GOSPODARKA SUROWCAMI MINERALNYMI

Tom 18 2002 Zeszyt 4

PIOTR SAŁUGA*

# The new instruments in mineral projects evaluation

Key words

Mineral projects, economic evaluation, new methods of evaluation

Abstract

Discounted cash flow analysis (DCF) is worldwide used tool of mineral projects evaluation. Practice shows, however, that these techniques systematically undervalue mining projects. This defect of DCF technique is partially compensated by popularized in last years option-pricing methods, which were adopted from financial market practice. Such methods allocate value to managerial flexibility. Option-pricing research shows that this methodology always provides with higher values than DCF technique. The primary objective of this paper is critical assessment of classic discounted methods and presenting, as an alternative, the methodology based on option theory.

## Introduction

The discounted cash flow analysis (DCF) forms the basis of most investment decisions. These techniques use predicted yearly cash flows, adjusted for the time value of money.

There are two basic measures of project feasibility for use in DCF analysis:

1) net present value (NPV), which is a measure of value or of a stock of wealth,

2) internal rate of return (IRR), also called discounted cash flow rate of return (DCFROR), which is a measure of the efficiency of capital use or the rate of accumulation of wealth.

The formula for NPV can be written as

$$NPV=\left[\sum_{t=1}^{n} \frac{CF_t}{(1+i)^n}\right]-I_0$$

* M.Sc., Polish Academy of Sciences, Mineral and Energy Economy Research Institute, Kraków, Poland.

Reviewed by Prof. Roman Magda

where

$CF_t$ — cash flow in year t,
$I_0$ — initial investment = $CF_0$,
i — discount rate,
n — total number of years for project.

IRR may be defined as that discount rate at which NPV equals zero

$$NPV = 0 = \left[\sum_{t=1}^{n} \frac{CF_t}{(1+IRR)^n}\right] - I_0$$

DCF techniques still are basis of investment valuation. Nevertheless many practitioners claim to be dissatisfied with them. NPV and IRR — in spite of their simplicity and popularity — have some crucial shortcomings. The most important can be listed as follows:

1. Cash flows must be forecast over the expected lifetime of the project — the input values must be known with certainty, and there must be no uncertainty or risk.
2. An appropriate, correct risk-adjusted discount rate must be obtained.
3. The DCF analysis assumes that a project will be undertaken today and will continue to produce until reserves are depleted. It does not take into consideration the managerial flexibility in choosing the timing of projects and then, once the mine is operational, the managers' discretion concerning output rates, cut-off grades, capacity expansions, temporary closings, reopenings, and eventual abandonment of a venture.

These are the reasons, why DCF techniques systematically undervalue mining assets (Moyen et al. 1996; Davis 1998; Dzieża et al. 2002). The value of above-mentioned flexibility distinguishes methods based on option theory from DCF analysis. In particular, mineral projects contain option-like characteristics that enhance their value that is not taken into account in DCF calculations.

## Comparison between financial and real options

A financial option gives the owner the right, but not the obligation, to buy (a call option) or to sell (a put option) a specified number of a financial asset (underlying asset) for a specified price (the exercise price) on or before fixed date. If the option is not exercised by that date, it expires and become worthless.

Since this right has a value, options have price. So that modern methods that adjust for risk and allocate value to flexibility have revolutionized financial market practice. The basic method of option pricing was developed by Black and Scholes (1973). All the option-pricing techniques are, unfortunately, sophisticated.

The term "real option" was first used by S. Myers (1977), who identified the fact that many corporate real assets can be viewed as financial call options (first application to mineral industry was introduced by Brennan and Schwartz (1985). Indeed, investing in a mineral project has much in common with exercising a financial option. First, both are at least partially

irreversible — once a financial option has been exercised it is worthless, and once development of the project has started, investment expenditures cannot be recovered. Second, the exercise timing is essential. Table 1 indicates comparison between financial and real options for undeveloped mining property (Paddock et al. 1988; Moyen et al. 1996).

TABLE 1

Comparison of the terminology of financial options and undeveloped mining properties

TABELA 1

Porównanie terminologii modeli wyceny opcji finansowej na akcję i opcji realnej (tu: złóż nieudostępnionych)

| Financial option | Undeveloped mining property |
|---|---|
| Current asset price | Present value of developed reserves |
| Variance of rate of return on asset | Variance of rate of change of the value of developed reserves |
| nowidctlparExercise price | Per unit development cost |
| Expiry date | Relinquishment requirement |
| Risk-free discount rate | Risk-free discount rate |
| Dividend | Cash flow net |

Although there exist substantial similarities between real and financial options there are also important differences. First, for real options it is important to consider the time to 'build' underlying asset (for mining projects there is a lag between the dates of investment expenditure and production start-up). Second, real options have longer expiry dates than financial options. At the end, most real assets are equivalent to a sequence of options (Fig. 1): purchasing a property gives the owner right to explore, exploring results give him the option to develop, and finished development phase gives him the option to mine. After a mine is fully operational the owner has the option to expand, to close temporary or to abandon a venture.

## Results of option pricing methodology

Using option price methodology one gets more precise results than these obtained form DCF analysis. The typical sensitivity graph is shown on Fig. 2. It plots the estimated value of a developed zinc-and-lead deposit, calculated using both DCF and option pricing methods (Saługa et al, 2002). Where zinc price is low, production is uneconomic and NPV is negative, but the reserves still have an option value. When price is high, the reserves have a positive NPV, but their option value is higher than NPV. The difference between net present and option values is a premium attributed to the flexibility to close temporary (or abandon) when price is low and to stay operating (or to expand) when price is high. The both lines get nearer as prices become higher. That is because of depreciation of the option value. It is no use waiting, when prices are high enough. In these cases NPV becomes a quite good proxy for the project value.

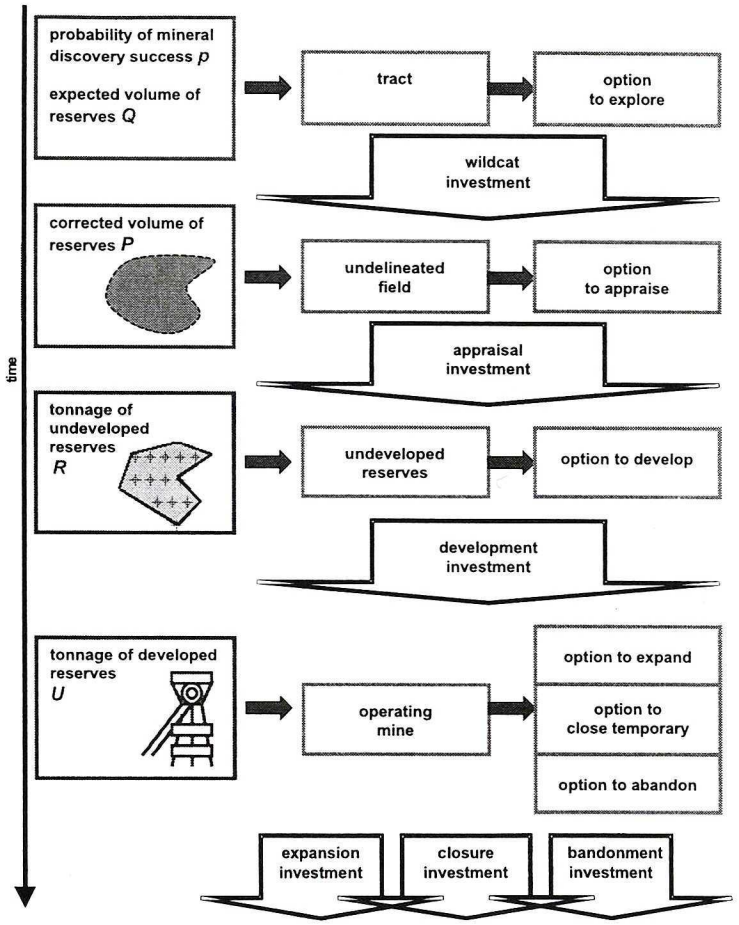


Fig. 1. Sequential options in exploration and mining (Dias)

Rys. 1. Sekwencje opcji realnych w działalności geologiczno-górniczej (Dias)

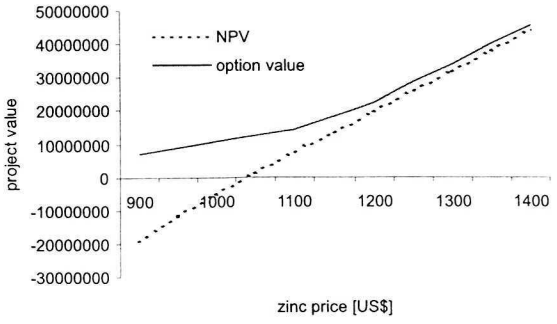


Fig. 2. Sensitivity of net present and option values of a developed zinc-and-lead project to zinc price

Rys. 2. Wrażliwość wartości NPV i wartości opcji udostępnionego złoża cynku i ołowiu na cenę cynku

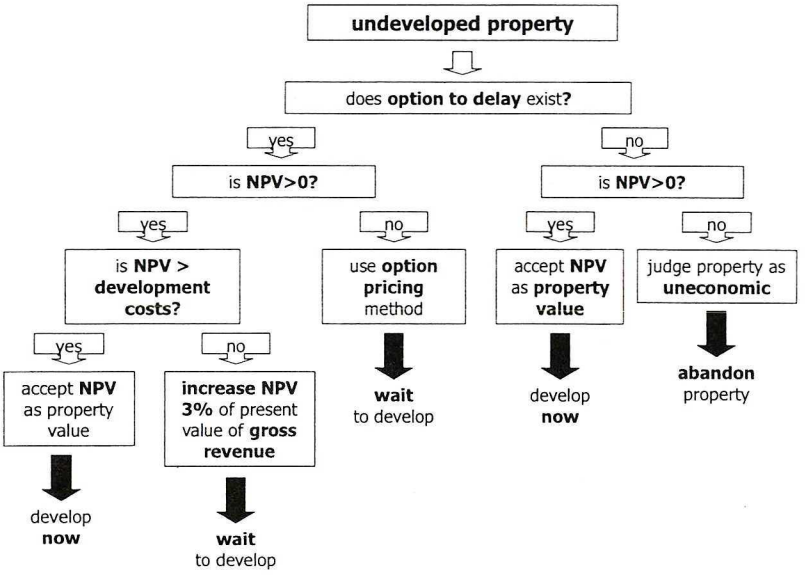


Fig. 3. Guidelines for selection of the economical evaluation techniques methodology for undeveloped mining properties

Rys. 3. Metodyka postępowania w zakresie doboru technik oceny ekonomicznej dla złóż niezagospodarowanych

Interesting is that in all case option pricing delivers positive values of a venture and that this methodology always provides with higher values than DCF technique. But, as we can see, option value is in some cases essential; in other it is less important. For this reason, even though it gives better results, it should be considered, whether the use of this methodology is worthwhile, due to its laborious and time-consuming procedure. With regards to the above let present suggestions, which method is more appropriate for given circumstances. Fig. 3 shows guidelines for selection of the proper economical evaluation techniques methodology for undeveloped mineral properties (Davis 1998; Saługa 2002).

## Summary

DCF analysis is worldwide used tool of mineral projects evaluation. However it can be frequently observed that mineral projects' NPVs calculated by this technique are lower than their market values. The explanation of these valuation surprises is that DCF analysis is not correct valuation method for mineral projects. In last years have been popularized the new instruments of mineral projects evaluation, based on option theory. The real option pricing research shows that this methodology always provides with higher values than DCF techniques. It is because of possibility of allocating value to managerial flexibility. In spite of the fact that option-pricing methods deliver more realistic estimates than DCF technique, they are always not worth conducting because of its complicacy. The put efforts cannot be sometimes compared to

obtained results. So, in some cases DCF value can be viewed as quite good proxy of evaluation. The importance of option value increases as efficiency of the project become much more uneconomic. Option pricing methods are the only methods for valuation properties with negative NPV.

As we can see option pricing methodology may not be appropriate for all investment situations. However combining it with DCF analysis, Monte Carlo simulation, decision trees, and mathematical programming promises to become extremely useful for project evaluation.

## REFERENCES


Black F., Scholes M., 1973 — The pricing of options and corporate liabilities. Journal of Political Economy, 81.

Brennan M.J., Schwartz E.S., 1985 — Evaluating natural-resource assets. Journal of Business, 58.

Davis G.A., 1998 — One project, two discount rates. Mining Engineering, April.

Dias M.A.G.: http://www.puc-rio.br/marco.ind.

Dzieża J.A., Kicki J., Saługa P., 2002 — Real options in mine projects budgeting — Polish mining industry example. Risk Analysis III, WIT Press, Southampton, 2002.

Paddock J.L., Siegel D.R., Smith J.L., 1988 — Option valuation of claims on real assets: The case of offshore petroleum leases. Quarterly Journal of Economics, vol. 103.

Moyen N., Slade M., Uppal R., 1996 — Valuing risk and flexibility: A comparison of methods. Resources Policy, vol. 22.

Myers S., 1977 — Determinants of capital borrowing. Journal of Financial Economics, vol. 5.

Saługa P., Dzieża J., Kicki J., 2002 — Real options in mineral projects evaluation (in Polish). Mineral Resources Management, vol. 18 — Special Issue. IGSMiE PAN, Kraków.

Saługa P., 2002 — Importance of option value in mineral project evaluation (in Polish). Mineral Resources Management, vol. 18 — Special Issue. IGSMiE PAN, Kraków.


PIOTR SAŁUGA

**NOWE INSTRUMENTY W OCENIE EKONOMICZNEJ GÓRNICZYCH PROJEKTÓW INWESTYCYJNYCH**


### Słowa kluczowe

Górnicze projekty inwestycyjne, ocena ekonomiczna, nowe metody oceny



### Streszczenie

Techniki zdyskontowanych sald pieniężnych (*discounted cash flow*, DCF) stanowią obecnie podstawę większości decyzji inwestycyjnych przedsiębiorstw. Jednak — jak pokazuje praktyka — techniki te systematycznie zaniżają wartość górniczych przedsięwzięć inwestycyjnych. Wadę tę częściowo rekompensują zaadaptowane z rynków finansowych i popularyzowane w ostatnich latach metody wyceny opcji realnych. Metody te przypisują konkretną wartość elastyczności decyzyjnej inwestorów. Badania w zakresie wykorzystania opcji realnych wskazują, że stosując tę technikę otrzymuje się wartości zawsze wyższe od wartości uzyskiwanych z analizy DCF. Celem artykułu jest krytyczna ocena klasycznych metod dyskontowych oraz przedstawienie, jako alternatywy, metodologii opartej na modelu wyceny opcji.