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## VALUATION OF GOLD MINING COMPANIES: BLACK-SCHOLES APPROACH

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Mineral and metal mining tends to be one of the most rapidly growing sectors of the global investment market nowadays. The importance of mining has become very sounding in recent years, as commodity and equity prices have soared. Therefore, investing in commodities is seen as a safe haven in times of economic crisis and provides a protection against currency devaluation, thus, becoming more attractive as a long-term investment (Farchy, 2011). Consequently, it is useful to know how to value metals and mining companies.

Mining companies' valuation is a complex task. A number of methods are available, but most of them cannot provide precise results and thus, are not useful or applicable in practice. According to Shafiee (2010), the reason behind this are the specific features of the industry and multifactorial model of underlying commodity's price formation, which is in most cases not determined by the relation of supply and demand (e.g. the gold price is significantly affected by inflation rate and economic stability). Furthermore, aside from the usual and financial risks, there are price cyclicality, ongoing changes in operating and capital cost structures, stock market vagaries, and volatility in circumstances (Baurens, 2010).

Previous researchers of approaches to valuation of mining companies have outlined different frameworks, which are summarized in Table 1.

The three approaches should not be viewed as being independent of each other. Generally, they draw mainly on the same sources of data, but the data is analyzed using different methods. The underlying idea is that the three approaches should complement the findings of each other. The approaches used to value a business depend on how marketable its assets are, whether it generates cash flows, and how unique it is in terms of its operations. (ibid). Damodaran (2010) highlights that, there can be significant differences in outcomes, depending on which approach is used.

Table 1 – Approaches to the valuation of mining companies.

| Valuation approach | Description | Valuation Methods |
|---|---|---|
| Income or Cash Flow | Relies on the "value-in-use" principle and requires determination of the present value of future cash flows over the useful life of the mineral property. | Discounted Cash Flows |
| | | Real Options |
| | | Monte Carlo Analysis |
| | | Probabilistic Methods |
| Market | Relies on the principle of substitution. The mineral property being valued is compared with the transaction value of similar mineral properties, transacted on an open market. | Comparable Transactions |
| | | Option Agreement Terms |
| | | Gross "in Situ" Metal Value |
| | | Net Metal Value per unit of metal |
| | | Value per Unit |
| | | Market Capitalization |
| Cost | Relies on historical and/or future amounts spent on the mineral asset. | Appraised Value |
| | | Multiples |
| | | Geoscience Factor |

The research conducted by Foester and Sapp (2011) claims that the Discount Cash Flow (DCF) method is a primary valuation methodology for mining companies. The underlying valuation premise is that value reflects the current net economic benefit of the net cash flows that are expected to be generated over the life of the project. Calculating this benefit involves estimating expected after-tax cash flows and converting these cash flows into a present value or net asset value through discounting by using an appropriate discount rate – both time value of money and risk factor.

However, there are several potential issues with the method. The main problem is this approach undervalues an asset that produces little or no cash now, but has a high future potential. This leads to the undervaluation of resource projects capitalization and in a competitive world is seen as an opportunity for the rivals.

As mentioned before, valuation approaches should be complemented by each other. Thus, using the Real Option Valuation (ROV) method along with the basic technique may eliminate the issue of underestimation of potential profits by DCF framework, as is based on the potential benefits of the reserves.

Real option valuation (ROV) is one of the modern valuation methods that provide a tool to adapt and revise mining projects under uncertainty and future variable movements. This is a proprietary valuation model is based on the Black-Scholes option pricing (BS) model (Fischer and Scholes, 1973):

$$C(S_t, T-t) = S_t \cdot N(d_1) - K \cdot e^{-rx(T-t)} \cdot N(d_2) \quad (1)$$

$$d_1 = \frac{\ln\left(\frac{S_t}{K}\right) + \left(r - \delta + \frac{\sigma^2}{2}\right) \cdot (T-t)}{\sigma \cdot \sqrt{t}} \quad (2)$$

$$d_2 = d_1 - \sigma \cdot \sqrt{(T-t)}, \quad (3)$$

where N(x) – standard normal cumulative distribution function,

e – the exponential function.

The rest of variables are described in Table 2, along with the analogies of the parameters in financial and real option models.

Table 2 – Parameters of the BS model.

| BSM Parameter | Analogous ROV Parameters | Example Sources of Uncertainty | Inputs into valuing Natural Resources Option |
|---|---|---|---|
| Value of underlying asset, St | Present value of expected cash flows from investment. | Market demand for commodities, labor supply and cost, materials supply and cost. | Estimated value of natural resources reserve. Usually estimated as the quantity of resources times the current price. |
| The exercise or strike price, K | Present value of required investment costs in real asset. | Availability, timing and price of real assets to be purchased. | Cost of developing the reserve. Generally assumed to be known and fixed. |
| The volatility of the underlying asset, σ | Volatility of underlying cash flows. | Volatility in market demand, labor cost, materials cost, correlation of model assumptions. | Since the quantity of the resource is assumed to be known, the volatility in price of natural resources. |

| | | | |
|---|---|---|---|
| The time of expiration, T | Period for which investment opportunity is available. | Product life cycle, competitive advantage. | Can be defined in one of two ways:<br>- If rights to the reserve are for a finite period, use that period.<br>- The number of years of production it would take to exhaust the estimated reserve. |
| Dividend rate, δ | Cash flows lost to competitors. | Product life cycle, competitive advantage, convenience yield. | Annual cash flow as a percentage of the value of the underlying asset. Once the reserve becomes viable, this is what the firm is losing by not developing the reserve (also cost of delay). |
| Risk-free interest rate, r | Risk-free interest rate. | Inflation, money market behavior. | Risk-free interest rate. |

According to Baurens (2010), option valuation is all about the value of flexibility. When metal prices drop, some mining operations are able to temporarily close and avoid losses. This type of option is analogous to a put option – incurring closure costs are exercising the option in order to avoid losses. Once closed, however, the project takes on the characteristic of a call option. Incurring reopening costs when metal prices have moved higher is analogous to exercising the option.

Thus, the proposed approach for the valuation is:

**Total Value of the Company =**

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**Value of Developed Reserves** (DCF Valuation: represent value of expected cash flow from extraction and sale of natural resources in developed reserves)

+

**Value of Undeveloped Reserves** (Option Valuation: Option Value of undeveloped reserves (valued either individually or in the aggregate)

The purpose of this paper is to describe the specific aspects of both valuation methods (DCF and ROV) from the perspective of gold mining companies. Further empirical research suggests application of the model to the sample of South African gold mining companies, in order to verify its validity in retrospective as well as the current market position.

Findings may be useful for potential investors, as an indication of fair market pricing, and mining companies, which are engaged in merger and acquisition processes.

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## УДОСКОНАЛЕННЯ УПРАВЛІННЯ ЛЮДСЬКИМ КАПІТАЛОМ ЯК ГОЛОВНА УМОВА ЕКОНОМІЧНОЇ БЕЗПЕКИ

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Категорія економічної безпеки є відносно новою для вітчизняної економіки. Формування ринкової економіки істотно змінило умови функціонування підприємств. В значній мірі ці зміни відбувались у відносинах власності, пріоритетах розвитку, підвищенні конкурентоспроможності, якості продукції тощо. В цей же час з'явилися нові проблеми, які стосуються використання людського, зокрема інтелектуального капіталу. Темпи розвитку науки, особливо впровадження наукових знань, підвищення інтелекту працівників, ділової репутації керівників, іміджу у ці роки значно зменшились, що спонукало економіку до