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FORMATION OF AN OPTIMAL PORTFOLIO OF VENTURE PROJECTS

Purpose. Development of a method for forming an optimal portfolio of venture projects taking into account risks, uncertainty in initial data and limited financial resources.

Methodology. To calculate the accuracy of forecasting prices, which are necessary for calculating the parameters of the stochastic optimization model for the formation of a portfolio of projects, we used the theory of random variables and regression analysis. The problem of choosing the optimal portfolio of venture projects was solved using stochastic mathematical programming.

Findings. A model for creating an optimal portfolio of venture projects has been developed. It is a stochastic mathematical programming model that can be used to solve problems of investing in venture projects in the extractive industry. This model takes into account the risks associated with obtaining the expected income from the implementation of each venture project, the uncertainty in the initial data for calculating the income from the projects selected in the portfolio, as well as the limited funds required to finance the project portfolio.

Originality. The stochastic optimization model for the formation of an optimal portfolio of projects, taking into account the peculiarities of venture projects, in particular, their high riskiness, has been significantly improved and adapted.

Practical value. The proposed model for the formation of an optimal portfolio of venture projects can be used at mining enterprises, whose development strategy involves the implementation of innovative, high-risk projects. The use of this model in strategic planning will allow an enterprise to receive the maximum income from venture projects in the face of a lack of financial resources, as well as instability of the innovation market.

Keywords: *venture project, project portfolio, optimization, stochastic programming, risks*

Introduction. Today, the success of a business in any area is determined by the introduction of the latest technologies. This also applies to the Ukrainian mining industry. Creation and implementation of innovations occur through the implementation of a venture project.

This type of project is aimed at creating a new product or technology that could provide high or extraordinary profit as a result of the commercial use of this product or technology.

Venture project is not always the main activity of the company, such as it is possible for large enterprises of the mining industry, where such projects are non-core business areas.

Typically, venture capital investors prefer projects related to high technology, especially if they are aimed at industrial products, i.e. b2b market (business-to-business). However, many venture capital investors are interested in investing to the extractive industry, which remains the leading one in Ukraine.

Like any venture project, a project in the mining field is unique and therefore associated with certain risks for the investor. Investments in such projects differ from investments in other business areas in that they are expected to have high profitability and a quick return on investment — within 3—5 years. A venture capital investor has to take risks, so they may not only fail to get profit, but may also lose all or part of their funds invested in the project.

The risks of venture projects are characterized by a high degree of unpredictability, which complicates their calculation. The peculiarity of the risk of a venture project is that it consists of two parts: the risk of the project (as in any project, for example, an investment one) and a "unique" risk that is inherent only in the venture capital sphere.

Thus, the risks of the project involve undesirable events that are specific to a particular industry in which the company operates (the mining industry, in our case). This risk is a kind of "basis" that will be the same for all projects in this industry. The "basic" risk is different because it can be measured by existing similar projects, namely information on the calculation of the average level of return on investment in projects in the industry.

As for the "unique" risk, it is individual for each individual venture project. In addition, these risks differ in that they can relate to several industries at once. As a rule, "unique" risks are higher for a starting venture project. In such a situation, the risks of developing and assessing the market conditions accumulate all the risks inherent in these areas.

The difference between "basic" and "unique" risk is significantly less if the venture project enters the start-up stage. At this stage, as a rule, the first sales of the project product begin. Nevertheless, the overall risk of a venture project even at the start-up stage will be quite high, since due to the novelty of the product, there is a risk of a low percentage of implementation.

The problem of reducing the risks of losing investments and obtaining the maximum possible profit from venture projects can be solved by forming a portfolio of such projects.

Literature review. This work [1] explores a synergistic approach for the selection of a project portfolio. The article highlights the factors that affect the choice of a project portfolio and examines the synergistic relationship between the subsystem of the strategic goals of the organization, the subsystem of a project portfolio and a subsystem of the area, which together constitute a complex system for selecting a project portfolio.

The authors [2] have developed a methodology for forming a portfolio of innovative projects, which makes it possible to highlight the main directions and substantiate the composition for innovative projects when the development trends of a project-oriented organization change.

This article [3] provides guidelines for presenting a portfolio of high-tech projects as a typical model for making decisions about investments in innovation. The process of making such a decision is inextricably linked with the internal environment of the enterprise, in which it arises and proceeds. Thus, all innovative investment projects, potentially considered for inclusion in the portfolio, will not contradict the strategic plans of the company, since they determine the general direction of its activities. This is the relationship between strategic planning and innovation and investment activities of the enterprise.

The authors of this article [4] propose a mechanism for forming a portfolio for innovative projects, which consists of

three steps. At the first step, the profitability of the project is estimated using the real options method.

At the second step, a comprehensive project assessment is carried out using the hierarchy analysis method, having previously determined the significance of the project assessment criteria, including the potential profitability of the project, its duration, as well as quality characteristics that affect the likelihood of such a project. The final step is the selection of projects based on priorities, taking into account funding constraints. Since some of the project evaluation criteria (team qualifications and project relevance) are subjective, this increases the risks associated with the implementation of the selected portfolio.

This article [5] focuses on the fact that the project portfolio is the tool that allows increasing the competitiveness of enterprises through the implementation of complex projects. It should contain projects that are focused on external and internal factors of ensuring competitiveness and form within the framework of the general structure of "goals-results" with their coordination between projects.

The authors of this article [6] propose a methodological approach to assessing the risks of developing and implementing a venture project, containing the main elements of the most common methods of quantitative analysis, which makes it possible to determine the amount of possible losses at each stage of development and implementation of a venture project according to an optimistic, most probable and pessimistic development scenario taking into account the influence of the time factor.

This article analyzes the formation of a portfolio of sustainable development of a metallurgical enterprise using the method of analysis of hierarchies [7]. The authors developed a model of the development portfolio, bringing together in the interaction of three elements: the economy, technologies and the analysis of the external environment.

Each of these elements is characterized by five criteria. The assessment of each of a potential portfolio component is based on the hierarchy analysis method. The sequence of stages of the methodology for selecting projects for the portfolio of sustainable development of a metallurgical enterprise is described. To determine the innovativeness of projects, the authors propose criteria that characterize their suitability for the characteristics of an enterprise.

The article [8] proposes a mechanism for the formation and management of portfolios of scientific projects for higher educational institutions under the risk-oriented approach. A mechanism for forming a portfolio for scientific projects of higher educational institutions has been developed, which allows the management of scientific activities of higher education institutions based on risk management models. The article proposes a method according to which the results of a scientific project are assessed by the indicators of strategic goals. The integrated indicator of project performance is defined as the length of the trajectory traversed by the institution of higher education towards the desired state.

This article [9] is concerned with the problem of using fuzzy sets to form a project portfolio. The authors consider innovative projects that are characterized by high returns and high levels of risk.

This article presents a model for the formation of a strategic portfolio of innovative projects. In this case, the target function of the model is the total value of the project portfolio, which characterizes its profitability. Thus, the portfolio value is formed only by the NPV indicators for each project.

The article [10] presents a mathematical model for the formation of an optimal project portfolio, the goal function of which is the maximum income for the period of the portfolio implementation. The model considers two sources of funding project portfolio: enterprise's credit and own funds. Moreover, it is stipulated that each bank offers the enterprise several credit and debt repayment schemes. Continuous variables are the values of loans and repayable debts. The developed model of forming a project portfolio is dynamic. It can be used to simulate a picture of the costs and benefits of a project portfolio during its implementation. This makes it possible, in particular, to determine the period of time from which the enterprise has sufficient circulating assets to ensure the functioning of the project for the foreseeable future (provided that there are no own funds to finance a project portfolio). With all the advantages of the model presented in [10], the risk of the investment portfolio is taken into account in it indirectly.

Unsolved aspects of the problem. A portfolio of venture projects differs from a portfolio of any other projects in a higher degree of risk; therefore, the problem of forming an optimal portfolio of venture projects is associated not only with limited financial resources, but also taking into account risk. Therefore, the formation of such an optimal portfolio of venture projects, which would take into account the above two said points, is a relevant objective.

Purpose. Purpose of the article is development of a method for forming an optimal portfolio of venture projects in the mining industry.

Methodology. In accordance with the goal of the article, the analysis of publications on the formation of a project portfolio, in particular venture or innovative ones was carried out. The theory of random variables, mathematical statistics, optimization methods, regression analysis and stochastic programming were used in solving the problem.

Results. Suppose the company is offered venture projects (P), from which it is necessary to select those projects that can provide the maximum amount of net income over time periods (T). Such indicators are known as: $s_p(t)$ costs for the pth project ($p = \overline{1, P}$) at time period t ($t = \overline{1, T}$); $d_p(t)$ — income from the pth investment project at time period t.

The company is considering the possibility of financing a portfolio of venture projects, both at the expense of borrowed funds — loans, and at the expense of a share of the enterprises' own profit δ at time period t $G(t)$.

The profit from the project portfolio, according to [10], in the time period τ, τ = 1, ...T is calculated as follows

$$\sum_{p=1}^{P} d_p(\tau)x_p + c(\tau) + \sigma G(\tau) - \sum_{p=1}^{P} s_p(\tau)x_p - E(\tau) - \tag{1}$$
$$-h(\tau-1)c(\tau-1),$$

where Boolean variable $x_p = 1$, if p project is included in the portfolio, $x_p = 0$ if this is not the case; $h(t)$ is the interest rate for the loan ($h(0) = 0$); $E(\tau)$ is duty paid during the time period τ.

It is assumed that loans will be taken at the beginning of the tth year and repaid in the next ($t + 1$) year. At the same time, in the last year of the planning period T, they will not be taken. Interest on loans taken in the tth year will be paid in the $t + 1$ year ($t = 1, ..., T - 1$). The loan repayment process is represented by the following expressions

$$E(1) = 0; \quad E(t) = c(t-1), \quad t = 2, 3, ..., T. \tag{2}$$

Total net income for t time periods $t = 1, ..., T - 1$, is calculated from (1) taking into account expressions (2), by summing expression (1) by τ = 1, ..., T. We have

$$I(t) = \sum_{\tau=1}^{t}\sum_{p=1}^{P} d_p(\tau)x_p + c(t) + \sigma \sum_{\tau=1}^{t} G(\tau) - $$
$$-\sum_{\tau=1}^{t}\sum_{p=1}^{P} s_p(\tau)x_p - \sum_{\tau=1}^{t-1} h(\tau)c(\tau), \quad t = 1, ..., T-1; \tag{3}$$

$$I(T) = \sum_{\tau=1}^{T}\sum_{p=1}^{P} d_p(\tau)x_p - \sum_{\tau=1}^{t}\sum_{p=1}^{P} s_p(\tau)x_p - \sum_{\tau=1}^{t-1} h(\tau)c(\tau), \quad t = T. \tag{4}$$

The (4) provides that in the Tth time period, loans are not taken, and the volume of net income does not contain the amount of self-financing in previous periods of time.

Suppose that all projects in the portfolio will provide a type of product. In order to manufacture this product, b types

of materials and energy are needed, and $a + b = M$. Let us also set $q_j(t)$, $j = 1, ..., a$ – the price of the jth type of product at t^{th} time period (random variable); $n_{pj}(t)$, $j = 1, ..., a$ is the planned volume of sales of products of the jth type for the pth project in the tth year, $n_{pj}(t) \geq 0$; $q_j(t)$, $j = a + 1, ..., M$ – prices of the kth type of materials at the tth time period; $n_{pj}(t)$, $j = a + 1, ..., M$, is the required amount of materials of the jth type at the tth time period for the p project, $n_{pj}(t) \geq 0$; θ is the share of income that is paid in the form of value added tax.

The values $q_j(t)$, $j = 1, ..., M$ represent the forecast of the corresponding product price at the tth time period. The price is random.

In order to determine the first two moments of this value, you can use the methods of univariate or multivariate prediction. In the case of a univariate forecast, the assumption is made that the price depends only on time value.

In the case of using a multivariate forecast, the forecast is calculated under the regression model that links the price with factors influencing it.

The indicator of the company's own profit $G(t)$ is also determined in a predictive way, which is also a random variable.

Sales volumes $n_{pj}(t)$, $j = 1, ..., M$ are determined directly by the project developers, therefore, we will further consider these values as deterministic.

We have

$$d_p(t) = \sum_{j=1}^{a} q_j(t)(1 - \theta)n_{pj}(t), \quad p = 1, ..., P, \quad t = 1, ..., T; \quad (5)$$

$$s_p(t) = \sum_{j=a+1}^{M} q_j(t)n_{pj}(t), \quad p = 1, ..., P, \quad t = 1, ..., T. \quad (6)$$

Due to $q_j(t)$, $j = 1, ..., M$, $k = 1, ..., N$ being random variables, $d_p(t)$ and $s_p(t)$, $p = 1, ..., P$, $t = 1, ..., T$, according to expressions (5, 6) are also random variables. From this it follows that the size of the net income from the implementation of a project portfolio in formulas (3, 4) is a random variable.

In turn, the values of interest rates are also associated with uncertainty, so we will also consider them as random variables. So then $I(t)$, $t = 0, 1, ..., T$ in (3, 4) depend on random variables $d_p(t)$ and $s_p(t)$, $p = 1, ..., P$; $h(t)$, $G(t)$, $t = 1, ..., T - 1$, which means they are also random variables.

It is advisable to require that in each of the time periods throughout the entire planning interval (except for the last period) the portfolio of projects is not unprofitable, i. e. so that the total net income in the tth period was more than 0.

Since net income is a random variable, the above requirement can be realized only in a probabilistic sense. This means that the total net income from the implementation of the entire project portfolio at the tth time period with a high degree of probability should be positive or zero.

Then, from (3), we derive the probabilistic constraints on net income

$$L\left\{\sum_{\tau=1}^{t}\sum_{p=1}^{P}\left[d_p(\tau) - s_p(\tau)\right]x_p + \sum_{\tau=1}^{t}c(\tau) + \sigma\sum_{\tau=1}^{t}G(\tau) - \right.$$
$$\left. - \sum_{\tau=1}^{t-1}h(\tau)c(\tau) \geq 0\right\} \geq \alpha(t), \quad t = 1, ..., T - 1, \quad (7)$$

where $L\{Z\}$ is probability of Z event, probability is $\alpha(t) \geq 0.9$, $t = 1, ..., T - 1$.

The essence of Z event is that the total net income for t time periods is positive or zero. This event should occur with a high probability, namely not less than $\alpha(t)$.

Taking into account (4), we denote the goal function in the form of two expressions

$$F \to \max; \quad (8)$$

$$L\left\{\sum_{\tau=1}^{T}\sum_{p=1}^{P}\left[d_p(\tau) - s_p(\tau)\right]x_p + \sum_{\tau=1}^{T-1}h(\tau)c(\tau) \geq F\right\} = \alpha(T). \quad (9)$$

According to (8 and 9), F threshold should be maximum, which the indicator of net income can exceed with a high degree of probability $\alpha(t)$ in the final period of time T. This establishes the following probability $\alpha(t) \geq 0.9$.

Since the implementation of a venture project involves the use of new technologies, and it is unique, it is to measure the expected revenue from this project was more objective, should take into account the possible risks.

The risk of venture projects combines the risk of lack of necessary resources (especially financial), the risk of low professionalism of the staff, the risk of unplanned expenses, the risk of contract termination, risks associated with marketing, the risk of lack of demand for the project's products, and so on.

In order to take this risk into account, it is necessary to introduce a restriction that will establish an acceptable risk boundary for the entire portfolio of venture projects. Let the total income for the project p

$$D_p = \sum_{t=1}^{T} d_p(t).$$

Then

$$\sum_{p=1}^{P} \frac{r_p D_p}{\sum\limits_{p=1}^{P} D_p x_p} x_p \leq R,$$

where r_p is a level of risk for p project, and the specified risk limit for the entire portfolio $R = 0.25$.

An enterprise that implements a portfolio of venture projects, at the beginning of its implementation, may not have free funds, which are necessary, including for the purchase of equipment. In this case, the following restriction should be introduced

$$I(0) = \sum_{p=1}^{P} u_p x_p \leq c(1) + \sigma G(1), \quad (10)$$

where u_p is the cost of the equipment provided for p project.

Due to the fact that the indicator $G(1)$ is a random variable, the above equality can be fulfilled only in a probabilistic sense. Therefore, the constraint must also be formalized in a probabilistic sense

$$L\left\{\sum_{p=1}^{P} u_p x_p \leq c(1) + \sigma G(1)\right\} \geq \alpha(0), \quad (11)$$

where $\alpha(0) \geq 0.9$.

Let us explain the meaning of this restriction. To implement the project, it is necessary to purchase equipment (technologies) at the beginning of the first period of time. The problem arises due to the fact that during this period there is still no income from the sale of the portfolio, which means that the purchase of equipment will have to be done at the expense of borrowed funds or the enterprise's own funds (internal financing).

Since the income of the enterprise in the first period of time $G(1)$obtained from activities not related to the portfolio will be known only at the end of a given period, then the value $G(1)$ is uncertain or random.

We impose the obvious restrictions on the continuous sought ones

$$c(0) \geq 0.9, \quad t = 1, ..., T, \quad 0 < \sigma \leq 1. \quad (12)$$

The optimization problem represented by formulas (7−12) belongs to stochastic programming problems with probabilistic row-by-row constraints. The desired variables in it are Boolean variables x_p, $p = 1, ..., P$ and continuous variables $c(t)$, $t = 1, ..., T - 1$ and σ.

To solve the problem of stochastic programming (7−12), it is required to make the transition to a deterministic optimization problem, which will be called deterministic equivalent problem (7−12).

Let us assume that

$$w_p(t) = \begin{bmatrix} w_{p1}(t) \\ \vdots \\ w_{pa}(t) \\ w_{p,a+1}(t) \\ \vdots \\ w_{pM}(t) \end{bmatrix}; \quad q(t) = \begin{bmatrix} q_1(t) \\ \vdots \\ q_a(t) \\ q_{a+1}(t) \\ \vdots \\ q_M(t) \end{bmatrix};$$ (13)

$$W_p(t) = \begin{bmatrix} w_p(1) \\ w_p(2) \\ \vdots \\ w_p(t) \end{bmatrix}; \quad Q(t) = \begin{bmatrix} q(1) \\ q(2) \\ \vdots \\ q(t) \end{bmatrix} \in \Re^{Mt}, \quad t = 1, \ldots, T,$$

where $w_{pj}(t) = (1 - \theta)n_{pj}(t), j = 1, \ldots, a; w_{pj}(t) = -n_{pj}(t); j = a + 1, \ldots, M$.

Manipulate these equations (3, 4)

$$I(t) = \sum_{\tau=1}^{t} \sum_{p=1}^{P} \left[d_p(\tau) - s_p(\tau) \right] x_p + \sum_{\tau=1}^{t} c(\tau) + \\ + \sigma \sum_{\tau=1}^{t} G(\tau) - \sum_{\tau=1}^{t-1} h(\tau)c(\tau), \quad t = 1, \ldots, T.$$ (14)

The equation for the first term in (14) has the following form, taking into account the notation (13)

$$\sum_{\tau=1}^{T} \sum_{p=1}^{P} \left[d_p(\tau) - s_p(\tau) \right] x = \sum_{p=1}^{P} f_p(t)x_p, \quad t = 1, \ldots, T,$$

where

$$f_p(t) = W_p'(t)Q(t), \quad t = 1, \ldots, T.$$ (15)

The coefficient vectors $K(t) \in R^{p+t+1}$ and the required variables $V(t) \in R^{p+t+1}$ appearing in (14) are introduced

$$K(0) = \begin{bmatrix} -u_1 \\ -u_2 \\ \vdots \\ -u_P \\ \ldots \\ 1 \\ O_{T-2} \\ \ldots \\ G(1) \end{bmatrix}; \quad K(1) = \begin{bmatrix} -f_1(t) \\ -f_2(t) \\ \vdots \\ -f_P(t) \\ \ldots \\ e_1(1) \\ O_{T-2} \\ \ldots \\ G(1) \end{bmatrix}; \quad K(t) = \begin{bmatrix} f_1(t) \\ f_2(t) \\ \vdots \\ f_P(t) \\ \ldots \\ e_t(1) \\ e_t(2) \\ \vdots \\ e_t(t-1) \\ e_t(t) \\ O_{T-t-1} \\ \ldots \\ \sum_{\tau-1}^{t} G(\tau) \end{bmatrix};$$ (16)

$$t = 2, \ldots, T-1; \quad K(T) = \begin{bmatrix} f_1(t) \\ f_2(t) \\ \vdots \\ f_P(t) \\ \ldots \\ e_T(1) \\ e_T(2) \\ \vdots \\ e_T(T-1) \\ 0 \end{bmatrix};$$

$$V = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_P \\ \ldots \\ c(1) \\ c(2) \\ \vdots \\ c(T-1) \\ \ldots \\ \sigma \end{bmatrix} = \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} \in \Re^{P+T}; \quad V_1 = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_P \end{bmatrix} \in \Re^P;$$

$$V_2 = \begin{bmatrix} c_1(1) \\ c_2(2) \\ \vdots \\ c(T-1) \end{bmatrix} \in \Re^{T-1}; \quad V_3 = \sigma \in \Re^1,$$

where V_1 is a vector of Boolean variables, V_2 components are the size of loans, V_3 is enterprise profit.

In equation (16)

$$e_1(1) = 1;$$

$$e_t(\tau) = \begin{cases} 1, \tau = t \\ -h(\tau), \tau = 1, \ldots t - 1 \end{cases}, \quad t = 2, \ldots, T-1;$$ (17)

$$e_T(\tau) = -h(\tau), \quad \tau = 1, \ldots, T.$$ (18)

O_F is F-dimensional zero vector.

Then formulas (7–11) take the form

$$F \to \max;$$

$$L\{K'(T)V \geq F\} = \alpha(T);$$

$$L\{K'(t)V \geq 0\} \geq \alpha(t), \quad t = 1, \ldots, T-1;$$

$$L\{K'(0)V \geq 0\} \geq \alpha(0).$$

Let us take the distribution of random variables $d_p(t)$, $s_p(t)$, $p = 1, \ldots, P, t = 1, \ldots, T; h(t), G(t), t = 1, \ldots, T-1$ are normal. In this case, it follows from formulas (15–18) that the distribution of vectors $K(t), t = 0, \ldots, T$ also is normal. $K(t) \sim M(\bar{K}(t), Y_K(t))$, where $\bar{K}(t)$ is the expected value of the vector $K(t)$, $Y_K(t)$ is covariance matrix. The result is that scalar values $I(t) = K'(t)V$ are distributed normally, $t = 0, 1, \ldots, T$. After that, we get the deterministic equivalent of problem (7–12)

$$\left. \begin{array}{l} p(1-\alpha(T))\sqrt{V'Y_K(T)V} + \bar{K}'(T)V \to \max \\ p(1-\alpha(T))\sqrt{V'Y_K(T)V} + \bar{K}'(T)V \geq 0, \quad t = 0,1,\ldots,T-1 \end{array} \right\},$$ (19)

where $p(v)$ is quantile of standardized normal distribution, v is probability (value of the distribution function of a standard normal random variable).

For vectors V_1, V_2 and scalar V_3 – components V are subject to the following restrictions:
- components V_1 – Boolean variables;
- components V_2 – non-negative continuous variables;
- scalar V_3 – non-negative continuous value.

Point (19) with the above restrictions relates to a nonlinear optimization problem with mixed variables. It can be solved using the "Solver" function of the MS Excel.

Conclusions. In the course of solving the problem of developing a method for forming an optimal portfolio for venture projects in the mining industry, the following results were obtained:

1. The use of a project portfolio has been substantiated as a reduction in the risks of loss of investment in venture projects.

2. A model for creating an optimal portfolio of venture projects has been developed. It is a stochastic mathematical

programming model that can be used to solve problems of investing in venture projects in the extractive industry.

3. The profit from the implementation of projects included in the portfolio is calculated. At the same time, it was taken into account that prices for raw materials and finished products are random.

4. The risks associated with obtaining the expected income from the implementation of a venture project was taken into account.

5. Uncertainty in the initial data for calculating income from projects included in the portfolio was taken into account.

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Формування оптимального портфеля венчурних проектів

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Мета. Розробка методу формування оптимального портфеля венчурних проектів з урахування ризиків, невизначеності у вихідних даних і обмеженості фінансових ресурсів.

Методика. Для обчислення точності прогнозування цін, що необхідні для розрахунку параметрів оптимізаційної стохастичної моделі формування портфеля проектів, використовувалася теорія випадкових величин і регресійний аналіз. Завдання вибору оптимального портфеля венчурних проектів вирішувалося за допомогою стохастичного математичного програмування.

Результати. Розроблена модель створення оптимального портфеля венчурних проектів. Вона являє собою модель стохастичного математичного програмування, яку можна застосовувати при вирішенні завдань інвестування у венчурні проекти у видобувній галузі. Дана модель враховує ризики, пов'язані з отриманням очікуваного доходу від реалізації кожного венчурного проекту, невизначеність у вихідних даних для розрахунку доходу від проектів, відібраних у портфель, а також обмеженість коштів, що необхідні для фінансування портфеля проектів.

Наукова новизна. Суттєво вдосконалена та адаптована стохастична оптимізаційна модель формування оптимального портфеля проектів з урахуванням особливостей венчурних проектів, зокрема, їх високої ризиковості.

Практична значимість. Запропонована модель формування оптимального портфеля венчурних проектів може бути використана на підприємствах гірничодобувної промисловості, чия стратегія розвитку передбачає реалізацію інноваційних, високо ризикових проектів. Застосування даної моделі при стратегічному плануванні дозволить підприємству отримати максимальний дохід від венчурних проектів в умовах браку фінансових ресурсів, а також нестабільності інноваційного ринку.

Ключові слова: *венчурний проект, портфель проектів, оптимізація, стохастичне програмування, ризики*