# Discounted Cash Flow Analysis
# Methodology and Discount Rates

Lawrence Devon Smith
*Manager, Project Evaluation, Rio Algom Limited*

**ABSTRACT**

*This paper examines the impact of the various assumptions that go into an economic evaluation, and shows how these can be combined to show an exciting result that may not really exist. An example of an embellished case (the kind that one frequently sees when projects are being promoted) is developed and the cumulative impact is analysed to show the actual project underneath. The paper also points out some areas to watch for overly optimistic assumptions such as prices, inflation, and debt. The concept of a "bare bones" base case is proposed (constant metal prices, constant dollars, no inflation, no debt, no interest, on a project basis, after tax) as a common reference point.*

*As well, the discount rate is examined as a fundamental means of reflecting risk in discounted cash flow evaluations. Current industry practice is discussed, and a methodology for the analysis of risk levels is proposed that assesses the constituent components of the discount rate: real interest, mineral project risks, and country risk.*

## INTRODUCTION

Often, the first time that all of the technical and economic data for a mineral project comes together in one place is when the economic evaluation is developed. This typically happens when work on the project has progressed to a sufficient level of detail that the effort to produce a year-by-year cash flow is justified, usually at the pre-feasibility or feasibility study stage. The data involved will include:

- production; tonnes waste and ore mined, ore grade, mining recovery, metallurgical recovery, metal sold
- revenue; metal price, smelting & refining charges, marketing costs
- operating Costs; mining, milling, administration, fees, royalties
- capital Costs; exploration, development, construction, indirect costs (engineering, management), contingencies, start-up, inventories, working capital, replacement and sustaining capital, closure costs
- taxes and royalties
- exclusions; depreciation (this is not a cash item), sunk costs (only costs going forward).

### Year-by-Year Cash Flow

The creation of the year-by-year cash flow is a significant team effort that produces the fundamental tool for ongoing evaluation. This work requires the project team members to work together to place their individual components in an overall project context. It is likely that this will be the first time that all of the information will be represented in the same place in the same units, that is, dollars. It is at this stage that overlaps, double counting, and missing pieces are most easily identified. It is also at this stage that data are put together in their relative position in time, an exercise that often identifies the need for additional costs and scheduling. The year-by-year cash flow also draws attention to the interrelationships between the time dependent variables, including:

- production (mining plans, grades, tonnages, recoveries)
- schedules (construction, start-up, initial production, full production, final production)
- debt (borrowing, interest, repayments)
- taxes (capital depreciation, loss carryforwards, tax deferrals)

### IRR and NPV

Virtually all modern texts on project evaluation conclude that the preferred methods of evaluation, when sufficient data is available (pre-feasibility through operating phases) are those that incorporate annual cash flow projections and that recognize the time value of money, particularly the net present value (NPV), and the internal rate of return (IRR), also referred to as the discounted cash flow rate of return (DCFROR), as opposed to those employing simple cost and revenue ratios or payback periods.

The IRR evaluation generates a percentage figure which is equal to the interest rate at which the project capital would have to be invested to generate the same series of annual cash flows that the project will generate.

The NPV gives the value of the project in as a dollar amount today. Each year's cash flow is discounted to the present at a predetermined discount rate, which reflects the project risk and the investors' minimum investment criteria. The NPV is the sum of these discounted annual cash flows.

While an entire project should not be judged by one or two summary numbers, if the IRR and NPV are used in conjunction with the annual cash flows, they are a powerful means of comparing and selecting investment opportunities. For these reasons, these two methods are used as the measure of the impact of assumptions in this paper.

## "BARE BONES" BASE CASE

Consider the opportunity to invest in one of two gold projects. Both are heap leach gold mines, both have the same grade, and both have a 10 year operating life. The results of economic evaluations for each are shown in Table 1.

Table 1 - Comparing Projects A & B

| | Project A | Project B |
|---|---|---|
| IRR | 10.0% | 60.2% |
| NPV at 10% | $0.0 | $18.6 |
| Total Cash Flow | $24.4 | $40.1 |

On the surface, the results would appear to favour Project B, but a closer examination would reveal that they are, in fact, the same project! By the judicious application of the most significant economic assumptions used in project evaluations, without changing any technical values, Project A can be transformed into Project B. The evolution from Project A to Project B involves a number of steps, which are dealt with individually in the discussions which follow. (Smith, 1999)

Project A represents the "bare bones" evaluation of this project. It has the following characteristics:
- constant metal prices
- constant dollars, no inflation
- no debt, no interest
- project basis (no corporate tax write-offs)
- after tax

**Advantages and Disadvantages**
There are a number of advantages to representing the project by this cash flow. Each one has an associated disadvantage.

Constant Price
Pro: Price projections and market forecasts are complex and notoriously inaccurate. A constant price avoids this problem. A constant price may represent an average value over the project life.
Con: Metal prices will not be constant over a prolonged period. They tend to follow a cyclic pattern so that a constant price will differ from actual future prices most of the time.

Constant Dollars
Pro: There are no assumptions or forecasts required for inflation. The capital costs, operating costs, and revenues for the project can be readily recognized and checked, free of the accumulating changes resulting from compounding inflation rates.
Con: Without the influence of inflation, IRR values will appear lower (by approximately the rate of inflation) than comparable inflated investment opportunities. Non-inflation discount rates must be used for NPV. Taxes tend to be understated because depreciation is also in constant dollars. In reality, inflation reduces the relative value

of depreciation over time.

No Debt
Pro: There are no financing and repayment considerations to cause a leverage effect.
Con: An actual project would likely be financed.

Project Basis
Pro: The results are calculated on a stand-alone or "project" basis. That is, there are no external influences, such as non-project corporate tax write-offs, which could mask the inherent value, or inherent weaknesses, of the project.
Con: The results ignore the benefits of non-project corporate tax deductions.

**Zero Is An Assumption Too**
It should be noted that, while the “bare bones” case appears to avoid the need to make assumptions, it requires just as many assumptions as any other case:
- constant price is an assumption
- 0% inflation is an assumption
- 0% debt is an assumption.

**Why a “Bare Bones” Case?**
No real project is likely to follow constant dollar cost and revenue projections. Historically, capital and operating costs have tended to increase with inflation, while prices have tended to follow a cyclic pattern. Nor would a project be funded entirely from equity. So why create a “bare bones” case? The reason is that it provides a common reference point that allows other projects to be evaluated in the same light (without layers of assumptions) so that investment opportunities can be compared one to another. This case is the most basic, "stripped-down" presentation that a project can have. It is essentially free of the economic, corporate, and financial considerations that may mask the real viability of a project.

Further, if a project shows itself well under these “bare bones” circumstances, it should show itself well under any circumstance. If a project does not show itself well under these circumstances, added assumptions and conditions may give it the appearance of a silk purse but it will still be a sow's ear at heart, and something worse if there is a downturn.

**Taxation**
In a viable project, it is not unexpected that taxes and royalties will account for a significant portion of the cash flow. The money going to the government (in its many forms) is often as much as what goes to the owner. It is appropriate, therefore, to develop the tax and royalty calculations in similar detail to the other major cost items such as capital and operating costs. This means that simplifying assumptions should be replaced by their more detailed and complex counterparts, most notably with regard to depreciation and deduction. The effect can be significant. With life-of-mine depreciation, capital assets are depreciated over the entire project life. With accelerated depreciation, assets are depreciated rapidly at the beginning of the project (in some jurisdictions accelerated depreciation rates can be up to 100% of income) thereby reducing tax in the early years, sometimes to zero, and causing higher tax in later years since all depreciation has been used up. The effect of this is to delay the payment of taxes until all of the capital costs are written off, thus allowing the owner to recover his investment in the early years of the project. This does not change the total cash flow of the project. However, the change in timing has a significant impact on the IRR and NPV as shown in Table 2.

Table 2 - Tax Depreciation Effects

| Capital Cost Tax Depreciation | IRR | 10% NPV | Cash Flow |
|---|---|---|---|
| Life of Mine (Project A) | 10.0% | $0.0 | $24.2 |
| 100% rapid depreciation | 11.5% | $2.0 | $24.2 |
| No Tax | 14.7% | $7.2 | $36.3 |

**Variance Analysis**
Having established a Base Case, it is important to determine how each of the major cost components of the project (revenue, capital costs, operating costs) influence its value. A sensitivity or variance analysis highlights which variables have the greater impact on the project. When plotted as a graph, the steeper the line, the greater the impact, or the greater

the sensitivity of the project to the variable. The variables to which the project is most sensitive are those which should be most closely examined for accuracy and reliability. An example of sensitivity graph is shown in Figure 1 and a variance analysis is presented it Table 3.

Figure 1 - Sensitivity (Spider) Graph

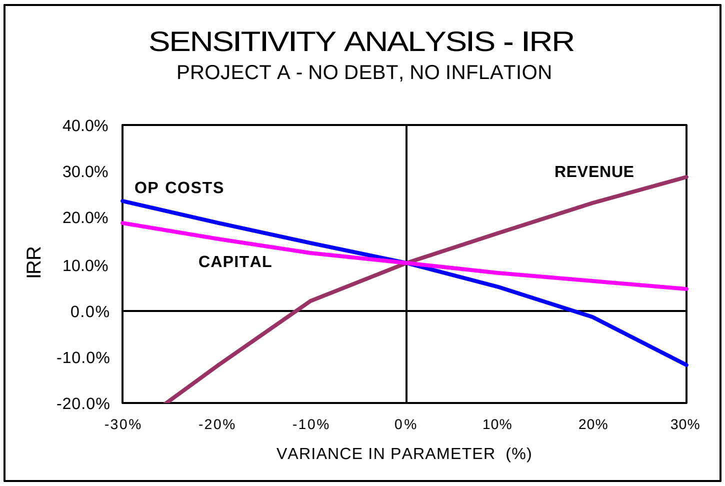



Table 3 - Variance Analysis Summary

| Variable & Variance | | IRR | 10% NPV | Cash Flow |
|---|---|---|---|---|
| Base Case | | 10.0% | $0.0 | $24.2 |
| Price | +20% | -11.6% | -$23.5 | -$19.0 |
| | -20% | 23.0% | $21.5 | $62.9 |
| Op Cost | -20% | 19.1% | $14.6 | $50.3 |
| | +20% | -1.4% | -$14.9 | -$3.0 |
| Capital | -20% | 15.3% | $6.6 | $31.2 |
| | +20% | 6.2% | -$6.6 | $17.1 |
| Inflation | +2% | 11.7% | $2.7 | $29.8 |
| | +4% | 13.5% | $5.7 | $36.1 |
| Debt | 30% | 10.4% | $.6 | $22.2 |
| | 50% | 10.9% | $1.0 | $20.6 |
| | 70% | 12.2% | $1.8 | $18.1 |
| | 90% | 16.3% | $3.0 | $14.4 |
| Repayment | 1 year | 12.2% | $1.8 | $18.1 |
| | 6 years | 12.5% | $2.0 | $17.6 |
| | 10 years | 15.2% | $2.9 | $14.4 |

Please note in Table 3, that the probability of a +/-20% change in each of the variables will differ significantly from one variable to the next. Since risk = probability x consequence, the risk of each of these happening varies accordingly.

The IRR and NPV are inversely proportional to capital costs and directly proportional to profit (revenue less operating costs), as follows:

$$\text{IRR \& NPV} = \text{fn} \frac{(\text{Revenue - Operating Costs})}{\text{Capital Costs}}$$

The extent of the impact of changes in these factors is determined by varying each factor individually over a likely range of values.

- *Price and Revenue* Revenue is usually the only positive component of the cash flow. It is largely determined by selling price, but any production factors that influence the amount of product sold (production rate, dilution, grade, recovery) will have a parallel effect. While the latter are usually fixed by technical considerations, price is open to a broad range of interpretations and offers considerable scope for variance.
- *Operating Costs* The cash flow is a direct function of the margin between revenue and operating costs, so operating costs exert a strong impact on the cash flow and the return.
- *Capital* In terms of the total cash flow, the capital cost can be a relatively small number. However, capital is input at the very beginning of project and has a high negative influence on the discounted cash flow, since the positive cash flows which follow are discounted increasingly the further away they are in time.

**Inflation**

Inflation cannot be ignored in an evaluation. At its lowest levels in decades, it still reflects itself as cost increases of 2% to 3% each year. If management chooses to exclude inflation from the evaluation, it should be aware of the consequences of this decision (Smith, 1987). The selection of the inflation rates to be used over the life of a project is not easy. In the absence of a strong personal or corporate policy on inflation, the consumer price index is often used.

Whatever rate of inflation is selected, the same rate of inflation is typically used for capital costs, operating costs, and price, in each year of the project. A common inflation rate increases the margin between revenue and operating costs at the same rate as the inflation and the cash flow therefore requires a higher discount rate to bring the discounted cash flow NPV to zero. Thus it gives a higher IRR. At low inflation rates, the IRR is increased by approximately the rate of inflation. At higher rates of inflation, the increase in the IRR is noticeably more than the rate of inflation. The mathematical relationship is given by the following equation:

$$(1+R) = (1+r)(1+i)$$

where:

$r$ = discount rate with no inflation
$i$ = inflation rate
$R$ = discount rate with inflation

The effect of selecting a higher rate of inflation for price than for costs is striking. Each year the margin increases at an accelerating rate. The IRR and NPV increase dramatically. While one may believe there is a valid reason for a higher inflation rate for price in the short term, the prolonged application of a higher rate is akin to printing money. On the other hand, if the differential for price goes in the opposite direction the results can be equally dramatic, and the prolonged application is akin to burning money. Differential inflation rates should be approached with extreme caution. A project should be evaluated using several rates of inflation in a variance analysis, in the same manner that variances in the other significant factors are examined.

**Loans and Debt**

It is unlikely that any project will be funded entirely from equity. Most corporations do not have large pools of capital available and it is usually very advantageous (in terms of IRR and NPV) to borrow the funds. Debt is also a means of mitigating risk by sharing it with the banks. The significant variables in terms of debt are:

- *Debt Ratio* Generally, if a project's IRR (before debt) is greater than the interest rate on the debt, it will be advantageous, in terms of IRR and NPV, to borrow money for the project. The more that is borrowed (the higher the debt ratio), the better the results. This effect is called leverage. As the debt ratio increases towards 100%, the IRR approaches infinity. In practice debt ratios are usually in the 50% - 70% range.

- *Interest Rate* The interest rate should be consistent with the inflation assumptions for the case. The interest rates quoted in the media and by banks include inflation. In an inflation case, the commercial prime interest rate plus a mining risk premium (1% and more) will be used. In a non-inflation case, the commercial prime interest rate should be reduced by the current rate of inflation. This subtlety is often ignored. The result is somewhat higher interest charges, which is conservative.
- *Repayment Period* The terms for the repayment of debt vary widely, but generally a bank will want to be assured that the project can repay its loan roughly two times over. Therefore, on a 10 year project, banks would seek a repayment schedule in the range of 4 to 6 years.

**Project B - The "Optimized" Project**

All of the variables discussed to this point are present in every project. In Project A, the "bare bones" base case, they have been set to mid-range values (price, capital, operating costs) or to zero (inflation, debt). However, using carefully selected combinations of these variables, it is possible to construct a view of the project that puts its best foot forward. This process is illustrated in Table 4 where Project A is transformed into an "optimized" Project B where the impact of accumulating small changes in the various assumptions is shown.

Table 4 - Project B - “Optimized” Case

| Variable Changed | IRR | 10% NPV | Cash Flow |
|---|---|---|---|
| Project A * | 10.0% | $0.0 | $24.2 |
| 100% Tax Write-off | 11.5% | $2.0 | $24.2 |
| Gold price +$10/oz | 13.6% | $4.9 | $29.2 |
| 2% inflation on all items | 15.6% | $8.0 | $35.4 |
| Price inflation 1% higher | 19.2% | $14.3 | $48.7 |
| 70% loan repaid ASAP | 25.4% | $14.9 | $43.5 |
| 70% loan repaid 7 years | 30.3% | $15.6 | $40.8 |
| $5 million gold loan repaid ASAP | 35.4% | $15.4 | $40.4 |
| $5 million gold loan repaid 5 years | 38.1% | $16.2 | $40.1 |
| Capital reduced 5% | 42.9% | $17.7 | $42.3 |
| Full production in year 1 | 47.1% | $18.5 | $43.4 |
| Higher grade at front end | 60.2% | $18.6 | $40.1 |
| Project B | 60.2% | $18.6 | $40.1 |

*Project A criteria:

- gold at $385/oz
- life-of-mine depreciation for tax calculation
- no inflation
- no debt
- no gold loan
- 85% production in year 1
- constant gold grade in all years

The progression from Project A to Project B is done without making changes to the overall technical parameters of the project:

- Modifications to tax depreciation, price, and inflation are usually the first changes made.
- The assumption that price will escalate at a faster rate than costs is always tempting.
- Debt, either as conventional bank financing or as a gold loan, adds substantially to the IRR, although not so significantly to the NPV in this case.
- There is always a temptation to assume a long term debt repayment schedule to help the results.
- When a project needs an extra boost, it is often proposed that capital costs can be reduced by purchasing used equipment and a figure of 5% is commonly suggested. This saving is usually fictitious.
- That production will reach full capacity immediately, rather than the gradual rate that experience suggests, is another optimistic suggestion.
- Judicious mine planning can often be made to schedule the mining of higher grade material in the early years. This

is often optimistic.

On examining the results in Table 4, it is evident that the assumptions regarding debt ratios and debt repayment provide the most fertile ground for "optimization". It is for this reason that the 1995 VALMIN Code of the AusIMM states that a 100% equity assessment should be shown in order to provide a common reference point. (The code also proposes that this be on a pre-tax basis, with which I disagree, since taxes account for so much of the actual cash flow. However, the code is referring to a Technical Value assessment, which presumably deals with technical criteria only, and not taxes.)

**"Project C" - The "Optimized" Project Goes Bad**

The factors which combined to give such an attractive picture in Project B do not always act in a positive direction. Often they will act to a greater or lesser degree in different directions to give a more balanced view of the project. However, if too many of the variables have been assumed to act at the most positive end of their range for the evaluation, but fail to do so in the real project, the effect can be severe. This is illustrated by Project C, which begins with Project B but has the following reversals in assumptions:

- gold price only $375/oz (-$10/oz from base)
- relative growth in price is **negative** by .25% per year
- bank debt must be repaid in 4 years
- gold loan is only $3.0 million
- gold loan must be repaid ASAP
- capital costs overrun by 5%
- full production is only achieved at the end of year 2

Each one of Project C's reversals from the "optimized" case is not only reasonable, but perhaps even expected. Stripped of the embellishments, and with inflation removed, the resulting case shows a IRR of 10.3%. This might appear acceptable, but the "bare bones" version of this case (no debt, no inflation) shows a IRR of only 7.7%. These projects are summarized in Table 5.

Table 5 Project C - The "Optimized" Case Goes Bad

| Project Assumptions | IRR | 10% NPV | Cash Flow |
|---|---|---|---|
| Project A "bare bones" | 10.0% | $0.0 | $24.2 |
| Project B "optimized" | 60.2% | $18.6 | $40.1 |
| Project C "optimized" goes bad | 10.3% | $0.2 | $11.5 |
| Project C with "bare bones" criteria | 7.7% | -$3.2 | $16.8 |

**"Bare Bones" Conclusion**

It is possible to make a project appear to have just about any IRR or NPV that is desired. The technical details of the project, the facts which can be checked and confirmed, do not need to be altered. Only the assumptions relating to the economic factors need to be changed. Since these assumptions are often a matter of interpretation and opinion, they can be difficult to refute. When you are either developing, or reviewing, a cash flow projection and its IRR or NPV, the following should be borne in mind:

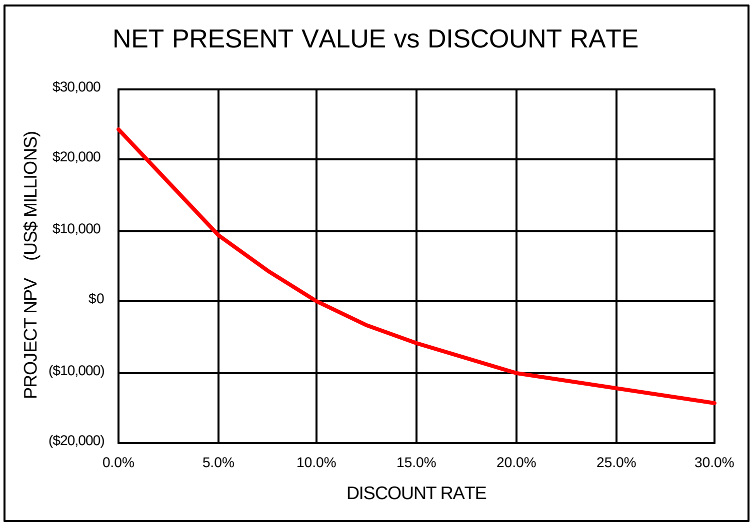
- Understand the impact of all assumptions, both individually and in combination.
- Ensure that competing projects are evaluated on the same basis.
- Be aware of invisible assumptions. (eg; inflation in interest rates, non-cyclic metal prices, ever increasing margins)
- Do not mislead yourself!
- Always check back to reality. The "bare bones" base case is a good place to start.

## DISCOUNT RATES

The variables that have the greatest impact on a discounted cash flow evaluation are the reserves, the metal prices, and the discount rate. A discussion of reserves and metal price is beyond the scope of this paper. However, the components of the discount rate are examined and a method of estimating project-specific discount rates is proposed.

The motivation for this work comes from experience of project evaluations in which owners and purchasers had agreed on virtually every aspect of the evaluation; reserves, grade, recovery, capital costs, operating costs, taxes, and, by combining these components, even on the final cash flow values. The only difference in opinion concerned the *discount rate* to be used in the calculation of the net present value. Depending on the life of the project, such differences of opinion can cause a variation of more than 50% in the value placed on a project! This is illustrated in Figure 2.

Figure 2 - NPV vs Discount Rate




### An appropriate discount rate

The mathematics that is required to generate the NPV and IRR values is straightforward, but both methods require the definition of an appropriate discount rate to establish investment criteria. This rate is used as the discount rate in the NPV method, and the minimum rate for the IRR.

Unfortunately, the literature on discounted cash flow evaluations does not deal specifically with the selection of discount rates for mineral project evaluations. Most texts focus on the calculation of the corporate cost of capital. However, it is possible to determine a discount rate that is appropriate for an individual project, on the basis of industry expectations for project returns (IRR), the risk factors associated with mineral projects in general, and the risks related to the specific project.

### Corporate Cost of Capital

Economic and finance theory proposes the use of the corporate cost of capital as a discount rate. This value is the weighted average cost of the funds available to a company, including equity (common stock), debt (after tax rate), and preferred shares. Referred to as the *Weighted Average Cost of Capital (WACC)*, it is expressed as an interest rate and is calculated as follows:

$$r_{WACC} = r_e p_e + r_d p_d + r_p p_p$$

where:

$r_{WACC}$ = weighted average cost of capital (expressed as %)

$r_{e,d,p}$ = proportional costs of equity capital, debt (after tax), and preferred stock, (all expressed as %)

$p_{e,d,p}$ = proportions of equity capital, debt (after tax), and preferred stock that make up the corporate capital where $p_e + p_d + p_p = 1.00$.

For evaluations on an *all equity* basis, only the cost of equity capital needs to be considered. The *Capital Asset Pricing Model (CAPM)* is perhaps the most widely used method of assessing the cost of equity capital and expressing it as an interest rate. The basis of this method is that the return on an individual corporate stock can be related to the stock market as a whole by the relationship:

$$r_e = f + R\,\exists$$

where:

| | | |
|---|---|---|
| $r_e$ | = | expected return on the common stock |
| f | = | risk-free return (usually based on government bond rates) |
| R | = | risk premium of market returns above long term risk free rates |
| ∃ | = | Beta factor for the common stock. The beta factor expresses the variability of the common stock with respect to the variability of the market as a whole. By definition, the beta of the market is 1.00 |

There are, however, a number of problems with using a market based beta to evaluate an individual mineral project:

- betas measure the variation in a stock price relative to the market; as the market fluctuates so does the beta
- betas measure the variability of the share price of an entire company, not of an individual project
- beta values for a company (or industry) vary over time, implying that the value of a specific project would vary over time (via the discount rate) with the fluctuations of a company's share price
- relative betas for gold and base metals vary over time so there is not necessarily a consistent relationship between gold and base metals discount rates (although the pattern has been to apply lower discount rates to gold projects)

**Industry Practice**

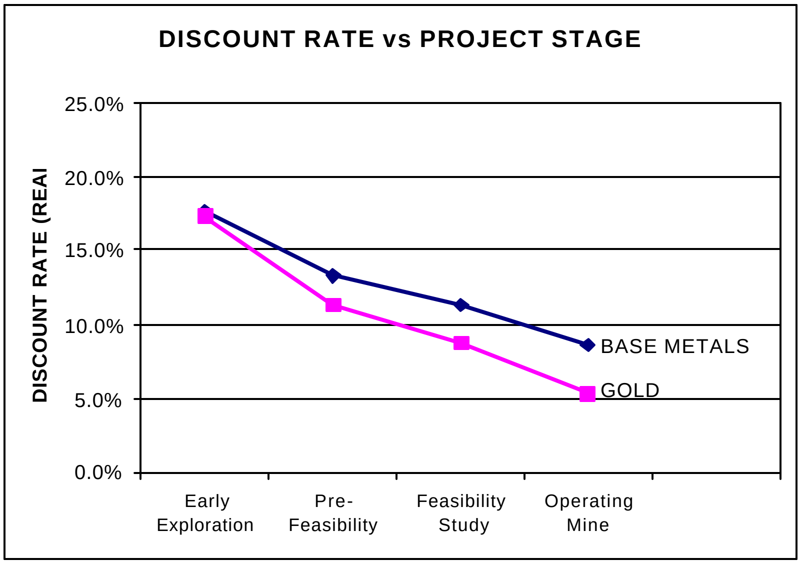
It is the author's experience that, for cash flow evaluations at the feasibility study level of projects in low risk countries, mining companies use a discount rate in the region of 10% for evaluations in constant (real) dollars, at 100% equity, after tax. This is based on:

- a survey conducted by the author of CIM Mineral Economics Society members which indicated that they were suing the following rates for feasibility studies (See Figure 3):

| | |
|---|---|
| Base metals | 11.3% |
| Gold | 8.8% |

- discussions with mining companies
- published evaluations by mining analysts
- direct experience in studies undertaken for mining companies
- various published references (Smith, 1995)

Figure 3 - CIM MES Survey - Discount Rate vs Project Stage



There does not appear to be a theoretical basis for a discount rate in the 10% range, other than the fact that a 10% rate of return (no inflation) after taxes is a reasonable rate of return compared with the return on government bonds (3%-5%, no inflation, before taxes). Since this rate is used by major mining investors to make decisions that involve millions of dollars, it must be felt to have validity. The conditions under which companies apply this rate are specific, as outlined in the following paragraphs:

- *Constant Dollars* It is difficult to obtain agreement on inflation forecasts, and many evaluations avoid the problem by leaving inflation out (although, by using constant dollars, inflation is effectively projected at 0%, which is as much an assumption as projecting it at any other rate).
- *100% Equity* The reasoning behind 100% equity cash flows is that an evaluation should measure the inherent value of a mineral project, not the ability of an owner to finance a project on favourable terms. Financing is as much a function of the owner's credit rating and the money market as the project itself. If financing is involved it would be necessary to modify the discount rate accordingly, by means of a lower discount rate to reflect the lower risk in the debt portion.
- *After Tax* Since tax is a cost of operating, it should be included in the calculation of a cash flow. Some feel that taxes should be considered as a risk component in mineral projects, a view that the author does not share. With the exception of a radical change in taxation policy (which is really a function of *country risk*) it is possible to make an accurate estimate of both the amount and timing of the tax liabilities incurred by a project since the method of tax calculation is set out in detail in tax legislation.
- *Feasibility Studies* This condition implies a high level of data development and a high level of certainty. The term *feasibility study* has a specific meaning for mineral projects, particularly to the banks and the major stock exchanges.

**Risk Components In A Mineral Project**

A discount rate for a mineral project comprises three principal components; the risk-free interest rate, mineral project risk, and country risk. Brief descriptions of each are given below.

- *Risk-Free Interest Rate* The value of the long-term, risk-free, real (no inflation) interest rate is approximately 2.5%. Long term averages range from 2.3% to 2.6%. The 2.5% value is supported by numerous references in the literature and is set out in Ontario law (Ontario Rule 53.09).
- *Mineral Project Risk* Mineral project risks include risks associated with reserves (tonnage, mine life, grade), mining (mining method, mining recovery, dilution, mine layout), process (labour factors, plant availability, metallurgy, recoveries, material balances, reagent consumption), construction (costs, schedules, delays), environmental compliance, new technology, cost estimation (capital and operating), and price and market.
- *Country Risk* Country risk refers to risks that are related to country-specific social, economic, and political factors

Using these components, it is possible to calculate a project specific discount rate:

| | | |
|---|---|---|
| + | Real, risk-free, long-term interest rate | 2.5% |
| + | Mining project risk (varies with level of knowledge) | 3.0%-16% |
| + | Country risk | 0.0%-14% |
| = | Project specific discount rate (constant dollar, 100% equity) | 5.5%-25% |

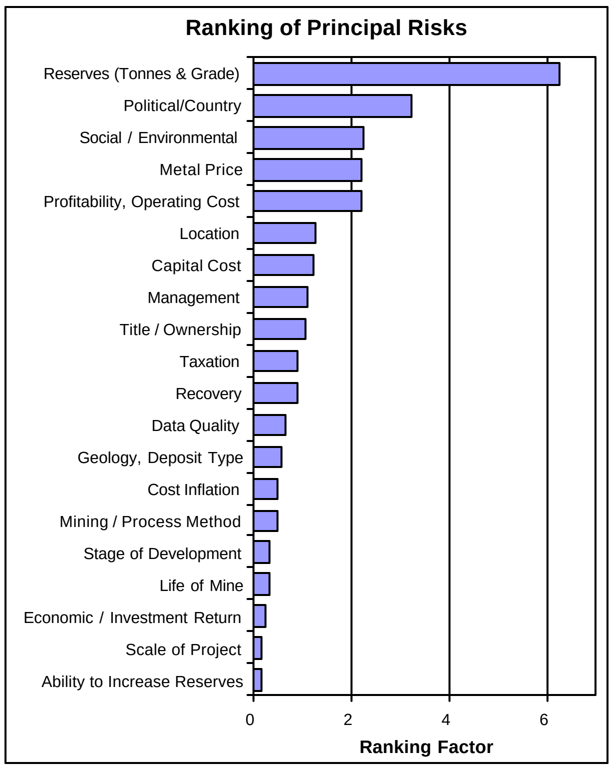
**Mining Project Risk Component**

The knowledge of a mining project at the feasibility study stage describes a certain comfort level and a degree of certainty as to the outcome of the project, and therefore a measure of risk that is then reflected in the selection of the mining project risk component of the discount rate. While the specific content and size of a feasibility study is not legislated, there seems to be general agreement in the industry as to what comprises a feasibility study in terms of content, level of detail, and size. This is due in part to the level of expectations that the stock exchanges and commercial banks bring to the review of these documents.

Studies are often made at much earlier stages of project development than the feasibility study. For example, a broad order-of-magnitude study is usually undertaken to rank and possibly reject, potential projects in the early stages. A *pre-feasibility* study is undertaken when more data are available, and is generally used to justify continuing expenditures towards a final feasibility study. Because these studies are made at much earlier stages of development, there is less data, the degree of uncertainty is higher so the risk level is higher and the discount rate will higher accordingly.

As a project moves past the feasibility stage and into detailed design, construction, start-up, and full operation, the uncertainty associated with the risk components is reduced. For example, once construction is complete, the capital cost risk is reduced to zero, since all of the capital has been spent and the costs are known. Uncertainty regarding operating costs diminishes rapidly after the first year of operation. Metallurgical recovery levels are usually well established after several years of operation. There is, however, less reduction in uncertainty with regard to the reserves, mine life, and grade until well into the operating life, and because of the inherent unknowns in geology, some uncertainty persists until the end of the life of a mine. On the last day of the last year, when the mine and mill close, there are no further **operational** risks and only the interest rate remains. Environmental liabilities may remain at the end of the mine life, but this topic is not addressed in this paper. Figure 4 shows the results of a recent CIM MES survey where the respondents were asked to rank a list of mining project risks.

Figure 4 - CIM MES Survey - Principal Project Risks




### Analytical Risk Assessment Techniques

The most common risk assessment techniques use discounted cash flow evaluation methods. For example, the Monte Carlo simulation would be used to give a probability distribution of the NPV or IRR for a project. Although a discussion of the merits of risk assessment techniques is beyond the scope of this paper, the most significant are:

- Most Likely Case (Base Case)
- Best Case / Worst Case
- Sensitivity Analysis
- Decision Tree
- Monte Carlo Simulation
- Root Sum of Squares (RSS) Procedure (O'Hara, 1982)

**A Word of Caution!**

The convention regarding the use of discount rates to calculate an NPV, based on DCF theory and industry practice, is to select a single discount rate based on the level of knowledge (uncertainty or risk) of a project at the time of the evaluation. This is supported by the definition that the IRR is the single discount rate that, when applied to each year of the cash flow stream, gives an NPV of zero. However, some writers have suggested that a series of different discount rates can be used in a single NPV valuation. They propose that the discount rate for the construction stage be higher than for initial operating years, and the discount rate be even lower for later operating years since, by then, the project variables will be well known. Not surprisingly, this approach gives a much higher NPV than the traditional method, since the initial capital (the only negative value) is discounted more than the production cash flow, and the later cash flows are discounted at increasingly lower rates. This is misleading and is not in keeping with industry practice. The flaw in this reasoning is that, **at the time of the evaluation**, the knowledge of the details of the project's later years is no better than the knowledge of the mid-years or construction years. Only as these stages approach and pass will the knowledge of them be sufficient to apply lower discount rates to the evaluation at that time.

**Country Risk**

All references to this point have been to projects in Canada and the USA to simplify the discussion of the components of discount rates. Traditionally, since these two mining nations have been considered to have zero risk with regard to political and economic stability, the country risk portion of the discount rate has been zero and has had no effect on the discount rate. However, not all projects are developed in countries that can be considered to have zero country risk, so it is necessary to assess the effect that the geo-political location of a mineral project can have on the discount rate and valuation. This is illustrated generically in Figure 5. The components of country risk are listed in Table 6.

Figure 5 - Components of Risk Factored Discount Rate

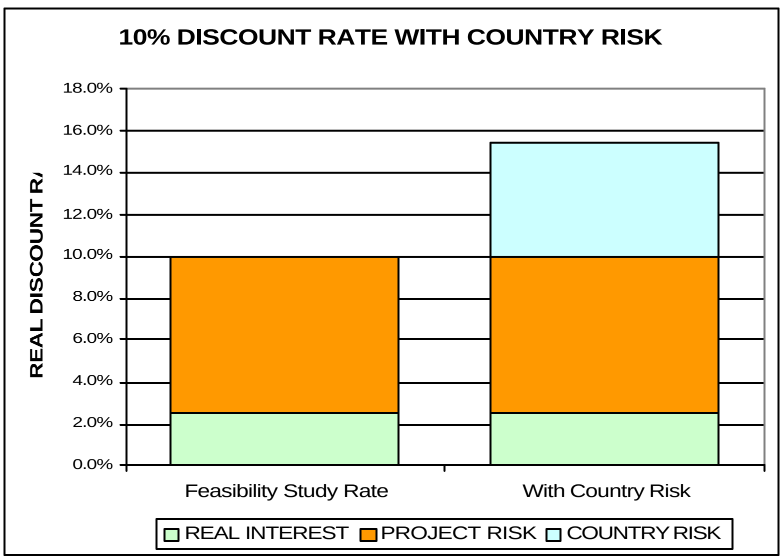


Table 6 - Components of Country Risk

| | |
|---|---|
| Political Risk | Government stability |
| | Political parties |
| | Constitutional risk |
| | Quality of government |
| | Foreign ownership policy (risk of nationalization) |
| | Foreign policy |
| | Government crises |
| | Taxation instability |
| | Environmental policy, environmental protectionism |
| | Land claims and protected areas |
| Geographic Risk | Transportation |
| | Climate |
| Economic Risk | Currency stability |
| | Foreign exchange restrictions |
| Social Risk | Distribution of wealth |
| | Ethnic or religious differences within the indigenous population |
| | Literacy Rate |
| | Corruption |
| | Labour relations |

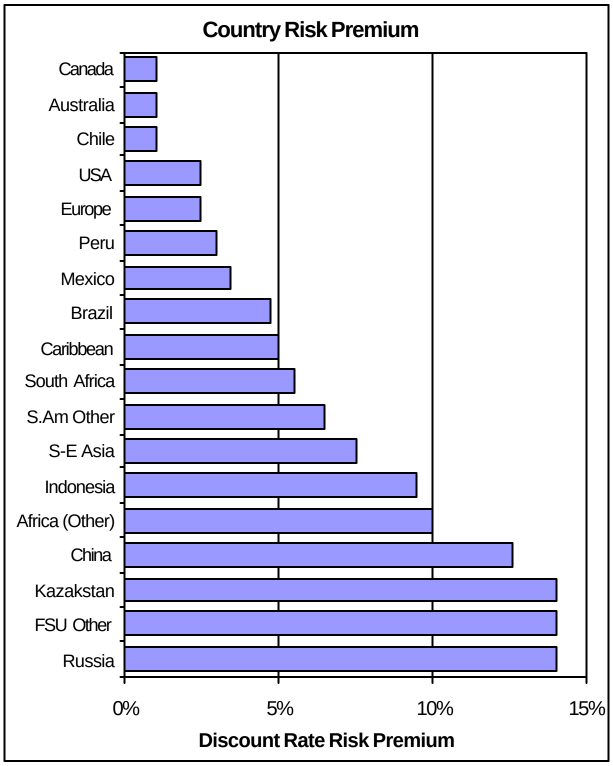
The level of risk varies from country to country and from year to year. It is essential to have both a current assessment and an historical record of a country's risk level when considering mineral investment. Measures of country risk can be obtained from a number of sources but there is considerable difficulty in obtaining a complete listing of all countries where mining may or does take place, and it is difficult to obtain a country risk figure expressed as an interest rate that can simply be added to the discount rate.

There are, broadly speaking, three sources of country risk measurements:

- *Country Rating Services:* Several agencies provide country risk ratings that usually take the form of a score that is assigned to a country on the basis of several significant variables, such as: debt levels, debt repayment record, current account position, economic policy, and political stability. The scores generally range from 100 to 0, but unfortunately, cannot be readily converted to discount rate components.
- *Bank Rating Services:* Banks express their opinions of a country's risk level in two ways: by the terms of the loans they will make to a country (life and interest rate), and by a country credit rating. The former are often confidential and not generally available. The latter are published regularly and are expressed by a letter scale. As risk increases the rating moves downward: AAA, AA, A, BBB, BB, B. Below the B level no rating is assigned and a country is referred to as "unrated". Because this scale excludes many countries where mining is carried out, it does not provide a good basis for determining a discount rate.
- *Forfaiting Rates:* Forfaiting rates are the discount rates that forfaiters apply when purchasing various governments' bonds and paper and include a basic interest rate and a risk component. Because they are expressed as interest rates they are useful for estimating discount rates. Unfortunately they are not broadly traded and are felt by some not to be fully representative of a country's risk.

Based on the author's experience, the country risk premium ranges from 0% (although environmental concerns have added a uncertainties associated with delays to countries that were traditionally considered to be risk free such as Canada and the USA) to 10% and occasionally as high as 13% or 14%. This range is presented in Figure 6 which shows the results of the CIM MES survey.

Figure 6 - CIM MES Survey - Country Risk Premiums




**Discount Rate Conclusions**

A risk-factored discount rate alone cannot be used to assess the risk associated with a project. However, analytical risk assessment techniques that employ discounted cash flow methods require the application of an appropriate discount rate, and it is with the selection of that rate that this paper has concerned itself.

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. The examples used in the paper are not meant to suggest that, for example, a 10% discount rate should be used for every mineral evaluation at a feasibility study level. Each project will have a specific set of risk characteristics. Although the use of a consistent set of criteria for feasibility studies helps to provide a common basis for comparison, no two projects or studies will be the same. However, in the absence of any other information such a rate gives a reasonable starting point and is a reflection of what the mineral industry is using to value properties.

Increments of country risk can range from 0% in low risk countries to values as high as 10% and more. These can increase a discount rate substantially and have a corresponding reduction in the NPV of the project.

It is important to distinguish between the IRR "hurdle rate" for decision making purposes and the discount rate used to value the NPV of a property. For example, an exploration prospect that indicates a IRR of 15% (real) may be worth spending more money on, but one may use a 20% discount rate to determine what to pay for it. The 15% reflects the project's potential, but the 20% reflects its risk at the exploration stage.

The use of a project-specific discount rate may reflect a project's unique risks but it does not necessarily determine the purchase price of the property. Rather, it is a guide (especially if it is being used to rank investment alternatives). The buyer will try to pay as little as possible and the seller will try to obtain as much as possible. There is always considerable negotiation when mineral properties change hands. The actual price is whatever a willing buyer and a willing seller agree upon.

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