DEALING WITH MINING PROJECTS UNCERTAINTIES IN MOROCCO: A REAL OPTIONS PROFITABILITY EVALUATION

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ABSTRACT

Reopening a lead mine in Morocco is an investment project with multiple sources of uncertainties and high risks, however it represents a great potential of profitability expansion and of financial growth. Thus, this project requires a clear overview of the lead reserve of the mine but also an evaluation method capable of assessing it particularities. In this paper, the mine of Zaida is studied by defining its geological and mineral aspects as a first step to reopen the mine and to start the extraction of the lead, before examining the nature of investing in mining projects and the categories of the uncertainties related to this type of projects. Furthermore, the methodology of the real options as a project valuation tool is introduced and applied to this study in order to evaluate this project’s profitability and to reassure investors concerning the profitability of this mining project.

Key words: Mining Project, Mine Uncertainties, Project’s Profitability, Real Options, Project’s Evaluation.


1. INTRODUCTION

The use of appropriate project evaluation techniques is more important in the mining industry than the other industries. This is because the mining industry is extremely capital intensive, require many years of production period before a positive cash flow commences, and requires
longer project life compared to other industries. The major challenge for a valuation technique is to be able to consider the project risk, effect of time and management of flexibility in the valuation [1]. The risk associated with a mining project comes from the uncertainties involved in the industry. Uncertainties can be classified as internal and external sources [2]. Commodity price is an important risk factor for mining companies, as price volatility is a key parameter for mining project evaluation and investment decision making [3].

In this paper, the project is implemented by a Moroccan company specialized in the exploitation of mines and quarries. It started the reopening of the lead deposit of Zaida. The project is today ready to start production, and the risks related to the reserves and the feasibility are completely reduced because this mine is a brown one and the only reason of its closing is the dropping of the Lead price in the mid-eighties. The company has an immediate need of 100 million dirhams to mount the existing plant and start the first production phase with a capacity of 600 kilotons per year, to acquire and mount the new equipment to increase the capacity to 1.2 million tons per year; and to finance the starting cash flow.

Nowadays, the lead market displays a good dynamics of growth, due to ascending demand and insufficient offer. The price of lead today is currently promising and encouraging to reopen this mine. As a consequence, the company mandated studies to seek financial advisory and assistance in raising the necessary funds to start the production of the lead in Zaida.

This article starts with a description of the area of this mine, by presenting its geological location and its lead potential in order to display its reserves level. Moreover, a discussion about uncertainties in the mining industries is established to overcome this issue and to resolve one major source of uncertainty for this project’s profitability evaluation. Finally, an application is done using the mine’s data and the real options methodology to assess its profitability potential for its reopening and the starting of the lead extraction and sale.

2. DESCRIPTION OF THE STUDY AREA
2.1. Identification of the Mine
Zaida is an open pit deposit discovered in 1958. The ONHYM formerly known as BRPM (The Moroccan mining research and participation bureau) (the equivalent of the USGS) has conducted; exploration studies and technical works on an area of 35 Km2, development studies and built a pilot production plant during the period 1958-1971.

In 1971, BRPM went into a joint venture with other investors to create a company called SODIM. SODIM main goal was to extract, process and commercialize the Zaida lead. This deposit was cited, as a Red-Bed or Sandstone deposit, in most of the highly respected international geological records. In 1984-85 and due to the drastic fall of lead market prices, SODIM decided to close the mine of Zaida.

Zaida lead deposit is located on the Moulouya river at the cross section of road N°13 30km NW of the town of Midelt and 150Km SSE of the town of Meknes. The deposit has an area of about 35 Km2 and is laid on both sides of the river [4].
2.2. Geological Context

The Zaida deposit is located on the Moulouya basin within the western part of the high plateau. It is a basin surrounded by the high and the middle Atlas. The Hercynian substratum is morphologically composed of two boutonneries (Fig. 2): Boumia in the SW and Aouli in the East. The deposit is hosted in the detrital Arkose formations Triassic layers.

It is mainly present in the Paleo channels and spreads in the SW direction all the way to Boumia region. The Zaida mineralization is composed by 70% Cerusite and 30% Galena. Barite is incidentally present to reach 9% in some of the panels.
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Figure 3 Diagrammatic section showing the position of the mineralization in the buttonhole of the High Moulouya and its coverage, according to Emberger (1965b), (approximate scale).

2.3. Lead Potential
The Zaida lead deposit is listed internationally as Sandstone or Red-Bed type deposit. It has, for instance, been listed in the Mineral Deposit Models, USGS Bulletin 1963 and 1987 editions.

- Keeping in mind that proved reserves are higher than 9 million tons, the correlation between the deposits proportions of this kind present on the globe and the reserves in millions of tons reveals that Zaida deposit is within the top 30% category.
- It is also true for the correlation between the deposits proportions of this type and their lead content. In other words, for an average lead content of 3%, the Zaida deposit is within the 30% range.

Numerous studies were conducted during the 1965-1985 period and provided the following:
- Core drillings; 30500m
- Destructive drillings; 170000m
- Geological maps on a scale range; 1/50000 to 1/200
- Geochemical studies;
- Geophysics studies; Electric and gravimetric methods.

The studies cited earlier allowed the illustration of the proved reserves mounting to 18 million tons averaging 3% lead content.

2.4. Extraction Method
Zaida will be mined as an open pit mine. The Arkose thickness averages between 2m to 7m, 0 to 50m of overburden. The overburden to the Ore ratio averages around 2.55. This Open-pit mine will involve:

- Removal of overburden will be carried out by:
  - Blasting,
  - Excavators
- Loading will be carried out by Backhoe loaders
- 32 to 40-ton capacity trucks will carry out transporting the broken ore to a mill for processing.
We intend, however, to initiate few changes. This will be carried out in order to improve the quality of the concentrate produced by the newly installed plant. All of which will be done within the environment protection set of rules.

The processing plant will be built according to the following flowsheet:

- The crushing phase is designed in three steps. The ore will be fed at a size of 0 to 1000 mm. The product will come down to a ore of a size of 10 mm.
- The ore will be grinded to a size of less than 290 micrometer
- A silo of a capacity of 10000 tons will be installed between the crushing and the ball mills.
- The floatation phase is schematized with a conditioner and floatation cells. The cells will insure the roughening and the backwashing.
- The final product will go through thickening and consequently a filtering phase.
- The tailings will be pumped out straight to the tailings dam.

Figure 4 Illustration of the processing plan of the lead extraction

3. PROJECT’S VALUATION METHOD
3.1. Particularities of Investment in Mining
When managers estimate what it costs to invest in a given project and what its benefits will be in the future, they are coping with uncertainty. The uncertainty arises from different sources, depending on the type of investment being considered, as well as the circumstances and the industry in which it is operating. Uncertainty can result from economic factors, market conditions, taxes, and interest rates, among many other sources.

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 [5].

The main sources of uncertainty arising at the beginning of a mine project can be categorized into three groups:
- Exploration uncertainties: such as geologic uncertainty, data collection, interpretation, modeling, deposit classification, reporting and so forth.
Engineering uncertainties include bench heights determination, planned grade control, minimum stopping widths, choice of stopping method, dilution factors, geotechnical and hydrological parameters, mining recovery factors and metallurgical recovery.

Economic uncertainties represent one of the most crucial sources of uncertainty and, if left unchecked, may have a critical impact on the evaluation of the mining project. The fluctuation of commodity prices and the exchange rate are, singularly and combined, the most important external uncertainties facing mining companies.

According to the results of a Canadian Mineral Economics Society survey, where respondents were asked to rank a list of mining project risks, the highest risk comes from mineral reserves and ore grade, then political, social and environmental, metal price, profitability/operating cost, location, capital cost, management and so on [6]. Blais et al. [7] mentions that the mining industry has been increasingly focusing on using a sophisticated approach to define the effect of risk on the project value and mine policy. Moel and Tufano [8] carried out an empirical study to define the main reasons for annual mine opening and closing decisions using 285 developed North American gold mines in the period 1988–1997. The decisions on mine closures are affected by the price and volatility of gold, operating cost, proxies for closing costs and size of the reserves. It is documented that the mine opening and closing flexibility is used frequently and the project evaluation technique needs to capture these flexibilities. Lilford and Minnitt [9] studied project valuation methodologies for mineral deposits. At the end of the study, it was concluded that the selection of the valuation methodology depends on the ability to correctly interpret all of the available information and fundamental factors (commodity prices, exchange rate, technical information, economic information, comparative transactions, uncertainty risk) required for each valuation methodology in order to guide selection process [2].

These sources of uncertainty influence future cash flows. Thus, managers need to assess the uncertainty associated with a project’s cash flows in order to select value-adding projects. One of the challenges in evaluating an investment opportunity is capturing the flexibility options that a project offers.

3.2. Proposed Valuation Method: Real Options

3.2.1. Presentation and Definition

Real option’s definition is the right but not the obligation to make favorable future choices regarding real asset investments. The methodology of real options is still unknown by many project managers, yet this approach is derived from the financial options. Real Options Theory is based on the analogy between investment opportunities and financial options. The literature in the area is relatively recent, almost four decades.

The Real Options methodology was developed, at least partly, as a response to the inadequacy of traditional methods for the evaluation of capital budgeting decisions under uncertainty, namely Net Present Value and Decision Analysis. Since its inception, the Real Options methodology has gained acceptance among the finance community, and has been applied to a variety of capital investment decisions.

3.2.2. Historical Review

Options valuation was introduced when Black and Scholes [10] established a mathematical derivative model known as the Black-Scholes option pricing model back in 1973. Based on their model in 1977, Myers [11] used, for the first time, the term "Real Options (RO)" observing that corporate investment opportunities can be viewed as call options on real assets, pointing out the similarities between the financial options and the real options.
In 1985, Brennan and Schwartz [12] applied option pricing techniques to the evaluation of irreversible natural resource investments. They studied the problem of how to estimate the value of a copper mining project with a high-risk cash-flow. In their research, they constructed a financing portfolio including short-term assets of futures contracts, and long-term assets of mineral resources, and then obtained a partial differential equation of copper values.

The energy sector, since 1970, has suffered market, regulatory and technological changes. In this new context traditional capital budgeting methods are no longer sufficient to properly evaluate investments in this sector. This change opened the way to the application of the real options theory. An increase on the interest and application of the real options theory to the energy sector decision making has been noticed during the last years, as seen in the presented literature review, this theory has been used to all sectors in the energy. This increase reveals that the interested parties in the energy sector now understand the limitations of the traditional techniques, given the potential of the real options theory. The renewable energy sector is no exception and a few studies using the real options theory appeared recently in the literature, although this particular literature is still limited.

Despite extensive research in investments under uncertainty using real options in natural resources investments, only a limited literature addresses mining project evaluations using real options under uncertainty [13].

4. RESULTS AND DISCUSSION

4.1. Financial Market and Context

The world production of lead was of 5.3 million tonnes in 2013, with a progression of 6.4% over the previous year. The production of lead depends from the international demand, mainly China, 1st producer and consumer of the metal in the world, but also by United States, Europe and the emerging countries. The main market is the automotive industry, which is growing at an annual rate of over 8%.

On a long-term view, the growing demand of lead is at 2.8% since 1977, with an increase at 3.9% since 2000. This trend must continue in the future.

Until 2025, Deutsche Bank expects an annual demand of 15 millions of tons of refined lead growing at an annual rate of 2.5%. That implies an annual growth of 3.8 to 4.8 million tons per year in 10 nearly years.

Deutsch Bank expects an indicative price of lead of $2095 per ton in 2016 and at more long term reaching $2400 per ton in 2018.

Figure 5 Lead 10 years Historical Price Chart.
4.2. Review of the Investment
Given the history of the mine of Zaida, plus the updated geological and engineering studies and based on the clear Lead potential of this mine, it had therefore initiated an investment of about $6 Million.

This amount was invested mainly towards the following but not only:

- The acquisition of the mining licenses;
- The Geological, Engineering and Environmental studies.
- The Acquisition of the equipment required to building the processing plant.
- The plant of Zaida still required an additional investment of 97.5 million dirhams for the following reasons:
  - Mounting the exiting equipment for 15 million dirhams
  - Acquiring and mounting the new equipment to reach the full capacity of processing 1.2 million tons of mine ore per year, for 82.5 million dirhams

We assume this additional investment of 97.5 million dirhams to be made in the first quarter of 2018. The total amount that has been invested to reopen, explore and launch production of this mine is: 103.5 million dirhams.

The profitability analysis was done over 10 years of mine production, considering the lead price as the most important source of uncertainty with a price volatility of 23.7% and a risk-free rate of 5%.

4.3. Results & Analysis
The valuation of the mine is conducted using the real options methodology, by adopting a combination of options for a better valuation and optimization use of flexibility inherent in them. The managers have the possibility to choose between 3 different options thus strategies as previously established and explained in details in previous work [14]:

- To EXPAND the production of the mine of 40% by investing 40 million Dirhams,
- To keep the option open and wait and see future changes,
- To Contract 60% its production to save 50 million Dirhams.

The calculations of the options values have been done using a binomial tree for this application [15]. Figure 6 represents the final version and the results obtained using this methodology.

Numerical results of the real options valuation of the mine project in Zaida, using the option to choose, provided a value of 132 million. MAD. The initial investment of the project was 103.5 million. MAD. The difference of 28 million. MAD is the substantial added-value to the project by real options which management can take into consideration in making the project decisions. Figure 6 shows the strategic choices this project’s managers would make at different points during the option life.

It also appears that, at the end of the 10 year, the mine is highly productive and the expansion of its production is recommended given the fact that the option’s value at this node is more than 1510 million. MAD.
Moreover, this study was conducted only on a short period of time (10 years) which is obviously not enough to explore the total capacity of the mine, but only to provide a glimpse of the project’s profitability for investors and to encourage mining engineers to develop more competitive technologies to expand the extraction rates of this mine as recommended earlier.

5. CONCLUSIONS

This paper proves that reopening the Zaida mine in Morocco is a profitable project for the investors who conducted a series of geological and mining studies in order to assess this project’s potential. In fact, the reserves level determined by the mineral engineers are very promising given the lead’s upscaling prices for the next years.

For this study, dealing with the mining project uncertainties came up to concentrating on the high volatility risk one: the ore price. To properly visualize the development of the mine’s profitability, the real options methodology was introduced as a strategic tool capable of integrating the risk factor in order to proactively manage the future years’ flexibilities and take advantage of the market’s changes to help the growth of the mine’s production and maximize the gains. Thus, the project turned out to be highly profitable and promising.
The real options had proven once more their powerful effect over handling investment projects uncertainties and proactively managing future changes. This methodology should be applied more often in the mining industry and the infrastructures projects overall.

REFERENCES


