RELEVANT ASPECTS OF MINING PROJECT EVALUATION

Mirela Iloiu[1], Sorin Iloiu[2]

[1]University of Petrosani, 332006, mirelailoiu@yahoo.com
[2]University of Petrosani, 332006, soralisu@yahoo.com

ABSTRACT. Investment projects in mining industry are considered as being risky. The main difficulty of the project evaluation process is how to deal with the uncertainty involved in capital investment. This paper presents four methods used for evaluating mining projects: Discounted Cash-Flow analysis, Decision Trees, Monte Carlo Simulation and Real Options Also, pros and cons of them are discussed in the final section..

НЯКОИ АСПЕКТИ ПРИ ОЦЕНКА НА МИННИТЕ ПРОЕКТИ

Мирела Иойу[1], Сорин Иойу[2]
[1]Университет Петрошани, Петрошани, Румъния, 332006, e-mail:mirelaloiu@yahoo.com
[2]Университет Петрошани, Петрошани, Румъния, 332006, e-mail:soralisu@yahoo.com

РЕЗЮМЕ. Известно е, че инвестиционните проекти в минната промишленост са едни от най-рисковите.Основният проблем при тяхната оценка е да се определи степента на сигурност на капиталовото инвестиране. Докладът разглежда четири метода за оценка на минните проекти: Анализ на кешовите потоци, Дърво на решенията, Метод на Монте Карло и Метод на реалните опции, техните предимства и недостатъци.

Introduction

The use of adequate project evaluation techniques is more important in the mining industry than in the other industries. This is because the mining projects are extremely capital intensive, requires many years of production before a positive cash-flow commences and tHeir life is much longer 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.

The risk of a mining project comes from the uncertainties involved in the industry. These uncertainties can be internal and external. Internal sources of uncertainties relate to the orebody model and in-situ grade distributions, technical mining specifications such as ground condition, equipment capacities, workforce and management. The external uncertainties consist of commodity price, political/country risk, environmental conditions, legislation and government policy.

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. For example a ±10% change in grade and tonnage can have a significant effect (35%) on project cash flow. An empirical study carried out 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 decision on mine closures are affected by the prices and vollatility 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. The selection of a 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.

Mining project evaluation techniques

Discounted Cash Flow analysis

One of the most common evaluation methods for mining projects is the DCF method. DCF techniques constitute the basis of investment decisions for most mining companies. In 1995 Bhappu and Guzman surveyed 20 mining comapnies from USA, Canada, Mexico, Australia and Great Britain and obtained the results shown in Table 1. Almost all the companies use one of the DCF techniques for their investment decisions.

Table 1
Priorities of 20 selected mining companies for investment decisions

Priorities	NPV	IRR	Payback period	Other methods
Primary	8	11	3	3
Secondary	5	3	6	0
Tertiary	0	1	2	0

The DCF technique evaluates the whole project by adjusting, or discounting, the project net cash flow for the effects of risk and time. The greater the project risk, the higher the discount rate should be. Under this method, Net Present Value (NPV) , Internal rate of Return (IRR) are the most common methods for evaluationg a mining project.

Net Present Value

It is the difference between revenues and costs calculated at the minimum rate of return. In other words NPV = Present Worth of Revenues and Savings. If the NPV is positive, there is more than enough revenue to cover costs at the minimum rate of return.

Internal Rate of Return

Although it is the most preferred evaluation technique, analyses of total investment rate of return alone will not always lead to the correct economic choice because the project with the largest total IRR is not always the best one. Incremental Investments IRR must be used for evaluation of mutually exclusive multiple investment analysis.

The Decision Tree method

Decision Tree analysis is a method which comes from operation research and game theory. The method estimates the probability of possible outcomes of a project by generating appropriate decision branches that have probabilites of their likelihood of occurence. It is a flowchart or diagram representing a classification of a system or of a probabilistic model.

The tree is structured as a series of simple questions. The answers to those questions generate a path down the tree. The values are determined for each of the possible outcomes in the analysis. In order to construct the decision tree, all the appropriate decision nodes, represented by squares, i.e. whether to make the investment or not, and uncertain event nodes, represented by circles,i,e, ore grade, commodity price, project investment, ore recovery. Branches are straight lines that emanate from the nodes. At the end of each branch the generated NPV is denoted.

The decision tree allow for the decision maker to break down a large, complicated problem into a series of smaller, simple problems. The decision maker can see the whole picture of the project and the outcomes of the possible routes with respect of NPV. In addition, a sensitivity analysis can be generated from the outcomes in order to see which variables (price, ore grade, production cost) impact more on the expected NPV of the project. Decision Tree method is mostly utilised in the probabilistic analysis of mining projects.

Monte Carlo Simulation

This technique has been used increasingly as an important tool for analysing projects with uncertainty because of the development of computer technology. The fisrt step, in order to perform a Monte Carlo Simulation, is to develop an analytical model to evaluate. The second step is to generate a probability distribution from subjective or historical data for each variable (not defined) in the model. The method calculates the outcome of the project by using the marginal distribution of all the parameters appearing in the NPV equation. The method uses statistical distributions, such as normal, lognormal, triangular, and uniform, to evaluate the uncertainty in the parameters within the project. In every simulation the values are selected randomly from each parameter distribution for every time period and substituted into the NPV equation in order to generate one possible outcome of the project. This process is repeated hundred or thousands of times so it will calculate an average or expected NPV of the project. The more simulations done, the more accurate the approximation of the outcome of the project will be.

In most cases, the variables are assumed to be independent from one another, in order to simplify the calculation. But, in reality, most of the variables are correlated. In mining, for example, ore grades are positively correlated with ore recovery. Similarly, the commodity prices are correlated between time periods. The method not only can be used as an important tool for the project uncertainty analysis, but with any other evaluation tool together also.

Real Options methods

Black and Scholes (1973) described a financial model for valuing options. Since that moment, puts and calls contracts began to be developed. These contracts give their owners the right, but not the obligation, to sell or buy a specified number of shares or a quantity of a commodity such as gold, copper, oil at or before a speccified date. If the option is exercised only on the expiration date specified in the option contract, this option is called a European. If it takes place any time, it is called an American option. A European option is easier to evaluate than an American option because while the European option can only be exercised on a specific date, the American option can be exercised at any time up to the maturity date.

An option valuation technique is mainly based on the flexibility of the project. The more flexible the project is, the more valuable it is, because it allows the owner to respond to future events in ways that will increase the value of the firm. Option valuation gives extra value to the project because of flexibility. Keswani and Shackleton (2006) show that the value of the projects can increase very much wuth increasing

degrees of future managerial flexibility. As I said before, mining projects mainly consist of a great amount of uncertainty and most of them require flexibility in order to generate the optimum strategy of the project.

One of the difficulties one might face when evaluating a mineral deposit using real options is finding an appropriate numerical procedure to perform the analysis out of several valid methodologies.

In last years, the standard DCF approach to evaluate the projects is gradually being supplemented with Real Option Valuation. Numerous applications have been practiced on mining projects using Real Options and comparing the results with DCF.

Comparative analysis

The similarities and the differences between the valuation techniques are presented below:

Uncertainty in the values of input parameters

DCF methods assume that the input variables, such as price of the commodity, ore grade, recovery, mining and processing cost and production rate, are known with certainty for the entire life of the project. The risk associated with these variables across the time and projects is managed in a constant manner – using a constant discount rate. Decision Tree method eliminates this disadvantage by giving dicrete probabilites of occurence for these variables. The tree gets larger as the number of occurences of these variables. Monte Carlo method uses probability distributions (normal, lognormal, triangular and unform distribution) for input variables. In this case the expected NPV from the project is presented as a histogram. Related to Real Options, price is the principal source of uncertainty. Anyway, less studies have been done on other input parameters (ore grade, costs, ore reserve) because real data ob them are very difficult to obtain. Accuracy of the input parameters of a mining project is the main factor for reliability of all methods.

Managerial flexibility

The DCF method assumes that the scenario and the project life are fixed. The management will not be able to react to gold price changes or the emergence of technological developments. Decision Tree analyses different managerial strategies and calculate all the outcomes from the strategies. On the other hand, Monte Carlo Method focuses on modelling the uncertainty with the input parameters and ignores the managerial strategy. Generated NPV distributions represent the project outcomes beforehand. Real Options studies possible management choices such as "wait one more year to begin the project in order to reduce the unceratinty in the variables", temporary shutdown – when the price is lower than

it can be, permanent closure – when the price drpos too low too long. In conclusion, Real Options assume a multi dimensional dynamic series of decision, where manager has the flexibility to adopt and correct as the new information becomes available and uncertainty is resolved.

The time value of money concept

The three methods: Discounted Cash Flow, Decision Tree and Monte Carlo method use the traditional discount rate; Real Options uses a risk free rate in order to consider the time value of money in the evaluation of the project. The selection of the correct discount rate is the most important decision because it affects the outcome of the projects when we apply the first three methods. In most cases, discount rate is the most sensitive variable and the most difficult variable to correctly quantify. The value of the discount rate reflects bothe time value of money and the riskiness of the project. Real Options is a risk natural valuation approach, in which futute cash flows are discounted at the risk free rate.

Complexity of the methods

Discounted Cash Flows methods have been used in most of the mining companies because it is easy to calculate and does not require a deep knowledge of the economy. Discount Tree is also easy to calculate, but it has the disadvantage that as the number of the possibilities increases, the tree grows exponentially. Related to Monte Carlo method, there are sophisticated software available for calculation and to Real Options – it is easy to evaluate European options but is more difficult to evaluate American options.

Conclusions

A perfect project evaluation method gives the answer to the following questions: First - when to make the investment and development of the project ? and second – how much to produce annualy?. All four methods presented above can be used in project evaluation, but there is no single method we can say that is entirely adequate for the evaluation of mining projects.

Although Discounted Cash Flow method do not allow for managerial flexibility, all the input parameters are known with certainty for the entire life of the project and decisions are made on a „now or never'' basis, so the usage of appropriate discount rate is very important.

Decision Tree analyses different managerial strategies and calculate all the expected NPV from these strategies and it is helpful to see the whole picture of the project. It can be misleading when the discrete probability of the variable is not estimated correctly. Also, the Decision Tree method can get complex when the number of variables increases. This method

is mostly utilised in the probabilistic analysis of the mining projects.

Monte Carlo method tries to reduce the uncertainty on the variables by assigning statistical distribution on the project's parameters. The decision maker can see possible outcomes of the project and develop an optimal investment scenario. This method can be used as an important tool for the project uncertainty analysis, but with any other evaluation together.

The evaluation of the mining projects is very difficult because of the uncertainty on the input variables. It is very important to have managerial flexibility on the evaluation of the project. Real Options studies possible management choices and uses certain models for the behaviour of the variables. The projects in mining industry which operates under uncertainty and management have the strategic and operational flexibility. Real Options provide much better reliable information and value for the evaluation of the project compare to other methods.

REFERENCES

Bhappu R., Guzman J., *Mineral investment decision making*, Engineering and Mining Journal, 1995

Black F., Scholes M., *The pricing of options and corporate liabilities*, Journal of Political Economy, 1973

Bowlin O.D., Martin J.D., Scott D.F.,*Guide to Financial Analysis,* McGraw Hill Inc., 1990

Duchene M., *Economie de l'entreprise miniere*, Ecole Nationale Superieure des Mines, Paris, 1990

English J.M., *Project Evaluation – a Unified Approach for the Analysis of Capital Investment*, Macmillan Publishing Co., New-York, 1984

Keswani A., Shackleton M.B., *How real option disinvestment flexibility augments project NPV*, European Journal of Operational Research, vol.168, 2006

Stoica M., Ioniţă I., Botezatu M., *Modelarea şi simularea proceselor economice*, Editura Economica, Bucureşti, 1997

Recommended for publication of Editorial board