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A practical real option methodology for the evaluation of farm-in/out joint venture agreements in mineral exploration

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A B S T R A C T

Although the "real option valuation" (ROV) methodology offers extremely valuable insights in optimising investment decisions in the face of uncertainty, its practical acceptance in the mining industry has until recently been slow because of its perceived computational complexity. Recent conceptual advances in the use of binomial lattices and software developments in the areas of decision trees and dynamic programming, have significantly simplified ROV analysis and made it of practical application in day-to-day financial evaluations and decisions involving uncertainty. This paper provides general background on the ROV methodology and an example of how a typical farm-in/out agreement, as a preliminary to the establishment of a joint venture (JV), can be valued as a series of sequential and compound real options. For illustrative and quality assurance purposes, a simple farm-in/out agreement is valued from the point of view of the party acquiring equity in the project (the farm-inee) using two distinct methods, i.e. (a) a binomial lattice and (b) a decision tree in combination with binomial stochastic processes, in both cases neutralising risk using the user-friendly "risk-neutral probability". The fact that exactly the same ROV is obtained by both methods provides confidence in the modified decision tree approach, which opens up the capacity to value the more complex sequential/compound real options inherent in real-life farm-in/out agreements. The model is then modified to incorporate a number of realistic contractual conditions often encountered in typical exploration and mining farm-in/out deals. The paper demonstrates how the increased complexity of the model can be relatively easily addressed using a decision tree with dynamic programming capability.

Introduction

Farm-in/out agreements: general considerations

Every day, a large number of mineral exploration projects become the subject of farm-in/out agreements. Farm-in/outs are mechanisms to acquire/divest equity in a project as a preliminary to the establishment of a joint venture (JV).

The motivation for divesting equity through a JV may be to spread risk and/or raise the funds necessary to advance a project to the next and more expensive phases of exploration, while the acquiring party or farm-inee may be driven by strategic and fiscal corporate considerations.

Typically a farm-in/out is a clearly staged contractual arrangement whereby the farm-inee acquires the right but not the obligation to advance to and fund successive phases of exploration and development while gaining equity in a project. Asides from firm commitments to fund exploration programs as agreed for each successive stage, consideration may also include cash and/or other forms of payments such as in shares or options or the granting of a royalty on future production. Successful exploration progressively dispels uncertainty and increases the value of a project, thus justifying progression from the less expensive initial exploration stages, to more expensive expenditure commitments to deeper drilling, resources delineation and feasibility studies.

Frequently increased expenditure commitments are matched by progressive acquisition of equity in the project until the desired equity split is reached and the final joint venture is established.

If, on the other hand, exploration is unsuccessful, diminishing the prospectivity and therefore the value of a project, then the farm-inee can decline to progress to the next stage and leave the JV altogether generally with no penalty and sometimes retaining some equity in the project.

This right but not the obligation to advance or not to successive stages of a farm-in/out agreement, for which the conditions had been firmly set at the start, represents a sequence of real call options on the project in the hands of a farm-inee (Estrada et al., 2009; Amram and Kulatilaka, 1999, p. 156). This makes the real option valuation (ROV) methodology ideal to value this type of agreements.

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An outline of the real option valuation (ROV) methodology

Following awarding of the Nobel Prize for Economics to Black and Scholes (Black and Scholes, 1973) in 1973, a significant body of research has been developing about the application of option pricing theory to the valuation of contingent options or contingent claims on underlying non-financial or "real" assets, hence the name "real option" valuation or ROV coined by Myers (1977). A number of seminal books have since then been written on the subject of real options (e.g. Trigeorgis, 1996; Dixit and Pindyck, 1994; Copeland and Antikarov, 2003; Munn, 2002; Amram and Kulatilaka, 1999), but none specifically on the application of this methodology to the valuation of mining projects.

Interest in real options has initially been mainly academic because its relative conceptual and computational complexity discouraged broader commercial and industrial application. With recent development of more user-friendly computational techniques and training courses, however, the ROV methodology is gaining broader acceptance by industry including the resources sector.

A call option is the right but not the obligation to buy an asset on or before a pre-determined expiry date and for an exercise price (X) set in the present. An option is valuable if the value of the underlying asset is volatile as measured by the standard deviation (σ) of annual returns from holding the asset and if there is time (T expressed in years) to the expiry date of the option. Because an option is not an obligation, one would exercise it only if on or before the expiry date the value (or spot price) of the asset (S) exceeds X, otherwise the option would be left to expire. Thus the optimal decision rule for a call option is MAX($S-X$ or zero).

All the parameters necessary to value financial derivatives based on underlying standardised assets (shares, commodities, etc.), continuously traded in efficient markets largely devoid of opportunity for arbitrage are easily estimated using statistical techniques. This is not the case for options on real assets such as mineral and petroleum projects which are very different from one another and infrequently traded in generally less efficient markets.

There are essentially two ways of overcoming this difficulty: the "twin security" (Borison, 2003) and the "Market Asset Disclaimer or MAP" approach (Copeland and Antikarov, 2003, p. 94).

The first entails using the parameters of an unleveraged listed security regularly traded on the stock exchange with similar assets and risk characteristics as those of the project under consideration.

The second (MAP) approach is to recognise that, similar to financial assets, the value of a mineral project, hence a proxy for its spot price (S), is the present value of all its future net after-tax operating cash flows and that the exercise price (X) necessary to acquire them is the present value of all initial and future capital investments in the project (Copeland and Antikarov, 2003, p. 94). Both S and X are of course influenced by broad economic (commodity prices, exchange rates, etc.) and project-specific (quantity and quality of the resource, etc.) uncertainty, but their mean or expected values can be derived from the base case cash flow model of the project discounted at an appropriate risk- and time-adjusted discount rate (RADR). This value is generally referred to as the "fundamental" value of the project. Consistently the volatility (σ) will be the annualised standard deviation of the returns from holding an asset (Benninga, 2008, p. 515), in the case of a mineral project being that of the net after-tax operating cash flows. As discussed later, σ is the hardest parameter to estimate.

While there is generally a high degree of correlation between the "fundamental" value of a firm and its capitalisation on the market, the latter includes a "market premium" which is generally, but by no means always, positive and highly variable in response to changing market sentiment.

Real option value (ROV) is essentially the value of flexibility, inherent to or designed into a project or in a commercial deal, which allows managers to make successive decisions after gaining knowledge of emerging circumstances, i.e. with the "wisdom of hindsight" after uncertainty has been dispelled. Given flexibility a manager can judge the situation and take that course of action that maximises benefits or conversely minimises losses. ROV is normally not captured by the net present value (NPV) generated by static discounted cash flow (DCF) analysis, based on an inflexible base case and on a "now or never" attitude to investment, and needs to be added to it to determine the true or "expanded net present value (ENPV)" of a project (Munn, 2002, p. 168).

Real options can be:

- *Simple*, if there is only one alternative course of action to the *status quo*. For example the option to defer an investment until the results of a pilot plant are known, the option to expand operations by securing a right on neighbouring mineral resources, the option to abandon operations at minimum cost by building flexibility in labour and supply contracts, etc.
- *Multiple*, if more than one alternative, mutually exclusive course of action is open to the decision-maker. For instance the option to continue mining at the current run of mine throughput or to expand production to accommodate the extraction of lower-grade ore or to contract it to higher-grade ore or to abandon operations in response to variations in commodity prices. This option is inherent in many orebodies with wide tonnage-grade trade-offs and can be enhanced by appropriate mine design.
- *Sequential and compound*, if the decision-maker confronts a series of chronologically staged decisions which are conditional on one another. This type of option is very common in mineral exploration and mining given the staged nature of these activities. As already indicated farm-in/out agreements can be analysed as sequential compound options.
- *Switching*, if the system allows a manager to switch from one status to another and alternate between the two. For instance the value of creating flexibility to be able to switch power generation from diesel to gas or the value of designing and managing an economically marginal mine to facilitate intermittent temporary closures and re-openings in response to commodity price fluctuations.

There are many methods to calculate the value of an option and all, if correctly applied, give approximately the same result (Benninga, 2008, p. 465). These include:

- *Closed-form equations*: Most of these have been derived from the famous Black and Scholes formula (Benninga, 2008, p. 509) for which the authors were awarded the Nobel Prize in 1973. Closed-form equations give consistent results and are easy to use in the context of financial options, but based on assumptions which are unrealistic in the context of real options and incapable to handle their greater complexity.
- *Simulation*: This approach, while of academic interest, is of limited practical application in the context of real options in mineral exploration and mining.
- *Binomial lattices*: This method first described by Cox et al. (1979) and more recently covered by a book by Munn (2002) relies on the generation of a lattice of all possible values that the underlying asset may assume during the life of the option given that at each interval of time the asset value may either go up or down as a function of its volatility. The relevant maximisation rule is applied to all the asset value (S) combinations possible at the expiry time of the option after deducting from them the relevant exercise price (X) to determine all possible related option values. These are then