Practical Considerations for Commodity Investment Analysis

Thomas Brady, Ph.D.
Executive Director, J.P. Morgan Center for Commodities at the University of Colorado Denver Business School

Thomas Brady, Ph.D., Executive Director of the J.P. Morgan Center for Commodities (JPMCC), presenting at the JPMCC's 2nd International Commodities Symposium, which was held at the University of Colorado Denver Business School in August 2018.

Introduction

Mining and oil and gas companies face future production profiles that inevitably decline over time, meaning that without further investment, the firm will eventually go out of business. As a result, companies must continually invest to replace production through funding exploration, internal project development and/or merger and acquisition activities. Whether the project or investment is funded internally, through free cash flow (FCF)[1], by issuing additional liquidity via the debt and equity markets or a combination thereof, a key element of the investment decision is the economic evaluation of the investment alternative at hand. Critical to these valuation estimates has traditionally been, and continues to be, the systematic and consistent application of a discount rate to the expected after-tax FCFs of the potential investment. Please see an example FCF model in Figure 1 on the next page.

Figure 1
Example Cash Flow Model (In Nominal Terms)[2]

	2020	2021	2022	2023	2024	2025	2026	2027	...
Gold Produced (koz)	18	33	33	37	94	157	187	167	...
Copper Produced (mm lbs)	-	-	-	-	29	47	45	48	...
Gold Revenue	$22	$40	$42	$49	$126	$220	$262	$234	...
Copper Revenue	-	-	-	-	94	164	158	169	...
Total Revenue	**$22**	**$40**	**$42**	**$49**	**$220**	**$384**	**$420**	**$403**	...
Smelter	-	-	-	-	-	-	-	-	...
Net Revenue	**$22**	**$40**	**$42**	**$49**	**$220**	**$384**	**$420**	**$403**	...
Gold CAS	(1)	(25)	(28)	(35)	(47)	(75)	(98)	(94)	...
Copper CAS	-	-	-	-	(35)	(56)	(59)	(68)	...
Total CAS	**($1)**	**($25)**	**($28)**	**($35)**	**($82)**	**($131)**	**($156)**	**($162)**	...
Exploration	(1)	0	-	-	-	-	-	-	...
Advanced R&D	(5)	(3)	(4)	(4)	(4)	(2)	(1)	(1)	...
Corporate G&A	-	-	-	-	-	-	-	-	...
Reclamation Accretion	21	18	16	13	3	1	(0)	(2)	...
Other Expense	-	-	-	-	-	-	-	-	...
Other Income	(0)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	...
EBITDA	**$36**	**$30**	**$24**	**$22**	**$135**	**$250**	**$261**	**$238**	...
DD&A	-	-	-	-	(0)	(55)	(119)	(122)	...
EBIT	**$36**	**$30**	**$24**	**$22**	**$135**	**$195**	**$142**	**$116**	...
Interest	27	29	31	9	10	6	9	4	...
Taxes	(11)	(6)	(6)	(8)	(50)	(72)	(53)	(43)	...
Net Income	**$53**	**$54**	**$49**	**$23**	**$95**	**$129**	**$99**	**$77**	...
CAS Inventory Change	-	-	-	-	-	-	-	-	...
DD&A (Add Back)	-	-	-	-	0	55	119	122	...
Reclamation Accretion (Add Back)	(21)	(18)	(16)	(13)	(3)	(1)	0	2	...
Cash Reclamation	0	1	2	4	4	5	17	36	...
Working Capital	-	-	-	-	-	-	-	-	...
Other Non-Cash Adj	-	-	-	-	-	-	-	-	...
Operating Cash Flow	**$32**	**$36**	**$36**	**$14**	**$96**	**$188**	**$235**	**$236**	...
Sustaining Capital	-	(4)	(4)	(1)	-	(16)	(10)	(19)	...
Development Capital	(104)	(186)	(274)	(395)	(106)	(13)	-	-	...
Other Investing Cash Flow or Acq. Cost	-	-	-	-	-	-	-	-	...
Free Cash Flow	**($72)**	**($154)**	**($242)**	**($382)**	**($10)**	**$159**	**$225**	**$217**	...

Abbreviations
CAS stands for Cost Applicable to Sales;
R&D stands for Research and Development;
G&A stands for General and Administrative expense; and
DD&A stands for Depreciation, Depletion, and Amortization.

This article aims to provide practitioners with practical steps to calculate and communicate discount rates for project valuation, capital budgeting and the many other uses throughout a typical commodity based firm. Traditionally academic and industry professionals have focused on determining "theoretically precise" discount rates. A second objective of this article is to argue that given the inherent uncertainties within the calculation of discount rates themselves and more importantly with the cash flow estimates to which these rates are applied, practitioners should focus on simplification and the consistent application across investment alternatives over a quest for precision.

Discounted Cash Flow (DCF) Analysis

For consistent evaluation and communication across investment alternatives, it is critical to have a consistent economic analysis template (such as in Figure 1.) Whether evaluating an external merger and acquisition (M&A) target or internal development projects, a standard template lends itself to effective capital budgeting.[3] A discounted cash flow (DCF) analysis is used to estimate a potential investment based on the future cash flows. The utility of DCF is that this puts all investment alternatives on a common evaluation basis of handling the time value of money where cash flows are discounted back to the present with a compounded interest rate of return.

$$DCF = \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} + \cdots + \frac{CF_n}{(1+r)^n}$$

where:

CFi = cash flow in year i

n = period (say, a month or a year)

r = country specific discount rate

= (1) WACC + (2) other risk premiums

As shown, discount rates comprise an estimate of the weighted average cost of capital (WACC), which may or may not include other premiums for country risk and/or company size.

Practical Steps to Calculate Discount Rates

The weighted average cost of capital is a calculation of a firm's cost of capital where each source of capital is proportionally weighted. In general, a firm's financing (or sources of capital) come through two sources, equity and debt.[4]

Weighted Average Cost of Capital (WACC)

$$WACC = \frac{E}{V} * k_e + \frac{D}{V} * k_d * (1 - T)$$

where:

k_e = cost of equity

k_d = cost of debt

E = market value of firm's equity

D = market value of firm's debt

V = total value of capital (firm's equity + debt)

T = corporate tax rate

This section will progress through the steps to estimate the costs of equity and debt with descriptions of how best to communicate resulting discount rates to the many and varying end users of these rates.

Step 1: WACC -- Determine the Cost of Equity

$k_e = R_f + \beta * (R_m - R_f)$ + *other risk premium(s)*

where:

R_f = *risk-free rate (for example, the yield on the 10-Year Treasury bond)*

β = *beta (which is the volatility of the stock price's returns relative to the volatility of the overall market (S&P 500) * the correlation of the stock price's returns with that of the overall market)*

R_m = *market return*

$R_m - R_f$ = *market risk premium (which is the extra yield earned by investing in the market relative to investing in a riskless asset)*

Other risk premiums may be due to firm size and country risk.

The cost of equity can be interpreted as the sum of the risk-free rate and premiums to compensate for risk associated with the overall market (the "systematic risk" inherent with the overall market or the market risk premium) and risks specific to a particular company ("unsystematic risks" that may include risks associated with small companies and/or the country where a potential investment is geographically located.)

Data Sources

To obtain estimates of the various components for the cost of equity, I typically use averages from 2 to 5 years of daily historical data (usually 5 years) rather than current prices and rates. The choice of the data period requires judgment. As examples, if there has been a structural change in the markets of concern (such as the Global Financial Crisis or the widespread use of horizontal drilling/fracking in the U.S. oil segment), I would shift the horizon to only evaluate market conditions following the disruption. For simplicity and communication purposes, I use the same historical period of observations for all variables throughout the WACC calculation. In my experience, one can obtain all necessary historical data required for WACC calculations from widely available sources such as Bloomberg and Thomson Reuters. I have found that in publicly traded firms, internal and external audit personnel will likely be required to review all data and calculations and having notable data sources eases their abilities to complete independent reviews.

Cost of Equity: Risk-Free Rates

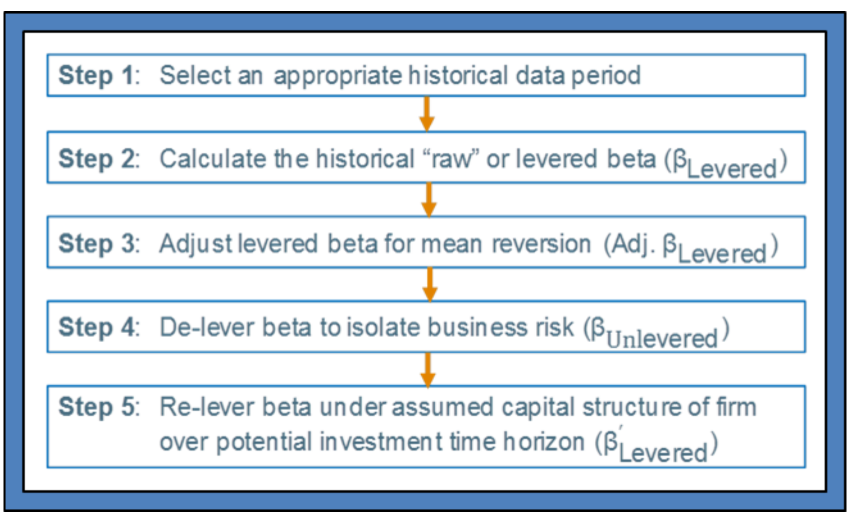
For an asset to be considered "risk free," there can be no default risk, and by definition these can only be government issued securities as governments are the only entities that control a country's money supply. It is generally best practice to match the duration of the risk-free asset with that of the potential investment. Across the commodity sector, investment horizons can span multiple decades. In the U.S., this would mean using the yield on the 30-year Treasury bond and the risk-free rate. However, given that there is traditionally minimal differences between the 30- and 10-year Treasury yields, I use the yields on the 10-year.[5]

It is important that the risk-free rate be consistent with how the free cash flows (such as shown in Figure 1) are defined for a potential investment. For example, if the cash flows are in U.S. dollars then yields on U.S. Treasuries should be used for the risk-free rate. If the cash flows are in Australian dollars, then the yield on an Australian government bond should be used.[6]

Cost of Equity: Calculating an Appropriate Beta

Figure 2 displays the practical steps in calculating a beta to be used in determining the cost of equity piece of the overall WACC calculation. As shown, these steps include determining an appropriate period of time (if a historical period approach is attempted), estimating a "raw" beta, adjusting the raw beta for mean reversion, de-levering the beta (to eliminate the impact that any debt outstanding a firm may have) and finally to re-lever under an assumed capital structure representative of the time horizon of the potential investment.

Figure 2
Determining Beta (β)



Consistent with other WACC estimates, for an appropriate historical data period (Step 1), I tend to use 5 years of daily data. The most straightforward method to estimate a "raw" or levered beta (Step 2) is to regress the daily percentage changes of a stock price on the daily percentage changes of a benchmark index, which is a proxy for the overall market (such as the S&P 500 in the U.S.)

Step 3 involves adjusting the raw beta to account for mean reverting behavior of the beta statistic. While there may be disagreement as to whether or not betas mean revert, my rationale for this adjustment is that the resulting beta is more stable over time, and therefore, this measure is better to apply to investment cash flows that may extend many years into the future.[7] Whether or not a practitioner chooses to include this step, the key is to select the estimation approach, apply it consistently and stick with it over time.[8]

A further complication with both the raw and adjusted beta is that these are levered, meaning these estimates include two components of risk: (1) the company specific business risks and 2) the risk from the firm taking on leverage (or debt.) To isolate the business risk component, an unlevered beta[9] is calculated (Step 4):

$$\beta_{\text{unlevered}} = \frac{\beta_{Levered}}{1+\frac{D*(1-T)}{E}}$$

where:

E = market value of firm's equity

D = market value of firm's debt

T = corporate tax rate

An unlevered beta provides a more accurate picture of a company's operating stability; it is the risk attributed to the company's assets, disregarding the capital structure of that firm.

Step 5 in Figure 2, and the last in the beta calculation process, includes re-levering the beta using the assumed capital structure of the firm over the potential investment horizon:

$$\beta_{Relevered} = \beta_{Unlevered} * \left(1 + (1 - T') * \frac{D'}{E'}\right)$$

where:

E' = assumed market value of firm's equity

D' = assumed market value of firm's debt

T' = assumed corporate tax rate

For example, assume a firm has a current capital structure of 80% equity and 20% debt. To fund a potential investment, the firm may need to issue additional debt to cover development costs. As such the firm's capital structure may be assumed to migrate to 60% equity (E' in the equation above) and 40% debt (D').

A Note on U.S. GAAP and IFRS Guidelines for Beta Calculations

For Generally Accepted Accounting Principles (GAAP) in the U.S., betas and other WACC inputs may be based on a single company (i.e., the firm actually evaluating the investment.) However, under International Financial Reporting Standards (IFRS), these inputs must be based on a "representative set" of comparable companies. For example, the international reporting of accounting valuations may be subject to IFRS guidelines. Figure 3 summarizes the various beta calculations for an example gold mining project in Australia, both under U.S. GAAP (assuming the individual investing company is Barrick Gold) and under IFRS with a "representative" group of gold mining companies in the country. As shown, under U.S. GAAP, Barrick's unlevered beta is 0.36 whereas under IFRS, the mean of the set of representative companies would be 0.51.

Figure 3
Calculating Beta (β) Under U.S. GAAP and IFRS

	(A)	(B)	(C)	(D)	(E)
					$= \frac{B}{\left[1 + \left(\left(\frac{D}{100}\right) * \frac{C}{100}\right)\right]}$
Company	**Levered Beta**	**Adjusted Beta**	**Debt to Equity (%)**	**Marginal Tax Rate (%)**	**Unlevered Beta**
Goldfields Limited	0.28	0.52	54.9	28.0	0.37
Anglogold Ashanti Ltd	0.38	0.58	105.9	28.0	0.33
Barrick Gold Corp	0.42	0.61	84.8	15.0	0.36
Newcrest Mining Ltd	0.56	0.71	36.1	30.0	0.56
Evolution Mining	0.51	0.67	15.8	30.0	0.60
Northern Star Resources	0.53	0.68	2.9	30.0	0.67
Regis Resources	0.51	0.67	3.8	30.0	0.65
Mean	**0.46**	**0.64**	**43.5%**	**27.3%**	**0.51**
Median	**0.51**	**0.67**	**36.1%**	**30.0%**	**0.56**

Beta:
Levered ("raw") beta estimates using 5 years of daily data.
Adjusted beta is .67 * raw beta + .33 * the market beta.
Debt to equity ratio is the average of the previously reported 5 years.
Marginal tax rate is the national rate associated with the country of incorporation.

U.S. GAAP
May use "expected" debt/equity tax rates and unlevered betas specific to investing company

IFRS
Use averages of "expected" debt/equity, tax rates and unlevered betas for the "representative group"

Cost of Equity: Market Risk Premium

The market risk premium measures risk that affects investments in the overall market (the systematic risks that are not firm specific). This risk is not diversifiable and is measured as the expected market return less the return on a "riskless" asset (or the risk-free rate) and represented as (Rm – Rf) in the above cost of equity equation. There are multiple methods to estimate the market risk premium including surveys (where market participants such as corporate Chief Financial Officers are queried for their expectations on equity returns), other forward-looking techniques where implied risk can be determined from prices in the option (or derivatives) markets or by examining historical return averages. As mentioned, my approach is to average historical daily data over the most recent 5 years to obtain these estimates. My personal view is that the market can migrate through extended periods of over-and undervaluation, as such using historical averages is an adequate path. Again, it is key to be consistent with the approach over time.

Cost of Equity: Other Risk Premiums

Company Size

Smaller companies tend to be more exposed to risk than larger firms, which may result in the need for an additional factor. In other words, the CAPM model may understate risk associated with smaller market capitalized companies. Previous studies have shown there is evidence of a persistent premium associated with smaller companies; however, this is very volatile. Studies of U.K. listed equities imply these premiums are ~4% (Dimson and Marsh, 1986). Surveys in Australia reveal that practitioners in that country apply premiums in the 5% range for companies with market capitalizations of less than $A50M (KPMG, 2017). In the past, I have not applied additional premiums for smaller market capitalized equities due to the past volatility of these estimates. For those analysts who do include this risk factor, I would caution against the potential to "double count" risk such as by including risk premiums for company size as well as for the lack of market liquidity for an equity.

Country Risk

Another key component included in the cost of equity is country risk, which measures the additional risk associated with political and economic conditions in the geographic region of the potential investment. Country risk is included as it is assumed that global markets have some level of significant positive correlation, and these risks cannot be diversified away.[10] There are multiple, practical methods to evaluate country risks including the use of country bond spreads and rankings from public and proprietary sources.

Country Bond Default Spreads

A fairly common approach for estimating country risk is to simply take the difference on the yields from bonds of comparable tenure in a country relative to a developed market such as in the U.S. Under this approach, the yield on a bond in the country of interest (such as the Peruvian 10-year bond) is compared to the U.S. 10-year Treasury yield.

$$Country\ Bond\ Spread_i = Country_i\ Bond\ Yield - Country_{Reference}\ Bond\ Yield$$

Again, using Peru as an example (for $Country_i$), the bond spread would be calculated as the yield on the country's 10-year government bond, at say 6.2%, less the yield on the U.S. 10-year Treasury as the reference bond yield for a mature market, at say 2.5%, resulting in a spread of ~3.7%.[11] This country risk premium would be added to the cost of equity for a potential Peruvian investment. A problem with this method is that this measures the risk of default on debt and for completeness, country risk estimates should also include a measure of risk associated with a country's equity market, as in the calculation on the next page.[12]

$$Country\ Risk\ Premium\ (CRP)_i = Country\ Bond\ Spread_i * \frac{\sigma_{equity\ market_i}}{\sigma_{govt\ bond_i}}$$

where:

$\sigma_{equity\ market_i}$ *is the annualized standard deviation of the equity market in country i*

$\sigma_{govt\ bond_i}$ *is the annualized standard deviation of the selected government bond in country i*

For the above Peruvian example, the country's bond spread is modified by the relative volatility of the equity and bond markets (3.7% * 14.2%/12.7%) = 4.1% where 14.2% and 12.7% are the annualized standard deviation of the equity and bond markets, respectively.[13] As shown, under this approach the country risk is slightly higher due to the relatively higher risk associated with the equity market compared to the bond market. At times, I have found that incorporating the relative volatility of equity and bond markets useful in the country risk premium calculation as many of the external audit firms such Deloitte, EY, and KPMG rely on this approach or some close variant to estimate country risk.

A cautionary note in using default spreads is a potential for a lack of data associated with emerging markets that may not have widely traded equity and/or bond markets.

Public and Proprietary Country Risk Indices

Other approaches to measuring country risk are available from both public and private sources including the World Bank, Eurasia Group, IHS Markit, the Economist Intelligence Unit (EIU) and the Fraser Institute, among others. Generally, these sources may provide more comprehensive relative rankings of country risk, typically on a scale of 1 (least risky) to 100 (most). For mining related projects, the Fraser Institute ranks countries and states within key countries in terms of mineral potential (geological attractiveness) and mining policies (transparency of tax and legal systems, enforcement of regulations, and infrastructure.) While mineral specific, a drawback to the Fraser survey is that it only covers ~50 countries. The World Bank, EIU and IHS services cover more countries and generally rank countries over a mix of risk factors including economic, geopolitical stability, security, infrastructure and social risks. Risks in each of these categories are evaluated by combining in-country personnel assessments with publicly available data.[14]

With these sources, my approach is to take the difference between the risk indices for the country of concern and that of a mature market (the U.S.) Noting a definite level of subjectivity, this risk difference (or delta) can then be scaled into an appropriate range of additions to country risk (typically in the range of -1%, 0%, +1%, …, 10%.) Countries such as Syria, Venezuela, and Yemen would be given a country risk factor of 10% whereas those countries deemed less risky than the U.S. (such as Switzerland, Sweden, Norway, and Greenland) would be given a risk factor of -1%.

Applying "Other Risk Factors"

Analysts may apply an estimate of country risk to the cost of equity and the cost of debt. My personal assumption is to only add this premium to the cost of equity under the view that any debt raised for a potential investment will typically be issued in the country where the investee is incorporated and will be priced in accordingly; in my experience this was primarily in the U.S. When including the country risk premium (CRP) in the cost of equity (k_e) calculation, there are different approaches with some adding the premium(s) to the cost of equity while others scale the risk premium by the beta estimate; the two approaches are shown below in equations (a) and (b), respectively.

(a) $k_e = R_f + \beta * (R_m - R_f) + \text{company size} + CRP$

(b) $k_e = R_f + \beta * (R_m - R_f + CRP) + \text{company size}$

My approach has been to use alternative (a) to add risk factors to the cost of equity. Others may scale the country risk factor via the beta estimate (as in alternative (b)), which implies that a company's exposure to country risk is proportional to its exposure to the overall market. From my point-of-view, a more conservative approach is to add other risk factors vs. scaling with a beta estimate since beta measures risk relative to the overall market which, in turn, may not adequately reflect country risk.

Step 2: WACC -- Determine the Cost of Debt

The cost of debt is the return a company provides to the holders of its debt securities. These creditors require compensation for the risk exposures that they take on by lending to the company (the risk that the company may default on its obligations in the future.) There are a few alternatives to calculate the cost of debt, based on whether the debt is publicly and widely traded, the debt has been rated by a credit agency (such as S&P, Moody's, Fitch) or neither.

Yield to Maturity (YTM) Approach

If a firm has publicly traded debt outstanding the current market interest rate on the debt (or the yield to maturity (YTM)) can be used as the cost of debt.[15] This method requires a liquid trading market for the corporate debt that is representative of the debt of the firm. With these conditions met, the cost of debt (k_d) calculation is both accurate and timely:

$$k_d = \left(\frac{d_1}{D} * i_1 + \frac{d_2}{D} * i_2 + \cdots + \frac{d_n}{D} * i_n\right) * (1 - T)$$

where:

i_i = *the YTM of the* i^{th} *outstanding debt instrument*

d_i = *the market value of the* i^{th} *outstanding debt instrument*

D = *total market value of debt outstanding by the firm*

T = *corporate tax rate*

Here the cost of debt is the weighted YTM for a company's outstanding debt. A limitation of this approach may be the availability and trading liquidity on longer-term bonds that relatively match the long investment horizons of potential investments in the commodity space. For example, if a firm has a 20- or 30-year bond outstanding, is the trading of this bond liquid enough that the YTM is representative?

Debt Ratings Approach

If a company's debt is not publicly traded (i.e., market price information is not available or is difficult to obtain), the cost of debt may be estimated via ratings from credit agencies, provided these agencies have rated the debt. Under this approach, the cost of debt is calculated as a default spread over a selected risk-free rate, representing the compensation the firm has to pay creditors for the risk of defaulting on their financial obligations.

$$k_d = \left(R_f + Default\ Spread\right) * (1 - T)$$

where:

R_f = risk-free rate

Default spread = spread over a riskless asset

T = corporate tax rate

The default spread is based on other bonds rated similarly by the credit agencies that are publicly traded over a risk-free rate.[16] In essence, the approach estimates a proxy cost of debt based on the credit rating on firm's debt. For example, the default spread on a corporate bond with the highest credit rating (Aaa by Moody's and AAA by S&P) may have spreads well below 1% (typically in the 0.4% to 0.8% range.) Under this approach, bonds rated Aaa/AAA would be assigned this default spread. Bonds with moderate risk (Baa/BBB) will have higher default spreads (usually in the ~2% to 3% range) where the poorest quality issues (rated as C category) may have ratios well above 10%.[17]

A limitation of this approach is that different bonds issued by a company may have different credit ratings. As such taking an average across all bonds will not be as accurate or timely as the previous YTM method.

Financial Ratios Approach

If a firm does not have any debt outstanding and is unrated by a credit agency, a synthetic rating can be estimated based on the firm's financial ratios, specifically the interest coverage ratio:

$$Interest\ Coverage\ Ratio = \frac{EBIT}{Interest\ Expenses}$$

where:

EBIT = earnings before interest and taxes

Under this approach, firms with higher interest coverage would receive higher credit ratings and thus lower default spreads. The calculated interest coverage ratio may then be translated into credit ratings and default spreads using the same methodology described in the *Debt Ratings Approach* discussed on the previous page.[18]

In the past, I have predominately used the YTM approach to estimate the cost of debt. While many calculate a weighted YTM based on all outstanding bonds for a company, I typically obtain the YTM on the bond outstanding with a tenor that most closely matches the time horizon of the potential investment. For mining projects, this usually translates into obtaining the longest tenured debt as the estimate. For example, the longest dated bond for Newmont Mining is due in 2042, from which I obtain the current YTM for use as the cost of debt.

Cost of Debt: Corporate Tax Rates

Within the calculations to un-lever and re-lever betas and to calculate the cost of debt, there are multiple alternatives to estimate the tax rates to be used. While I have used various approaches over my career, for ease I tend to utilize the marginal tax rate of the country in which the company is incorporated. This assumes that the income generated abroad will eventually be repatriated to the country of incorporation, at which point the company will pay the marginal rate. As shown in Figure 3, the national marginal tax rate is 15% in Canada (where Barrick is incorporated), 30% in Australia and 28% in South Africa.

For multinational firms, it is possible to calculate a weighted average of marginal rates for the relevant countries where income generating operations are present. A downside to this approach is that the calculated average rate may change as the operating portfolio of a company evolves. While there are multiple alternatives as to which tax rates to use, again I focus on simplicity and using the marginal rates is generally more conservative. Another alternative is to use a company's effective tax rate. Effective rates are the actual taxes paid as a percentage of reported income and are typically lower than marginal tax rates due to the use of accelerated depreciation, tax credits, deferrals, and tiered tax rates. A complication of using effective rates is that these tax "deductions" typically cannot be assumed to remain effective in perpetuity.

WACC: Market Value of Debt and Equity

Once the cost of equity and debt are estimated, these need to be weighted by the firm's capital structure, the split of the firm's value attributable to equity and to debt. For publicly listed companies, the market value of equity is the diluted shares outstanding multiplied by the share price where my approach has been to use the current share price. As described above, for those companies that have public debt, this cost should reflect the yield to maturity (YTM) on the firm's long-term debt, which is generally sourced from applications such as Bloomberg. For those firms that do not have observable market values or that do not have obtainable debt information, these may be evaluated using comparable company analysis and/or the aforementioned default spreads (or financial ratios.)

Communicating Discount Rates

The previous section provided practical steps to calculate discount rates. This section reviews the sources of uncertainty within the calculations of these rates and provides my recommendation on how to communicate and use these rates. To review, the previous section aims to provide practical steps toward calculating discount rates. An additional goal is to provide readers with an appreciation of the many sources of uncertainty inherent within the estimation of these rates. Figure 4 provides a summary of these various sources of uncertainty.

Figure 4
Sources of Uncertainty within a Discount Rate Calculation

Within Discount Rate Calculation Uncertainty Sources
Will forward-looking or historically based estimates be used?
If historical, the period to use (2-, 5-, 10- or 20-years of data?) and the data frequency (daily, weekly or monthly?)
To calculate betas, are estimates assumed to mean revert or not? How will market volatilities be measured (using natural logs or percentage changes)?
Which government issued security will be used as a proxy for a riskless asset (i.e., the U.S. 10- or 30-year Treasury bond)?
How will the overall "market" be measured (returns on the S&P 500, etc.)?
Will U.S. GAAP or IFRS accounting regulations be followed?
Will additional premiums for firm size and/or country risks be included? If so, how will these be measured?
How will the cost of debt be measured (YTM, default spreads, etc.)? Will a weighted average cost of debt be used or that of the longest-tenured bond outstanding be employed?
How will a corporate tax rate or group of rates be estimated (marginal or effective)?
How will the market values of a firm's debt and equity be estimated?
What assumed capital structure for the firm will be used (the assumed mix of debt and equity)?

Figure 5 on the next page displays the many representative groups/personnel within a company who may require the use of discount rates (from Accounting to mine and business planning teams, for example.) The objective is to have a consistent application of rates across the company. If an external M&A opportunity is being evaluated in Ghana for example, it should be using the same discount rate that a potential internal development project in that country is using; that is, the same rate a Ghanaian supply chain team is using to evaluate a potential contract (if this requires discounting.)

For effective capital budgeting across a company, having a single source for these rates is critical. If varying teams are allowed to set their own discount rates, effective capital budgeting across the entire portfolio of potential investments of a company cannot be achieved. A further argument is the varying monetary incentives that may exist within a firm. In many companies, project development and corporate development teams may be financially rewarded for the eventual funding and completion of their projects. Having these teams set their own discount rates is very problematic and a definite conflict of interest.

Figure 5
Example Users of Discount Rates within a Firm

Organization / Individual	Purpose
Accounting	Valuation of liabilities reported in financial statements (mining related, pension related, etc.)
Business Planning	Evaluation of annual business plans and alternatives
Corporate Development	Evaluation of external investment opportunities and potential capital structuring alternatives
Mine Planning	Evaluation of physical mining plans for current operations and portential new projects
Reserves/Resources	External reporting of ore reserves and resources
Project Teams	Evaluation of early and later stage development projects and alternatives
Environmental & Social Responsibilty	Evaluation of reclamation liabilities
Supply Chain	Evaluation of current and potential contracts
Tax	Evaluation of tax structure alternatives

Driven by all the uncertainties inherent within discount rate estimation and within the cash flow models themselves (as reviewed in the next section) as well as the vast number of varying individuals who may use these rates, my recommendation is simplification over the false assumption of precision. As shown in Figure 6 on the next page, my approach is to segment various country specific discount rates into a small number of distinct buckets, four in this case. Notice that associated with each category is a discount rate that is rounded to the nearest whole number (again no false assumed precision with multiple decimal points.) All countries within a given category use the same discount rates.

Simplification greatly assists with communication across a wide variety of users and enforcing a proper "portfolio approach" to capital allocation across a firm. As an example, prior to the above estimation and communication approach, I remember a 15-minute investment review meeting with a Chief Executive Officer and the project team on the prospect for continued investment in a Canadian development project. For 13 of the 15 minutes, the conversation centered on discount rates versus a proper discussion on the specific steps that the team was going to complete in order to ensure the economic viability of the project. It is noted that any individual communicating discount rates under this approach is very likely to get significant pushback from various groups, including those that may have personal financial interests. An example pushback is of the nature: "How can you possibly assign the same discount rate in Ghana as in Mexico?" Again, given all of the uncertainty with rate and cash flow estimates, in my view this is a valid approach.[19] It is also recognized that the level of simplification presented in Figure 6 may not be appropriate for all uses (specifically for mineral and business appraisers tasked with determining fair market values for assets.) However, it is anticipated that this article provides readers tasked with these responsibilities further understanding of the uncertainties within these assignments.

Figure 6
Example Nominal Discount Rates

Category 1 (Lower Risk) 7%	Category 2 (Moderate Risk) 10%	Category 3 (Considerable Risk) 13%	Category 4 (Extreme Risk) 16%
Australia	Brazil	Argentina	DRC
Canada	Bulgaria	Burkina Faso	Guinea
Chile	Colombia	Cote d'Ivoire	Haiti
New Zealand	Ecuador	Ethiopia	
Spain	Fiji	Eriatria	
United States	Ghana	Guyana	
	Mexico	Liberia	
	Kazakhstan	Indonesia	
	Peru	Mali	
	Philippines	Mauritania	
	Romania	Papua New Guinea	
	Serbia	Russia	
	Suriname	Uzbekistan	

Nominal and Real Discount Rates

It is critical that discount rates and the cash flows to which they are applied are aligned in terms of including the impacts of inflation (or are in nominal terms) or exclude inflation (in real terms.) Nominal cash flows are the actual cash flows that are expected to be received or paid out in the future whereas real cash flows are in today's or current terms and do not include the impact of inflation. By intention or not, it is not uncommon for practitioners to mix the application (applying a real discount rate to a nominal cash flow model or a nominal rate to real cash flows.)

The example discount rates in Figure 6 (7%, 10%, 13%, and 16%) are in nominal terms, designed to be applied to cash flows that include the impact of inflation. Given the significant time horizons of investment projects in the commodity space, I advocate using models and rates in nominal terms. As a further incentive, having cash flow models include inflation may also assist the firm in enforcing cost and capital discipline. In many instances, however, real rates may be required. For example, under various accounting regulations, certain liabilities such as reclamation and pension contracts may need to be publicly reported in real terms.

For investment projects where the majority of the spending is in U.S. dollars, in order to adjust nominal cash flows and/or discount rates to real terms, I rely on inflation rates implied by prices of Treasury Inflation Protected Securities (TIPS) to assist with the conversion.[20] Specifically, by taking the difference between the yields on the U.S. 10-year Treasury bond (2.5%, for example) and the U.S. 10-year TIPS (0.5%, for example) implies inflation expectations of roughly 2% (2.5% - 0.5%) over the next 10 years. In the examples on Figure 6, real rates would be estimated at 5% (7% - 2% expected inflation) for Category 1, 8% for Category 2, and 11% and 14% for Categories 3 and 4, respectively.

Cash Flow Model Uncertainties

As mentioned previously, my contention is that the many uncertainties within discount rate calculations are significantly outweighed by the uncertainties within the cash flow models to which these rates are applied. As an example, and which will be discussed in this section, there are huge amounts of uncertainty in the very first line of a typical commodity investment cash flow model: the expected production (let alone the many other lines in a cash flow model that have uncertainty such as the costs and capital estimates.) This section provides a very high-level view of how production estimates are obtained within the gold mining sector as an example. In particular, this section progresses from exploration through geostatistical modeling to mine plan development, from which estimates of metal production are derived. The goal is to provide an introductory understanding of the uncertainties inherent in each step.

Exploration

Mineral exploration is the search for an ore deposit and typically starts with reconnaissance. Reconnaissance is the preliminary examination of the overall geological factors and characteristics of a region. Activities during this phase include geophysical surveys, widespread geochemical and geophysical sampling. Geophysical methods measure the earth's magnetic conditions such as the resistance to electric current. As shown in Figure 7a on the next page, magnetometers can be used on the surface or in small airplanes to generate magnetic/gravity maps of an area. As an example, these maps may reveal the existence of minerals with high iron content (deep purple areas on the figure.)[21] Given the geology, this may indicate the presence of gold and other potentially profitable metals such as copper.

If remote sensing surveys reveal positive indicators, activities to more closely examine a region may follow. At this point, geologists will typically be on the ground, mapping geological characteristics of the region of interest, including rock types and structures such as faults. Geochemical sampling will also occur that consists of analyzing the mineral content of soils, plants and water as these may provide indications of what lies beneath the earth's surface; please see Figure 7b.

Figure 7a
Aerial Geophysical Surveying

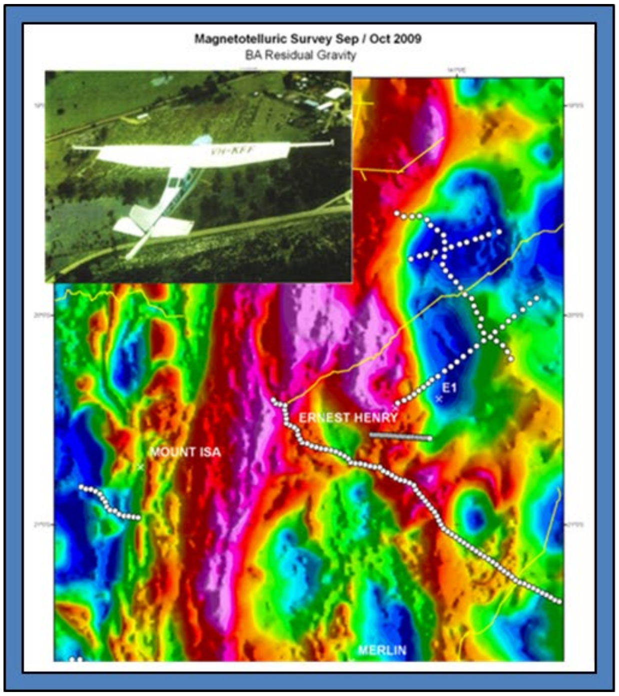


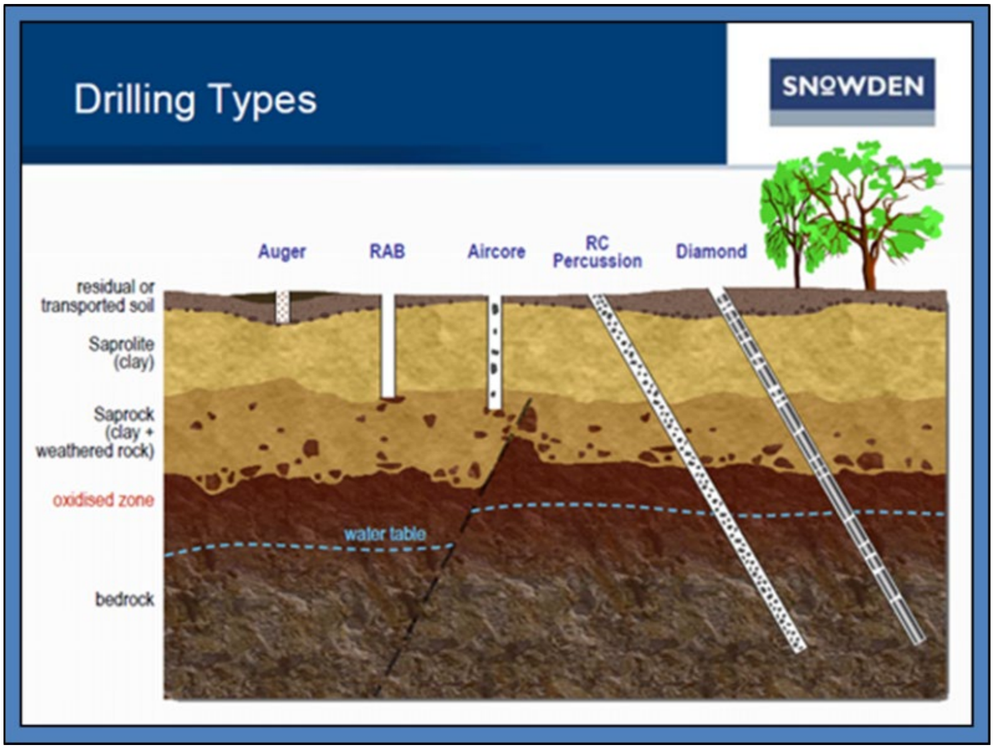
Figure 7b
Geophysical Sampling

Sources include Newmont Goldcorp Exploration.

If the mineral potential is high enough in a region following reconnaissance activities, subsurface evaluation may follow (if the mining company has funds available in exploration budgets.)

Figure 8 displays various drilling methods that may be employed. Selection of the drilling technique or the combination of methods is a trade-off of speed, cost, environmental concerns and the resulting sample quality.

Figure 8
Exploration Drilling Methods

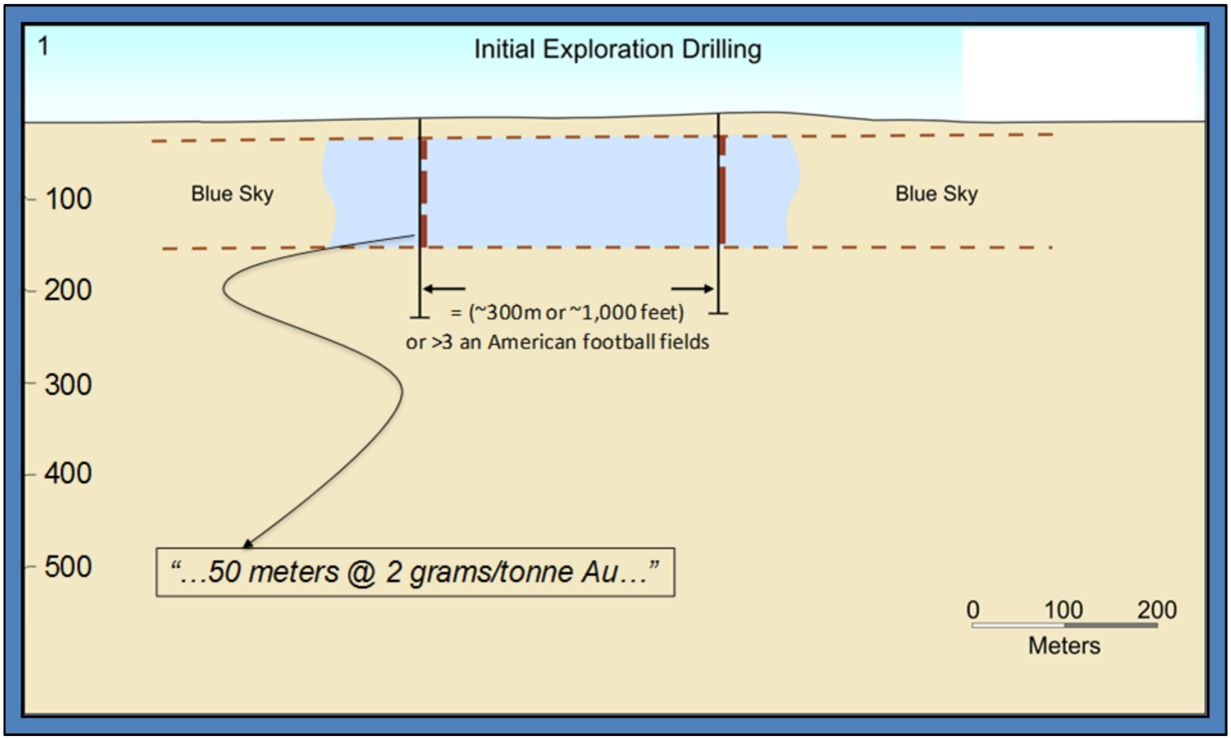


Source: "Geology for Non-Geologists" Professional Education by the Snowden Group.

As shown in Figure 8, methods range from fast and inexpensive Auger and Rotary Air Blast (RAB) techniques to diamond drilling, which can be extremely expensive but generates the highest quality geological information. Reverse Circulation (RC) and diamond drilling can generate samples that are very deep from ~1,600' to nearly 6,000' below the surface, respectively. The biggest advantage of diamond drilling is the resulting generation of a solid rock core that can be subsequently logged and geologically mapped. At Newmont Mining, the average diamond drill hole was ~500', costing ~$125,000 each. It is important to note that the cost as exploration budgets are limited, particularly when metal prices and company revenues are low. As such, there is a trade-off between how much drilling can be afforded and the need for information to eventually build cash flow models.

Continuing with the discussion on exploration, the example on Figure 9 displays a cross section of a geological area of interest (depicted in light blue) with two exploratory drill holes, each over 250 meters in depth (over 800 feet.) As highlighted in the red areas of each drill area are notable drill intercept results (found by the subsequent analysis of the drill cores.) In this case, a mining company might issue a press release stating, "…drill intercept of 50 meters in length at 2 grams/tonne gold." Also note the distance between these two drill holes of ~300 meters (or 1,000' or the equivalent of over three American football fields.)

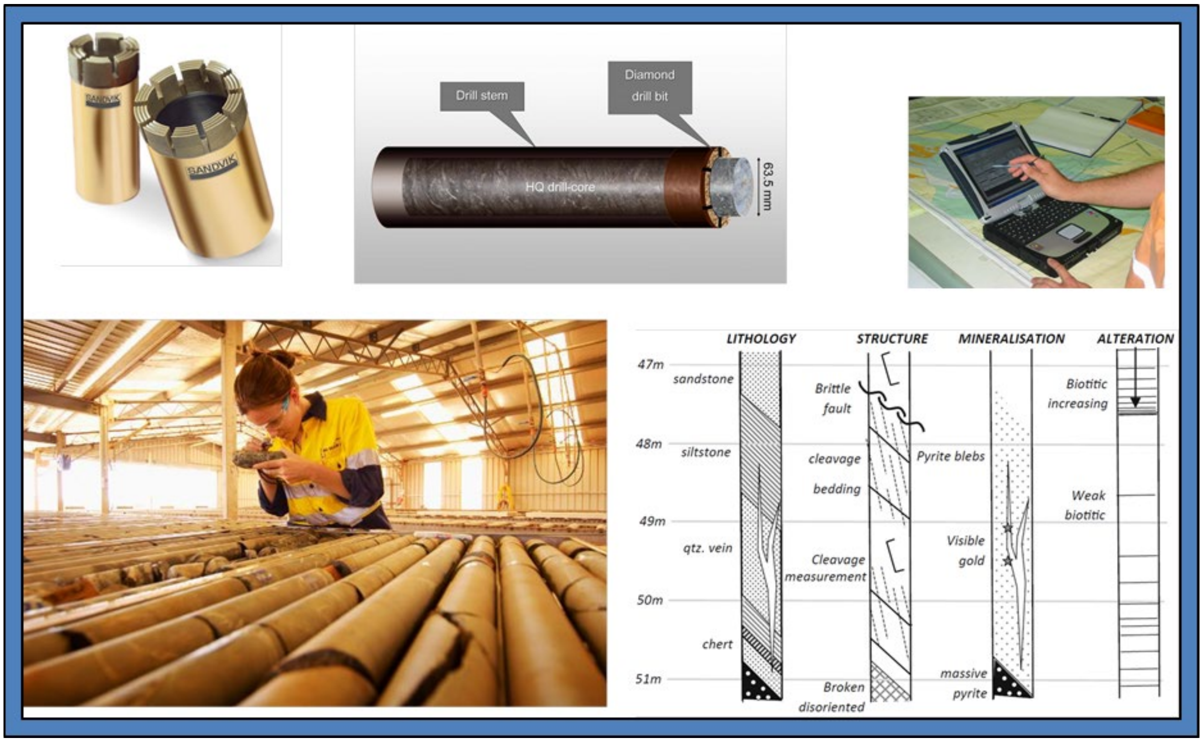
Figure 9
Example Early Stage Exploration Drilling (Cross Section)



Source: Newmont Goldcorp Exploration; figure was modified for demonstration purposes.

As depicted in Figure 10, diamond drilling generates a solid rock core by the use of a hollow, rotating bit, studded with industrial diamonds. With the resulting drill core, geologists complete logging (or identifying the attributes of the sample) that may include the grade, the structure and the physical characteristics of the rock. This information is recorded onto tablet computers from which eventual geological models are created.

Figure 10
Diamond Drill Core Logging



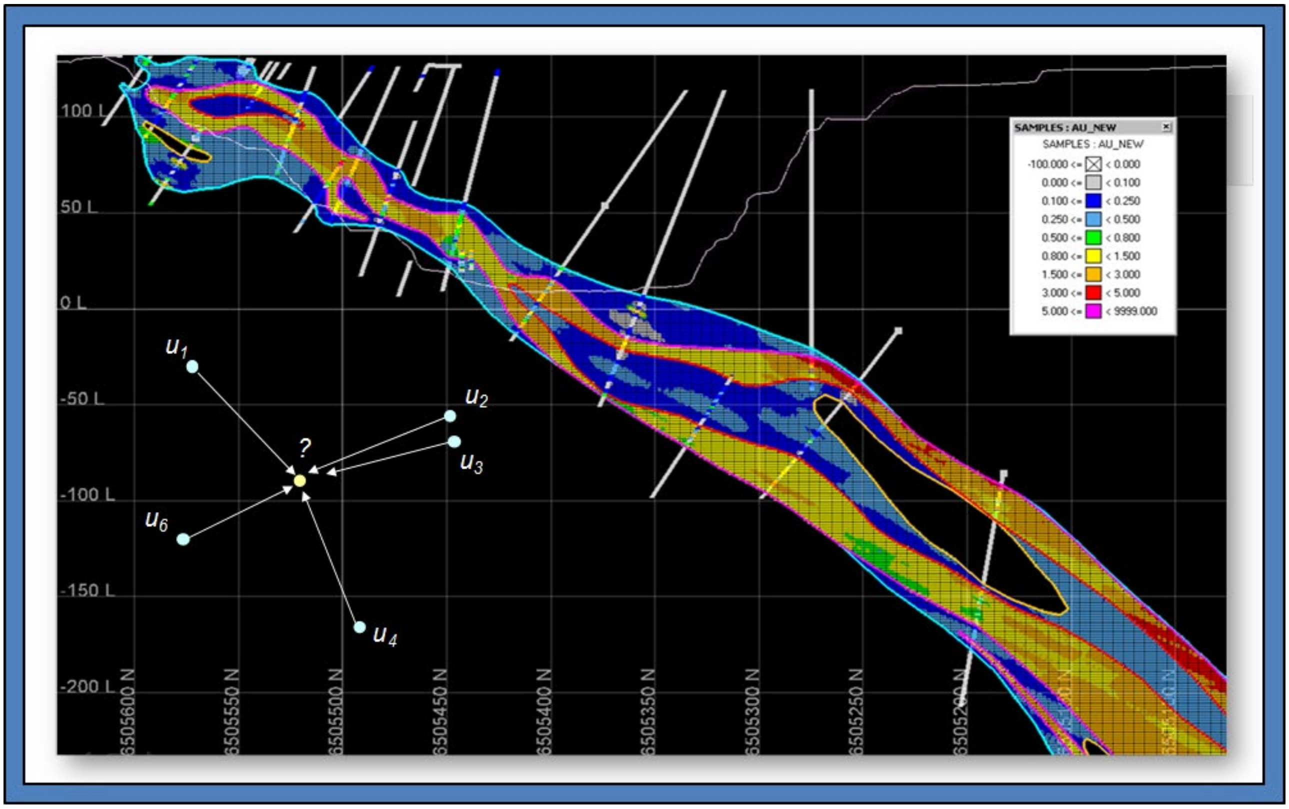
Sources include Newmont Goldcorp Exploration.

Once drill information is logged, the information is then handed over to geologic modeling teams whom utilize geostatistical models to estimate a potential mineral resource.

Figure 11 on the next page provides an example of a 3D image of a computer-generated block model that assigns a mineral grade to each individual block in the resource based on information from drilling samples. Within the figure, individual drill holes are shown as the white lines. Through geostatistical (or spatial) modeling, known grade information from the drill holes is used to interpolate potential grades in areas between the drill holes with the blue through yellow to purple colors indicating blocks with increasingly higher ore grades. As such, these models generate better (i.e., less uncertain) estimates the closer the drill holes are to each other, thus requiring lower degrees of interpolation.

A simple version of an interpolation routine within these models is shown in the lower left of Figure 11 where the goal is to estimate the grade at a given location (depicted with "?") from 6 available drill samples (labeled u1 to u6.) As a reminder, the example initial drill holes discussed in Figure 9 were ~1,000’ apart: this is a huge amount of space to interpolate a resource, but it is what mining companies will generally start with for metal production estimates as initial cash flow models are developed.

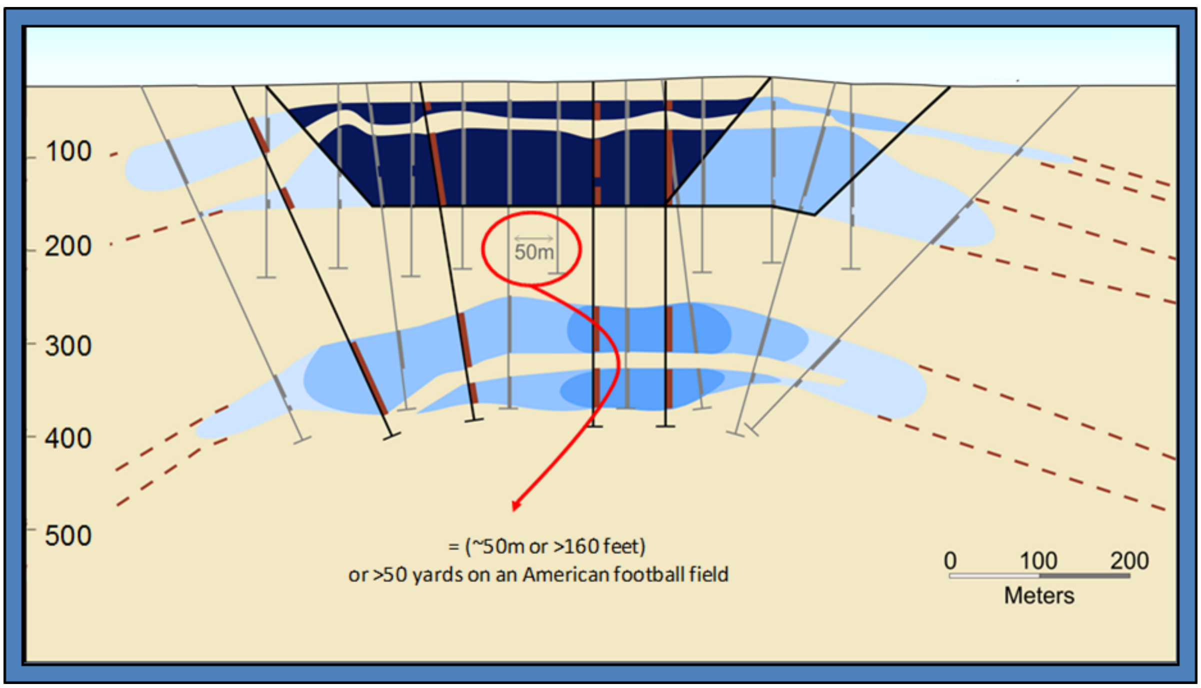
Figure 11
Geostatistical Modeling of a Potential Resource



Source: Newmont Goldcorp Technical Services.

As corporate and exploration budgets and personnel permit, if a resource has significant potential, more drilling can be completed as shown in Figure 12, which is a continuation of the previous example. As shown, additional drilling on the resource has been completed to the point that the spacing between the holes has been reduced from 300 meters in Figure 9 to 50 meters (~150' or 50 yards on an American football field.) As mentioned previously, this added information greatly improves geostatistical and mine planning models, but does not eliminate uncertainty. Further, with spacing of ~50 yards, typical levels of uncertainty of estimated production would be +30% (or if annual production is expected to be 100,000 gold ounces, with a down- and upside of 70,000 to 130,000 ounces, respectively.) As the company drills and spends more studying a given resource, the uncertainty may be reduced to +15%. However, even with this level of uncertainty, a faulty quest for discount rate "precision" can be swamped by uncertainty with attempting to estimate production estimates (let alone the many other elements of a cash flow model needed to estimate FCF.)

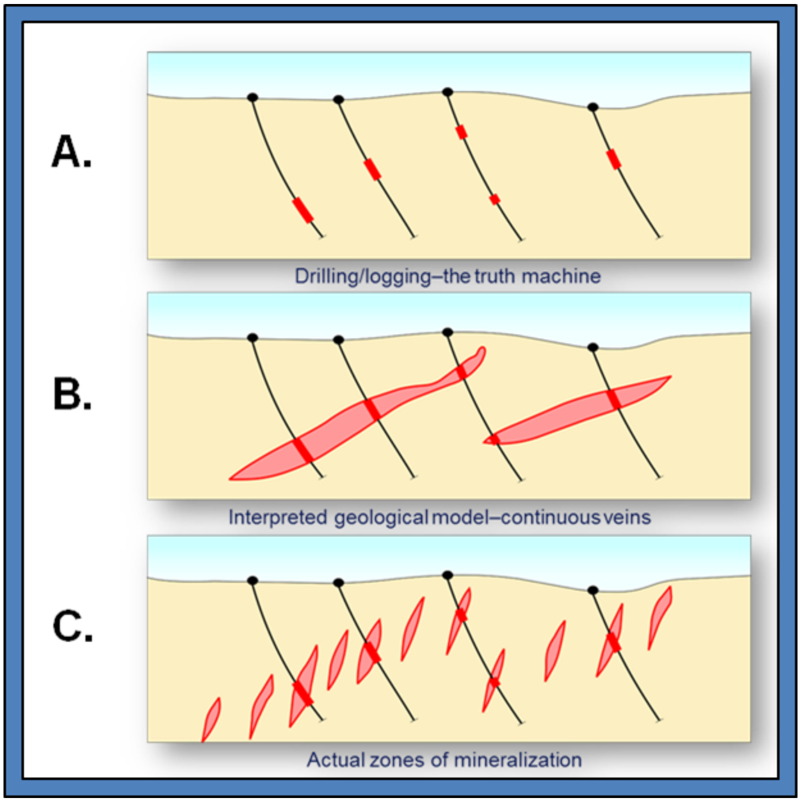
Figure 12
Continuing Exploration Drilling



Source: Newmont Goldcorp Exploration; figure was modified for demonstration purposes.

As a further example, even with best intentions, geologic modeling carries uncertainty. Consider the schematic in Figure 13 on the next page which, while simple, definitely occurs in the exploration for and modeling of metal deposits. In this example, through exploration, the mining company has completed four drill holes (Part A of the figure) with varying intercepts of higher-grade material (again identified in red.)

Figure 13
Geologic Modeling Uncertainty



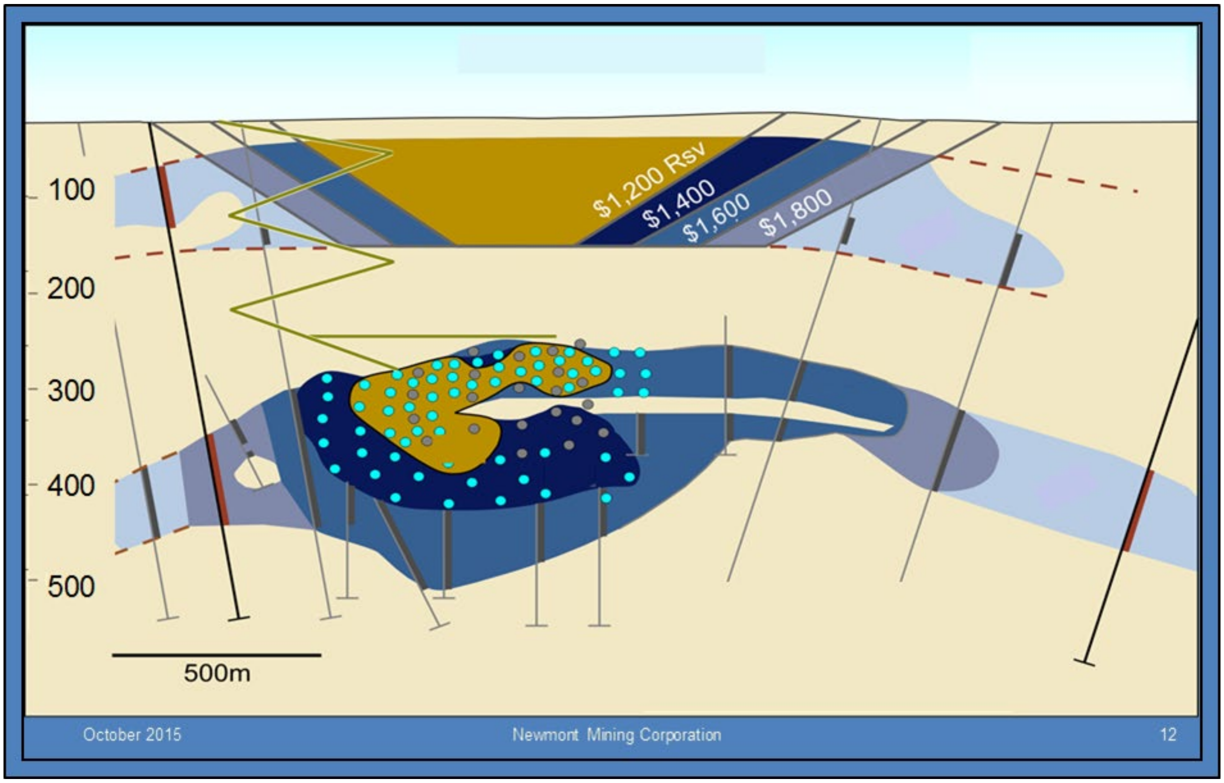
Source: Newmont Goldcorp Technical Services.

As previously described, with the core information from the four drill holes, the geologic modeling team interpolated a mineral resource that through modeling was thought to be relatively contiguous (as shown in Part B.) However, after the mining company fully invested in the development of the project, the actual mineral resource resembled Part C with drastically fewer gold ounces that could be profitably mined.[22]

Other Sources of Uncertainty

To this point, we have reviewed the uncertainties inherent in cash flow modeling associated with expected production due to the levels of interpolation that occur in resource modeling. Uncertainty from required interpolation can be extended by uncertainty with metal prices as shown in Figure 14 on the next page. As shown in this figure, the gold shaded areas represent areas of a potential mine that a representative company is highly confident that can be profitably mined at gold prices of $1200 per ounce. As shown, the number of mined ounces that have a high level of confidence of being profitably mined increases with the metal price (at prices of $1,400, $1,600, and $1,800.) As another reason to not become overly concerned with discount rate precision, trying to predict metals prices in the next 3 months, let alone over multiple decades, has quite uncertain success.[23]

Figure 14
Estimated Mine Production at Various Gold Prices



Source: Newmont Goldcorp Exploration; figure was modified for demonstration purposes.

Conclusion

This article attempts to provide distinct, practical steps for estimating, applying and communicating discount rates to the many users throughout a firm. The article demonstrates the multiple sources of uncertainty that lie within any discount rate calculation. These risks, however, are outweighed by the uncertainties inherent in the cash flow estimates to which these rates are applied. For investment analysis, capital budgeting and other applications for discount rates across the commodity sector, the methods presented in this article provide an appropriate mix of theory and practice.

We welcome feedback on this article; accordingly, comments and suggestions can be emailed to gcard@ucdenver.edu.

Endnotes

1 As a reminder, FCF is the cash that a project or investment may generate from inflows of money (for example, from gold or copper sold) less the necessary outflows (cash operating and other costs, interest, taxes and capital expenditures) as well as non-cash items (including depreciation and amortization). FCF represents the discretionary funds that a firm may use to pay dividends, repay debt, buyback shares or to fund growth.

2 Nominal prices and rates include the effects of inflation (and are discussed in the article.)

3 A further benefit is that with standard templates, multiple models may be combined to evaluate investments with a portfolio view.

4 Equity may include common shares outstanding and as applicable, preferred shares outstanding.

5 In addition, trading liquidity on the 10-year is significantly higher than on the 30-year.

6 Damadoran (2008) provides a nice write up on using risk-free rates.

7 Additionally, EY (2018) suggests using adjusted betas (mean reverting betas) as this tendency has been shown for industrial firms.

8 Damadoran (1999) also describes the use of adjusted betas.

9 Specifically, the equation is the Hamada formula and is used to separate financial risk of a levered firm from its business risk. Note: if a firm has no debt outstanding then the levered beta is equal to the unlevered beta.

10 These positive correlations increase significantly during times of financial and economic stress (as during the Asian and Global Financial Crises in 1998 and 2008/9, respectively.)

11 Again, due to the volatility in these markets, I typically use 5-year historical averages for these bond yields.

12 For further details on this approach, see Damadoran (2003).

13 To annualize an estimate, multiply by the square root of 252 ($\sqrt{252}$) if using daily data (there are 252 trading days in a year) or by the square root of 12 ($\sqrt{12}$) if using monthly averages.

14 At Newmont Mining, we worked with both IHS Markit and the EIU to create mining specific risk indices that included the availability of water, mineral rights, and access to land.

15 YTM is the interest rate at which the current market price of the bond is equal to the present value of all future cash flows of the bond.

16 Professor Aswath Damodaran of the Stern School of Business at New York University suggests matching the tenor of the government bond used for the risk-free rate to that of each bond analyzed. However, for simplicity I generally use the 10-year Treasury yield. However, as mentioned later in the article, for simplicity I typically do not analyze all bonds outstanding for a company and instead use the longest dated bond as a proxy.

17 The best free online source for default spreads that I have found is provided by the National Association of Insurance Commissioners.

18 Damadoran (2019) provides a table to translate interest coverage to default spreads.

19 As an aside, in my experience if and when project teams become overly concerned with discount rates, tax rates, this throws up a potential red flag as to the eventual economic value of the project for the firm.

20 For projects outside of the U.S. with the majority of the initial and continuing spending in local currencies, many markets may not have inflation-protected bonds. In these instances, I would rely on the farthest dated inflation forecasts that one can find such as from the IMF, World Bank, and Bloomberg in an attempt to be as consistent as possible across countries.

21 Specifically, these types of deposits are iron oxide copper gold (IOCG) and have relatively simple metallurgy and high ore grades.

22 Unfortunately the mining company spent multiple billions of dollars to develop this resource: mining is a tough and uncertain business!

23 One of my responsibilities as Chief Economist at Newmont Mining was to provide commodity price and FX rate forecasts throughout the firm. Rather than attempting precision, I typically estimated multiple structured forecast scenarios.

References

Damadoran, A., 1999, "Estimating Risk Parameters," Stern School of Business, New York University. Accessed via website: http://people.stern.nyu.edu/adamodar/pdfiles/papers/beta.pdf on July 10, 2019.

Damadoran, A., 2003, "Measuring Company Exposure to Country Risk: Theory and Practice," Stern School of Business, New York University, September. Accessed via website: http://people.stern.nyu.edu/adamodar/pdfiles/papers/CountryRisk.pdf on July 10, 2019.

Damodaran, A., 2008, "What is the Risk-Free Rate? A Search for the Basic Building Block," Stern School of Business, New York University. Accessed via website: http://people.stern.nyu.edu/adamodar/pdfiles/papers/riskfreerate.pdf on July 10, 2019.

Damodaran, A., 2019, "Ratings, Interest Coverage Ratios and Default Spread." Accessed via website: http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/ratings.htm on July 10, 2019.

Dimson, E. and P. Marsh, 1986, "Event Study Methodologies and the Size Effect: The Case of UK Press Recommendations," *Journal of Financial Economics*, Vol. 17, No. 1, September, pp. 113-142.

EY, 2018, "Practitioners Guide to Cost of Capital and WACC Calculations: EY Switzerland Valuation Best Practice," February. Accessed via website: https://www.eycom.ch/en/Publications/20180206-Practitioners-guide-to-cost-of-capital-And-WACC-calculation/download on July 10, 2019.

KPMG, 2017, "Valuation Practices Survey 2017."
Accessed via website: https://assets.kpmg/content/dam/kpmg/au/pdf/2017/valuation-practices-survey-2017.pdf on July 10, 2019.

Author Biography

THOMAS BRADY, Ph.D.
Executive Director, J.P. Morgan Center for Commodities at the University of Colorado Denver Business School

Prior to being named the Executive Director of the J.P. Morgan Center for Commodities at the University of Colorado Denver Business School, Dr. Thomas Brady was the Chief Economist at Newmont Mining Corporation where he was responsible for generating key commodity price, foreign exchange and other financial assumptions used throughout the company. In this role, Dr. Brady also developed methods to effectively quantify and communicate the economic impact of Newmont's operations to host communities and countries. Prior to this position, Dr. Brady led Newmont's Strategic Planning function that developed and implemented portfolio modeling analytics. Before Newmont, Dr. Brady was a Senior Manager at Risk Capital Management, a consultancy that advised energy and natural resource companies on financial risk, valuation and commodity hedging. He has also worked with CQG, Inc. where he developed a suite of automated trading systems for commodity futures contracts using the company's short-term, price and volume charting methods.

Dr. Brady is also a member of the J.P. Morgan Center for Commodities' Research Council at the University of Colorado Denver Business School. He holds a Ph.D. in Mineral Economics with research emphases in commodity markets from the Colorado School of Mines. In addition, Dr. Brady holds a Master's degree in Mathematics, also from the Colorado School of Mines.