A crystal ball for cashflow valuations

*Predicting values of mining projects, even before feasibility studies have been undertaken, is an uncertain process but, says **Robert Duffin**, there are methods which can reduce the uncertainty.*

The valuation of development projects at the pre-feasibility stage is an important but often difficult task for specialist valuers of project assets. This paper focuses on the valuation of pre-feasibility mining projects, but similar issues to those discussed arise in studies of the commercial potential of projects in the manufacturing sector.

Discounted cashflow (DCF) methods have been routinely applied in valuing resources projects since the mid-1960s. Techniques are well developed (at least in principle, although there can be some tricky problems in practice) and the methodology is generally well understood by company executives and investment managers.

Issues to be considered in the valuation vary from the simple (for example, valuation of an operating colliery, where reliable production and cost reporting systems have often been in place for many years, and where there is little product price volatility and, generally, very limited resource risk) to more difficult (for example, valuing a highly geared polymetallic mine operating in an inflationary environment where commodity prices are volatile and where the mine's owners aggressively hedge their foreign exchange exposure). Gentry and O'Neal (1984) provide a comprehensive summary of the application of DCF methods for valuation purposes.

DCF analysis cannot be used in a meaningful sense to ascribe values to properties without quantified resources and reserves. Here, methods based on values related to exploration expenditure levels, or values imputed from commitments under joint-venture agreements, are more commonly used. A recent paper by Goulevitch (1991) provides a good summary of valuation techniques for these types of properties.

Between properties at the exploration phase and those in production lies a range of projects, including those in the pre-feasibility phase. Pre-feasibility projects are defined here as those where a resource thought likely to be viable has been outlined, but where a detailed feasibility study, on which finance for the development of the project can be committed, has yet to be completed.

The valuation of pre-feasibility projects is particularly important to company managers and investment

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TABLE 1: Beta factors, selected mining companies

Company	Beta	Company	Beta	Company	Beta
Aberfoyle	1.30	Ashton	1.29	Austen Butta	0.68
Aust Mining	1.32	Aztec	1.54	Bougainville	0.85
Coal & Allied	0.85	Cons Rutile	0.93	Delta Gold	0.90
Emperor Mines	1.20	Indon D'mond	1.29	Kidston	0.91
Lachlan Res	1.60	MIM Holdings	1.37	Minerals MM	0.81
Nicron Res	1.43	Niugini	1.42	NBH Peko	1.32
Nth Flinders	1.42	Oakbridge	1.17	Pancont'l	1.17
QCT Resources	0.61	Renison	1.32	Triako	1.69
Western Mining	1.39	West Sands	0.97	Energy Res	0.83

Source: Australian Stock Exchange Limited, January 1992

analysts, as investment in projects in this phase of the development cycle gives considerable scope for adding to shareholder wealth as the project grows into a cash-generating business.

In any industry, pre-feasibility projects are correctly perceived as more risky than established ventures. The widely accepted approach to valuing such projects is to use the same method as would be used if the project were in production, but to increase the discount rate used to accommodate the extra risk element. It is relevant to ask whether penalising perhaps many years of cash-generating ability with a high discount rate is fair to the project when, intuitively, only the earlier years should bear a risk premium.

Finance theory revisited

For the sake of simplicity, this paper ignores cost and price inflation, currency and commodity price hedging, and the effects of gearing on project values. We assume that the corporate body which owns the project is taxed at the full rate of 39 per cent of net profits.

Conventional finance theory requires DCFs for an any particular investment analysis to be calculated according to the familiar equation

$$NVP = \sum_{k=1}^{n} \frac{E(C_k)}{(1+r)^k} \quad \ldots (1)$$

where NVP is the discounted net present value of the investment, $E\ (C_k)$ are the expected cashflows for years k=1 to n and r is the risk-adjusted discount rate.

The appropriate risk-adjusted rate used to discount the future cashflows in Equation (1) is derived from the capital asset pricing model (CAPM) (Van Horne, 1975).

The CAPM postulates that the return $\overline{Rj}$ expected by a rational investor who purchases a specific asset j can be expressed as

$$\overline{R}_j = i + \left(\frac{\overline{R}_m - i}{\sigma_m^2}\right)(S_{jm}\sigma_j\sigma_m) \quad \ldots (2)$$

where i is the interest rate appropriate to investment in risk-free assets (for practical purposes, generally taken to be the return on long-dated government bonds)

$\overline{R}_m$ is the expected value of the return on a portfolio of similar assets

σ_m is the standard deviation of the probability distribution of possible market returns

σ_j is the standard deviation of the probability distribution of possible returns for that particular asset

and S_{jm} is the correlation coefficient between returns for that asset and the market portfolio of similar assets.

Meaningful statistics for use in Equation (2) on the market for mining project assets are virtually impossible to obtain, and so statistics for listed mining company equities, which are widely available, are often used as a proxy for mining assets when mineral projects are valued. Under these circumstances, the CAPM equation is generally expressed in the more familiar form (for example, Guzman, 1991) as

$$R_j = i + \beta_j\,(R_m - i) \quad \ldots (3)$$

where R_j is the expected return on a particular security

R_m is the expected return on a market portfolio of similar securities

and βj (known universally as the "beta factor") is a measure of volatility of the particular security in relation to the volatility of the market for similar securities.

The beta factor is a measure of the risk of investment in a particular security relative to the overall market risk. The higher the beta, the more the risk attaching to investment in that particular security. Beta factors for listed Australian mining stocks are published by several sources, including the Australian Stock Exchange. Table 1 shows recent beta factors for a selection of listed mining companies.

It seems that stockmarket investors perceive coal mining to be less risky than metalliferous mining and open-pit mining to be less risky than underground mining.

The interpretation of these data is somewhat subjective. However, it seems, for example, that stockmarket investors perceive coal mining to be less risky than metalliferous mining and, for companies mining a similar mix of commodities, open-pit mining to be less risky than underground mining. Investment in companies whose main assets are projects largely at the pre-feasibility stage (for example, Lachlan Resources) or which still have yet to reach their full potential (for example, Niugini Mining) is seen to be more risky than investment in established miners.

The CAPM postulates further that the appropriate risk-adjusted discount rate r to be used in Equation (1) in the calculation of the NPV of a particular investment is Rj derived from the solution of Equation (3).

In solving Equation (3), we come up against the aberrations of statistics. All three parameters on the right hand side of this equation can vary, mainly with time: the (real) return on long-term Australian government bonds is currently about 6 per cent per annum but has generally been lower in the past; R_m-i has been shown to be about 7 per cent for investment in securities but is possibly higher (although reliable statistics are difficult to obtain) for project assets;

It is clear that the risk attaching to a project declines in a quantifiable way as the project moves from the pre-feasibility stage to a mature mine.

beta factors are calculated from historical data (present or future values ought be used but obviously are not available).

With these reservations accepted and inserting the above values in Equation (3), together with appropriate beta factors taken from Table 1, it seems investors in metalliferous mining company equities currently expect (real) returns in the order of 17.2 per cent, 15.7 per cent and 13.7 per cent per annum respectively, depending on whether the company's main assets fall into the pre-development, established underground or established open-pit mine categories.

The differential between returns required by investors in companies whose main assets are existing open-pit mines and those whose main assets are still in the pre-feasibility category can be interpreted as the risk premium attaching to highly promising but undeveloped projects. While recognising that a substantial leap may be required to move from the relatively well-studied environment of investment in mining company equities to investment by companies themselves in mining assets, it is clear that the risk attaching to a project declines in a quantifiable way as the project moves from the pre-feasibility stage to a mature mine. The extent of the improvement in the project's risk profile depends on the mining method implemented.

According to equations (1) and (3), the discount rate which is used in the application of the CAPM is time-invariant; in other words, a single rate should be used to discount future cashflows expected from a given asset. This approach is almost always used in practice.

However, Hodder and Riggs (1985) pointed out that it is reasonable to expect that the discount rate to be used when assessing investments should change over time, if the risk profile of the asset is likely to change. It is suggested here that the data in Table 1 can be interpreted to mean that a variable discount rate should be used in assessing pre-feasibility projects, if the project is likely to move from the pre-development stage to an open-cut or underground mining operation.

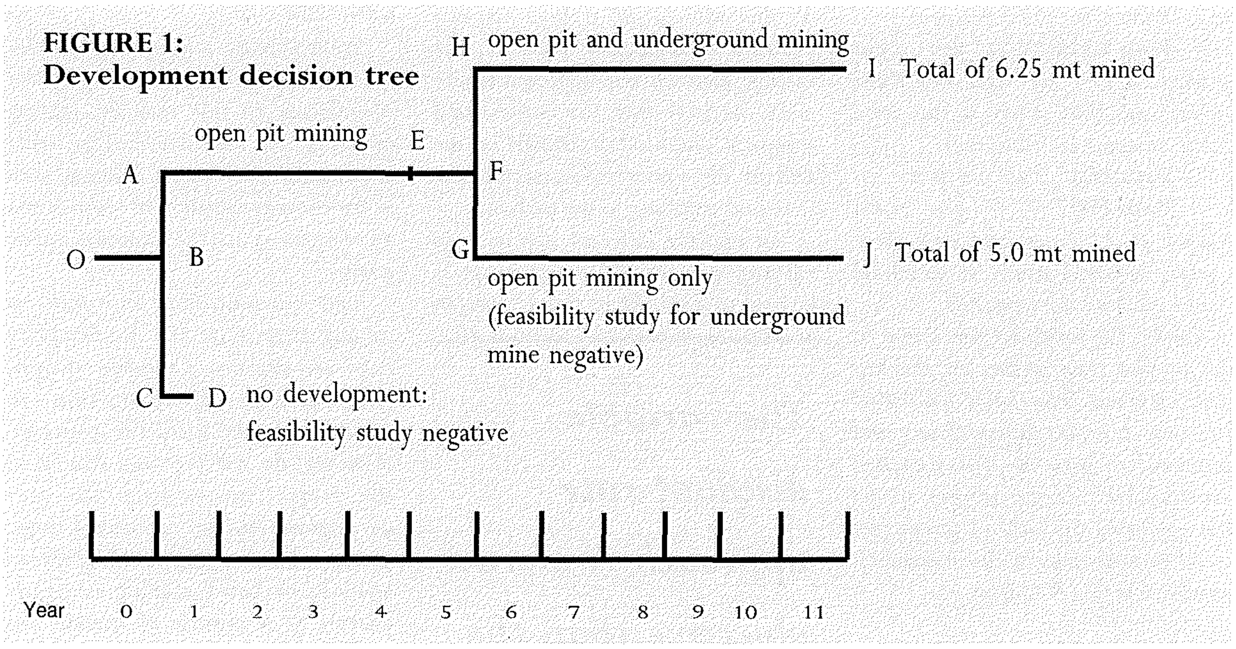
Consider an undeveloped silver-lead-zinc deposit in a remote area of Australia. Drilling has shown the deposit to consist of two lenses—a shallow lens of modest grades suitable for development by low-cost open-pit mining methods, and a smaller, deeper but higher-grade lens suitable for development as an underground operation. A conceptual mine plan has been mapped out which envisages the

TABLE 2: Key facts—mining development

Key assumption	Open-pit lens	Underground lens
Tonnage (000 t)	5,000	1,250
- % Zn	10.0	17.5
- % Pb	5.0	8.0
- g/t Ag	50	100
Maximum mining rate (000 tpa)	500	250
Mine life (years)	11	6(1)
Operating costs ($/t)		
- mining	13.25	38.50
- treatment plant	13.00	11.50 (2)
- administration	5.00	5.00
Capital cost ($000)		
- mine development	10,500	22,000 (3)
- treatment plant	11,000	2,500 (3)
- infrastructure	6,000	

Notes: (1) Underground mine developed subsequent to open pit but then operated concurrently (2) Reduced unit operating costs in the treatment plant reflect higher throughput when underground mine developed (3) Marginal capital expenditure (assumes open pit mining operation already in place)

FIGURE 1:
Development decision tree



phased development of the open-pit mine and the construction of a treatment plant, with the development of the underground mine and upgrading of the concentrator to handle the additional ore from the underground mine to follow later.

A pre-feasibility study has been completed by the project's owners, using capital and operating-cost estimates computed partly from first principles and partly from knowledge of cost structures in similar projects elsewhere. These estimates, together with key production assumptions, are summarised in Table 2.

The pre-feasibility study has indicated that the project would produce high-quality lead and zinc concentrates, which could be sold to foreign smelters under normal smelting treatment schedules. Long-term metal prices of \$US0.55 and \$US0.25 per pound of zinc and lead respectively, and \$US4.00 per ounce of silver, are assumed. An exchange rate of \$A1.00/\$US0.75 is also assumed. No intractable problems are expected in obtaining the permits necessary to develop the project.

Management has estimated that a full "bankable" feasibility study for the development of the open-pit mine and the concentrator would cost \$2 million, and would take one year to complete. A feasibility study for the development of the underground mine, and the upgrade to the concentrator, would cost a further \$2 million, but would only be commenced once the open-pit mine was commissioned.

The question is: What is a fair market value for this property at its present stage of development ?

Development strategy and project valuation

The company owning the property has, perhaps unconsciously, developed a decision tree for the proposed development, as shown in Figure 1.

Key elements of the company's development strategy are:

- **Path OB:** During this 12-month period, the full "bankable" feasibility study will be completed. This work will consist of further drilling, mine planning, metallurgical studies, and all other work necessary to give sufficient comfort to providers of debt and equity funds that a viable operation can be developed. This work is budgeted to cost \$2 million.
- **Path BCD:** This path will be followed if the feasibility study produces disappointing results, and the decision is not to mine. From previous experience, the company believes that the probability of a negative outcome of the feasibility study is about 25 per cent.
- **Path BAEF:** This path will be followed if the feasibility study produces positive results, and the decision is made to start an open-pit mining operation and to construct a concentrator. During this period, production will build up to 0.5 million tonnes per annum. Management believes that the probability of the project being viable is about 75 per cent.
- **Path EF:** After the open pit is well established and operating as planned, management intends to commit to a second feasibility study designed to upgrade the capacity of the concentrator and to develop the underground mine. The cost of this feasibility study is estimated to be \$2 million.
- **Path FGJ:** This path is followed if the second feasibility study is negative and the decision is taken to continue to mine the open-pittable ore only. The company expects that the probability of the second feasibility study producing negative results is about 20 per cent.
- **Path FHI:** This path will be followed if the second feasibility study produces positive results and the decision is taken to open an underground mine and to increase the capacity of the concentrator. The company has assessed an 80 per cent probability that the second study will produce positive results.

We have developed a discounted cashflow model of the various phases of the project, based on the possible development paths shown in Figure 1, and the key production, costing and revenue assumptions previously outlined. A variable discount rate has been used for the key path elements within the decision tree, according to the analysis previously developed for pre-feasibility, open-pit and underground metalliferous mines, as follows:

- **Path OB** 17.2 per cent
- **Path BAEF** 17.2 per cent falling to 13.2 per cent over three years, and held steady at that level until reserves are exhausted
- **Path FGJ** 13.2 per cent
- **Path FHI** 17.2 per cent falling to 15.7 per cent over three years, and held steady at that level until reserves are exhausted.

Finally, the cashflows discounted to the present time datum for the key path elements have been multiplied by their relevant probabilities and summed, to give the risk-weighted expected NPV of the project. Using this approach, the NPV of the project at its current state of development is estimated at $51.9 million.

Alternative approaches to valuation

The common approach to the assessment of values for pre-feasibility projects is to treat the project as if it were already in production, but to use a (single) higher discount rate to accommodate the risk premium attaching to pre-development projects. Often, a sensitivity study would then be undertaken to show the effect of assumed discount rates on assessed NPVs.

The discount rate chosen by the valuer in this approach is subjective, and reflects the valuer's expectation of the degree of risk premium attaching to the development project. For the example outlined above, a discount rate of between 17.5 per cent and 25.0 per cent might commonly be used. Using these two extreme values, the assessed NPV would be estimated to lie between $71 million and $49 million. To reproduce the valuation computed using the variable discount rate approach, a discount rate approaching 25 per cent would be required; many valuers would probably argue that this figure is too high in today's economic environment.

To be fair, the variable discount rate approach has produced an NPV which is within the range of assessed values produced by the conventional approach with a much higher discount rate. However, the method is better able to handle "what-if" questions, such as the assessment of future values if particular paths in the decision tree are taken, and analysis of the effects of delays to key elements of multiphase projects. The variable discount rate approach is also more objective than the conventional approach, which relies strongly on the skill of the valuer to assess the risk premium attaching to the project.

An entirely different approach to valuing pre-feasibility projects is known as contingent claims analysis (CCA). Using this method, mine investment is treated as being equivalent to purchasing an option on a bundle of commodities whose composition is defined by the minerals within the deposit, and where the option exercise price is equivalent to the costs of development.

The variable discount rate approach is more objective than the conventional approach, which relies strongly on the skill of the valuer to assess the risk premium.

The value of the property is equal to the value of the option, which comprises both intrinsic value (more-or-less equivalent to a valuation of the mine by conventional DCF analysis), and a time premium, which values management's flexibility to respond to changes in the assumptions made in the DCF valuation.

CCA methods, while difficult to apply in practice, are (at least in principle) better able than DCF methods to handle anticipated future commodity price volatility and management's ability to make dynamic decisions (Brennan and Schwartz, 1986; Palm, Pearson and Read, 1985).

Conclusions

Pre-feasibility mining projects are clearly more risky than mature operations. In this respect, mining projects are similar to projects encountered elsewhere in business, such as the commercialisation of research and development in the manufacturing sector.

The conventional approach to valuing projects at the pre-feasibility stage uses discounted cashflow analysis, with a high discount rate to accommodate the extra risk premium. However, the risk premium will fall as the project moves from the pre-development to the operational stage. Using statistics compiled from an analysis of listed mining company equities, it is possible to quantify the extent of the extra risk, and to build this declining risk profile into a discounted cashflow model of the project using variable discount rates.

In practice, the variable discount rate approach may not produce discounted cashflow valuations significantly different from those produced by an experienced analyst using the conventional single discount rate approach. However, the variable discount rate approach is less subjective than the conventional method, and it offers a more rigorous base for conducting further analysis.

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