Vol. 13, No. 36, Fall 2023, Pages 79-90

Journal of Analytical and Numerical Methods in Mining Engineering

Journal home page: http://anm.yazd.ac.ir/

Research article

Strategic decision to storage option in gold mines, using the Real option theory

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(Received: *June 2022* , Accepted: *February 2023*)

DOI: *10.22034/ANM.2023.18528.1556*

Keywords

Real options
American call option
Final product storage
Option pricing
Binomial tree
Mean reverting process

English Extended Abstract

Summary

Mining has been always one of the riskiest and most uncertain activities. Although this uncertainty in conventional economic models (traditional method of net present value or NPV) is considered costly due to the risk of forecasting error, the theory of real options, by considering the value of managerial flexibilities in dealing with these uncertainties, has a positive value. Contrary to the theory of real options, traditional methods of financial evaluations, ignore the value of managerial options and the flexibility of the project. One of the management options in mines, which has been studied in this research and a scientific strategy has been presented for its use, is the authority to store the final product of the mine for a specific period. In this study, assuming that the final product price of the mine follows the Mean Reversion Process (MRP), the type of storage option of the final product of the mine is determined as well as its parameters such as the option time to maturity, option Strick price and the cost of acquisition, and then the option value is evaluated using the binomial lattice network. Finally, using optimization methods, the best market price for gold storage and the expected limits for storage profitability have been determined. The results of this study show that at present, for a mine with sufficient working capital for 6 months of production and a storage cost of $ 5 per ounce, storing the final gold product at a market price of less than 1371 $2022/Oz has a positive (profitable) expected value. Also, the highest value of storage decision was obtained at the world price of 670 $2022/Oz and with the value of 130$2022 per ounce. The relative efficiency of storage is estimated to be up to 21%. It is worth mentioning that to use this article in different mines, its results must be updated by changing the assumptions and new market conditions.

Introduction

In this paper, using the concept of real options theory, the decision-making value regarding the storage of the final product of gold mines is determined. In this research, using the Real Options theory, the expected value of the decision about the storage of mining gold product, according to the storage time, the volatility of the gold price in the world market, the current price of gold (at the beginning time of storing), Risk-free interest rate and storage costs are calculated. Then, the most appropriate time to store the gold product of a mine, in other words, the most appropriate market price for this purpose is calculated.

In this paper, by analyzing the historical gold prices, the values of various parameters influencing the decision to store such as price volatility are calculated and then using the theory of real options, the value of stockpiling option is calculated by the binomial option pricing model. The whole hypotheses of this research are as:

1- The only uncertain parameter of the analysis is the price of gold in the world market.
2- The base currency of this study is the US dollar.

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3- The US dollar value in each time also the discount rate is calculated using the Producer Price Index (PPI).
4- Sale of the mine products to the market is instantaneous and pre-sale contracts is not considered.
5- Changes in the price of gold in the market follow the Mean Reversion random Process (MRP).
6- In order to store gold, it is only necessary to pay the warehousing fee (Storage Cost).
7- At the time of storage, all the operational activities of the mine, including extraction and processing activities, are underway like previously.

Real powers are derived from conventional financial options in the stock market and defined by the same view but for physical assets. In recent years, the application of the Real Option Valuation theory (ROV) in mining has expanded greatly. In 1998, for example, Kelly used the binomial tree method, one of the methods of real option valuation, to economically evaluate a gold mine. He exercised his right to expand the mine when the price of gold was higher than a specific limit [2]. In 2001, Slade evaluated the economic value of Canadian mines using real options theory, by considering the temporary closure and reopening options with the effects of price, cost and reserves uncertainties. They considered two random processes for commodity price, and find that: the value obtained by the Geometric Brownian Motion (GBM) was higher than the value of Mean Reversion Process (MRP) [3]. In 2002, Moel et al. Economically evaluated 285 mines in North America using the real-option method, taking into account the temporary closure and reopening options [4]. In 2007, Dimitrakopoulos et al. Evaluated mine design with consideration of price, foreign exchange rates and geological uncertainties, using the abandonment option with the Monte Carlo simulation valuation method. As a result, they have found that the value of ROV-based design leads to a project value of 11-18% higher than the value of NPV-based design [5]. Li Shu-xing and Knights Peter (2009) used the ROV theory to maximize profit and minimize the fuel consumption of mining trucks in short-term production planning [6]. Akbari et al. In 2009, considering the expansion option and using the binomial tree pricing method, the ultimate limits of an open pit under the price uncertainty [7]. Thompson in 2014, obtained a mine cut-off grade, by considering the option of temporary closure and reopening of the mine, taking into account the price uncertainty [8].

Although various new options have been considered in mining projects in recent years [9] - [13], the option of storing the final product for future sale has not been discussed yet. Due to the sharp fluctuations in the prices of some mining products, especially gold in the world market, the possibility of storing the final product is a valuable option for the mine managers. In this paper, the strategy for using the storing option, the best time for storing, the duration of storage and the expected value of this option are discussed. [9].

Methodology and Approaches

The key methodology points and steps are as below:

1- Obtaining the historical price of mine commodity for the last 10 years (Gold prices in this case).
2- inflation adjustment of currency values using the Producer Price Index (PPI).
3- Obtaining the Mean Reversion Process (MRP) parameters of commodity prices adjusted for inflation using one of the proposed methods in [21-23] references.
4- Considering the storing option as an American call option with the maturity time equal to the duration of the working capital cycle, strike price equal to the storage warehousing cost and capture cost equal to the current commodity price.
5- Option pricing of storing using the modified MRP binomial tree lattice.
6- Finding the proper prices for storing and the best storing price that maximize the decision's expected value.

Results and Conclusions

According to this analysis with the parameters of Table 1, the decision to storing gold for 6 months at prices below 1371 $2022/Oz is profitable and at 670 $2022/Oz has the highest expected value and the cost effectiveness of this decision obtained at around 590 $2022/Oz with the value of 21% based on Figure 1. Of

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course, it is necessary to rerun the analysis in other times according to the fluctuations of the world price of gold and real duration of working capital cycle.
High fluctuations in the base currency (US $ in this study) will reduce the accuracy of the analysis. Since the value of the US dollar fluctuated sharply during the years 2020-2022 according to the producer price index, considering this period can reduce the analysis accuracy. In this study, similar calculations for the price of gold between 2009 and 2019 were repeated, according to that, 6-month storage at prices below 1257 $2019/Oz was economical, while the highest decision value for storage was obtained at 922 $2019/Oz gold price.

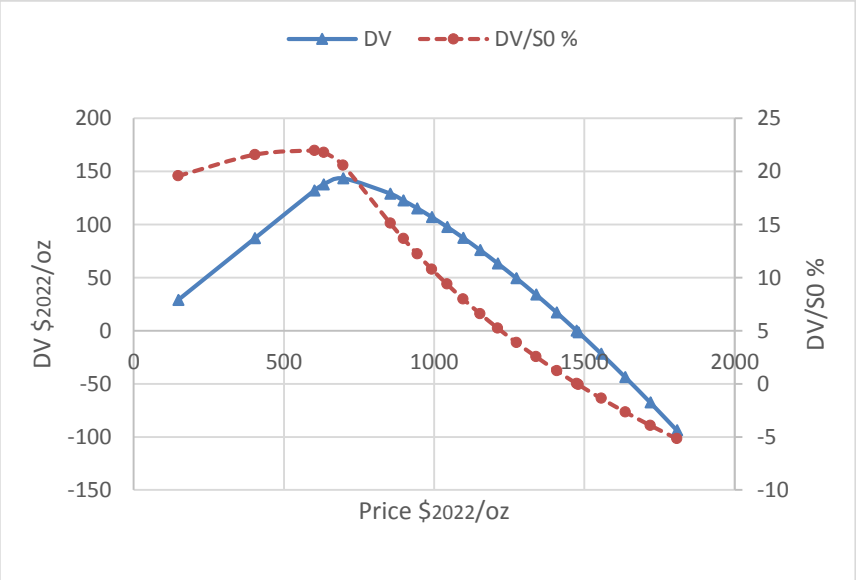

Fig. 1 . Storage decision values and relative effectiveness at different market prices ($2022/Oz)

Table 1. Parameters used in the analysis

Parameter	Symbol	Value
Process Mean	μ	7.5
Mean reversion speed	λ	0.05
Volatility	σ	0.0442
Risk Free Rate	r	0.018
Strike Price	K	5$/oz
Time to Maturity	T	6 months

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