# A REAL OPTION MODEL TO VALUE AN EXPLORATION MINING PROJECT: AN APPLICATION

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## 1. Summary

In this paper we develop a dynamic model to assess the financial viability of a mining project in exploration stage using the real options approach. The model simulates the decision making process and determines the value of the real options associated with the mining project. The firm has the option to defer investment, and once invested, to abandon or expand the project. On the other hand, considering that the firm is listed in the stock market, the model assesses the likely impact of these options on the firm´s market value. The results show that the combined real options associated with the project have a significant impact on its value, which indicates the firm´s stock is undervalued by approximately 40%.

## 2. Introduction

The mining industry in Peru is currently facing a difficult economic environment due to high volatility in metal prices. Currently there are many mining projects, especially in the exploration stage, which find it difficult to fund their different investment stages as investors are unsure of the value the project will generate. This uncertainty can be clearly seen in the behavior of their stock prices as shown in Figure 1 which illustrates the evolution of prices in the last five years of an index that follows a set of mining companies (Junior Mines) in the world.

**Figure 1: Evolution of Junior Mines prices**

While mining projects may involve socioeconomic and environmental factors that may appear due to the needs of the communities located in the vicinity of the project. These factors may impact positively or negatively the economic value of the project; however, this study only considers market uncertainties (metal price changes) for simplification purposes and information accessibility.

In this context, it is necessary that a mining firm rely on a complementary methodology to evaluate with reliability of their projects considering uncertain scenarios. Mining investments are particularly irreversible and involve many uncertain factors, therefore these variables and the correct timing of the investment must be clearly understood.

In the particular case of the proposed mining project, the factor of market uncertainty that will be assessed is price of silver. The evolution of this factor will have an effect on the real options the project presents during its life. The options associated with the project are:

- Option to defer investment (invest in two stages)
- Option to abandon the project at any time.
- Option to expand at the end of the fifth year

All options are initially assessed individually as single options, and later the options are assessed jointly to quantify their impact on the project value. The decision process is represented in a binomial tree using DPL software for a better understanding. Finally, we compare the current market value of the firm with the market value the firm would have considering the real options attached to the project.

This paper is organized as follows. After this introduction, we present a brief review of real options literature applied to mining projects, and then we introduce a case study and analyze the main uncertainties of the project and the model used. In section four we model and determine the value of the existing options, in section five we analyze the results and present our conclusions.

## 3. Review of the Literature

Decisions to invest in mining enterprises are affected by many uncertain factors throughout the life of the project. Some of these factors, especially the metal prices, can be modeled using stochastic processes to describe their behavior over time.

Stochastic processes can be defined as variables that evolve in discrete or continuous time in an unpredictable or partially random way. The behavior of metals prices can be evaluated considering that they follow a Geometric Brownian Motion (GBM) (Brennan & Schwartz, 1985; McDonald & Siegel, 1986) especially in short periods of time. Some studies such as Dixit and Pindyck (1994) showed that a GBM is the most convenient process to model the behavior of commodity prices. When it is assumed that metal prices tend to revert to a long-term average price, a Mean Reversal Movement (MRM) may be more appropriate to evaluate their price behavior (Ozorio et al., 2013). The selection of the stochastic process is important since it has a direct impact on the behavior of the real options associated with the project. It also influences directly in the economic evaluation of the project and the investment decision.

Other authors combine both processes, generating models that can explain the behavior of the price of a commodity considering its evolution in the short and long term. Some authors consider both a GBM and MRM in a two factor model to evaluate the behavior in the long and short term respectively (Gibson & Schwartz, 1990; Schwartz & Smith, 2000; Schwartz, 1997).

In this present work, since the evaluation period is over a short period of time (five years), a GBM will be used to model the stochastic diffusion process of silver prices. To validate the use of this process, we present the results of a linear regression and significance tests that were made to consider the silver price follows a GBM process.

## 4. An application

This study is based on a real case of a Peruvian firm, which we will call ABC. This firm has several mining projects, but only one of them will be assessed. The mining project to be evaluated has a large potential production of Silver, Zinc and Lead. However, considering that 80% of potential production is silver, this metal will be taken as the only metal to influence in the value of the project.

It is important to mention that the mine belongs to an investment group (private equity fund) and its core business is to invest in the development of a mine at the exploration stage (junior mines) and then sell it when the mine begins stable production. Therefore it is estimated that the firm could achieve its stability in five years, which is the time used to analyze the project.

## 4.1 Price analysis

For silver price analysis we use historical data of the last four year monthly prices of the Future contract expiring in December 2014: SIZ4 (see Annex 1). This asset is considered in order to obtain the data because the month of expiration coincides with the month the firm would take the decision to invest in the project. It is assumed that future prices converge and are equal to the spot price of the physical asset on the expiration date, otherwise there would be arbitrage opportunities.

A linear regression is performed to obtain the parameters for modeling the behavior of silver prices. The model used is a log-linear model as follows:

$$\ln P_t = a + b \ln P_{t-1} + \varepsilon \qquad (1)$$

Where:

$P_t$: Silver price at time $t$ (dependent variable)
$P_{t\text{-}1}$: Silver price at time $t$-1 (independent variable)
$\varepsilon$: random error

If the price (P) silver follows a GBM, the following equation explains the behavior of its variations:

$$dP = \alpha P dt + \sigma P dz \qquad (2)$$

Where:

$dz$: is Winner process that follows a normal distribution $N$ (0, 1)
$dt$: time interval
$\alpha$: expected return
$\sigma$: expected return volatility.

Applying Ito´s Lemma is possible to deduce that Ln P follows an Arithmetic Brownian Motion (MAB) given by the following equation:

$$d \ln P = \left(\alpha - \sigma^2/2\right) dt + \sigma dz \qquad (3)$$

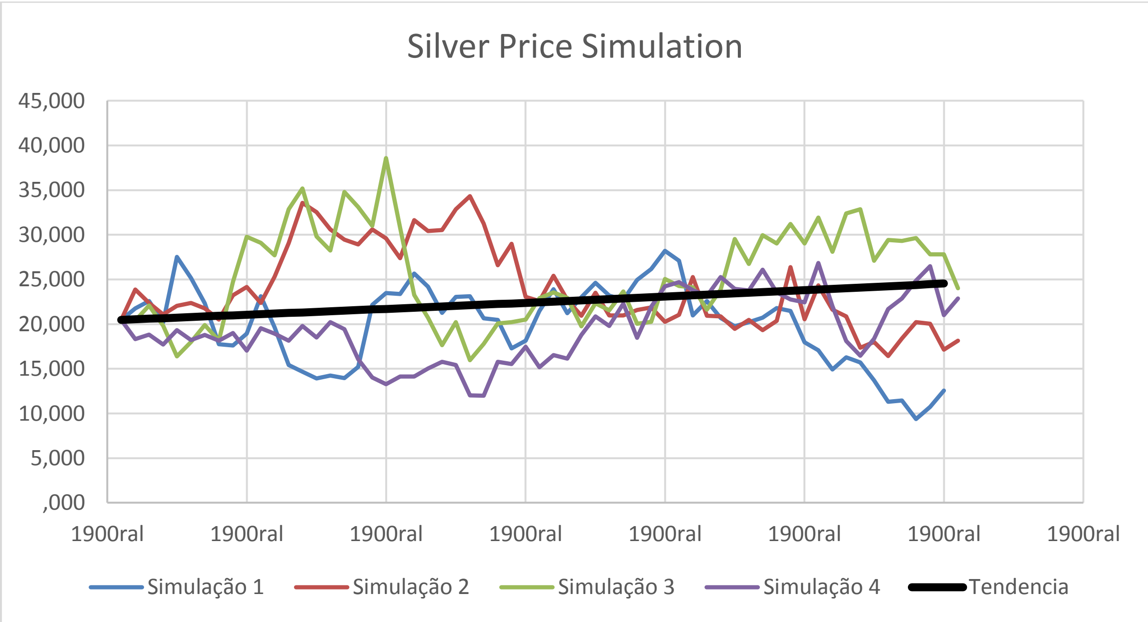
The results of the lineal regression show that the independent variable coefficient, "*b*" (0885) is quite important and implies that the silver price at time *t*-1 significantly influences the price at time *t*. On the other hand, the "*t*" value to test statistical significance of "*b*" is high, *t* = 13.934. Therefore, considering the values found in the regression we cannot reject the fact that the price of silver, in a short period of time (4 years), follows a GBM.

According to the regression results and the data shown in Annex 1 we can obtain the values of α = 11.60% and σ = 39.80% in annual terms. Based on equations (2) and (3) and the calculated values for α and σ, we obtain the expression for calculating future prices of silver.[1]

$$P_t = P_{t-1}\, e^{\left(\alpha-\sigma^2/2\right)\Delta t+\sigma N(0,1)\sqrt{\Delta t}} \qquad (4)$$

Figure 2 shows the behavior of prices for the next five years for four simulations of silver prices.

Figure 2: Evolution of silver prices following a GBM




In Figure 2, the black line represents the trend (drift) of silver price for the next 5 years. According to this line it can be appreciated that silver price has a slightly positive trend, but with high volatility.

[1] The variables´ value are expressed in monthly terms.

Table 2 shows the average price of silver for the next 5 years. These averages were obtained by Monte Carlo simulations with 5,000 iterations.

**Table 4: Year average projected prices for silver**

| (USD/ounce) | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|
| Silver price | $21,28 | $24,40 | $27,93 | $30,56 | $34,07 |

## 4.2 Production and costs

The firm has a production potential of silver, zinc and lead. The most important resource for the mine is silver. This metal represents 80% of production. Silver is the only metal considered for the financial evaluation. It is also important to mention that in the initial feasibility study of the project done by the firm, the production costs are expressed in terms of ounces of produced silver. For instance, although the mining project can produce three important metals, the firm uses only silver as a benchmark to evaluate the project financial viability. Levels of estimated silver production for the coming years is presented in Table 3:

Table 3: Silver estimated production in five years

| Year | Ore Mined (Tonnes) | Silver Grade (G/T) | Lead Grade (%) | Zinc Grade (%) | Silver Production (MIL OZ) |
|---|---|---|---|---|---|
| 1 | 11316 | 129 | 0,63 | 1,37 | 0,051 |
| 2 | 97886 | 244 | 1,71 | 2,61 | 0,842 |
| 3 | 170872 | 332 | 1,66 | 3,27 | 2,001 |
| 4 | 259160 | 365 | 1,77 | 3,05 | 3,337 |
| 5 | 283979 | 341 | 1,44 | 2,18 | 3,416 |

The Initial production of silver is 0.051 million ounces in the first year and increases each year up to 3,416 million ounces at the end of the fifth year. The total estimated production is 9.647 million ounces within five years.

For assessment purposes, we assume that the cost of production is constant over the five years. The production costs assumed is $ 15 per ounce of silver produced. However is important to mention that the cost could have a variable behavior depending on factors that are not considered in this case.

## 4.3 Investment, costs and discounting rate

The project requires an initial investment of USD 48 million. This investment will be needed to cover the costs of mine construction and working capital to keep running the mine during the two following years. For the remaining three years of the project, there are maintenance expenses that would be considered in the respective period.

By other side, it is considered that the firm depreciates its assets in a linear way, so they are depreciated 20% each year. The income tax paid by the firm is 25%. The adjusted discount rate risk (μ) is calculated using the CAPM model considering equation 5:

$$\mu = r_f + \beta\left(E[R_m] - r_f\right) + r_p \qquad (5)$$

Where:

$u$: expected project return

$r_f$: risk free rate (five year T-Bills rates)

$\beta$: project risk factor

$R_m$: Market expected return

$R_p$: country risk

Considering a risk free rate of 1.5%, a market expected return of 15%, a project risk factor of 1.2 and a country risk of 2%, we have[2]:

$$u = 1.5\% + 1.2\ (15\% - 1.5\%) + 2\% = 19.7\%$$

$$u \approx 20\%$$

## 4.4 Cash flow and firm´s initial value

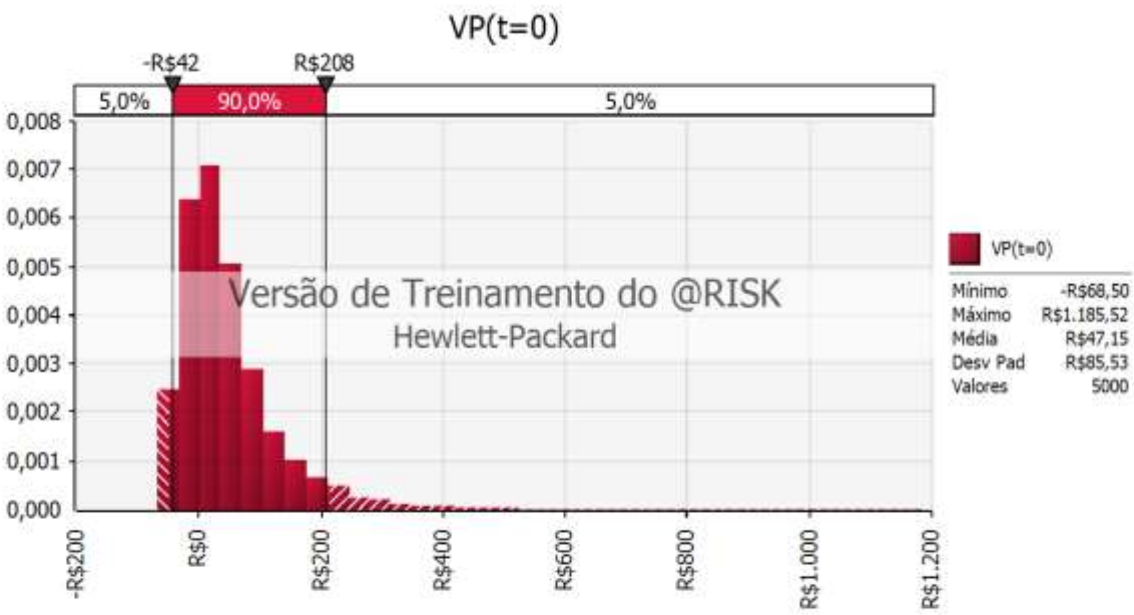
According to the price simulations and production levels and costs we obtain the free cash flow for the project (see Annex 2). We use Monte Carlo simulations for this.

From the project's cash flow, we get its present value (PV). This present value is assumed as the initial value of the underlying asset (initial project without options).

[2]The value of β is obtained from Damoradam website. This is the risk factor for mining companies in the exploration stage.

The value of the underlying asset is estimated to be USD 47 million approximately, and it has a standard deviation of USD 85 million. The PV´s standard deviation gives an idea of the high volatility and risk involved in the mining project. In Figure 3, we can also appreciate that value of the underlying asset follows a log normal distribution.

Figure 3: Distribution of PV results without options




Considering the Net Present Value (NPV) as an indicator of project viability; the project is not viable since it has a negative NPV of USD 1 million.

$$VPL\ (t_0) = VP_0 - Inv._0 = 47 - 48 = -1$$

## 4.5 Project Volatility

To estimate the project volatility ($\gamma$) is considered the indicator developed by (Brandão, Dyer, & Hahn, 2012) (BDH), which evaluates the volatility of the profitability of the project in the first year conditioned to the expectations (estimated) of the present values from the second to fifth year. Therefore, the following formula applies:

$$\tilde{\gamma} = \ln\left(\frac{\tilde{V}_1}{V_0}\right) = \ln\left(\frac{\tilde{F}_1 + \sum_{t=2}^{n} E[\tilde{F}_t] e^{-\mu(t-1)}}{\sum_{t=1}^{n} E[\tilde{F}_t] e^{-\mu t}}\right) \quad (6)$$

That is, the volatility indicator only evaluates the volatility of the project value in the first year. So we can eliminate a tendency to consider a higher or lower volatility generated by the uncertainty of the remaining periods.

The volatility of the project is the volatility of returns in the first year considering as known (estimated) the PV values in the following years. Since it is assumed that the project follows a GBM, the volatility is assumed constant over the project life. The following table shows the estimated values of the project in each period.

Table 4: Project´s present value by year

| | | | | |
|---|---|---|---|---|
| | | | E(VP1) em t=0 | 45,399 |
| E(VP2) em t=1 | 55,86 | | E(VP2) em t=0 | 45,736 |
| E(VP3) em t=1 | 48,69 | | E(VP3) em t=0 | 39,860 |
| E(VP4) em t=1 | 37,25 | | E(VP4) em t=0 | 30,500 |
| E(VP5) em t=1 | 19,58 | | E(VP5) em t=0 | 16,032 |
| Soma de E(VP2-5) em t=1 | 161,38 | | Soma de E(VP2-5) em t=0 | 177,527 |

Working with Monte Carlo simulations for the project values at $t$ = 1 (F1 in formula 6) the following results are obtained for project´s profitability (α) and volatility (σ):

$$\alpha = 11.6\%$$

$$\sigma = 39.06\%$$

To verify that the simulation was done properly we can calculate the original value of μ. Given that the project follows a GBM, using the Ito´s lemma we have:

$$\mu = \alpha + \frac{\sigma^2}{2}$$

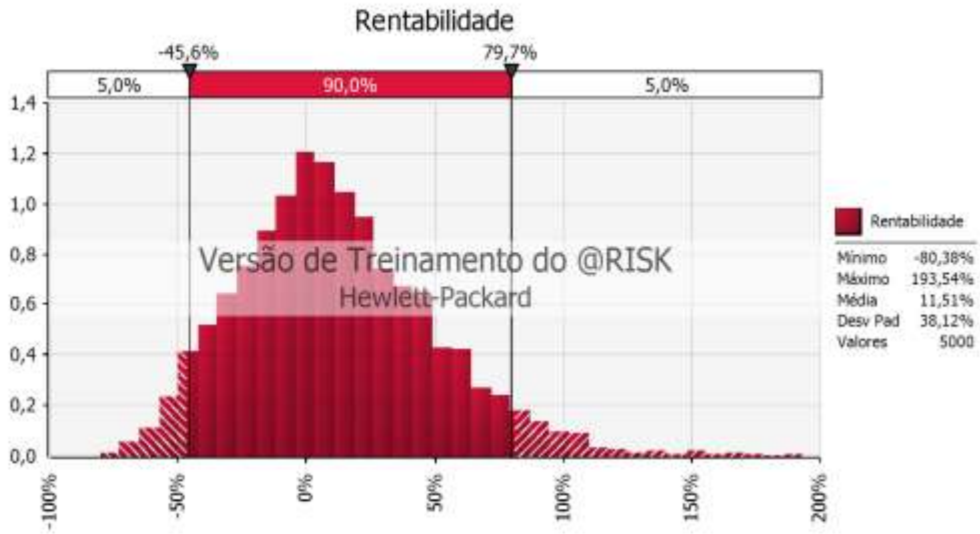
$$\mu = 0.116 + \frac{0.3906^2}{2} = 0.192 = 19.2\%$$

$$\mu \approx 20\%$$

The calculated value of $\mu$ is equal to the one obtained using the CAPM formula.

Figure 4 shows the Monte Carlo simulation results for the project profitability and volatility.

Figure 4: Project´s Profitability and volatility results




## 5. Underlying asset and its associated real options.

In order to assess and have a better understanding of the options the project has, we build binomial decision trees. The software used to build these trees is the Decision Program Language (DPL). Using this program we model and value the base case underlying asset (project without options) and then underlying asset with options.

To model the behavior of the underlying asset and the options to use the parameters we have found so far: the project volatility (σ), the risk free rate (*r*), the risk neutral probability (*p*) and levels of increment (*u*) or decrement (*d*) of project´s value. The parameters are shown in Table 5.

Table 5: Parameters to build binomial tress

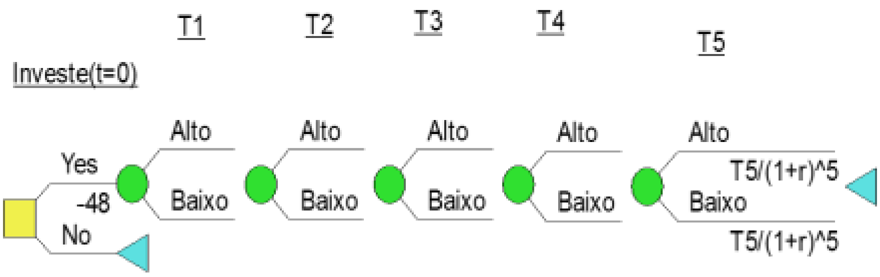
| Parameters | Value |
|---|---|
| Risk free rate (r) | 1.5% |
| Volatility (σ) | 39.09% |
| High: u ($e^{\sigma\sqrt{T}}$) | 1.47 |
| Low: d (1/u) | 0.67 |
| Risk neutral probability (P =(1+r-d)/(u-d)) | 43.12% |
| Inital Project´s value ($VP_0$) | 47 |
| Investidor (t=0) | 48 |

There are three options associated with the project that will be evaluated. These options may be exercised at different times during the life of the project. Below we define and model the underlying asset and the project´s options.

5.1 Underlying Asset:

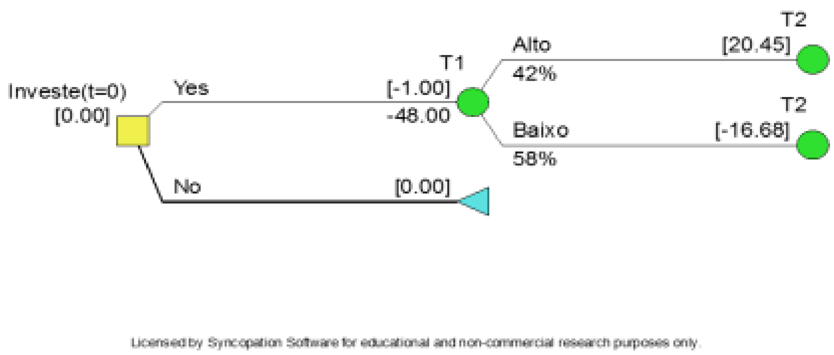
The primary asset is the project without any options. In this context, we only consider the viability of the project itself as the firm was investing all in year zero. The project value is obtained discounting the cash flows using an adjusted risk rate $\mu$ = 20%, as found in Section 4.3 using the CAPM model. The project life process is expressed using DPL software and is showed in the following figure.

**Figure 5: Underlying Asset**




We obtain a negative Net Present Value (NPV) of -1 million dollars for the underlying asset, or base case project, which indicates that the project is not feasible.

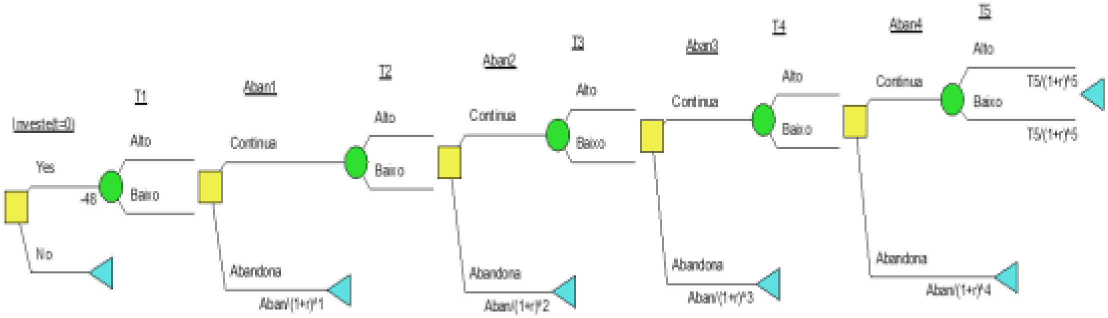
**Figure 6: Value of the primary asset (without options)**



5.2 Abandon Option:

The firm has the option to abandon the project at the end of each year if the project is not viable.[3] In case the firm abandons the project, this could be sold by USD 24 million. In the following tree we show the decision-making process where the firm has the abandon option.

**Figure 6: Project with abandon option**

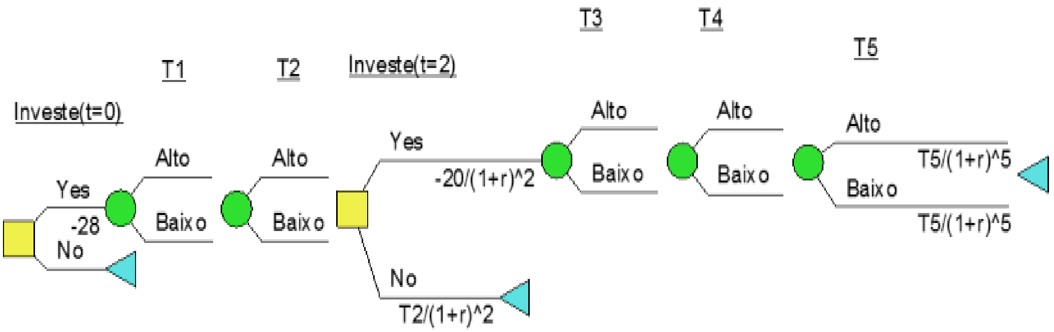



The flexibility to abandon generate added value at any time the firm takes this decision. The added value generated by this option is USD 1.32 million dollars. This means that this option increase project´s value in USD 2.32 million dollars. Then the abandon option (PUT option) has a USD 2.32 million dollars value.

5.2 Option to invest in two tranches

In this situation we assume the firm can invest in two different moments. In the first moment (first year) the firm invests USD 28 million to start the project. After evaluating the factors of uncertainty at the end of year 2, the firm decides whether or not to invest the remaining USD 20 million.

**Figure 7: Project with option to invest in two instances**



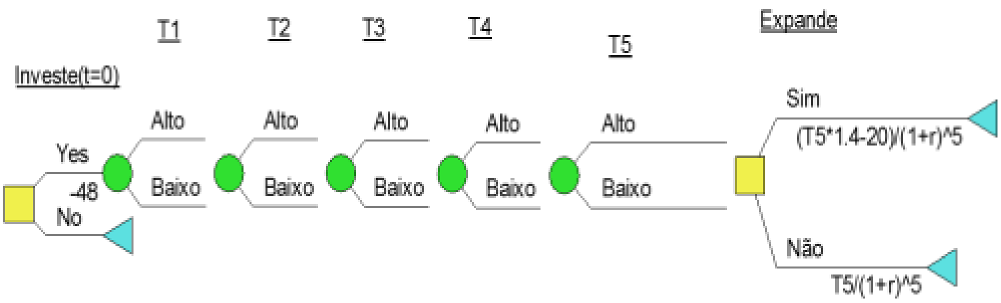

[3] The assessment is made until year 4 since the Project has only 5 years life.

If the firm does not invest, it is assumed that the firm could sell the project at the current value that the firm is taking the decision. This option increase the project´s value to USD 19 MM

## 5.3 Option to expand:

Under the terms of the contract, the firm can only expand at the end of year 5. If the firm optimally decides to expand the project, it must invest USD 20 million, but the project value would increase in 40%.

**Figure 8: Project with option to expand**

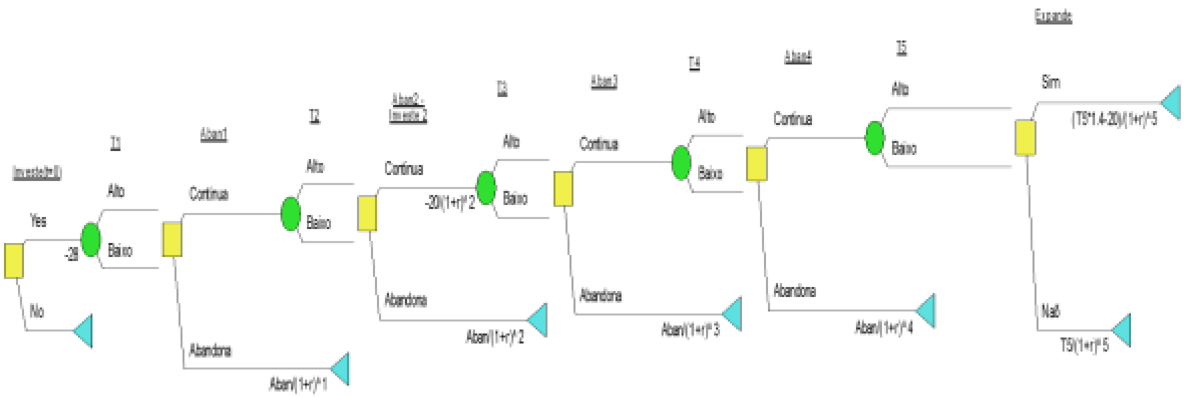



The value generated by this option is USD 5.69 million if the firm decides to expand at the end of the fifth year.

## 5.4 All options

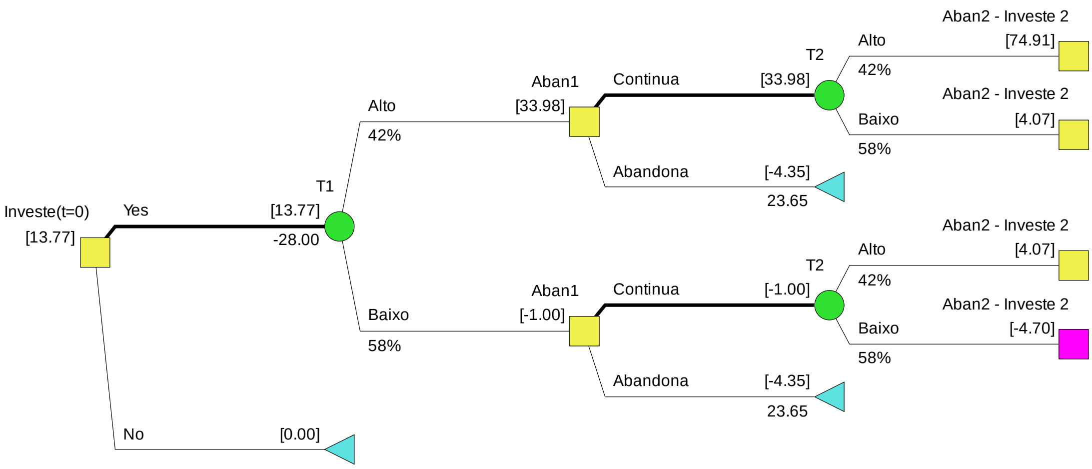
In this section we evaluate the case in which the firm exercises all the options mentioned above. We must comment that this is the most likely scenario considering the current firm´s objectives.

**Figure 9: Project with all options**



Considering this more feasible scenario for the firm, it can be seen that the project increases its value to USD 13.77 million. So, the option to exercise all the options together have a value of USD 14.77 million.

**Figure 10: Project value with all options together**

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It is clear that when the firm considers the flexibility derived from the optimal exercise of all the associated options of the project, it has a higher value. This is the flexibility one may have in this type of projects. Most mining projects in the exploration stage has several scenarios (options) to evaluate. Table 8 summarizes the effect of each alternative in project´s value (in millions of dollars).

**Table 8**

| Asset | Value | Value with options |
|---|---|---|
| Initial | -1 | |
| with abandom option | 1.32 | 2.32 |
| with option to invest in two ins | 19 | 20 |
| with option to expand | 5.69 | 7.69 |
| all options | 13.77 | 14.77 |

## 6. Impact of options value over Market value

An important aspect to asses is the impact that real options could have over firm´s value, specifically over a mining firm in the exploration stage. To better understand this impact we will explain the context in which the project is evaluated.

Junior Mining companies seek access to capital markets to finance their project by listing their shares. Usually companies list the shares on the capital market of the country where they will have the mining project. Not every country has this alternative in it capital market, the countries where this market is most active are: Canada, Australia, and Peru. In these countries, there are more facilities for this type of companies to list on the stock exchange.

Given the fact that companies list their shares to develop the project, the firm's value is basically the value of the project at the time they decide to list their shares in the market. Companies are evaluated by investment banks or brokers that are its promoters. The method mainly used for assessing project´s value is the NPV method.

It is clear that if another approach is used to prepare the project evaluation, like real options for example, this would have a major impact on firm´s value. This impact could be seen not only in the moment of listing project´s shares (IPO)[4] but also during project´s life.

The following table shows the possible effect of including the real options associated to the project in order to determine the fundamental value of project´s shares.

**Table 9: Impact over firm´s market value**

| Asset | Value |
|---|---|
| Share Market price (USD) | 0.025 |
| Number of common shares (MM) | 380 |
| Company´s market value ($ MM ) | 9.5 |
| Company´s market value with options ( $ MM) | 13.77 |
| Fundamental value (USD) | 0.036 |

From the above table it can be seen that the price of shares in the market should have a value of USD 0.036 today [5]

[4] Initial Public Offering
[5] Today is November, 19th 2014

## 7. Conclusions and final observations

The evaluation of mining projects using real options (especially mining projects in exploration stage) provides a better analysis tool for taking investment decisions. In some cases this approach can even affect firm´s market value, as we can see in the ABC Company showed in this work.

For a full review of the project we would need to consider other uncertain factors, for example, the firm´s natural resources, costs and other technical uncertainties that may appear during the project execution (Costa Lima & Suslick, 2006).

There are other external factors that may impact the project´s viability, such as socioeconomic and environmental factors. Since most of mining projects are executed in rural communities, the improvement perception is very important for inhabitants of these areas. If they feel that the mining project will not contribute to economic improvement, or has the potential to contaminate their natural resources, they will aim to ban the project. In case of Peru, this problem has already occurred with several mining projects. In fact, there are several communities that have banned the development of mining projects, and these investments have been frozen.

These latter factors could be analyzed with the behavioral finance theory, and the effects could be quantified and included in the financial valuation model. This topic still needs more research, although there are several articles that examine these factors in some mining projects in other countries (Ndiaye & Armstrong, 2013).

## 8. Bibliography


Brandão, L. E., Dyer, J. S., & Hahn, W. J. (2012). Volatility estimation for stochastic project value models. *European Journal of Operational Research, 220*(3), 642-648. doi: 10.1016/j.ejor.2012.01.059

Brennan, M. J., & Schwartz, E. S. (1985). Evaluating Natural Resource Investments. *Journal of Business, 58*(2), 135-157.

Costa Lima, G. A., & Suslick, S. B. (2006). Estimating the volatility of mining projects considering price and operating cost uncertainties. *Resources Policy, 31*(2), 86-94. doi: 10.1016/j.resourpol.2006.07.002

Dixit, A. K., & Pindyck, R. S. (1994). *Investment under Uncertainty*. Princeton: Princeton University Press.

Gibson, R., & Schwartz, E. S. (1990). Stochastic Convenience Yield and the Pricing of Oil Contingent Claims. *Journal of Finance, 45*(3), 959-976.

McDonald, R., & Siegel, D. (1986). The Value of Waiting to Invest. *Quarterly Journal of Economics, 101*(4), 707-728.

Ndiaye, A. A., & Armstrong, M. (2013). Evaluating a small deposit next to an economically viable gold mine in West Africa from the points of view of the mining company, the government and the local community. *Resources Policy, 38*(2), 113-122. doi: http://dx.doi.org/10.1016/j.resourpol.2013.01.003

Ozorio, L. d. M., et al. (2013). Investment decision in integrated steel plants under uncertainty. *International Review of Financial Analysis, 27*(0), 55-64. doi: http://dx.doi.org/10.1016/j.irfa.2012.06.003

Schwartz, E., & Smith, J. E. (2000). Short-Term Variations and Long-Term Dynamics in Commodity Prices. *Management Science, 46*(7), 893-911. doi: 10.1287/mnsc.46.7.893.12034

Schwartz, E. S. (1997). The Stochastic Behavior of Commodity Prices: Implications for Valuation and Hedging. *Journal of Finance, 52*(3), 923-973.

ANEXX 1

Historical Silver Prices (Future contract with expiration in December 2014)

| Date | Mês | Last Price SIZ4 | Ln (t) | Ln (t-1) | Ln (t)-Ln(t-1) |
|---|---|---|---|---|---|
| 31/12/2009 | 1 | 17,73 | 2,88 | | |
| 29/01/2010 | 2 | 16,83 | 2,82 | 2,88 | -0,05 |
| 26/02/2010 | 3 | 17,15 | 2,84 | 2,82 | 0,02 |
| 31/03/2010 | 4 | 18,24 | 2,90 | 2,84 | 0,06 |
| 30/04/2010 | 5 | 19,32 | 2,96 | 2,90 | 0,06 |
| 31/05/2010 | 6 | 19,08 | 2,95 | 2,96 | -0,01 |
| 30/06/2010 | 7 | 19,32 | 2,96 | 2,95 | 0,01 |
| 30/07/2010 | 8 | 18,59 | 2,92 | 2,96 | -0,04 |
| 31/08/2010 | 9 | 20,01 | 3,00 | 2,92 | 0,07 |
| 30/09/2010 | 10 | 22,41 | 3,11 | 3,00 | 0,11 |
| 29/10/2010 | 11 | 25,21 | 3,23 | 3,11 | 0,12 |
| 30/11/2010 | 12 | 29,15 | 3,37 | 3,23 | 0,14 |
| 31/12/2010 | 13 | 31,93 | 3,46 | 3,37 | 0,09 |
| 31/01/2011 | 14 | 28,35 | 3,34 | 3,46 | -0,12 |
| 28/02/2011 | 15 | 32,95 | 3,49 | 3,34 | 0,15 |
| 31/03/2011 | 16 | 37,43 | 3,62 | 3,49 | 0,13 |
| 29/04/2011 | 17 | 47,93 | 3,87 | 3,62 | 0,25 |
| 31/05/2011 | 18 | 37,59 | 3,63 | 3,87 | -0,24 |
| 30/06/2011 | 19 | 34,69 | 3,55 | 3,63 | -0,08 |
| 29/07/2011 | 20 | 39,50 | 3,68 | 3,55 | 0,13 |
| 31/08/2011 | 21 | 41,01 | 3,71 | 3,68 | 0,04 |
| 30/09/2011 | 22 | 29,51 | 3,38 | 3,71 | -0,33 |
| 31/10/2011 | 23 | 33,89 | 3,52 | 3,38 | 0,14 |
| 30/11/2011 | 24 | 32,49 | 3,48 | 3,52 | -0,04 |
| 30/12/2011 | 25 | 27,71 | 3,32 | 3,48 | -0,16 |
| 31/01/2012 | 26 | 33,07 | 3,50 | 3,32 | 0,18 |
| 29/02/2012 | 27 | 34,68 | 3,55 | 3,50 | 0,05 |
| 30/03/2012 | 28 | 32,47 | 3,48 | 3,55 | -0,07 |
| 30/04/2012 | 29 | 31,02 | 3,43 | 3,48 | -0,05 |
| 31/05/2012 | 30 | 27,69 | 3,32 | 3,43 | -0,11 |
| 29/06/2012 | 31 | 27,55 | 3,32 | 3,32 | -0,01 |
| 31/07/2012 | 32 | 27,89 | 3,33 | 3,32 | 0,01 |
| 31/08/2012 | 33 | 31,47 | 3,45 | 3,33 | 0,12 |
| 28/09/2012 | 34 | 34,62 | 3,54 | 3,45 | 0,10 |
| 31/10/2012 | 35 | 32,46 | 3,48 | 3,54 | -0,06 |
| 30/11/2012 | 36 | 33,46 | 3,51 | 3,48 | 0,03 |
| 31/12/2012 | 37 | 30,49 | 3,42 | 3,51 | -0,09 |
| 31/01/2013 | 38 | 31,72 | 3,46 | 3,42 | 0,04 |
| 28/02/2013 | 39 | 28,75 | 3,36 | 3,46 | -0,10 |
| 29/03/2013 | 40 | 28,72 | 3,36 | 3,36 | 0,00 |
| 30/04/2013 | 41 | 24,49 | 3,20 | 3,36 | -0,16 |
| 31/05/2013 | 42 | 22,55 | 3,12 | 3,20 | -0,08 |
| 28/06/2013 | 43 | 19,71 | 2,98 | 3,12 | -0,13 |
| 31/07/2013 | 44 | 19,86 | 2,99 | 2,98 | 0,01 |
| 30/08/2013 | 45 | 23,68 | 3,16 | 2,99 | 0,18 |
| 30/09/2013 | 46 | 21,87 | 3,09 | 3,16 | -0,08 |
| 31/10/2013 | 47 | 22,04 | 3,09 | 3,09 | 0,01 |
| 19/11/2013 | 48 | 20,48 | 3,02 | 3,09 | -0,07 |

ANEXX 2

CASH FLOW SIMULATION

| | | 2014 | 2105 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|
| **Revenues** | | | | | | | |
| Silver production (Millions ounces) | | | 0,05 | 0,84 | 2,00 | 3,34 | 3,42 |
| Silver price (USD/ounce) | | | $ 30,68 | $ 25,06 | $ 45,89 | $ 98,20 | $ 112,66 |
| Revenues from Silver (Millions USD) | | | $ 1,58 | $ 21,11 | $ 91,82 | $ 327,65 | $ 384,83 |
| **Total Gross Revenues** | | | $ 1,58 | $ 21,11 | $ 91,82 | $ 327,65 | $ 384,83 |
| | | | | | | | |
| **Operational Costs** | | | | | | | |
| Treatment costs (USD/TN) | | | $ 15,00 | $ 15,00 | $ 15,00 | $ 15,00 | $ 15,00 |
| Total ( Millions of TNs) | | | 0,05 | 0,84 | 2,00 | 3,34 | 3,42 |
| | | | | | | | |
| **Annual Operating Costs (Millions USD)** | | | $ 0,77 | $ 12,64 | $ 30,02 | $ 50,05 | $ 51,24 |
| | | | | | | | |
| **Total Net Revenues** | | | $ 0,81 | $ 8,47 | $ 61,81 | $ 277,60 | $ 333,60 |
| | | | - | - | - | - | - |
| **Pretax Profits (Millions USD)** | | | $ 0,81 | $ 8,47 | $ 61,81 | $ 277,60 | $ 333,60 |
| | | | | | | | |
| **Capital Expenditures** | | | | | | | |
| Feasibility (Millions USD) | | $ 2,00 | | | | | |
| Capital expenditures (Millions USD) | | $ 46,00 | | | $ 7,00 | $ 5,00 | $ 5,00 |
| **Depreciation** | | $ - | $ 3,83 | $ 3,83 | $ 4,42 | $ 4,83 | $ 5,25 |
| **EBIAT** | | $ - | $ (3,03) | $ 4,64 | $ 57,39 | $ 272,77 | $ 328,35 |
| **Taxes (25%)** | | $ - | $ (0,76) | $ 1,16 | $ 14,35 | $ 68,19 | $ 82,09 |
| **PAT** | | $ - | $ (2,27) | $ 3,48 | $ 43,04 | $ 204,57 | $ 246,26 |
| | | | | | | | |
| **Adjustments:** | | | | | | | |
| Depreciation | | $ - | $ 3,83 | $ 3,83 | $ 4,42 | $ 4,83 | $ 5,25 |
| Capital expenditures | | $ 48,00 | $ - | $ - | $ 7,00 | $ 5,00 | $ 5,00 |
| **Free Cash Flow (Millions USD)** | | $ (48,00) | $ 1,56 | $ 7,31 | $ 40,46 | $ 204,41 | $ 246,51 |
| | | | | | | | |
| **PV Calculations** | | 0 | 1 | 2 | 3 | 4 | 5 |
| Incomes | | | $ 1,58 | $ 21,11 | $ 91,82 | $ 327,65 | $ 384,83 |
| Total costs | | $ 48,00 | $ 0,77 | $ 13,80 | $ 51,36 | $ 123,24 | $ 138,32 |
| **Net Free cash Flow (Millions USD)** | | $ (48,00) | $ 0,81 | $ 7,31 | $ 40,46 | $ 204,41 | $ 246,51 |
| | PV (expected) | 226,81 | 272,17 | 325,63 | 381,99 | 409,83 | 246,51 |
| | VP (Esperado) | 47,07 | 55,45 | 68,23 | 72,63 | 67,88 | 43,58 |