Information technology: effects of application in the mining industry

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Abstract. The influence of information technology application in the main business processes on direct and indirect effects received by mining enterprises is considered. The purpose of the study was to develop a scientific and technical approach to assess the economic effects of information technology application in the mining industry, based on parametric and scenario modeling of discounted cash flows. The results were the development of a scientific and technical approach and an algorithm for its step-by-step implementation to assess the economic effects of information technology application for a particular enterprise in the mining industry.

1 Introduction

The mining industry at the present stage is experiencing important problems of both ore extraction and production, which are as follows [1, 2]:

- reduction of reserves available for high and medium profitable mining at developed ore deposits;
- significant complication of mining and geological conditions of reserves development and growth of production costs due to the transition of mining operations to greater depths;
- significant increase in production costs due to a significant deterioration in the quality of processed ore mass;
- still insufficient level of informatization, automation and digitalization of business processes in the mining industry, despite the intensive and widespread use of information technologies.

World experience shows that the introduction of information technology into the main business processes of mining production contributes to the overall solution of mining industry problems. The application of information technology, or the level of informatization of a mining enterprise, can be different, from the initial simple to complex complex: information support of processes and operations, automation of processes and operations, robotization of machinery and equipment, widespread use of digital technologies, transformation of mining business process due to digitalization (Figure 1) [3, 4].

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The works [3, 5] show that the application of information technology allows mining enterprises not only to achieve a new level of production management, but also to benefit in the form of economic effects. For example, at JSC "Apatit" digital solutions allowed to optimize mining operations, improve the quality and reliability of surface surveying, reduce operating costs; at JSC "Kovdorsky GOK" - to build 3D geological-structural and hydrogeological models of the deposit, to apply modern radar systems to control the stability of the sides of the open pit and, thus, to improve the safety of work; at JSC "Kola MMC", GOK "Oleniy Ruchey" - to increase the efficiency and detail of the information received and, thus, to reduce uncertainty and risk. There are other examples of wide application of digital technologies at mining enterprises, which allowed to automate operations, equipment and used mining mechanisms, and reduce operating costs [3, 6].

To date, there is no universal methodology for quantitative assessment of economic effects [3, 7-9], but some works provide examples of saving tens and hundreds of millions of rubles by reducing operating costs, increasing productivity and safety.

Researchers of the Russian Federation, the Republics of Belarus and Kazakhstan [8-10] propose approaches to assessing both the level of informatization of the enterprise as a whole, and the resulting quantitative and qualitative effects of information technology. In particular, the assessment can be carried out with the use of both simplified (summation of expert indicators of digitalization of the main technological processes, taking into account their weighting coefficients) and strict (ratio of the sum of expert indicators of digitalization of the main technological processes with their weighting coefficients and the sum of the coefficients themselves, if the logical conditions and requirements for the levels of computerization, informatization and digitalization of processes are met) approaches. It should be noted the obvious subjectivism due to the involvement of experts, firstly, with different degrees of qualification, and secondly, the very procedure of determining for the technological process of the ball evaluation and weight coefficient.

Another approach to assessing the economic effects of information technology application is based on the NPV method [11]. It considers the possibility of cash flows formed both as a result of technological processes and from material stocks and resources. In this approach it seems unlikely to determine with the necessary accuracy and use in specific calculations the quantitative values of a number of considered indicators and factors (e.g., improving the accuracy of work planning, environmental safety, the degree of customer focus, etc.).

It is also necessary to note the works on the subject under consideration [12-15], primarily in terms of assessing the level of informatization (as innovation) of an enterprise or project.

![Diagram: Degree of application of information technology in business processes of mining production.](image)

**Fig. 1.** Degree of application of information technology in business processes of mining production.
Generalization of these works allowed us to identify 6 main applied models: Berkeley, OPM3, Harald-Kerzner model, CMM® SE model and its development for the assessment of software directly, as well as the methodology of the European Foundation for Quality Management. These methods consider, as a rule, 4-6 levels (from initial to complex maximum), with different tools (evaluation methods) offered and, accordingly, somewhat different final results obtained.

On the basis of the performed analysis it is revealed that economic effects of complex application of information technology in business processes of mining enterprises are expressed both in quantitative indicators (profit, cost reduction, productivity increase) and in indirect ones (safety improvement, scientific and technical, social effects).

The purpose of this work was to substantiate the scientific and technical approach to assessing the economic effects of information technology application in the mining industry, based on parametric and scenario modeling of discounted cash flows.

2 Methods

Methods and approaches based on information and logical analysis of published research were used in the work to identify both direct and indirect economic effects. Parametric modeling based on multivariate computer calculations was used to assess the formation of discounted cash flows. The method of scenario formation (basic and with the use of information technology at three levels) was used and scenario modeling was performed. Comparative analysis of the resulting discounted cash flows for the basic scenario and scenarios with the application of information technologies was used to analyze the results obtained.

To assess the economic effects of information technology application in business processes of mining production, reflecting additional profits, cost reduction, increased labor productivity, increased safety, a scientific and methodological approach based on parametric and scenario modeling of discounted cash flows is proposed.

In the proposed approach, the economic effect for a certain design year is determined from the ratio of revenues and costs for different modeled scenarios:

- Basic (without information technologies);
- Initial - investments in information technologies increase capital costs, but economic effects are not obvious;
- Medium - investments in information technologies increase capital costs, but some economic effects are achieved;
- High - investments in information technology increase capital expenditures, and subsequent investments in maintenance and service of information technology allows to obtain accumulating economic effects.

For these scenarios, calculations of discounted cash income are performed and, using comparative analysis of the generated cash flows, the presence (or absence) of economic effects is established and their quantitative values are estimated.

3 Results

A scientific and technical approach to assessing the economic effects of information technology application in the mining industry based on parametric and scenario modeling of discounted cash flows is proposed. For practical realization of the approach an algorithm has been developed, which can be performed in 7 resultant steps.
1. For the main business processes, a technical and economic assessment is performed and a base scenario is determined in terms of capital and operating (current) costs, on the one hand, and profitability indicators, on the other.

2. 3-4 scenarios with the application of information technologies are formed, taking into account: informatization (information support), automation, robotization, digitalization (introduction of MGIS) and transformation of business processes due to digitalization.

3. For the adopted scenarios, using multivariate calculations and parametric modeling, discounted cash flows are calculated, reflecting in detail the ratio "income-costs".

4. Modeling in different ratios of the base scenario and scenarios with the use of information technology (scenario modeling).

5. By synchronization of the generated cash flows the main indicators of economic effects of information technology application are estimated: additional profit, reduction of current costs, increase in productivity, increase in safety and others.

6. The conditions for the presence of positive indicators of direct and indirect economic effects are checked.

7. The application of information technology is evaluated as effective in the simultaneous fulfillment of the conditions of obtaining positive values of direct and indirect economic effects.

On the basis of the proposed scientific and technical approach, multivariant parametric modeling of the formation of discounted cash flows for typical scenarios: Basic and with the use of information technology of different levels: Initial, Medium and High.

The proposed scientific and technical approach was implemented for one of the promising ore mineral deposits in the Kola region. The results of calculations of discounted cash flows using multivariant parametric modeling are shown in Figure 2, the graphs of which allow us to synchronize the scenarios with different levels of information technology application and the Basic (without IT) scenario.

Based on the analysis of Figure 2, the most characteristic dependencies have been identified, which to a certain extent reflect the level of informatization through the ratio of income, increase in capital expenditures and cost reduction. The calculated dependencies, for a certain design year, show from the ratio of income and costs for different modeled scenarios: Basic (without IT) and scenario with Initial IT level - IT investments increase capital costs, but economic effects are not obvious; Basic (without IT) and scenario with Medium level of IT - IT investments increase capital costs, but some economic effects are achieved; Basic (without IT) and scenario with High IT level - IT investments increase capital costs, but subsequent investments in IT development, maintenance and service allow to get accumulating economic effects.

It should be noted that in Figure 2 the results are presented for the initial period of field development (calculation horizon of 20 years) in conventional values (in rubles of conventional dimension). Specific initial data for this object for calculations will be accepted by the investor, and in this case parametric and scenario modeling will allow to perform quantitative assessment of both the formation of discounted cash flows and economic effects of IT application.
4 Discussion

The results of parametric and scenario modeling obtained on the basis of the proposed scientific and technical approach allow us to identify the most typical cases of IT application in mining production.

Synchronization of discounted cash flows for the adopted scenarios (Figure 2) showed that single (one-time) investments in information technology, leading to an increase in the total amount of capital expenditures, can both give economic effects and not provide them. In the latter case, the graph of discounted cash flow will be lower in comparison with the Basic one, and the positive balance of economic effects is not formed.

If investments in information technology, despite the increase in capital expenditures, will lead to a comparable reduction in costs, then after a certain time a positive balance of economic effects will be formed. In the third case, when investments in information technologies increase capital expenditures, but at the same time, taking into account subsequent investments in development, maintenance and service, costs are reduced, the application of information technologies makes it possible to obtain accumulating economic effects.

The implementation of the approach for a specific ore deposit in the Kola region provides quantitative confirmation of the revealed regularities. A higher level of information technologies, expressed through increased investment in the implementation and development of digital solutions, allows reducing the payback period of capital expenditures from 10 to 8 years and generating tangible positive economic effects by the 20th year of mining.

5 Conclusion

The paper developed a methodological support for assessing the economic effects of information technology application in the mining industry, which consists in developing a scientific and technical approach. For the main business processes the technical and economic evaluation is performed and the basic scenario of mining production is determined. Then three scenarios with Initial, Medium and High level of IT are formed, taking into account...
account: informatization, automation, robotization, digitalization and transformation of business processes due to digitalization. Using multivariate calculations and parametric modeling, discounted cash flows reflecting the "income-cost" ratio are calculated. Scenario modeling is performed in different ratios of the base scenario and scenarios with different levels of information technology application. Economic effects of information solutions application are determined. The application of information technology is evaluated as effective if the conditions for obtaining positive values of direct and indirect economic effects are met. The proposed scientific and technical approach is tested on the example of one of the promising ore mineral deposits in the Kola region.

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References