Resources Policy 37 (2012) 109–117

Contents lists available at SciVerse ScienceDirect

Resources Policy

journal homepage: www.elsevier.com/locate/resourpol

Determination of the effect of operating cost uncertainty on mining project evaluation

Hesam Dehghani [1], Majid Ataee-pour *

Faculty of Mining and Metallurgical Engineering, Amirkabir University of Technology, Tehran, Iran

ARTICLE INFO

Article history:
Received 21 October 2011
Received in revised form
28 November 2011
Accepted 29 November 2011
Available online 4 January 2012

JEL classification::
Q39

Keywords:
Economic uncertainty
Metal price
Operating costs
Net present value
Binomial tree technique

ABSTRACT

Mining projects are complex businesses that demand constant risk assessment. This is because several kinds of uncertainties influence the value of a mine project, typically. These uncertainties may be classified as exploration uncertainties, economic uncertainties and engineering uncertainties. The evaluation of a mine project under these uncertainties is a complicated job, which may lead to making a wrong decision by managers and stockholders. Therefore, at first, the engineers must recognize the mining uncertainties before carrying out the project evaluation. The economic uncertainties are the most important factors, which may affect the project evaluation. Among the mentioned uncertainties, the operating cost uncertainty is an important and effective factor, which is ignored to a certain extent.

This research uses the binomial tree technique to compute the net present value of the Cayeli copper mine under three scenarios: (1) assuming certainty for both price and operating costs, (2) assuming uncertainty for metal price and certainty for operating costs and (3) assuming uncertainty for both price and operating costs. It is concluded that the mine evaluation suggests greater net present value when uncertainty is considered for both price and operating costs.

Introduction

Mining projects are complex businesses that demand a constant assessment of risk. This is because the value of a mine project is influenced by many underlying economic and physical uncertainties, such as metal prices, ore grades, costs, schedules and environmental issues. Therefore, evaluating and estimating a mine project without mentioning the risk for future losses (or opportunities) will lead to invalid results. Consequently, managers and stockholders of a mine company make an indiscreet decision based on invalid information.

The main sources of uncertainty arising at the beginning of a mine project can be categorized into three groups: exploration uncertainties, engineering uncertainties and economic uncertainties. Exploration uncertainties will occur in the duration of resource evaluation stages such as geologic uncertainty, data collection, interpretation, modeling, deposit classification, reporting and so forth. Many researchers such as Dowd (1997), Dimitrakopoulos et al., (2002), Dimitrakopoulos et al. (2007); Godoy and Dimitrakopoulos (2004), Leite and Dimitrakopoulos (2007), Rendu (2007) and Dimitrakopoulos et al., (2009) studied these types of uncertainties.

Engineering uncertainties include bench heights determination, planned grade control, minimum stoping widths, choice of stoping method, dilution factors, geotechnical and hydrological parameters, mining recovery factors and metallurgical recovery. This type of uncertainty will affect the ultimate pit (stope) limit and scheduling period.

Economic uncertainty is another important source of uncertainty, which has a critical impact on mine project evaluation. From the economic point of view, future metal prices and operating costs are the most important factors of uncertainty. The metal price is the real cash-settlement that represents the equilibrium or non-equilibrium of the metal market. Since this market is based on demand, supply and other factors such as speculation, news events and dividend payouts (Fanning and Parekh, 2004; Case and Fair, 1989; Taylor et al., 2000), uncertainty on future metal prices arises because of two main factors (MacAvoy, 1988):

- The lack of exact knowledge of those factors leading to the increase/decrease in metal supply and demand.
- The practices that producers or consumers perform in the face of powerful speculative and political motives.

In the mining industry, metal prices are normally modeled as the average price for the last three years, especially for those

* Corresponding author. Tel.: +989122523159.
E-mail addresses: hesam.dehghan@aut.ac.ir (H. Dehghani), map60@aut.ac.ir (M. Ataee-pour).
[1] Tel.: +989122523159.

0301-4207/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.resourpol.2011.11.001

commodities whose price is listed on open markets, such as precious and base metals (Rendu, 2006). Even though the use of a single commodity price makes the comparison between companies easy, it prevents the use of excessively optimistic prices. It may be misleading when evaluating mining projects. For example, an overestimated metal price may result in a favorable rate of return for a project, which is otherwise doubtful. Conversely, an underestimated metal price may result in an unfavorable return for the project, which is otherwise profitable.

Cost is another source of uncertainty when evaluating a mine project. The economic evaluation component of the feasibility study is based on the information that provides an answer to the question, 'what is it going to cost?' (Gentry and O'Neil, 1984). Since the estimation of capital and operating costs is an important requirement for open pit mine evaluation, uncertainty in costs arises due to the lack of engineering or economic information at the beginning of the mine project. Simply put, current mining companies do not know with absolute certainty how much they will be able to spend tomorrow, let alone next month or next year (Camus, 2002).

Numerous research works have been carried out for price uncertainty (Brennan and Schwartz (1985); Trigeorgis (1993); Moyen et al. (1996); Kelly (1998); Moel and Tufano (2002); Monkhouse and Yeates (2005); Abdel Sabour and Poulin (2006); Samis et al. (2006); Shafiee et al. (2009)). But there is no noticeable research on operating cost uncertainty. Indeed, the operating costs are determined as a certain parameter in the previous research works, mostly. While, some parameters such as market variations, government policy changes, novel technology, management adjustments and so forth may change the operating cost, unpredictably. Thereupon, for determining the real and correct project value, it is necessary to consider the operating costs uncertainty.

In this paper, for determining the effect of operating cost uncertainty on the project value, the project net present value was computed and compared under three scenarios: (1) assuming certainty for both price and operating costs, (2) assuming uncertainty for metal price and certainty for operating costs and (3) assuming uncertainty for both price and operating costs. The binomial tree method was used for studying the operating cost and price uncertainties.

Binomial tree

The binomial model is a well-known alternative discrete time, which is developed by Cox et al. (1979). The method of binomial pricing tree is a flexible, powerful and quite a superb method. A binomial pricing tree is a structure that maps all possible trajectories of metal price (or operating cost) through time as are allowed by the model. This structure consists of nodes and branches. Each node in a given layer corresponds to a potential metal price (or operating cost) at a particular point in time. Nodes are identified with traversal probabilities, as well as with metal prices (or operating costs). Nodes and the data items with which they are associated are easily indexed as elements in matrices. A convenient indexing scheme has the layer or time step represented by j (a number between 1 and n, the number of layers or time steps) and the nodes within each layer (the potential metal prices or operating costs) by i (a number between 1 and m, the number of nodes in the layer). Depending on whether or not the tree is recombining, the node count m for any given layer may range from j to twice the number of nodes in the previous layer. Each branch or path in a binomial pricing tree represents a possible transition from one node to another node later in the tree and has a probability and a ratio associated with it. Branches to higher nodes reflect up probabilities (p_r) and multipliers (u), while branches to lower nodes implement the down probabilities ($1-p_r$) and multipliers (d). A schematic binomial tree on the metal price at time zero (P_0) with three steps are shown in Fig. 1. The up (u) and down (d) factors and the probability of occurrence were determined using the following formula:

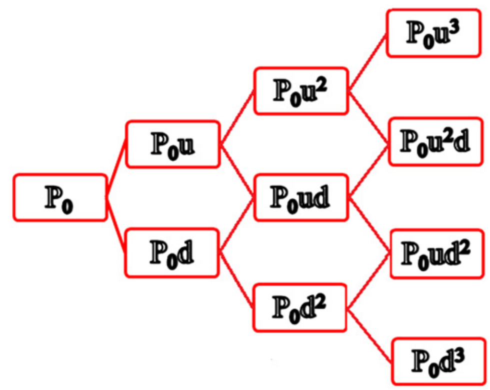

Fig. 1. Three time step binomial tree.

$$u = e^{\sigma\sqrt{\delta t}} \quad (1)$$

$$d = e^{-\sigma\sqrt{\delta t}} = \frac{1}{u} \quad (2)$$

$$p_r = \frac{(1+rf)-d}{u-d} \quad (3)$$

The basic inputs are the volatility of the metal price or operating cost (σ), the risk-free rate (rf) and stepping time (δt).

Methodology

In this section, three different scenarios were studied to investigate the effect of the uncertainty of the economic parameters such as metal price and operating cost on a mining project:

Scenario 1: NPV computation under certain metal price and operating cost situation,
scenario 2: NPV computation under uncertain metal price and certain operating cost situation,
scenario 3: NPV computation under uncertain metal price and operating cost situation.

Scenario 1: certain metal price and operating cost situation

In this scenario the project NPV was calculated using the traditional DCF technique. For this purpose, at the first step, the free cash flow (FCF) was determined using Eq. (4).

$$FCF_{n,k} = \{([(P_n - C_n)Q_n] - FC_n - D_n)(1 - Tax_n)\} + D_n \quad (4)$$

where FCF_n is the free cash flow to the firm at time n, P_n is the mineral commodity price at time n, C_n is the variable cost at time n, Q_n is the production rate at time n, FC_n is the fixed cost at time n, D_n is the deprecation at time n, Tax is the corporative tax and n is the time period.

There are many methods for estimating the future metal price and operating cost such as using the average of the previous metal price and operating cost data and regression analysis. After