Key words: risk-adjusted discount rate; cost of capital; mining project evaluation

Risk-adjusted discount rate estimation for evaluating mining projects

While the preferred methods of mining project evaluation (net present value and internal rate of return) require the definition of an appropriate risk-adjusted discount rate (RADR) to establish investment criteria, most of the literature focuses on the calculation of the company’s cost of capital. This approach, however, can create problems if the company’s new projects do not have the same risk as its existing business. This paper discusses the methods for selecting the discount rate – in theory and in practice, both for mining and general projects – and proposes some guidelines for selecting the RADR.

The literature on discounted cash flow evaluations does not deal specifically with the selection of discount rates for mining project evaluations (Smith 1995). Most texts focus on the calculation of the company’s cost of capital. However, it is possible to determine a discount rate that is appropriate for an individual project considering the stage and category of the mining project.

Cost of capital
The company cost of capital is usually calculated as a weighted average of the after-tax interest cost of debt financing and the cost of equity – the weighted average cost of capital (WACC).

The cost of debt is the firm’s borrowing rate and measures the current cost to the firm of borrowing funds to finance projects. Several models for estimating the cost of equity are presented, however, three models are generally accepted: dividend growth models, earnings models and the capital asset pricing model (CAPM).

Company cost of capital in practice
In the past two decades several surveys into the practice of capital budgeting have been conducted in different countries. These surveys have covered a range of issues such as: which capital budgeting techniques were used; how firms ranked the importance of these techniques; and how discount rates were determined. Some of these surveys have studied the methods that are used by the firms in Australia, the United States, Canada and a number of European countries to determine the discount rate (Brounen et al. 2004; Gitman and Vandenberg 2000; Graham and Harvey 2001; Jog and Srivstava 1995; Kester et al. 1999; McLaney et al. 2009; Truong et al. 2008). Truong et al. (2008) presented a brief comparison of these findings. The results are summarised in Figure 1A and the details of surveys are presented in Figure 1B.

These studies found that CAPM and dividend growth models are the most popular methods used in the estimation of the cost of equity. Other methods have less popularity and the models like the Fama & French three factor model, arbitrage pricing model (APT) and multi-factor asset pricing model are rarely used in practice.
A project and its cost of capital

A project's cost of capital is the minimum expected rate of return needed to attract the required capital. Generally, this is different from the company's cost of capital. The project cost of capital depends on the use to which that capital is put. Therefore, it depends on the risk of the project and not on the risk of the company (Brealey et al. 2001, p. 422).

Some authors (Brealey et al. 2001, p. 423; Damodaran 2004, p. 5) have proposed various methods and guidelines for estimating the project cost of capital. These methods are not effective in practice. Anderson et al. (2000) have suggested the premium or discount approach to estimating the cost of capital for projects by using the firm’s cost of capital (WACC) plus or minus a premium to adjust the WACC to take account of differences in risk. If the
CAPM and dividend growth models are the most popular methods used in the estimation of the cost of equity. Other methods have less popularity and the models like the Fama & French three factor model, arbitrage pricing model (APT) and multi-factor asset pricing model are rarely used in practice.

Company’s overall risk is \( R \) with the associated WACC, then the project cost of capital will be:

- \( \text{WACC} + \text{premium} \) if Risk is greater than \( R \)
- \( \text{WACC} \) if Risk is equal to \( R \)
- \( \text{WACC} - \text{discount} \) if Risk is less than \( R \)

One selects the discount or premium applied after careful analysis of the nature and risk of the project’s cash flows compared to the risk of the firm’s existing operating cash flows. Some of the proposed comments are shown in TABLE 1. Tajirian (1997) proposed some estimations for the risk premium/discount as shown in TABLE 2. These figures may be used as a rule of thumb.

**TABLE 1:** The premium/discount approach to estimate the cost of capital for project

<table>
<thead>
<tr>
<th>Project category</th>
<th>Discount rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>For expansion of scale of a project, for same product line, same risk of sale, just more of it. Added capacity not expected to adversely affect market prices.</td>
<td>WACC</td>
</tr>
<tr>
<td>Cost reduction project will reduce the variable costs and so, reduce firm operating risk</td>
<td>WACC – discount</td>
</tr>
<tr>
<td>Unknown product acceptance, uncertain incremental markets, known technology</td>
<td>WACC + Premium for market risk</td>
</tr>
<tr>
<td>Unknown product acceptance, uncertain incremental markets, unknown technology</td>
<td>WACC + Premium for market risk + Technology risk</td>
</tr>
<tr>
<td>Foreign investment</td>
<td>WACC used for domestic projects + premium political risk</td>
</tr>
</tbody>
</table>

Source: Anderson (2000).

**TABLE 2:** Premium/discount for different project categories

<table>
<thead>
<tr>
<th>Project category</th>
<th>Premium/discount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvement, known technology</td>
<td>-5%</td>
</tr>
<tr>
<td>Expansion of existing business</td>
<td>0</td>
</tr>
<tr>
<td>New product</td>
<td>10%</td>
</tr>
<tr>
<td>Speculative venture</td>
<td>15%</td>
</tr>
</tbody>
</table>


**Project cost of capital in practice**

This section is based on part of the studies by Gitman and Vanderberg (2000) and Truong et al. (2008) including the methods used to estimate the project cost of capital or discount rate for project evaluation in Australia. Figure 2 reports findings on how Australian firms estimate the discount rate and related key assumptions in project evaluation. The survey sample includes 356 firms. However, there were only 87 useful responses.

**Mining project discount rate**

The discount rate for evaluating mining projects performs the same function as it does in the evaluation of any project: it accounts for the time value of money and project risk. As a result, it could be expected that standard financial theory, such as the CAPM, could be used to determine the appropriate discount rate for a given discounted cash flow approach. However, due to the limitations and disadvantages of these methods, many firms use other methods.

Since 1981 many authors have attempted to develop a procedure for estimating an appropriate discount rate for evaluating mining projects. In general, two methods are used for estimating the discount rate:

1. Calculating the company cost of capital by the WACC method based on CAPM model for calculating the cost of equity. Some authors have proposed the dividend growth or E/P models. For example, Gilbertson
(1980) used the CAPM method for important mining and mining-finance shares of Johannesburg Stock Exchange (JSE). He estimated $\beta$ by regression analysis. Equation 1 was presented by the cross-sectional regression of the expected returns for a large number of individual shares.

$$\bar{R} = 18.5\% + \beta(6.8\%)$$  \[1\]

2. **Summing up the discount rate components.** These components are mentioned with some differences in different texts. For example, Smith (1995) related the discount rate to three components in the following equation:

$$d = R_F + R_p + R_c$$  \[2\]

where: $d$ is the project-specific, constant-dollar, 100% equity discount rate; $R_F$ is the real, risk-free, long-term interest rate; $R_p$ is the risk portion of the project discount rate; and $R_c$ is the risk increment for country risk.

The risk associated with a project varies with the stage of development of the project. This variation can be reflected in the discount rate that is used to evaluate the project.

A survey conducted on Mineral Economics Society (MES) members of Canadian Institute of Mining Metallurgy and Petroleum (CIM) indicated that they were using different rates for stages of the mining project (Figure 3). However, there is no sound procedure to calculate these discount rates (Smith 2002).
Discussion

Among the methods for estimating the risk-adjusted discount rate for evaluating mining projects, the company cost of capital (WACC) seems to be an essential starting point. Then the project cost of capital is determined by applying some adjustments. In practice:

- capital asset pricing model (CAPM);
- dividend yield plus forecast growth rate; and
- E/P Ratio,

are the most common methods used to estimate the cost of equity. Nevertheless, the use of these methods is still subject to some debate and, in practice, they face some limitations.

Among these methods the capital asset pricing model has been most commonly used but it is also subject to considerable criticism. In the valuation of mineral projects, there are inadequacies regarding the use of the market-based beta. These shortfalls include (Lilford 2006):

- betas indicate the volatility of a share price and not of a specific asset within a listed company, such as a mineral property or specific mining operation;
- betas of a specific listed entity vary as the market varies and not independently of the market;
- betas vary over time so that the value of a project will also vary over time through a changing discount rate; and
- owing to the cyclicality of the different minerals’ prices (supply and demand balances vary differently for each mineral), relative betas will vary so that a perfect correlation becomes improbable.

In spite of these debates, the CAPM continues to be the main method used particularly by large-sized firms, because there isn’t yet a better method available.

The problem with the dividend growth models is the obvious uncertainty in the determination of the anticipated future dividends from one period to the next, being the dividend growth rate $g$. For mining projects, this uncertainty is exacerbated by the fact that many mining companies reinvest their distributable income into capital growth assets and therefore do not pay dividends at all, or certainly not over extensive periods. A company’s gearing will also impact on whether it pays dividends or whether it uses free cash flows for its desired debt reduction profile (Lilford 2006).

Obviously, the E/P model is more suitable than the dividend valuation model for firms that pay low dividends or none at all. However, this method has shortfalls associated with the use of earnings per share (EPS). The most important is that the earnings figures do not adequately reflect risk.

**FIGURE 4:** A method to estimate the risk-adjusted discount rate (RADR) for evaluating mining projects

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**Methods:**
- Use company’s discount rate
- Refer to discount rates of other mining companies
- Use the discount into representative of mining industry
- Use cost of debt plus some premium
- Use financing rate (e.g. borrowing rates)
- Based on previous experience
The limitations and shortfalls of these methods force practitioners to use some other methods for determining the company cost of capital. As a last resort, the discount rate may be determined by a direct approach. The main difference is that the above-mentioned adjustments are not applied. In general, estimating project risk, and therefore also the risk-adjusted discount rate, is never going to be an exact science. However, more favourable results seem to be achieved using the flowchart shown in Figure 4 along with the following guidelines.

In general, the main method used to determine the discount rate for evaluation mining projects is based on company cost of capital using CAPM. However, it faces limitations in relation to:
- insufficient data about company and market returns;
- inappropriate correlation between the data; and
- inability to estimate the risk premium, and two other methods i.e. dividend growth or E/P methods also have their limitations.

Some other methods:
- average historical returns;
- regulatory decisions;
- cost of debt plus some premium for equity; and
- investors’ required returns,
are also proposed. It is suggested that more than one approach should be used.

WACC is the minimum acceptable hurdle rate used to evaluate projects having the same risk as the risk complexion of the company but, for more or less risky projects, this is not the same. In these cases, WACC would need to be adjusted according to the stage and category of the project:

The WACC for an operating company would represent the risk level of a fully operating mine. This would have to be increased to reflect additional risk at an earlier stage of development.

There is a different level of risk depending on the stage of the project. According to TABLE 2, the ranges shown in TABLE 3 may be useful as a rule of thumb.

To make adjustment considering the category of mining projects, these projects may be classified as below:
1. Capital investment aimed at improving an existing mining company by reduction in operating costs and so, reducing firm operating risk, with the same output:
   \[ \text{Discount rate} = \text{WACC} - \text{discount for cost reduction} \]
2. Capital investment used to expand production (i.e. increasing output) with same production method. The discount rate would be approximately the WACC:
   \[ \text{Discount rate} = \text{WACC} \]
3. Adding a new project to an existing complex. The discount rate would be the company WACC plus the riskiness of the new project.
   \[ \text{Discount rate} = \text{WACC} + \text{Premium for project risk} \]
4. Capital investment in foreign projects The discount rate would be the WACC used for domestic projects plus the political risk:

   TABLE 2 proposed some premium/discount to determine the discount rate, these figures may be reproduced for mining projects as shown in TABLE 4. It may be necessary to adjust for the size effect of the project. Smaller projects involve higher levels of risk. Smaller dollar size projects tend to involve smaller reserves or a shorter project life and, consequently, higher risk and a higher discount rate.

   As a last resort, the discount rate of a project may be directly estimated by methods like:
   - using the company's discount rate;
   - referring to discount rates of other mining companies;
   - using the discount rate representative of mining industries;

TABLE 3: Ranges of premiums for mining projects vs. project stage

<table>
<thead>
<tr>
<th>Project stage</th>
<th>Risk premium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating mine</td>
<td>0</td>
</tr>
<tr>
<td>Feasibility study</td>
<td>3-5%</td>
</tr>
<tr>
<td>Pre-feasibility study</td>
<td>6-8%</td>
</tr>
<tr>
<td>Early exploration</td>
<td>10-12%</td>
</tr>
</tbody>
</table>

TABLE 4: Premium/discount for different mining project category

<table>
<thead>
<tr>
<th>Project category</th>
<th>Premium/discount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aimed at improving an existing project</td>
<td>-(3-5%)</td>
</tr>
<tr>
<td>Used to expand production</td>
<td>0</td>
</tr>
<tr>
<td>Adding a new project to an existing complex</td>
<td>8-10%</td>
</tr>
</tbody>
</table>
It may be necessary to adjust for the size effect of the project. Smaller projects involve higher levels of risk. Smaller dollar size projects tend to involve smaller reserves or a shorter project life and, consequently, higher risk and a higher discount rate.

- using the cost of debt plus some premium;
- using the financing rate (e.g. borrowing rates); and
- based on previous experience.

The first four methods should be used only if the project has at least the same risk as the company’s existing business.

**Conclusion**

Both methods of mining project evaluation, i.e., NPV and IRR, require the definition of an appropriate discount rate to establish investment criteria. The conventional method of estimating the discount rate is to calculate the company’s or firm’s weighted average cost of capital or WACC. But, if a project does not have the same risk as its existing company, this approach can complicate the decision making process.

For example, in different stages of the development of a mine such as early exploration, pre-feasibility study, or feasibility study, the risk level is not the same as that during the operation of the mine, thus a unique WACC cannot be used. Another problem is that the methods used to calculate the cost of equity, typically CAPM, are not applicable or do not obtain proper results in many cases. This may force the practitioners to use other methods, which are mostly intuitive. Nevertheless, the main proposed method to estimate RADR is based on the company’s WACC and the level of risk of the project.

To take into account the level of risk of the project, two adjustments are applied. The first adjustment relates to the stage of the project, and the second one relates to the category of the project. These adjustments are applied in the form of a premium or discount, i.e., $RADR = (WACC + premium)$ or $RADR = (WACC − discount)$. However, in practice, this method cannot always be applied, so two other approaches are proposed.

The first approach involves estimating the cost of equity by using methods such as average historical returns, regulatory decisions, cost of debt plus some premium for equity or investors’ required returns. The second approach involves direct estimation of RADR by using the company’s discount rate, referring to discount rates of other mining companies, using the representative discount rate of the mining industry, using the cost of debt plus some premium, and using the financing rate (e.g. borrowing rates). In general, it is recommended that more than one of these methods is used.

**References**


