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THE IMPROVEMENT OF ECONOMIC EFFICIENCY FORECAST EVALUATION METHODS FOR ORE MINERALS MINING

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УДОСКОНАЛЕННЯ МЕТОДИКИ ПРОГНОЗНОЇ ОЦІНКИ ЕКОНОМІЧНОЇ ЕФЕКТИВНОСТІ РОЗРОБКИ РОДОВИЩ РУДНИХ КОРИСНИХ КОПАЛИН

Purpose. The improvement of methods for evaluating expected economic efficiency of investment in ore minerals mining.

Methodology. The research is based on the use of the following methods: scientific generalization while formulating objectives and general conclusions; systematization, grouping and comparison while assessing advantages and disadvantages of the most common determination models of the investment discount rate; abstraction, analysis and synthesis to disclose methodological approaches to improvement of economic efficiency forecast evaluation of ore minerals mining investment.

Findings. It is defined that the forecast of the effectiveness of ore minerals mining should be based on identifying and evaluating investment return discounted indicators. However, it is necessary to consider the features of the mining enterprises' investment process. Improved methods of investment return discounted indicators calculation in mining industry are suggested.

Originality. Improvement of the methods for economic efficiency forecast is as follows: 1) the cash flows arising from the development of mineral resources must be adjusted by the amount of cash flows related to the extraction of associated minerals; 2) inclusion of the amount of depreciation to incoming cash flows is advisable after the appearance of cash receipts from selling the main and related products of mining companies; 3) it is necessary to determine the amount of the mining investment risk premium using the special integral indicator.

Practical value. The proposed methodical approach will determine further appropriateness of ore minerals mining with the introduction of innovative technologies. It will provide reduction of the costs and increase in volumes of manufacturing mining products.

Keywords: *mining enterprise, efficiency of investment, investment projects discount rate*

Introduction. Permanent growth of energy prices and significant dependence of Ukrainian mining industry on the changing conditions of world raw material markets requires continuous search for the ways of reducing the costs and increasing production with continuance of domestic mining enterprises' activities.

However, the prescription of ore mining, the gradual deterioration of geological conditions of this kind of business and low efficiency of real investment complicate the solution of these problems very much. Therefore, the introduction of innovative technologies is required for reducing the costs and increasing the production of mining products. Thus, in terms of permanent influence of natural factors on the final results of the innovative investment, forecast evaluation of their efficiency is a priority in investment mining.

Analysis of the recent research and publications. In financial literature there are a lot of foreign and domestic scientists' works devoted to the economic efficiency evaluation methods of investment. The common problems of forecasting methods for the economic efficiency evaluation of investments are studied in well-known foreign and Ukrainian scientists' works. These are the works of such scholars as G. Birman, I. Blank, V. Bocharov A. Bystriakov, P. Vilenskyi, L. Hitman, V. Gryniova, M. Jonk, A. Zahorodnii, T. Maiorova, I. Majo, A. Mertens, A. Peresada, K. Reilly, R. Holt, D. Chervaniov, V. Sheremet, W. Sharpe, E. Shylov, S. Shmitt and others.

Among the scientists studying the substantiation of expediency of mining investment and its risks, it is worth paying attention to the works of I. Hryhoriev, Y. Izmailov, J. Mosakovskyi, T. Rohova, S. Shaklein. However, in financial literature much less attention is devoted to evaluating economic efficiency of investment in mining industry.

Unsolved aspects of the problem. Considering the fact that the main activity of studied companies is ore mining, the research of methodological approaches to the evaluation of investment economic efficiency should

be focused on the rationale for further development of ore mineral deposits using various innovative technologies.

In our opinion, methodical approaches to determining the expected return of investment in ore minerals mining should include calculation of well-known indicators of its economic efficiency. At the same time, we should pay attention to the fact, that in the mining industry, an investment period is usually quite long. And mineral deposit preparation works are proactive by their nature. Therefore, the assessment of expediency of further mineral deposit development should be based on the definition and analysis of discounted indicators of economic efficiency of investment.

Considering the significant specifics of mining companies, we believe that methodical approaches to economic efficiency forecast evaluation of further ore mineral mining require some clarification and improvement.

Objectives of the article. The main purpose of the article is improvement of expected efficiency methods for investment in ore minerals mining.

Presentation of the main research. The improvement of the methods of discounted indicators calculation of mining investment is highly important both for its economic efficiency evaluation and researched companies' investment attractiveness. It is connected with great amounts of financial resources for implementing investment projects. As a result, mining companies usually need to attract the external financing. Therefore, in many cases the rationale for ore minerals mining investment increases the opportunities to receive additional financial resources.

So, the expected efficiency of ore minerals mining should be based on calculation of the following indicators:

- Net Present Value (NPV);
- Discounted Payback Period (DPP);
- Internal Rate of Return (IRR);
- Profitability Index (PI).

Although, in economic literature great attention is paid to the research of the methods for calculating these indicators, inclusion of amortization in incoming cash flows from the investment project is controversial. So, domestic scientists T. Ben, A. Khotomlianskyi, P. Znakhurenko, V. Shemaiev and O. Romodan believe that amortization does not characterize the return of investment costs. In their opinion, only a newly created value (profit or net income) is investment profitability.

Contrary to this viewpoint, a number of famous domestic and Russian economists such as V. Vitlinskyi, V. Makarenko, Y. Mossakovskyi, M. Aiupova, T. Chernata, I. Sinenko and others consider the amortization as part of incoming cash flows from investment.

The amortization as a part of expenses returns to the company in the form of working capital, resulting from the sales. Therefore, in our view, it is reasonable to increase cash inflows by the amount of amortization of fixed assets acquired (created) from investment activities only after cash receipts from sales of ore and related products.

So, net present value or discounted net income (NPV) is defined as the difference between cash inflows from the development of ore mineral deposits, increased by amortization of fixed assets and total cash outflows from such activities. These cash outflows consist of capital and current (operational) costs. Keeping the economic content of well-known way of determining this indicator, and taking into consideration the specifics of mining industry, we offer to calculate it as follows

$$NPV = \sum_{t=0}^{T} \frac{CF^{+}_{bp_t} + CF^{+}_{rp_t} + A_t - (B_t + K_t)}{(1+e_d)^t},$$

where NPV is Net Present Value; t is current period of mining cash flows evaluation, year; T is the period of investment project's life cycle, year; $CF^{+}_{bp_t}$ stands for cash inflows from the selling the main products in "t" period, UAH; $CF^{+}_{rp_t}$ stands for cash inflows from selling the related products in "t" period, UAH; B_t is cash outflows from operational costs from investment project in "t" period, UAH; K_t is cash outflows from capital costs in "t" period, UAH; A_t is amount of amortization in "t" period, UAH; e_d is cash flows discount rate from ore mineral mining, relative shares.

Accordingly, we offer to determine the amount of cash outflows from current (operational) costs as follows

$$B_t = \sum_{t=1}^{T} (C_{bp_t} \times Q_{bp_t} + C_{rp_t} \times Q_{rp_t}) + T_t,$$

where B_t is cash outflows from current (operational) costs from investment project in *"t"* period, UAH; C_{bp_t} is cost per unit of basic products in *"t"* period, UAH; C_{rp_t} is cost per unit of related products in *"t"* period, UAH; Q_{bp_t} is production of basic products in *"t"* period, ton; Q_{rp_t} is production of related products in *"t"* period, ton; T_t is amount of paid taxes and obligatory payments from revenue in *"t"* period, UAH.

The difference of the proposed method of determining the net present value from the common practice of calculating of this indicator is:

- firstly, the structure of cash inflows is specified, considering the specifics of the mining industry. So, the author proposed to include incoming cash flow from the selling associated extracted minerals (sand, clay, gravel, etc.) to the general cash inflows;

- secondly, cash outflows of operational costs should include outgoing cash flows associated with the production of related minerals.

The determination of the discount rate of cash flows from investment in the ore minerals mining requires some refining. It is mainly connected with the peculiarities of mining investment.

Agreeing with O. Tereshchenko's opinion, we offer to define a discount rate as a coefficient used to determine the present value of future cash flows, and it indicates the minimum remuneration for investment risk [1].

In practice of investment analysis, there are various methods of determining the discount rate. The most common ones are:

1. The Capital Asset Pricing Model (CAPM).
2. The Method of Weighted Average Cost of Capital (WACC).

3. The Cumulative Construction Method (CMM).

The technology of calculating the investment discount rate by this method is generally known. However, it is necessary to pay our attention to the main advantages and disadvantages of the most common methods for determining the discount rate.

So, the Capital Asset Pricing Model (CAPM) was first developed by William Sharpe and John Lintner in 1965. According to this model, the discount rate consists of the return rate from risk-free investments and additional rate, offsetting the uncertain investing risk [2].

Summarizing the main results of the investigations of practical value of this method, we turn our attention to the main disadvantages:

- ignoring a company's unsystematic risk;
- no consideration of industry specifics and a company's peculiarities.

Over time, the method of determining the discount rate for the CAPM model was improved by taking into account a company's unsystematic risk. However, according to this method a company's unsystematic risk should be determined by an expert. So, its practical value has not increased essentially.

Fama's J. and French's K. research studies have allowed eliminating the main Capital Asset Pricing Model's drawback, by taking into account a company's size and industry factors influencing the level of project income. So, again improved Capital Asset Pricing Model was as follows [3]

$$r_i = \gamma + \beta \times (r_m - r_f) + s_i \times smb_t + h_i \times hml_t,$$

where r_i is discount rate for the CAMP model; r_f is return rate from risk-free investments; r_m is average market rate of return; β is beta coefficient of company's systematic risk; s_i, h_i are coefficients affecting the i-asset's profitability; γ stands for expected asset returns without influence of all risks on it; smb_t is difference between the returns rate of weighted average stock portfolios of small and large capitalization; hml_t is difference between the returns rate of weighted average stock portfolios with large and small ratio of a book value to a market one.

Subsequently, J. Fama's and K. French's three-factor CAPM was improved by M. Karhartom in 1999. It took into account the rate of share price change for some period. And it was named as a "moment" [4]. Thus, a modified Capital Asset Pricing Model was as follows

$$r_i = \gamma + \beta \times (r_m - r_f) + s_i \times smb_t + h_i \times hml_t + wml_t,$$

where wml_t is the moment, the rate of share price change over the previous period.

It should be emphasized that the use of CAPM for determining the discount rate of the project is appropriate for companies whose shares are traded in developed stock market. Its use in the Ukrainian realities is related to high complexity of model components definition. Besides, a common drawback of all CAPM modifications is an opportunity to use a single source of investment financing – a company's own funds. Considering the above, the possibility of its use for evaluation of the investment efficiency in Ukrainian enterprises is significantly limited.

The second most common method of the discount rate determination is the method of Weighted Average Cost of Capital (WACC). It is known that the economic content of WACC application is the calculation of the minimum return level of project profitability [5].

Systematizing scientific research studies, we consider that the main advantages of this method are:

- the possibility of applying it for various sources of investment financing;
- no difficulties in getting baseline data to calculate the discount rate.

However, WACC method for calculating the discount investment rate has some drawbacks. The main ones are:

- the possibility of its using only for existing businesses;
- the necessity of considering the term of project's "life" in the discount rate calculating [2];
- WACC is the average value of the whole enterprise. So, use of WACC as a discount rate for investment projects is not quite correct, because they are different by their nature and have diverse risks;
- using WACC as a discount rate implies that the internal rate of return of any investment project, carried out by an enterprise, must be higher than its weighted average cost of capital. However, when considered that WACC is the average indicator for the whole company, first of all it comes about a company's investment portfolio. At the same time, it is characterized by some inside deviations [5].

Cumulative method for the discount rate determination provides an assessment of factors accumulating the risk of not receiving planned revenues. As the CAPM method, it is calculated using the risk-free rate of return. However, unlike the CAPM, using the cumulative method of the discount rate determination is possible in the undeveloped stock market. The economic essence of using the cumulative method is based on the assumption that an investor's demands for the project profitability directly depend on the level of its risk.

We believe that in order to determine the discount rate of ore minerals mining investment efficiency it is advisable to use the cumulative construction method, because it allows taking into account the factors leading to the risk of non-receiving planned revenues from mining investments

$$e_d = e_f + \sum_{i}^{I} R_i,$$

where e_d is discount rate, %; e_f is return rate from risk-free investments, %; R_i is compensation for the risk, %.

Considering the fact that the risks are characterized by different degrees of impact on the final results of the investment process, we offer to determine the value of the risk premium using the integral mining activity risk indicator

$$R_{out} = \sum_{i=1}^{M} (w_i \times x_i),$$

where R_{out} is the integral mining activity risk indicator, %; w_i is proportion of "i" risk; x_i is index characterizing the risk level; M is quantity of risks influencing the final results of the investment.

Thus, the discount rate of cash flows, generated by investments in the mining, will be determined by the following algorithm

$$e_d = e_f + R_{out}.$$

The author offers to determine risk-free rate of return on the basis of the average yield of risk-free alternative capital investments – currency bank deposits for legal entities in Oshchad Bank of Ukraine (3.85 % as of March 2017) [6].

Analysis of domestic and foreign scientists' research studies on the risk assessment of mineral resources use allows determining the main types of mining risks associated with it:

- risks of changes in mineral resources volumes (geological risks);
- risk of price increases for raw materials used in the mining industry;
- price variability of the mining products;
- possible increase in operating costs;
- inexactness of rock positioning;
- probable increase in capital costs;
- change in tax regime;
- inaccuracy of geological characteristics of mineral resources;
- way of mineral deposits mining;
- stage of mineral deposits mining;
- variability of ore reserves.

Results of foreign and domestic specialists' expert assessment will be initial data for the determination of the integral indicator of mining activity risk (Table).

Thus, the coefficient rate of discounted cash flows from the introduction of innovative technologies in the mineral deposits mining will be 11.93 %.

So, we can say that the author's suggestions regarding the methodology of net present value determining are as follows:

1. During the ore minerals mining, both the main types of products and related minerals (sand, clay, gravel, etc.) are usually extracted. Therefore, cash inflows from ore minerals mining should include both incoming cash inflows from basic and related products produced.

2. It is necessary to consider both the cost of the main and related products produced while determining operating expenses.

3. Cash flows discount rate should be determined as the sum of the risk-free rate for alternative investments and the integral indicator of mining risk.

4. It is necessary to include incoming cash flows from depreciation after cash inflows from selling basic and related products of mining.

It should be noted that definition of other discounted indicators of expected investment efficiency will be based on the same principles as the method for calculating the net present value.

Table

The calculation of the integral indicator of mining activity risk

Type of risk	Degree of risk (x_i)	Risk share (w_i)	The integral indicator of risk mining ($x_i \times w_i$)
Risks of changes in mineral resource volumes (geological risks)	10	28.26	282.57
Risk of price increases	10	28.26	282.57
Price variability of the mining products	10	9.41	94.09
Operating cost increase	6	9.41	56.46
Inaccuracy of rock positioning	4	6.73	26.90
Capital cost increase	5	6.27	31.36
Change in tax regime	2	4.49	8.99
Inaccuracy of geological characteristics	3	3.14	9.41
Methods for mineral deposits mining	1	1.78	1.78
Stage of mineral deposits mining	7	1.36	9.49
Variability of ore reserves	5	0.90	4.52
Total	-	100.00	8.08

Discounted payback period (DPP) of investment shows a period of time, from the start of financing ore mineral mining, all discounted capital cash flows will be covered by an annual average of net discounted cash flows generated by the project. So, mathematical definition of DPP implies solving the equation

$$DPP = \frac{\sum_{t=0}^{T} K_t \times (1+e_d)^{-t}}{\sum_{t=0}^{T} \frac{(\mathrm{C}F_{bp_t}^{+} + CF_{rp_t}^{+} + A_t - B_t) \times (1+e_d)^{-t}}{T}},$$

where DPP is discounted payback period of investments in ore minerals mining, periods; B_t is cash outflows of operational costs in "t" period, UAH; $CF_{bp_t}^{+}$ is cash inflows from selling basic products in "t" period of mineral deposits mining, UAH; $CF_{rp_t}^{+}$ is cash inflows from selling related products in "t" period of mineral deposits mining, UAH; K_t is cash outflows of capital costs in "t" period, UAH; t – current period of mining cash flow

assessment, year; T is the period of investment project life cycle, year; A_t is amount of amortization in "t" period, UAH; e_d is mining cash flow discount rate, shares.

The next important discounted indicator of investment efficiency in ore minerals mining is an internal rate of return (IRR). It shows such level of positive discount rate when the net present value will be zero. Thus, according to the logic of the methodology of determining the net present value, offered by the author, a mathematical definition of the internal rate of return is defined by equation

$$\sum_{t=0}^{T} \frac{CF^{+}_{bp_t} + CF^{+}_{rp_t} + A_t - K_t - B_t}{(1+IRR)^t} = 0,$$

where IRR is internal rate of return, shares.

Profitability index (PI) shows by how many times the discounted net cash flows, generated by the investment (NPV), is bigger than the present value of cash inflows from the investment project

$$PI = \frac{NPV}{\sum_{t=0}^{T} \frac{K_t}{(1+e_d)^t}} \times 100,$$

where PI is profitability index, %.

It is important to notice that these methods for investment expected efficiency are actual both for assessment of ore deposits, which are being worked out, and determination of the economic efficiency of new mineral deposits mining. However, the gradual deepening of mine works is observed at all enterprises of Ukrainian mining industry without exception. So, it requires a rationale of expediency for further exploitation. In addition, mine works for minerals extraction are carried out only for a part of projected career (mine) capacity with an orientation on mining for 10–12 years. Therefore, in our opinion, it is reasonable to limit a calculated period of mining innovative investment efficiency by time interval of 10–12 years as well.

Conclusions and recommendations for further research. The financing of mineral resources mining requires significant investments. The rationale of investment expediency of this direction of mining companies' activities can significantly increase their investment attractiveness and create conditions for attracting external financing sources. Therefore, the improvement of the methods of investment economic efficiency of mine works should take into consideration the specifics of mining companies. Those are: 1) while determining the amount of cash flows from the investment project, cash in- and outflows connected with the production of basic and related products should be taken into account; 2) the discount rate of positive cash flows should be defined as the sum of the risk-free rate of return on alternative investments and the integral indicator of mining activity risks; 3) it is reasonable to include the amount of amortization in incoming cash flows after starting sales of mining products.

Thus, the use of advanced methods for expected efficiency evaluation of investment, offered by the author, will allow determining the expedience of further ore mining with introduction of various innovative technologies. At the same time, it will reduce the costs and increase the production volumes.

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Мета. Удосконалення методики оцінки очікуваної ефективності інвестицій у розробку родовищ рудних корисних копалин.

Методика. Проведене дослідження ґрунтується на використанні методів: наукового узагальнення – при постановці завдань і формулюванні загальних висновків; систематизації, групування й порівняння – при оцінці переваг і недоліків найпоширеніших моделей визначення ставки дисконтування інвестицій; абстракції, аналізу й синтезу – для розкриття методичних підходів до прогнозної оцінки економічної ефективності капіталовкладень у розробку родовищ рудних корисних копалин.

Результати. Встановлено, що прогнозна оцінка ефективності капіталовкладень у розробку родовищ корисних копалин повинна ґрунтуватись на визначенні та оцінці дисконтованих показників дохідності інвестицій. Разом з тим, необхідно враховувати особливості інвестиційного процесу гірничорудних підприємств. Запропонована вдосконалена методика розрахунку дисконтованих показників економічної ефективності інвестицій гірничодобувних підприємств.

Наукова новизна. Удосконалення методики очікуваної ефективності інвестицій полягають у наступному: 1) грошові потоки, що виникають у результаті розробки родовищ корисних копалин, необхідно коригувати на величину грошових потоків,

пов'язаних із реалізацією видобутих супутніх корисних копалин; 2) включати величину амортизаційних відрахувань до складу вхідних грошових потоків доцільно після появи грошових надходжень від реалізації основної й супутньої продукції добувних підприємств; 3) величину премії за ризик інвестицій у розробку корисних копалин необхідно визначати на основі інтегрального показника ризику, зумовленого специфікою добувного виробництва.

Практична значимість. Запропонований методичний підхід дозволить визначити подальшу доцільність розробки родовищ корисних копалин при запровадженні інноваційних технологій, що забезпечують зниження собівартості й нарощення обсягів виробництва гірничорудної продукції.

Ключові слова: *гірничодобувні підприємства, ефективність інвестицій, ставка дисконтування інвестиційних проектів*

Цель. Усовершенствование методики оценки ожидаемой эффективности инвестиций в разработку месторождений рудных полезных ископаемых.

Методика. Проведенное исследование основывается на использовании методов: научного обобщения – при постановке задач и формулировании общих выводов; систематизации, группирования и сравнения – при оценке преимуществ и недостатков распространенных моделей определения ставки дисконтирования инвестиций; абстракции, анализа и синтеза – для раскрытия методических подходов к прогнозной оценке экономической эффективности капиталовложений в разработку месторождений рудных полезных ископаемых.

Результаты. Сделано заключение о том, что прогнозная оценка эффективности капиталовложений в разработку месторождений полезных ископаемых должна основываться на определении и оценке дисконтированных показателей доходности инвестиций. Вместе с тем, необходимо учитывать особенности инвестиционного процесса горнорудных предприятий. Предложена усовершенствованная методика расчета дисконтированных показателей экономической эффективности инвестиций горнодобывающих предприятий.

Научная новизна. Усовершенствование методики ожидаемой эффективности инвестиций заключаются в следующем: 1) денежные потоки, возникающие в результате разработки месторождений полезных ископаемых, необходимо корректировать на величину денежных потоков, связанных с реализацией добытых сопутствующих полезных ископаемых; 2) включать величину амортизационных отчислений в состав входящих денежных потоков целесообразно после появления денежных поступлений от реализации основной и сопутствующей продукции добывающих предприятий; 3) величину премии за риск инвестиций в разработку полезных ископаемых необходимо определять на основе интегрального показателя риска, обусловленного спецификой добывающего производства.

Практическая значимость. Предложенный методический подход позволит определить дальнейшую целесообразность разработки месторождений полезных ископаемых при внедрении инновационных технологий, обеспечивающих снижение себестоимости и увеличение объемов производства горнорудной продукции.

Ключевые слова: *горнодобывающие предприятия, эффективность инвестиций, ставка дисконтирования инвестиционных проектов*

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