The 56th International October Conference on Mining and Metallurgy
22-25 October 2025, Bor Lake, Bor, Serbia
www.ioc.tfbor.bg.ac.rs

DOI: 10.5937/IOC25065J

Original scientific paper

SENSITIVITY ANALYSIS OF A COPPER ORE EXPLOITATION INVESTMENT PROJECT USING COMFAR III SOFTWARE

Marija Jonović[1a], Dejan Bugarin[1b], Tanja Stanković[1c]

[1] Mining and Metallurgy Institute Bor, Alberta Ajnštajna 1, 19210 Bor, Serbia
[1a] marija.jonovic@irmbor.co.rs, 0009-0000-8418-2523
[1b] dejan.bugarin@irmbor.co.rs, 0000-0002-9103-4614
[1c] tanja.stankovic@irmbor.co.rs, 0000-0002-2714-7016

Abstract

Investing comes with inherent risks, especially in complex economic environments. Using the COMFAR III software package enables detailed analysis of economic parameters, including investment risk assessment and sensitivity analysis, which are used in investments to better understand the impact of changes in key variables on the outcome of an investment project. This study presents the application of the COMFAR III software package on a specific example of a mining project for the exploitation of copper ore from the Bor river mine (B. R.) deposit above the XIX horizon. Identification of the variables with the greatest impact on the final results was performed using the COMFAR III software package. The internal rate of return (IRR) is 48.75%. The sensitivity analysis findings indicate that the project is most sensitive to changes in revenue, where each successive change in revenue by ±6% alters the IRR by ±10.94 – 14.8%. The project also shows significant sensitivity to changes in expenses, with each successive change in expenses by ± 6% altering the IRR by ±7.56 – 10.14%. The least sensitivity of the project is to changes in investments, where each continuous change in investments by ± 6% changes the IRR by only ± 2.88 – 6.93%. Sensitivity analysis using the COMFAR III software package clearly shows that the priority is effective management of revenues and expenses to ensure stable and positive project profitability, which is crucial for making investment decisions.

***Keywords*:** *COMFAR III Expert, Internal rate of return, Investment risk, Sensitivity analysis.*

1. INTRODUCTION

In today's climate of high-risk capital investments, particularly within the mining sector, the increasing demands for precise economic modeling necessitate the application of advanced analytical tools. Feasibility studies, as fundamental instruments for investment decision-making, must encompass technical, market, and financial dimensions, with particular attention given to risk assessment. In this context, sensitivity analysis plays a central role, as it enables the identification of variables with the greatest impact on profitability indicators, such as the Internal Rate of Return (IRR) and the Payback Period (PP). This paper presents the application of sensitivity analysis within a feasibility study aimed at rapidly defining the optimal production capacity in both mining and ore processing operations. The evaluation incorporates selected technologies, capital investments, projected costs, and revenues that ensure an adequate return, i.e., investment efficiency. Sensitivity analysis helps project teams anticipate future variability, set clear operational alerts and performance thresholds, embed risk management into decision-making, and launch forward-looking strategies. These strategies include expanding exploration of existing deposits (brownfield sites), applying cost-reduction initiatives, and improving efficiency across mining and processing operations [1].

The economic assessment and sensitivity analysis of key parameters were conducted using the COMFAR III Expert business Planner for Windows, **(***Computer Model for Feasibility Analysis and Reporting, Version III Expert, United Nations Industrial Development Organization,Vienna, 2003. available at* https://www.unido.org/comfar***)*** which facilitates comprehensive modeling of

the project's financial performance. The accuracy of feasibility studies, particularly those focused on investment and cost estimation, is typically within a margin of ±10% [2]. COMFAR III, developed by the United Nations Industrial Development Organization (UNIDO), enables modeling of financial and economic projects, feasibility analysis, and report generation. Sensitivity analysis is a powerful technique used in investment contexts to assess how changes in key variables may affect project outcomes. It serves as a vital tool for making informed and resilient investment decisions. By evaluating the potential impact of critical project parameters on economic indicators, sensitivity analysis helps identify the most significant risk factors. This approach facilitates modeling of boundary, optimistic, and pessimistic scenarios, defining the variability range for selected variables such as revenues, expenses, and investments. The aim of this research is to assess the influence of key financial variables on the Internal Rate of Return (IRR). Through sensitivity analysis, investors gain deeper insight into the potential risks and rewards of an investment and can formulate strategies to mitigate those risks. The subject of the study is to demonstrate that sensitivity analysis, supported by COMFAR III software, combined with adequate economic expertise, is essential for identifying risks and assessing the influence of variable factors on the profitability of mining projects. The COMFAR III Expert software, also developed by UNIDO, enables users to simulate financial and economic performance of investment projects, including feasibility analysis and comprehensive reporting. It supports the evaluation of variability in key factors and their impact on indicators such as Net Present Value (NPV), IRR, and Payback Period (PP), thereby facilitating more informed investment decisions. [3]. Especially in the context of financial risks, it is necessary to develop sensitivity and uncertainty analyses in order to first model the variables to which the outcome (NPV, IRR, or PP) is most sensitive, with a precise indication of the extent to which financial results will change in accordance with variations in those variables, assuming all other conditions remain constant [4].

2. EXPERIMENTAL

This research presents a sensitivity analysis of a copper ore exploitation investment project, conducted using COMFAR III software. Having in mind data protection the authors will not mention the name of a mining project for the exploitation of copper ore from the from the Bor river mine (B. R.) deposit above the XIX horizon.

General parameters of the mining project:

Project lifespan: 4.5 years; Production period: 4 years; Investment period: 6 months; Currency of calculation: $ USD; Discount rate: 10%; Mineral resource usage fee: 5% of net revenue (included in ore processing cost;

Ore Tonnage: 3,253,130 t (Ore Tonnage by Year: Year 1: 808,130 t; Year 2: 815,000 t; Year 3: 815,000 t; Year 4: 815,000 t;)

Copper cathode: 16,453.28 t.

The accepted price of copper cathode for revenue calculation is: $8,799 per ton.

Production Value (USD by year: Year 1: $ 35,963,803; Year 2: $ 36,269,535; Year 3: $ 36,269,535; Year 4: $ 36,269,535;) Total: $ 144,772,408

Total investment in fixed assets amounts to $ 23,697,254, and in initial working capital $ 4,000,000, totaling $ 27,697,254.

Cost Structure Overview:

Overlapping Operational Activities (Preparation of facilities, Ore excavation, Transport, export, and primary crushing of ore, Ventilation, drainage, and servicing) and Normative Costs for all 4 years: $ 29,683,187.

Depreciation costs are calculated at a rate of 2.5% of building value and 10% of equipment value; Maintenance costs are calculated at a rate of 3% of total fixed assets value; Insurance costs are calculated at a rate of 0.5% of total fixed assets value.

It is assumed that the investor will finance the project entirely from own funds. Therefore, the economic analysis does not include loan financing, and no financing costs are incurred.
According to available data, the mine currently employs 533 workers. The estimated average gross monthly salary is $ 1,500, resulting in an average net monthly salary of approximately $ 900.
Ore processing in flotation is calculated at $ 4.94 per ton of dry ore; Metallurgical processing is calculated at $ 644.35 per ton of copper cathode (as provided by the investor), with no additional cost for gold and silver refining; General and administrative costs are calculated at $ 3.5 per ton of copper cathode; Contingency costs are calculated at 3.5% of annual normative costs; Mineral resource usage fee is calculated at the legally prescribed rate of 5% of net revenue (total revenue minus metallurgical costs); Corporate income tax is calculated at the statutory rate of 15% of gross profit.
Based on the given parameters, economic and financial projections were carried out using the COMFAR III software. The resulting Internal Rate of Return (IRR) is 48.75%. Having in mind data protection, the authors will not mention the name of a mining project for the exploitation of copper ore from the B. R. deposit above the XIX horizon. The sensitivity analysis of a project will be presented with illustrations in Chapter 3.

3. RESULTS AND DISCUSSION

Table 1. Project Sensitivity to Changes in Revenues, Expenditures, and Investments

Change (%)	Revenues (%)	Investments (%)	Expenditures (%)
-30	-7.52	76.39	96.90
-24	3.42	69.46	86.76
-18	13.83	63.37	76.86
-12	24.85	57.96	67.21
-6	36.49	53.12	57.84
0	48.75	48.75	48.75
6	61.59	44.77	39.95
12	75.00	41.12	31.46
18	88.92	37.77	23.28
24	103.31	34.67	15.40
30	118.11	31.79	7.84

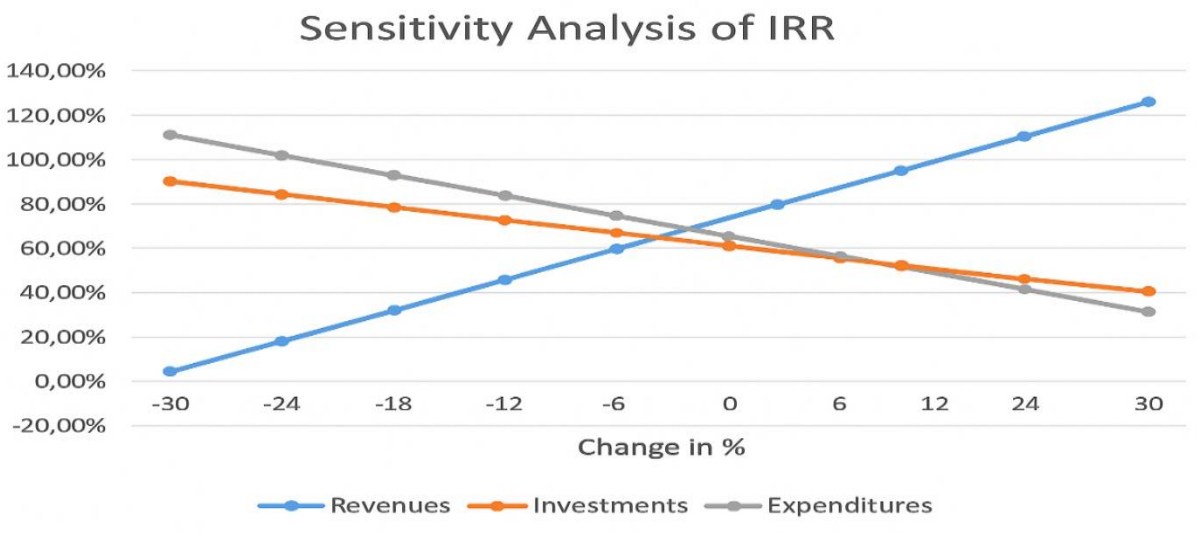

Figure 1. Movement of Economic Cash Flow and Its Cumulative Trend

Sensitivity Assessment by Risk Category:

Highest Risk: Revenues The project is most sensitive to changes in revenues. With each successive ±6% change in revenues, the Internal Rate of Return (IRR) shifts by approximately ±10.94–14.8 percentage points (pp). This indicates that even small fluctuations in revenues can significantly impact the project's profitability. Revenues represent the highest risk factor, as future income streams are difficult to forecast with a high degree of accuracy.

Lowest Risk: Investments The project demonstrates the least sensitivity to changes in investment levels. Each ±6% change in investment results in only a ±2.88–6.93 pp shift in IRR. This means that variations in capital expenditures have a relatively minor influence on overall project profitability, making this factor the least risky.

Moderate Risk: Expenditures The project shows a relatively high sensitivity to changes in operating expenditures. Every ±6% change in costs alters the IRR by ±7.56–10.14 pp. Although expenditures have a notable impact, their influence is smaller compared to that of revenues. While expenditures are generally more controllable than revenues, they still represent a significant source of risk.

4. CONCLUSION

The project carries the highest risk in the revenue segment due to the high sensitivity of the internal rate of return to changes in revenues. Investors should pay special attention to strategies for increasing and stabilizing revenues in order to mitigate risks. The project is least sensitive to changes in investments, while changes in expenditures represent a medium level of risk. Given this information, managing revenues and expenditures should be a priority to ensure stable and positive project profitability. Sensitivity analysis supported by COMFAR III software, along with a proper interpretation of economic indicators, is essential for a reliable assessment of the profitability of mining projects. This contributes to a more transparent and professional investment decision-making process, in accordance with international standards and best practices in capital investment evaluation.

ACKNOWLEDGEMENTS

This work was financially supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, Contract on realization and financing of the scientific research work of the Mining and Metallurgy Institute Bor in 2025, contract number: 451-03-136/2025-03/ 200052.

REFERENCES

[1] L. de la Torre Palacios, J.A. Espi, Bol. Geol. Min., 130 (1) (2019).
[2] M. Bugarin, G. Slavković, Z. Stevanović, Geološko-ekonomska ocena rudnih ležišta., ISBN978-86-7827-039-0; Bor, (2012) p.16.
[3] COMFAR III Expert: Computer Model for Feasibility Analysis and Reporting, Version III Expert, United Nations Industrial Development organization.Vienna, (2003). p.371. Available at https://www.unido.org/comfar).
[4] L. Suárez Nieto, G. Fidalgo Valverde, A. Krzemień, P. Riesgo Fernández, F. J. Iglesias Rodríguez, Resour. Policy, (2024) 105427.