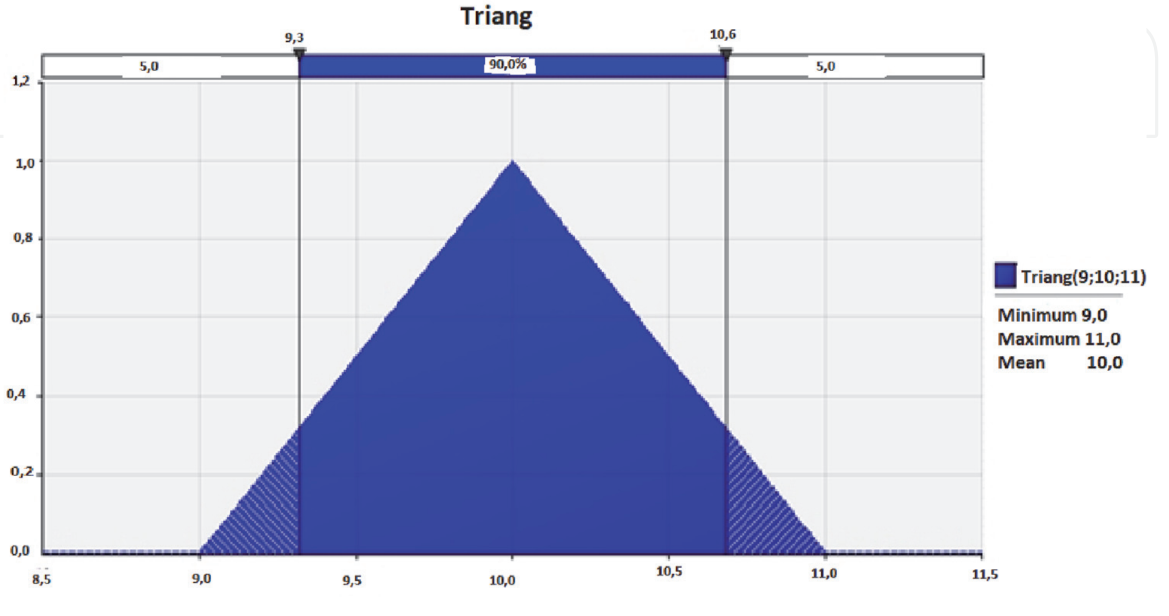

Figure 8.
The distribution of the input parameter "sales".

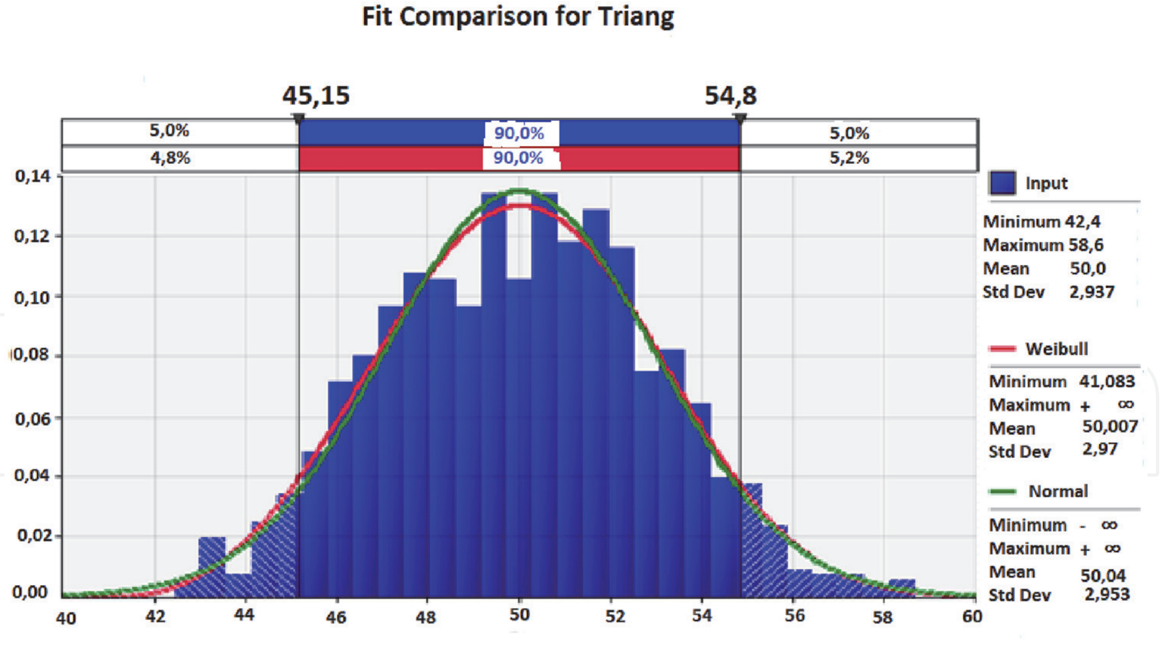

Figure 9.
The distribution of the output parameter of the business process in the distribution of the input data based on Triang.

For non-symmetric distributions of input data, final results, built according to the dependencies of the Eqs. (2)–(5) output a distribution with less asymmetry than the input.

It is interesting to evaluate the distribution of the output parameter of a business process with the participation of a set of input processes that are different in distribution. In **Figure 10** presents the simulation result of the mixture of the input data, distributed over 6 different laws. In this case, normal distribution has a matching mathematical expectation and standard deviation with the result from the simulation values of the distribution of the output parameter. The simulation results show that the model of the business projects can be based on analytical relations

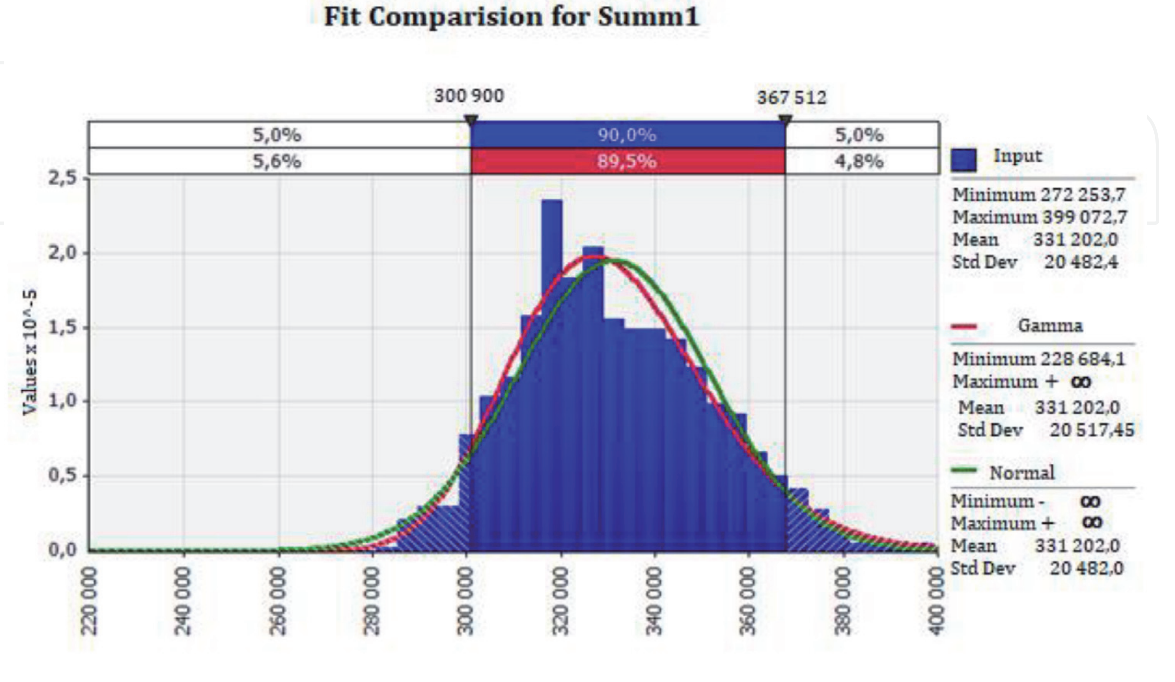

Figure 10.
The distribution of the outputs of the business process while increasing aggregate sales from various distributions of input data.

(3)–(6), with simplified analytical calculations and process simulations. Output parameters business processes in analytic calculations heavily depend on the accuracy of determining the statistical characteristics of the input parameters.

An important step of risk management is to optimize costs to reduce the impact. To reduce the impact of risks, anti-risk measures are used. When performing these measures, the characteristics of the impact of risk factors change. The organization of anti-risk measures is associated with the costs of their implementation. Risk optimization can be reduced to a comparative assessment of the cost of anti-risk measures and changes in the consequences after the occurrence of risk factors caused by the use of anti-risk measures. With a limited budget, it is not advisable to carry out all anti-risk measures, it is enough to limit yourself to those that give the greatest effect.

The feasibility of carrying out certain anti-risk activities based on an integrated assessment of the financial results of the project with different combinations of parameter K (**Table 1**). In E-Project uses a special add-in that enables the adopted criteria and conditions of restrictions to choose the optimal value of parameter K for all the risks involved.

When reducing the impact of risks, first of all, anti-risk measures are planned with the greatest efficiency [10]. **Figure 11** shows the dependence of financial loss from the implementation of the 24 anti-risk measures and the costs of implementation of these activities.

Anti-risk measures can be selected for implementation according to different rules. The limiting factor may be the allocated budget for these activities or the selection of activities whose effectiveness exceeds the established threshold. **Figure 12** shows the result of such optimization, where the financial losses from the initial risks and the same indicator is presented for a project with risk measures.

The proposed method allows to assess the impact of risk factors on the efficiency of the project, to assess the impact on financial performance anti-risk activities and to choose those which provide the greatest effect according to the chosen criterion of project evaluation.

A variant of estimating the influence of random parameters of input variables on the final results of modeling is obtained by using the "E-Project" program implemented in Excel with the ModelRisk add-in and using the simulation method.

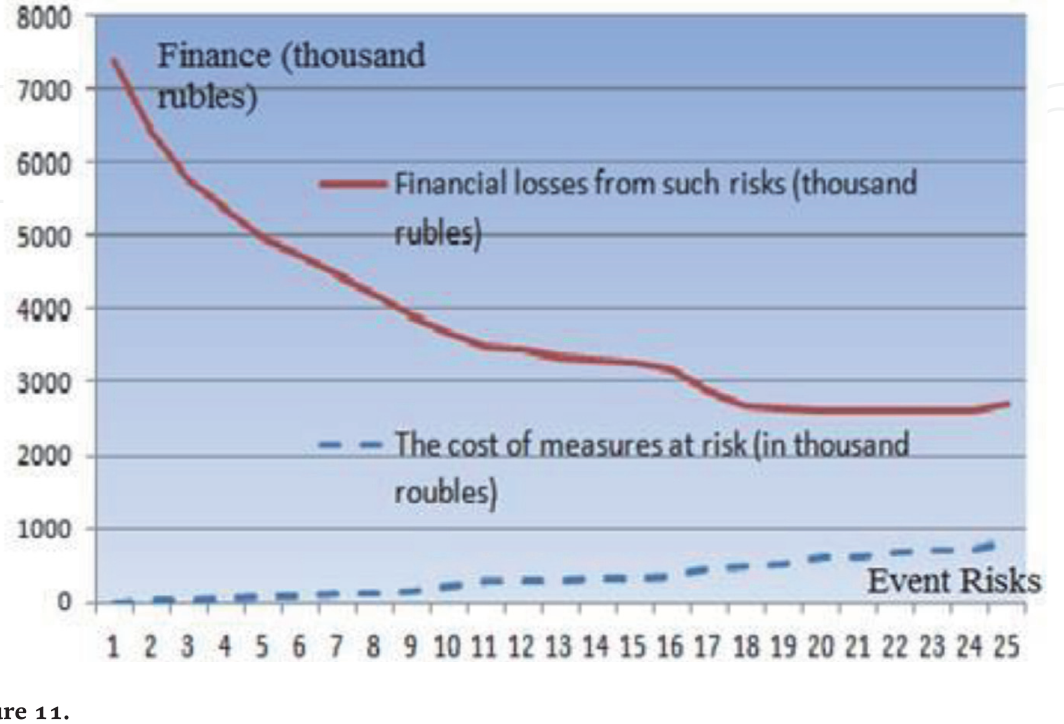

Figure 11.
Losses from risks and the cost of measures from them.

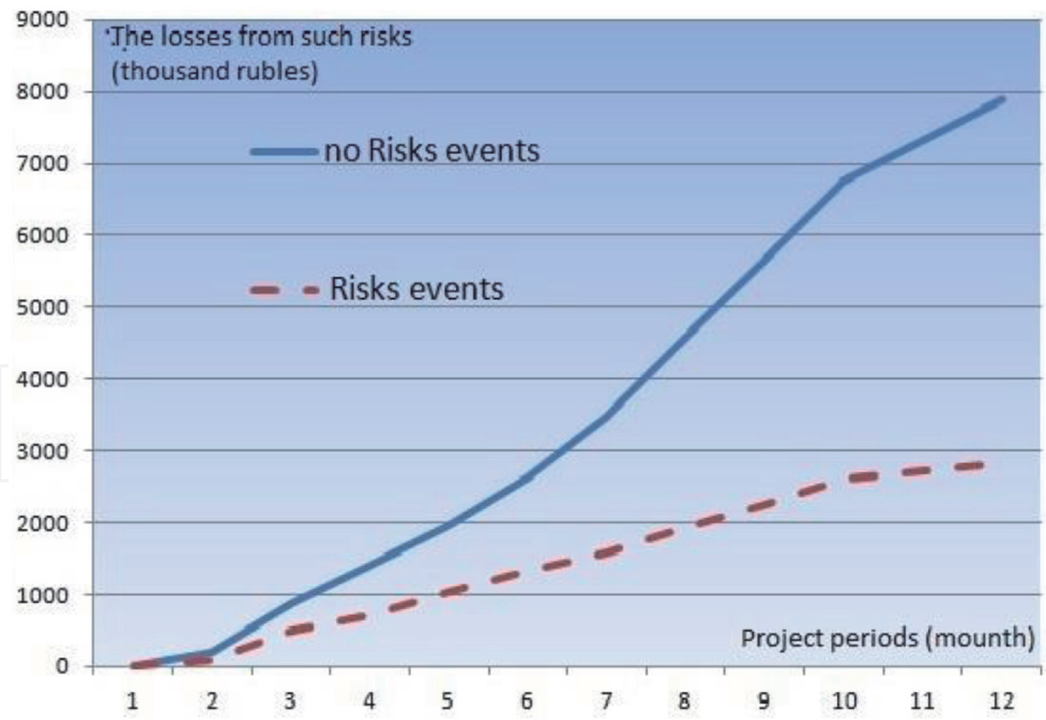

Figure 12.
Losses from risk source and risk after special events.

The "E-Project" program assumes a normal distribution of output data. This assumption is possible in cases where a large number of random variables are involved in the business process and the final result is a complex combination of these input actions.

For the presented graph, the duration of the process can be defined as a random variable that depends on the random parameters of individual operations. The use of the Monte Carlo simulation method when using statistical data for individual operations will allow you to obtain probabilistic estimates of the project duration. The probabilistic model of a business process involves the use of input variables with known distribution laws. For many models, these distribution laws are constructed in an expert way, in some cases they can be constructed on the basis of accumulated statistical material. The most common laws of distribution of random input variables for business processes can be considered as the following:

Normal distribution law, when a variable is formed under the influence of many random factors;

Discrete distribution law, when an input variable can take a certain number of values and the probabilities of these values are determined;

Asymmetric distributions, for which one extreme value is determined by some limiting factors, and the other may differ significantly from the first one by the distance from the value of the mathematical expectation.

For all input variables, an individual distribution can be given that corresponds to the nature of the input variable in question. For each given input variable, the distribution parameters are determined in the form of values of the minimum, maximum, average, mathematical expectation, variance, standard deviation, skewness indicators and quantile probability distribution. For the selected input variables, the skewness index in this example was at least 0.3.

For a particular sequence of operations, a critical path can be defined, which is the sequence of the longest sequence of network graph activities. Activities related to the critical path have the value K = 1. the Mathematical expectation of the time of the project being executed (**Table 2**).

№	The event	Beginning	Duration (T)	The critical path(K)	σ_i	D_i
1	Purchase Of Equipment	5	2	1	0.55	0,30
2	Preparation of the room	3	3	0	0.5	0,25
3	Connection of communications	3	3	1	0.62	0,38
4	Debugging of equipment	7	2	1	0.93	0,86
5	Product testing	9	4	1	1.07	1,14
6	Recruitment	7	5	1	0.93	0,86
7	Development of the technical process	9	4	0	1	1
8	Market analysis	4	5	0	1	1
9	Advertising campaign	2	7	0	2	4

Table 2.
Time characteristics of the project.

$M = \sum Ki * Di = 16$ weeks.

The variance of the project execution time is determined by the equation.

$D_P = \sum Ki * (\sigma_i)^2 = 3.54$ respectively $\sigma_p = 1.88$.

The ModelRisk add-in allows you to obtain the probability distribution of the output value using the Monte Carlo method. In this case, all input variables with a given distribution are assigned random values and the value of the output parameter is determined for these values according to the generated business process model. The procedure is usually repeated significantly more than a thousand times and the distribution of the output function is constructed for the obtained output values. In the example under consideration, the output function will be determined by the sum of time indicators of critical path events (for which K = 1). The program generates the distribution of the output function and displays the main indicators of the resulting distribution. In the example under consideration, for five random numbers with significant asymmetry (each of the input functions had an asymmetry index of at least 0.3), the resulting distribution of the profit received was calculated and it had an asymmetry coefficient of −0.04. This fact confirms that the output distribution formed as a result of the interaction of many random variables with an asymmetric distribution tends to a normal distribution with a low asymmetry index. As the number of operations and random variables increases, the deviation from the normal distribution law will decrease.

For calculating economic indicators, "E-Project" allows you to visualize information about the time of implementation and financial indicators of the project using built-in charts. For this purpose, the parametric system of ellipse equations is used:

$x = a * \cos \alpha$;

$y = b * \sin \alpha$;

where $\alpha \in (0; 2\pi)$,

a. first semi-axis of the ellipse corresponding to the deflection range of the financial parameter from its mathematical expectation,

b. the second axis of the ellipse corresponding to the deflection range of the temporary project setting its mathematical expectation.

As semi-axes in this equation, it is necessary to substitute the root-mean-square deviations of the cash flow and the project implementation time. Financial flows are

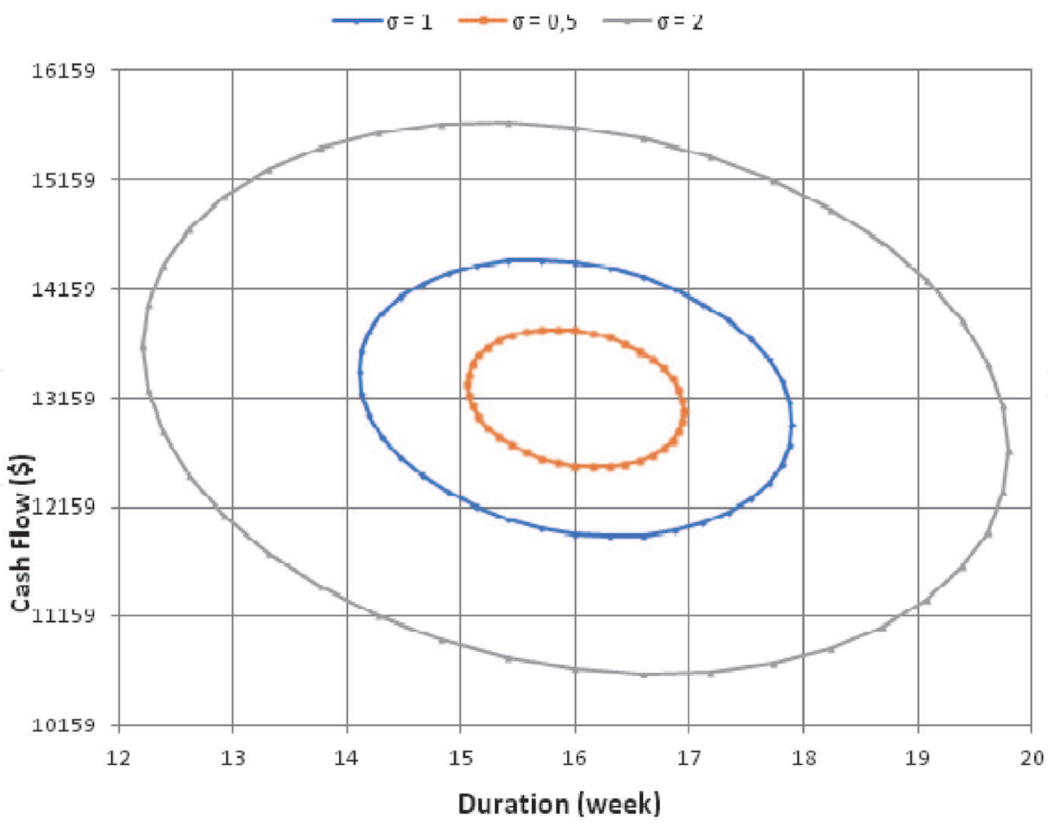

Figure 13.
Distribution of financial and time indicators of the project.

calculated in the "E-Project" based on the initial data. Taking into account that the center of the ellipse is located in the coordinates corresponding to the mathematical expectation of the planned profit (P_1) and the mathematical expectation of the project execution time (t_1), the system of equations will take the form:

$$x = t_1 + \sigma_t * \cos t; \quad y = (P_1 + \sigma_{p1} * \sin t) + C * (t_1 - x);$$

where σ_t - the standard deviation of the project implementation time; σ_{p1}– standard deviation of the cash flow taking into account risks; t_1– the average time of the critical path; P_1– the average value of the cash-flow, taking into account the risks; C– fixed costs per unit of time.

The diagram for the values of variables equal to 0.5, 1 and 2 standard deviations for both parameters (cash flow and time) is shown in **Figure 13**.

This diagram shows the ranges of cash flow and project implementation time within a certain value of the standard deviation of each of the parameters.

The area inside the smaller ellipse corresponds to the probability of achieving such a result at 65%, the average – 76% and the external-94%. The values obtained can serve as a guide for project adjustments if the financial or time characteristics do not meet the requirements of the project being implemented. Such financial and time estimates can be made not only for the end date of the project, but also for any of its internal intervals.

6. Conclusion

Most well-known financial models of projects use deterministic data to describe the internal processes of the planned business. Risks are inherently random processes. The model under consideration works with random numbers and allows you to take into account these random risk factors. The model allows us to assess the impact of anti-risk measures on the project performance indicators and limit ourselves to the most effective set of these measures.

Model the business process based on risk allows you to more accurately plan the development of the business. Before the start of the project has the opportunity to develop activities that improve the final result of the project with minimal cost.

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