SYSTEM DYNAMICS SIMULATION AND GENETIC ALGORITHMS FOR UNCERTAINTY BASED STRATEGIC MINE PLANNING

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ABSTRACT

Complex nature and the circular relationship among the major mine planning parameters make the long term mine planning a very challenging job in a large open pit mine. Moreover, geological parameter like total reserve of the mine, economic parameters like ore or metal price, capital and operating costs are stochastic in nature and these must be included in long term mine planning to determine the project value of a mine. In earlier research works, the stochastic nature of mine planning parameters was ignored and a traditional deterministic model was followed to calculate the project value of a mine.

In this study, a system dynamics model is developed to study the dynamic nature of mine planning parameters. Circular relationship among the major mine planning parameters have been represented with the help of causal diagram in system dynamics model. Single objective and multi-objective optimization models are developed to determine the mine planning parameters simultaneously. Further, stochastic mine planning parameters are simulated in system dynamics model and incorporated in the model to determine the stochastic conventional NPV of the mine. Next, a real option model is developed by introducing operational flexibilities according to the mineral price and production cost of the mine.

The proposed methodology has been applied to an Indian iron ore mine for project value evaluation. Exploratory bore hole data were collected from the mine and all the stochastic mine planning parameters were simulated. Initially, both single objective optimization and multi-objective optimization model were run and compared to the conventional mine planning optimization method. Using simulated values of stochastic mine planning parameters, both stochastic conventional NPV and NPV in ROV approach were determined.

The obtained results indicate that simultaneous single objective and multi-objective optimization model provides higher NPV when compared to the conventional deterministic NPV method. ROV method of mining project evaluation is more suitable to determine the actual project value of the mine as it provides 10% higher project value than the stochastic conventional NPV method.

Keywords: Strategic mine planning, Discounted Cash Flow, Net Present Value, System dynamics model, Stochastic conventional NPV, Real Option Valuation, Option value, Multi-objective optimization