



Guidelines for Technical Economic Evaluation of Minerals Industry Projects

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1 INTRODUCTION

The Australasian Institute of Mining and Metallurgy (The AusIMM) is the leading organisation representing technical minerals sector professionals in the Australasian Region. Members are bound by a Code of Ethics, and continual improvement of professional and industry standards within the sector in which they work.

The minerals industry has a bad history of decisions being underpinned by faulty economic evaluation modelling. These have ranged from minor mine-site decisions to major corporate acquisitions. Too often the modelling was convoluted, ‘sophisticated’ and personalised, so audit was tedious and frustrating. Consequently, people at all levels have called for ‘simple’ evaluation models. What they mean is modelling that is ‘easy-to-follow’ even when the subject is complex and so the model becomes long and detailed. If the models are made to be transparent, intuitive and fast to audit then these errors can be eliminated.

The AusIMM has taken up this challenge and established the *“AusIMM Guidelines for Technical Economic Evaluation of Minerals Industry Projects”*. It is a collation of sound practices that competent practitioners in economic evaluation have established over the years for the technical-economic evaluation of mines, processes, projects, studies, businesses, companies and industries.

These modelling practices are easy to understand and fast to adopt. The initial model might take fractionally longer to create, but from then on any use, updating, expansion, modification and checking is much faster – especially for others. The resulting model is easier and faster to audit. If the evaluation person suddenly is unavailable then others can take a copy and use it confidently. For everyone the model is friendly and intuitive. The modelling style does not belong to one person but is familiar across the minerals industry and is rigorous. Errors in logic and data are easy to identify. The model becomes a useful tool for all, helping to steer the project and giving confidence in the results.

The practices are described immediately below in Section 2: *“Guidelines for Spreadsheet Modelling”*. There is no support for a prescribed method, a universal model or a black box model. Instead a worked example is shown in Appendix A.

Section 3: *“Guidelines for Economic Evaluation”* is not part of the core purpose but is the sharing of experiences and approaches at a high level. Appendix B: Is a brief introduction to discount rates for analysts who do not have financial training.

The Guidelines are recommended for:

- Day-to-day assessment of operations at mine sites
- Highly technical studies
- Projects and Studies
- Corporate and company-wide models
- Major Corporate decision making

They are recommended for adoption by:

- Evaluation Specialists, whether from an operating, technical or commercial background.
- Consultants who need to be transparent in their advice.

- Technical specialists, even if the model is not for economic evaluation.
- Plant Managers who demand that assessments be readily understood.
- Project Managers and Study Leaders who demand that the economic evaluation be an easy-to-use working tool that helps steer the project, even if the project is most complex and so the model evolves to be long and detailed.
- Senior decision makers in companies and organisations who want 'simple' evaluations. They usually will not interrogate the model but must be confident there are no hidden major errors.

2 GUIDELINES FOR SPREADSHEET MODELLING

2.1 Purpose

The Guidelines for Spreadsheet Modelling outline the key principles and mechanics that should be adopted, not only for economic evaluation modelling, but also as current Best Practice Guidelines within our industry for any spreadsheet modelling exercises. It is recommended that these Guidelines are applied by Companies, Organisations, Consultants and Individuals whilst recognising that their adoption is voluntary. Worked examples that serve to illustrate these principles and the mechanics (along with those for the “Guidelines for Economic Evaluation”) are provided in Appendix A.

The following discussion uses the terminology and nomenclature used by Microsoft Excel™, which is the software used almost universally by industry practitioners. The same principles, however, apply regardless of the software used.

2.2 Key Principles

The key principles one should adhere to when spreadsheet modelling are simple but extremely effective. They are:

- Easy to follow
- Tailored-to-Purpose
- Transparent
- Disciplined, Rigorous, and Consistent
- Recording Sources of All Data
- Rapid to Audit

They make the model intuitive and readily followed even when it becomes long and detailed.

2.3 Easy to follow

2.3.1 Intuitive and Visual

“If you cannot readily understand my model you do not have a problem, I do!”

A person unfamiliar with the business should be able to receive the evaluation model remotely and be able to readily understand and follow the evaluation from beginning to end.

- The whole workbook should have an obvious visual flow from left to right, across labelled worksheets, and down each worksheet.
- Within each worksheet, the columns and rows should have obvious visual flows just like a simple text book.
- The titles and subtitles used in each sheet should cascade like one would see in a contents page.
- The workbook should begin with a brief introduction which explains the purpose and context of the document and how to interpret the formatting for faster understanding.
- Each worksheet should have its bold heading followed by an outline of its purpose and its broad links with other worksheets. Sections within each worksheet should be discrete, with obvious inputs, computations, outputs and graphs.
- Every cell should adhere rigidly to the formatting convention and so can be interpreted visually.

This principle should not be seen as a requirement to “dumb down” a model of complex processes. It means that every part should be intuitive, even to non-experts.

2.3.2 Time to do it properly

"Like painting a room at home it is 90% preparation."

- Time should be taken to understand the activity being modelled from ‘raw material’ inputs to ‘finished product’ outputs, be it a business activity, a technical activity or an intellectual activity.
- The evaluation model should be built speedily but carefully and methodically, rigorously using the modelling practices, so as to be easy-to-follow and making any errors recognisable during a quick audit.
- Shortcutting of modelling practices frequently produces hidden errors because there is inadequate transparency, consistency and rigour.
- Before any results are released, graphs should be generated of the key inputs and results as essential checks.
- Before any results are released the model should be properly audited – internally, then by an external party.

2.3.3 Architecture: Workbook Layout

The model's architecture should be intuitive, even to a non-expert, so that its structure is obvious and navigation around the parts of the model is rapid.

- There should be complete flexibility in the way the model is structured. Some models will evolve from one worksheet to multiple worksheets as more detailed modelling is justified.
- The flow of multiple worksheets should be a logical sequence from left to right. Each Worksheet has a tab name that shows its purpose.
- Usually the model should be saved so that it opens at the top of the first worksheet, where there is a brief description of:
 1. The purpose of the model,
 2. Contact details of the author and users,
 3. The directory location where it is securely stored,
 4. The Model's architecture if there are many worksheets,
 5. Any warnings or limitations,
 6. Audits completed,
 7. The modelling practices/formatting, and
 8. List all other models that are used for inputs or that are directly linked.
- The model should then include a summary of results and key inputs in numeric and graphic forms. The modelling may commence under that summary but more commonly on subsequent worksheets.

2.3.4 Worksheet Layout

A non-expert should readily understand the function of each worksheet, how it is arranged into component parts, how the data is entered, the computations, and the relative importance of the parts.

- The visual flow down and across each worksheet should be intuitive and logical.
- Each worksheet should have a bold heading followed by a brief outline of its purpose, and where helpful, its important links with other worksheets.
- Sections within each worksheet should be in discrete work blocks, with obvious subsections and subheadings using a cascading layout for subtitles.
- Visually each work block should be self contained with an obvious step-by-step development toward a bold subtotal for that work block.

- The separate work blocks should be in a logical sequence down and across the worksheet and their aggregation be obvious.
- Complex and extended computations should be shown in a series of small steps so that the logic is visible and the input parameters are obvious. There should be no need to interrogate the algorithm. Explain the logic of complex algorithms in a visible row note.
- Usually if a row of data that has already been presented above is needed again in a work block then the entire row should be repeated so that there is visual flow of the logic. If referenced from another worksheet then it should be coloured coded.
- Key inputs and results should be shown in graphs as a self-check and for rapid understanding.
- The Data Group and Outline facility can be used to define worksheet structure, collapse related groups of rows or columns to reduce visual clutter, and aid navigation.
- Each worksheet should have a header and/or footer so the source, date, etc can be identified when looking at printed copies.

2.3.5 Modular Construction

As much as possible, the model should be constructed as modules, each having a clear set of inputs, calculations, and outputs that are used in various other calculations downstream, or presented as final results.

- Calculate any parameters only once in the whole workbook, then use that one result in all other places where it is required. Changes need only be made in one place, rather than having to search through the model to find all places where the same parameters have been calculated.
- The testing of small independent modules facilitates error-checking and auditing.

2.4 Tailored-to-Purpose

2.4.1 Size and complexity

Greater sophistication and mathematical complexity does not automatically deliver a better model.

- Some major decisions, syntheses and risks can be evaluated with small, simple models, whereas some minor investigations/syntheses require elaborate mathematical modelling.
- In general the size of a model increases as a study progresses through conceptual, pre-feasibility, and feasibility levels but every model should match the materiality of a parameter to the detail of its computation.
- Long and detailed models may be required for some tasks.
- Increasing detail and size decreases the model's universal appeal, including its "auditability".
- Where a long and detailed model is required it should be made easy-to-follow.
- Intellectual prowess should be used to transform complexity into small steps.
- Modelling should proceed as a series of visually easy-to-follow steps rather than using complex algorithms and inbuilt software functions.
- Models should take the reader through the logic process in small steps rather than using a "trust my modelling" approach in a single cell or complex algorithm/function.
- There is a level of detail necessary to get a "good" outcome, but a more detailed level of analysis may be required to prove that it is good, particularly where results are counter-intuitive or unexpected.

2.4.2 Minimalist - as simple as appropriate

- Each evaluation should begin with the thought of having the entire activity sensibly represented in one worksheet.
- As the model matures and expands it is preferable to have only one main model to handle all the variations. It is difficult to manage and control multiple versions of the same model for different scenarios, especially when more than one person is using them or if a retrospective change is needed to each version.
- It may be useful to have stand-alone sub-models that evaluate subordinate issues. Once resolved the outcome should be incorporated into the main model.
- In a long and detailed model it may be helpful to have a diagram in the front 'Introduction' worksheet showing how the model's sheets interact and flow.

- Models should be commenced as minimalist. Computations should not be included in case they may be needed in the future. However, as part of the overall project specification, model capabilities that might be needed should be identified at the start of the project and the model constructed in such a way that they are not precluded and can be easily added later if required.
- Extra detail may be introduced when the extra rows of computations are justified.
- Computations, where used, should be “stepped-out” row-by-row without skipping “obvious” steps. Algorithms should be kept short so as to make the model easier to understand and follow.
- Computations should also not be complicated by mixing multiple activities, e.g. having a mathematical formula that models the process and also includes a change in units.
- Some results may be computed to sufficient precision using simple approximations. For example:
 - Operating costs may be simple fixed and variable until a detailed bottom-up computation is warranted.
 - Mineral concentrate prices may be better computed as a percentage of contained values rather than using the detail of complex historical pricing mechanisms.
- However, care must be exercised, as “simple” relationships will typically have a smaller range of validity than more complex relationships, which may limit the range of sensitivity analyses that can be validly conducted. The limits of the validity of simple relationships should be ascertained and clearly specified in a visible row note above the associated data items or calculations.

2.4.3 Matching detail and content with its importance

Computations should be tailored to match their importance.

- The computations that have greatest impact on the result should be given the most attention.
- The computations of secondary and tertiary importance should be given less priority and detail.
- Computations that are a focus of a particular person should not be given undue attention, for example working capital by an accountant.
- Income tax and working capital may be approximated in a few coarse computations, rather than to accounting detail.

- Accounting statements should be derived from the technical-economic cash flows, rather than vice versa.
- It is recognised that some key decision makers and influencers may have strongly-held views which may need to be proven or disproven by extra evaluation detail.
- Select appropriate time-scales for calculation of physical quantities, cash flows and reporting. These may all be different. There is a trade-off between accuracy, complexity and model size.
 - Small time increments (e.g. daily, weekly, monthly) may be too detailed for the level of study, imply an accuracy that does not exist, and increase the model size unnecessarily.
 - Large time increments (e.g. yearly) may be too coarse for some purposes, requiring complex logic to handle interactions between time periods (e.g. if the model is generating automated schedules with predecessor/successor relationships).
 - An intermediate time frame (e.g. quarterly, half yearly) may provide a balance between the various considerations.
 - Smaller modelling time increments can be easily summarised for final reporting of results.

2.4.4 Matching Data and Calculations

- Create data entry areas in a layout that makes it easy and natural for the user to understand and to enter the right data accurately.
- If necessary, pre-process the entered data to convert units used or into a different format that facilitates the development of simple, robust, error-free model logic.
 - Do not force the user to enter data in an unnatural way simply to suit the calculations.
 - Do not develop complex logic just because the data is entered in a particular way.
- Do calculations in “natural” or un-factored units e.g. tonnes, dollars etc (this does not affect calculation time or internal precision of floating point calculations).
 - Use grades and recoveries as decimal fractions (values between 0 and 1), not as percentages (values between 0 and 100). Make use of the spreadsheet’s number formatting features and styles to display percentages.
 - Avoid multiplying and dividing by 1000, 1000000 etc in the body of the model. This is error-prone and adds unnecessary computations. Make use of the spreadsheet’s number formatting features and styles to round the display to show thousands, millions, etc.

- Preprocess raw data once by these unit and/or scaling conversion factors if necessary before further use in the model.
- If exporting results to another model, create an export worksheet in the format required by that model, and do any unit or scaling conversions necessary (to percentages, thousands, millions etc) when populating the export sheet.

2.4.5 Direct involvement of Project Team members

Key Team members may assist with the creation of the model in their areas of expertise.

- Their enthusiasm for lots of detail to replicate the intellectual challenges of their special areas should be tempered by and matched with the relative level of importance.
- They should audit their own part of the model and so 'co-own' the model.

2.4.6 Helicopter View

Each team member needs to gain a working "helicopter view" of the modelling. Focus is given to the areas that matter the most. Work on intellectually stimulating but minor issues should be minimised.

- A summary section with graphs of key assumptions and results should appear near the front of the model to give Team Members and Management a readily understood overview.

2.5 *Transparent*

2.5.1 The complete evaluation flows like a simple story book

- By starting at the top of the first worksheet and reading on screen or printing to the end of the last worksheet the inexperienced, non-expert should be able to readily follow the logic.
- Non-expert readers should be able to readily understand how the model works and how its component parts fit.
- The architecture and adherence to "good/recommended" modelling practices should make the evaluation transparent.
- It should be easy to visually distinguish between:
 1. Input of raw data
 2. Referencing of data from other worksheets
 3. Computations

4. Outputs

- Every worksheet and every cell should have a purpose and genesis that is obvious on the screen and in print.

2.5.2 Input data is exposed

- Every piece of input data should be entered in a prominent coloured input cell before it is used in an algorithm.
- No input should be hidden in an algorithm, with the possible exception of everyday conversions such as dividing by thousands or converting pounds to kilograms. However, it is recommended that unit conversion factors also be entered once, and referred to where required. This avoids typographical errors or inconsistencies (e.g. the number of significant figures used) when the same factor is entered multiple times in multiple locations, and potentially at different times and by different people.
- A specific font colour should be used to readily identify data inputs. Blue is commonly used.
- Appropriate use of “Controls” (e.g. drop-down boxes, check boxes etc) can show the ranges or specific options for data values and scenario settings that may be validly used in the model, and limit entries to these.

2.5.3 Dubious data is highlighted

- A distinctive colour coding should be used to highlight input data or computations that are dubious or very preliminary. Pink may be used.

2.5.4 Source of data is recorded

- All data sources should be recorded (see section 2.7).
- a number of columns with historical data from previous years may be useful – this will help demonstrate the veracity of forecast data.

2.5.5 Algorithms flow visually

- Visually the sequence of computations should flow like a ‘simple story book’ down and across the spreadsheet.
- Complex algorithms should be broken into easy to follow steps.
- Computations should appear obvious and generally should not require interrogation of cells.

- Any change or inconsistency in a sequence of algorithms across a row (or down a column) should be highlighted.
- Links to other workbooks can be dangerous because the other model may be altered without the change being recognised. If links to other workbooks are used, the whole row/column with titles and labels should be referenced across so that covert changes can be seen. The linked row should be highlighted in colour.
- Macros that perform calculations cannot be readily followed visually or audited and generally are not trusted.
- Some spreadsheet Functions have a history of misuse and cannot be audited, whereas 'long hand' computations can be followed easily and visually.
- Multiple recalculations of the same thing should be avoided.
- If creating new logic that supersedes existing logic , it is recommended the modeller either:
 - Label the old logic clearly as superseded, and preferably move it away from the active logic, e.g. to the bottom of the sheet, or
 - Delete the old logic, but log the change, identifying the superseded version of the model that used it.

2.5.6 Language in full

- Units and technical expressions should be expressed in full at least once in a model. Consider using a list of Abbreviations or a Glossary of Terms. Abbreviations such as 't', 'T', 'm' and 'M' have different meanings to different people - some of which are not consistent with international standards. Examples include "dry tonnes" and "wet short Tons".
- If an algorithm requires data from another worksheet then the complete row is first referenced across, usually just above where it is needed.
- Every row that is referenced from another worksheet is shown in a distinctive colour coding and or font style.
- This means that every algorithm uses data already shown in its own worksheet. Auditing an algorithm will never show data that is referenced or linked from another worksheet.

2.5.7 Referencing other workbooks is avoided.

- Links to worksheets in other workbooks should be treated with extreme caution. If done it should be obvious, limited to special situations, and done with extreme care. The whole row or column or rectangular range should be linked across. A distinctive cell format should highlight such imports.

- Ideally this should only be done for importing data that will change infrequently (or not at all), often pre-processed into suitable table structures or summaries for use in the model. (Examples might include tables of Ore Reserves generated from data extracted from geological block models and mine planning software, or fixed and variable unit costs derived from detailed cost records.)
- Information from other workbooks should always be imported directly into cells similar to data entry cells with no other processing, and then used in calculations elsewhere. Formulas in a cell should never both import data from another workbook and perform some calculation on or with that external information.
- Separate external data files should be maintained for each version of such data, links from the main model should be carefully checked regularly.
- Information identifying the data version should be imported from the linked workbook as well as the data itself, so that it can be easily seen what is being used without having to edit the linkages.
- Calculation logic that flows from one workbook to another and back to the first should be avoided, as changes made early in the logic in the first workbook will not flow correctly to later stages of the logic if the other workbook is not open or links both ways between the two workbooks have not been correctly maintained. Such links can easily be broken if one workbook is saved with a new name while the other is closed.

2.6 Disciplined, Rigorous and Consistent

2.6.1 Trust what is seen

- What is seen on the screen or in print should represent what is happening in each row, column and cell.
- Every cell should adhere rigorously to the modelling practices which are shown at the start of the model.
- Every cell should be able to be trusted to be consistent with its neighbours of the same formatting.
- Any inconsistencies in algorithms should be highlighted.
- Worksheets, columns or rows should not be hidden. The 'Data Group' facility is acceptable because it marks the collapsed data.

2.6.2 Discipline and Rigour

- “Either use 100% modelling Practices or zero Practices”. Models that follow the Practices in the main but which covertly falter in other parts are far worse than models that have no Practices.
- Time should be allowed to use the modelling practices and properly audit the model before results are expected.

2.6.3 Aggregates and Totals

- Totals and subtotals should be obvious. It is recommended that a column on the left side of the spread sheet is used, where it is usually visible, rather than on the right. Total rows should be highlighted with bold font or borders.
- Each sequence of numbers being inputted (row and/or columns) should be aggregated and these totals made obvious so that they can be readily understood and can be checked against source data.

2.6.4 Column Headings

- The sequence of columns across every worksheet in a workbook should be identical unless clearly identified, especially for year (or other time period) headings.
- Once a sequence of column headings is established in one worksheet it should be maintained in all other worksheets. For example if the year 2018 is in Column K in one worksheet then it should be in column K in all worksheets. Exceptions should be clearly highlighted.

2.6.5 Ready-made Models and Worked Examples

- Models with blank input fields to be filled for entry into a ‘black box’ should be used with caution. They may be useful for sorting opportunities.
- “Worked Examples” of these AusIMM Modelling Practices can be used as the starting point for a new model and adapted.

2.6.6 Log of Changes and Model Versions

- Where a history of changes to the modelling needs to be recorded:
 - Version numbers should be given to models distributed, and

- Noted with outputs in reports, presentations etc (i.e. include filename, worksheet, date, and revision in footer or printed cell for published outputs).
- The model distributed or used for report tables and figures should be the last with that version number. Any subsequent work done should be with the next version number.
- Anyone editing the model should list all updates in a log of changes with:
 - Date and person
 - A description of the update (with figures noted), new NPV figure etc, and
 - Comments describing any reconciliation/explanation of the effect (if required).

2.7 Recording Sources of All Data

2.7.1 Row notes of the source of the data

- Anyone reading the model should be able to immediately identify the source and date of the data, and so assess whether it is the most recent and appropriate.
- This applies to every row of numerical input values and to computational logic that is unusual.
- The source of each item of information should be recorded with the date, person and/or document name.
- This should show as a row immediately above or below the inputted data and always appears in full on the screen or in print. It should not be in a hidden, embedded cell note.
- Some analysts may choose to use notes in cells as personal reminders of change for recording why algorithms change and/or a chronological record of all historical data used and updates.
- Any source data that is known to be dubious or to need checking should be identified in a specific font colour. Pink or magenta is being widely used.
- At the beginning of the model the name of the person performing the modelling should be stated, with the contact telephone and/or email address and the start date.
- Discipline is required to update source information when data is updated. There is little or no way to check on this later if it is not done at the time.
- It may be useful to retain previous data sets, with capability in the model to switch between them. In this case data source information might be entered in a particular column in each data row, and it will be more evident if some data sets have the same or no source information.

2.8 Rapid to Audit

2.8.1 Speed

- If the Practices have been followed rigorously the model should be easy to follow and therefore quick to audit. Consequently people are likely to be more willing to audit others' models.

2.8.2 Process of Audit

- Three phases of audit are recommended:
 - Self audit by the person who developed the model,
 - Audits by internal members of the Team who check “their own sections”, and
 - A formal audit of the entire model by an independent person(s) external to the model.
- The status of each of these three audits should be clearly visible on the “Introduction” worksheet.

2.8.3 Auditing Reports based on the Evaluation

- The person auditing the model usually should also audit the relevant sections of any reports based on that model.
- The interpretation of model results over the ranges of cases needs to be confirmed.

2.8.4 Auditing Mechanisms

- A common approach to audit is to work from the key outputs, such as NPV or production, back up the streams of computations to the inputs for each.
- Create “error checking” formulas within a model. The more of these formulas in a model the more “self-auditing” it becomes.
- The total for each data input over the life of the evaluation should be checked against the source data. Global totals of key inputs and outputs should be tested.
- Where the evaluation is part of a larger sized resource or business its validity and context should be investigated.
- Use of spreadsheet auditing/checking software should highlight inconsistencies and the use of data values hardwired into formulas.

- Consistency of algorithms across rows and down columns may be tested by copying the algorithm in the first row across/down all others. It is not uncommon for the first column to be different, though that should be highlighted. Copying the second column may be better.
- Audit down columns is better done in other than the first column – in case the first column was altered but mistakenly not copied across, or is different from the rest for some valid reason (in which case the difference should be highlighted).
- When auditing, it can be useful to create a new sheet at the front of the workbook with:
 - All auditing notes listed,
 - A prioritisation colour code noting high, medium and low ranked items (using red, yellow and green cell colouring), and
 - Links to the sections of the model that the auditing notes apply to.

3 GUIDELINES FOR ECONOMIC EVALUATION

3.1 Purpose

The Guidelines for Economic Evaluation discuss key concepts and mechanics in economic evaluations and are independent of the “Guidelines for Spreadsheet Modelling”. It is recommended that these Guidelines are applied by Companies, Organisations, Consultants and Individuals as current Best Practice Guidelines whilst recognising that their adoption is voluntary. Worked examples that serve to illustrate these principles and the mechanics (along with those for the Spreadsheet Modelling) are provided in Appendix A.

3.2 Context

3.2.1 Theory and Computation of NPV, IRR and Risk

Refer to Financial Theory, Risk Theory and related documents for the calculation of Discounted Cash Flow (DCF), Net Present Value (NPV), Internal Rate of Return (IRR), risk-adjustment and related metrics. Appendix B provides a brief introduction to discount rates for the information of technical analysts who do not have financial training.

3.2.2 Economic Evaluation and Financial Modelling

Preferably the evaluation of the economics of an investment is kept separate from the modelling of its financing.

- Evaluate the economics of the underlying cash flows without financing as the first step. Understand the viability of the underlying investment. This is “economic evaluation”.
- Consider ways of financing the investment, in financial modelling, as the second step. This is “financial modelling”
- If financing is combined with the economic evaluation then the discount rate will need to be adjusted.

3.2.3 Modelling, Valuation and Evaluation

- Evaluation is a three tier process. “Modelling” is creating the working tool at the bottom, “valuations” are the outcomes of using the model to test various possibilities and scenarios, while “evaluation” is the highest level process of understanding the best outcome for the business or organisation. Evaluation is the process of considering the economic worth of an activity. It should investigate all inputs, computations, outputs, cases and alternatives.

- Valuation is an outcome of the evaluation process where a single value or a range of values is/are produced under set/sets of conditions.
- The numerous assumptions involved can lead to varying views as to the value of a project, company, etc when applying the DCF technique. This tends to lend weight to experience being of particular importance.
- Valuation exercises are more accurate when ranking projects, etc, on a “relative” basis. That is, under a common set of assumptions, one can identify which project, within a suite of projects, will provide the greatest value.
- Valuations are undertaken in an “absolute” sense when an absolute value is attributed to the project, which is not ranked relative to other options. Values are always based on future estimates and hence a level of uncertainty is inherent.
- When undertaking valuations on an “absolute” basis a range of outcomes should be determined.

3.2.4 Stand Alone or Incremental Value

The overall approach to evaluation may be incremental value or absolute value.

- An existing business or activity is usually valued in absolute terms.
- An investment is usually valued as its incremental economic impact - the value of “proceeding” minus the value of “not proceeding”.
- Incremental evaluations should incorporate all impacts of a change. It may be better to model the whole business, with and without the change, rather than trying to isolate the incremental impacts only.
- In all cases the evaluation should consider whether there are alternatives i.e. staying with the status quo or whether it may improve its base activity with a smaller investment.
- Synergies brought by combining operations will usually require a stand-alone evaluation.

3.2.5 Stand Alone, Synergies, Using Tax Losses

Normally the assessment is to be of the entity on a ‘stand alone’ basis. If there is a special reason for cross-subsidy or cross-penalty then its quantum, importance and likelihood must be clearly described.

- Typical benefits/penalties from outside may include the realisation of pre-existing tax losses, (if usable), synergies from combining activities, and market position.

- This should not be included if the benefit/penalty is likely to be realised in the normal course of business without this activity/investment.
- The valuation should clearly differentiate between the value of the entity on its own ("stand alone") and the value of any special benefits/penalties from 'outside'.
- The conditions for receiving benefits/penalties from outside should be outlined. Other ways of realising these benefits/penalties should be outlined.

3.2.6 Gearing (Debt)

Normally the economic assessment is of the underlying economics before the introduction of any debt. If for some reason debt must be considered the discount rate must be adjusted and the quantum, risks and importance of the debt described.

In some cases, cash flow analysis is undertaken in nominal terms and inclusive of debt. This is commonly required by financiers to determine if interest on debt can be covered without periods of default, if the debt can be repaid, and what the equity value is via this particular approach.

- Normally the cash flows should be "unleveraged" or "ungeared" i.e. before the use of any debt and, hence, without interest costs on debt and their tax deductions.
- According to Financial Theory the discount rate is adjusted if debt is introduced.
- Faulty evaluations can make debt appear to improve the NPV.

3.2.7 Expected Values and Results

- There is an element of subjectivity when estimating what is expected in the future even if basing estimates on historical data, as past occurrences will not necessarily represent what will happen in the future.
- Certain variables will be more subjective than others: future commodity prices are generally unknown and can vary widely from the forecast, whereas future concentrator recovery rates for an operating plant might change but are more likely to be understood very well.
- The impact of a change to a parameter should be anticipated and checked against the result from the economic model. Unexpected effects should be reconciled.

3.2.8 Alternatives

The evaluation should consider all reasonable alternative activities/investments that are possible.

- Although one activity/investment is proposed there may be alternative activities/investments that achieve the desired outcome.

- The “do nothing” case usually is an alternative, and may be called the “base case.” If the investment is not made how would this base case be optimised?

3.2.9 Ranges and Likelihoods / Sensitivity Analysis

Within each activity/investment the evaluation should consider the range of possible occurrences and evaluate the spread and likelihoods.

- Unless only one result is possible the evaluation should consider the likely range of inputs, computations and results rather than reporting a single case.
- There are various methods of considering ranges and likelihoods.
- One method considers a series of discrete feasible cases from low to high and probability weights them.
- Another method uses software to generate a distribution of outcomes. If this method is used, the parameters included and excluded should be disclosed.
- Key inputs should be prioritised and varied by the amounts by which they can be expected to vary. Usually these are done at reasonable highs and lows and again at near extreme highs and lows. Sometimes these are best tested in clusters of parameters but usually it is testing one parameter at a time. Sensitivity testing of +/-10% and +/- 25% etc now is regarded as having low value. It is important to recognise that this type of valuation typically assumes only one variable changes at a time, and the same underlying physical mining, treatment and sales plan is maintained for all variations considered. It does not take any account of how decisions, and hence the plans, would change in response to real changes in the inputs being flexed in the evaluation. For example if the price is increased then the mine schedule probably should be re-optimised.

3.2.10 Input Data Quality Assessment

If distributions or likely ranges are not available for various input data items, the following ranking scheme is one of many that may be useful:

- A separate column beside the input numbers may be presented to indicate the reliability of various input data items. The score of input data would be put as a number e.g. from 1 to 3. For example, if the input is from a reliable supplier’s quote it may score 1, if from open literature and verified, 2, and if an educated guess with large uncertainty, score 3.
- Total scores may be averaged. Then uncertainty can be low, medium or high depending on the class of score the data received. If the input data quality scored less than 2, uncertainty is low, if above 2 but below 4, medium and if above 4 is high etc.
- In some situations the data quality may be required to score a “1” and in other situations, e.g. preliminary technical-economic evaluation or where the process is conceptual, a higher uncertainty is acceptable.

- Others may choose to describe the level of accuracy as conceptual (e.g. $\pm 30\%$), pre-feasibility (e.g. $\pm 20\%$) or feasibility (e.g. $\pm 10\%$) and reflect accuracy in context of some weighted average.

3.2.11 Real and Nominal

A “Real” model expresses a time series of cashflows in which the effect of inflation is excluded. The advantage of presenting data in “real” terms is that evaluations are more easily understood and audited. Economic models of whole-of-life projects and strategic plans are normally expressed in real terms.

A “Nominal” model expresses a time series of cashflows in the actual dollars of the period: that is with inflation included. Budgets, short-term forecasts and commodity price forecasts are usually expressed in “Nominal” dollars.

Care must be taken to ensure that the real and nominal information is not mixed and that each is clearly identified in the ‘units’ column. A real currency unit should be labelled with its year.

- Some practitioners use vertical font for real terms *and italics for nominal terms data*.
- If applying the correct real and nominal discount rates to the real and nominal cash flows, the NPV and IRR will be the same by either method, and IRRs from real and nominal cash flows will differ only by the inflation rate. Care must be taken to apply a nominal discount rate to nominal cash flows, and a real discount rate to real cash flows.
- For Real Terms evaluations the effect of inflation over the years is removed. Prices may increase/decrease in real terms because of production efficiencies, market demand/supply, foreign exchange movements and other non-inflation impacts.
- Care needs to be taken with inputs to distinguish whether they are specified in real or nominal terms.
- If working in real terms, there are two ways of handling tax depreciation and other items normally calculated in nominal terms.
 - model these items in nominal terms and convert back into real terms, or
 - Model these items in real terms and erode their value by inflation

3.2.12 Life of the Evaluation

Normally an evaluation is done for the full, remaining economic life from the present day to the end including closure and legacies. If there is a special situation and only part of the economic life is considered the parts of the life excluded and estimates of their impact on value should be clearly described.

- The Net Present Value (NPV) can be mathematically calculated at any point in the life of a cash flow. For practical purposes a convenient date in the recent past or the near future (as

a guide, within six months) is used with any significant cash flows in the intervening period clearly noted. Many companies specify a “valuation date” to be applied for consistency in all evaluations conducted. The remaining NPV at various times in the future (i.e. the NPV that would be determined by analysts at that time, assuming the project and the world economy proceed as predicted now) may also be a useful measure for comparing options in a long-life project.

- The end date should be a sensible time in the future when significant cash flows and liabilities are expected to finish.
- Estimates of closure costs and legacies such as on-going remediation may be substantial and can have a significant impact on NPV. A broad assumption that salvage will pay for closure costs and legacies is not usually valid.
- Sunk costs should be excluded from an NPV calculation as they do not represent a future cash flow. However, the written-down value (for tax purposes) of previously-purchased assets is relevant to future tax calculations and may be required.

3.2.13 After Tax

Normally evaluations are after all taxes. If there are special circumstances where pre-tax evaluation is appropriate the circumstances should be explained.

- Taxes other than company income tax and international withholding taxes are normally included in the capital costs, operating costs and revenue.
- Normally, company income tax and mineral royalties should be included as a discrete block of computations in the evaluation.
- Normally, the evaluation is unleveraged and so company income tax is before the introduction of debt-related cash flows.
- Where the valuation is of an entity in another country the impact of international taxes, such as withholding tax, should be estimated.
- Where international taxes are not yet adequately defined, a statement describing the range of possibilities, along with the impacts on value, should be included.
- Evaluations may be conducted at mine site level to select between various operating strategies. These might be conducted on a pre-tax basis where tax is the same for all or is relatively unimportant. This is usually satisfactory for options with similar levels of capital intensity, but may give misleading results if comparisons are between low capital/high operating cost and high capital/low operating cost options. It is advisable for the technical-economic evaluator to at least include a simple tax calculation to ensure the pre-and post-tax evaluations are not suggesting different strategies.

3.2.14 Risk and Uncertainty

The inclusion or exclusion of risk in an evaluation is of high importance.

- A complete economic evaluation requires an understanding of the impact of risk and uncertainty on the final outcome. Decisions should take into account the robustness in the expected performance. There are many ways of modelling risk and uncertainty in economic evaluations: these methods are touched on but not comprehensively covered in this document. To adequately evaluate risk and uncertainty, economic evaluations should include one or more of the following features:
 - Sensitivity Analysis: the impact of changing one variable at a time. These results have severe limitations because they typically neglect the flow-on impacts of that change on the plan.
 - Scenario Analysis: these are superior because they consider the dynamics of interrelated changes
 - Monte-Carlo Simulation: Independent or correlated variables are changed multiple times to reflect the probability distributions of their values, producing a probability distribution of the outcomes. These should be used with extreme caution to ensure all key parameters are varying, with mathematical relationships between them and not just with selected key parameters that are convenient to define, such as price, capex and opex.
 - Option analysis (see section 3.4.1)
 - Value at Risk (see section 3.4.2)
- The evaluation should clearly describe if risk was excluded and describe the risk context.
- The evaluation report should clearly describe the process by which risk was included and any recognised deficiencies.
- The risks may be introduced into the component cash streams during computations, or using expert knowledge, into the case as a whole by way of the discount rate.
 - If introduced into the component cash streams a risk can be reflected by adjusting the input related to the risk e.g. metallurgical recovery rate – lower recovery, lower valuation. Care must be exercised if “worst case” values are used for a number of variables: the probability of all the “worst case” scenarios occurring concurrently is generally very low. A probabilistic analysis is preferable if suitable distributions can be developed for all key input parameters.
 - If introduced by the discount rate then a risk premium can be added to increase the discount rate and generate a lower valuation. This need expert knowledge and is discussed further in Appendix B

- Some project managers will identify risks that are considered partially or totally avoidable. The assessors of such technical and non-technical risks will rely on their professional opinion and precedent to weigh up the validity of such assumptions. This does not guarantee the risks will be addressed as envisaged and the analyst in conjunction with the project members and leader will have to determine if these risks should be considered in the quantitative component of evaluation via the approaches described above or via an exercise in likelihood/sensitivity analysis.
- Evaluation specialists should not accept a methodology of incorporating risk without understanding and accepting it. Specialists should not be baffled by persons who appear to be experts persuading them to adopt a method which appears too complex to understand. If required to complete the exercise then the specialist should make the situation clear to team leaders and decision makers.

3.2.15 Materiality

The evaluation should match the quality (detail, precision, complexity) of each computation with its impact on the result.

- The evaluation should give most attention to the inputs and computations that have the greatest impact on value. Extra columns totalling cash flow and showing the contribution to NPV may help identify materiality.
- The evaluation should aim to reduce the complexity and detail of less important computations where this will not significantly reduce the validity/precision of the result.
- Focus should be on the key drivers of value. It avoids computations that are overly detailed in areas with minor impact on the key results.
- Usually, the computation of Revenue has the greatest impact on value, followed by Operating Costs and/or Capital Costs, and the least impact comes from Taxes.
- Normally the greatest focus is on the generation of revenue from the resource in the ground through production to sales volumes and product quality, and to price and foreign exchange rates.
- Operating costs in preliminary evaluations may be simple fixed and variable costs, whereas in precision evaluations they may be detailed fixed and variable costs. The variable costs at each stage in a process flow sheet should relate to the quantities being processed at each stage. They should not be related to the quantities of final product. Detailed variable costs usually use "Physicals x Unit Costs".
- Capital costs in preliminary evaluations may be coarse estimates, whereas in precision evaluations may be detailed estimates.
- In many evaluations taxes and working stock calculations can be greatly simplified without significant loss of precision.

3.2.16 Evaluation Framework

An easy-to-follow framework is to use the four cash streams of Production/Revenue, Capital Costs, Operating Costs and Taxes leading to Net Cash Flow and value measures such as NPV.

Reducing the evaluation to four cash streams makes computations, audit and understanding rapid.

Cash stream 1 = Revenue = Sales x Price +/- debtors

Cash stream 2 = Capital (cash spent not commitments)

Cash stream 3 Operating Costs = Consumptions X Costs (including related taxes) +/- Working Capital

Cash stream 4 = Taxes = Company Income Tax + Government Royalties (if not in operating costs) +/- adjustments for cash payment dates. International businesses usually should be valued at three levels:

1. The stand alone operation/business in 100% terms regardless of ownership to determine the 'health' of the underlying business.
2. The values to the various owners of their shares of the business, in country but after special deals and taxes.
3. The value to the various owners of their shares after repatriating cash flows to their home countries and paying top-up taxes there.

3.3 Process

3.3.1 Product Prices, Treatment and Refining Charges, and Foreign Exchange Forecasts

Usually forecasts of product prices and foreign exchange (forex) are amongst the most important assumptions for calculating an NPV. They not only partially determine revenue each year but they determine how much of the mineral deposit is economic. The following activities are recommended:

- Explain the sources of forecasts, and whether they were modified.
- Graph the key price(s) and foreign exchange in historical terms and the low, mid and high price(s) assumed into the future for the life of project.
- Usually the computations of revenue have greatest impact on value. Ironically computations of revenue in some commodities are relatively simple once production and sales are computed.
- Where the computation of price is complex – such as the treatment terms, refining charges and associated charges for metal concentrates – a top-down approach may be a superior method.
 - For example the history of Treatment Charges (TC) and Refining Charges (RC) is converted into graphs of how the value of each contained metal in the concentrate has been shared on a percentage basis, e.g. 67% to mines and 33% to smelters - and this is forecast rather than using TCs and RCs. However the split may vary with price and a more complex pricing model may be required.
- There are numerous approaches used for dealing with currency mixes and real and nominal terms within the economic evaluation. One approach is described in the section below on Operating Costs.

3.3.2 Sales: Volumes, qualities, working stocks/capital

Together with price and foreign exchange forecasts the sales volumes are important assumptions. It is recommended that the model:

- Outline market volume and quality assumptions.
- Outline the forecast impact of these sales on the market.
- Outline any unusual logistics.

- Working capital in debtors can be approximated e.g. 4 weeks/52 weeks x Sales Revenue for debtors (Same with costs for creditors). Revenue lags for base metals concentrates may be estimated from actual or typical sales terms.
- Working stocks of sales product should be approximated in the synthesis of production where they are significant.
- Establishing working stocks may be significant at project start-up and during ramp-up. There may be a significant lag between production ramp-up and product despatches until the business plateaus.
- Movements in working capital should be included in the computation of Cash Stream 1: Revenue.
- Simple stocks calculation methods can include:
 - Maintaining a specified stockpile size at the end of each time period, drawn down at the end of the life, or
 - Applying a time lag between production and sales dates.

3.3.3 Production: Volumes, head grades, recoveries, product grade, delivery.

The economic evaluation may synthesise the production process or use outputs from detailed computations and syntheses. It is recommended that the model:

- Outline the methods used to estimate production, including how Life of Mine (LOM) figures are determined, which may include mine and plant availabilities, mining volumes, mining recovery and dilution, head grade, process recoveries and product specifications for economic metals and key deleterious constituents.
- Describe the methods by which time frame of the life of the entity was estimated, including construction time, ramp-up, operational life and closure.
- Outline the various broad production cases considered.
- Disclose whether the resource and reserve figures used in the model are reported in accordance with the Australasian Joint Ore Reserves Committee Code (JORC) i.e. if the figures are existing Resources and Reserves, if the evaluation will be used to support publication of Reserve Categories, or if they are estimates that are not JORC-compliant (Note that the JORC Code is for public reporting of Resources and Reserves. Internal evaluations can do whatever is reasonable for the purposes of the evaluations, though JORC Code categories of resources and reserves may be important input information even if results are not to be made public).

3.3.4 Capital Costs

Estimates of capital costs can vary from high-level estimates to comprehensive estimates including contingencies and allowances. It is recommended that the model:

- Outline the method used to estimate capital costs, including indirect costs, contingencies, allowances, etc. Preferably these estimates would be based on studies that employ an industry accepted methodology and supported by appropriate documentation. The accuracy and confidence in the estimate is expected to increase as the project progresses through the conceptual, scoping, prefeasibility, feasibility and detailed engineering study stages.
- Outline the method (such as quotations, material take-offs, factors, benchmarking, etc) used to estimate capital costs, including indirect costs, contingencies, allowances, construction costs, EPCM, freight costs, local duties, etc.
- Outline the key construction costs and time to commissioning assumptions.
- It is not important if a particular item is classified as an operating cost or as a capital cost in the evaluation for determining pre-tax cash flows. It is important that each item is correctly treated in the tax and in any accounting computations. Correct classification is essential for determining depreciation and profit or taxable income for the modelling of both taxation and financial accounting. It should be noted that certain items may be capitalised for one set of calculations and expensed for the other, or capitalised but depreciated by different methods and/or rates for tax and financial accounting calculations.
- Outline the range of estimates of capital cost. The differences in NPV result across the range of capital costs should be computed and understood by decision makers.
- Consider the timing differences between capital construction and payment.
- Outline details of any bond (eg environmental) that may be required, distinguishing between non-cash accounting provisions and cash flows.
- On-going or sustaining capital, which maintains the capabilities acquired by the initial project, should be calculated from its drivers. It may be a proportion of the initial capital expenditure, or based on history in a more mature operation. Although often expressed as an annual cost, it may be more appropriate to express some components on a per-tonne basis if changes in production rates are to be modelled.
- Working Capital may significantly impact on early cash flows. Key items are typically:
 - “First fill” of consumables in the operation – e.g. grinding media, tyres etc
 - Major critical spare parts
 - Initial stocking of other warehouse consumables
 - Operating costs incurred before initial revenue is received.

3.3.5 Operating Costs

Estimates of operating costs can vary from broad approximations to detailed estimates. The principles discussed in the capital cost section on accuracy and data sources generally apply to operating cost. It is recommended that the model:

- Outline the method (such as quotations, material take-offs, factors, benchmarking, etc.) used to estimate operating costs, including fixed and variable costs, social and environmental costs, contingencies, etc.
- Categorise costs by function e.g. mining, milling, etc, or by cost element e.g. labour, fuel, consumables, power, maintenance, materials, etc. Cost structures that are built up by both function and cost element along with fixed and variable components are considered to represent the highest order of detail. It should be noted that when accessing historical accounting, functional and cost element information is generally available whilst the analyst will have to form a view on what costs are fixed and what costs are variable as accounting systems may not categorise on this basis.
- As a general principle, variable costs should be applied to each physical activity whose quantities will vary relative to the key activity quantities as a result of changes in inputs that may be flexed, or naturally as a result of changes in the resource being mined or the tonnage treated. However, materiality effects and the required level of accuracy of the study should also be taken into account – changes in the ratios of the physical quantities may be small enough to obviate the need for the more complex cost model, and a simple “fixed plus variable per tonne of ore” model may be adequate.
- Outline the commissioning and ramp-up assumptions.
- Working stocks are included in the synthesis of ‘Production’ and are approximated where there is insignificant impact on value.
- Private royalties are included as an operating cost but government royalties can be included either as an ‘Operating Cost’ or as a ‘Tax’ depending on custom. However, the procedure adopted in the evaluation should be defined.
- For leased equipment, note if the lease is an operating lease or a financed lease.
- As per the classification of capital costs, it is not important if a particular item is classified as an operating cost or as a capital cost in the evaluation for determining pre-tax cash flows. However, correct classification is essential for determining depreciation and profit or taxable income for the modelling of both taxation and financial accounting. It should be noted that certain items may be capitalised for one set of calculations and expensed for the other, or capitalised but depreciated by different methods and/or rates for tax and financial accounting calculations.
- The operating costs component of working capital may be simply modelled by:

- Maintaining a specified inventory at the start of each time period, drawn down at the end of the life, but allowing for spoilage and obsolescence, or
- Applying a lead time between production and spending.
- Outline the range of estimates of operating cost. The differences in NPV result across the range of operating costs should be computed and understood by decision makers
- There are numerous schools of thought when dealing with operating costs in various currencies and a mixture of real and nominal terms – one approach that can be applied to overseas operations is as follows:
 1. Initially model costs in the currency in which they are incurred.
 - a. It may be necessary to separate different currencies – e.g. expatriate and local labour costs, consumables sourced from various locations, etc.
 - b. Identify the costs which are quoted in one currency but are actually incurred in another – e.g. petroleum products.
 2. Derive as “real” (or perhaps more accurately, "uninflated") costs in the currency in which incurred, for the physical quantities scheduled.
 - a. Note the age of various data items and inflate/deflate to a common point in time if appropriate.
 3. Apply inflation for original currency, appropriate to each cash flow item - produces “nominal” cash flows in those currencies.
 4. Convert to the currency of the country taxing the operating entity (usually the country where the operation is located), using nominal exchange rates.
 5. Calculate depreciation for tax purposes, and hence taxable profit and tax, and hence net cash flow in the currency of the taxing country.
 6. Convert to the reporting currency, using nominal exchange rates. (Additional taxes may need to be calculated in this currency.)
 7. Deflate to “real” money amounts using the appropriate deflator for the reporting currency.
 8. Discount using real after tax discount rate.

3.3.6 Closure Costs

Estimates of closure costs can vary from broad approximations to detailed estimates. It is not adequate to assume that closure costs will be offset by the proceeds of salvage. It is recommended that the model:

- Outline the method used to estimate closure costs and on-going activities. Describe if indirect costs, contingencies, allowances, etc are included.
- If the evaluations will vary parameters that will change the mine life, it may be necessary to express rehabilitation, redundancy costs, salvage and scrap values as functions of the closure date.

3.3.7 Taxes (direct company level taxes)

In an economic evaluation, taxes are not usually computed to the precision of official income tax returns, but usually are more simplified so that the results match the precision and impact of other key computations.

- “Taxes” include company income tax, special company taxes, capital gains, carbon taxes, withholding taxes, international taxes and government royalties. Indirect taxes are usually included in capital and operating costs.
- Outline company income tax, other direct company taxes, government royalties and any international taxes. Describe any special tax issues e.g. if withholding taxes can be credited in the tax regime where profits are repatriated.
- Outline any tax benefits or penalties that are specific to this investment, such as pre-existing losses, or cross subsidy special government taxation arrangements. Describe the importance to value.
- Income tax may be approximated where the impact is not material. A few rows of algorithms may substitute for many rows of ‘longhand’ depreciation or other calculations. If the evaluation model is constructed to be flexible to permit the evaluation of a large number of options and scenarios, it is essential that tax calculations are also flexible within the model. It is not then appropriate to have taxes calculated in detail by tax accountants or for a few cases entered as data for many different cases.
- If capital costs are computed in real terms then in the evaluation model the tax deductions for capital (and any other deductions spread over years) should be eroded by inflation - unless the impact of inflation is not significant. Otherwise the tax depreciation is computed in nominal terms and converted back into real terms.
- As discussed in the section on Operating Costs, government royalties can be included in ‘Operating Costs’ or in ‘Tax’, depending on custom.

3.3.8 Discount Rate and NPV

Technical-economic analysts will rarely have to derive the discount rate to be used. Doing this is an expert task not normally within the expertise of such analysts. The Discount Rate is computed according to Financial Theory and is typically specified by the company commissioning the evaluation. Notes on the derivation of discount rates are included in Appendix B as background

information for technical evaluators without financial training. The important thing for the analyst is to ensure that the discount rate used and the cash flows to which it is applied are consistent.

- Historically in the Mining Industry there have been various conflicting approaches to computing discount rate. These include:
 1. Is the discount rate for the Company or for the industry sector being evaluated?
 2. How is debt included?
 3. Is the evaluation before or after tax?
- In an evaluation model the net cash flow can be converted to an NPV using several methods.
 - One method is to use a few rows of easy-to-follow computations ('longhand') rather than using NPV Functions or software. 'Longhand' computations are more readily understood and checked for base date and discount factor for the first periods.
 - The other method is to use spreadsheet functions. However these are often used incorrectly, and care is required with regard to the timing of cashflows.
- The discount rate must match the cash flow i.e. real or nominal terms, and before or after tax.
- Using the appropriate discount rate with a cash flow, whether in real or nominal terms, should give the same NPV. Before tax NPV and after tax NPV can differ.
- Cash flows from operations occur through any year, not necessarily at the start or end of a year. To reflect this, discounting from the midpoint of each period is recommended for an absolute valuation. For comparative valuations, this is less important, but consistency of approach for all cases is essential.

3.3.9 Auditing

Auditing is an essential component of the evaluation process. It best occurs progressively during the evaluation process, and must be undertaken before any results are released. The status of the audit should be progressively recorded in the 'Introduction' to every evaluation model.

Step 1: Periodic self audits of the evaluation model as it is developed.

Step 2: Audits of the parts of the evaluation by the experts in each of the parts.

Step 3: A thorough audit of the final evaluation model by parties external to the evaluation project. One party may audit the mechanics of computations while other specialists audit the validity of inputs and outputs.

- Additional tips on auditing:
 - Check the graphs for anomalies, inconsistencies and trends that look incorrect.

- Use software that analyses spreadsheets to find errors.
- Include self checks for totals and sub-totals throughout the model. Do these totals match the input data and external documents?
- Starting at the NPV work back up each of the cash streams to the inputs.
- Check a column away from the first column of computations in case a change has been made but accidentally not copied across the rows.
- Copy the algorithm in the first column of computations across to the end of life and see if the results change (but be aware of rows where the first column may legitimately be different from the others).
- Check the outputs of large evaluations by creating a stand-alone 'summary model' of only a few rows.
- When auditing, it can be useful to create a new sheet at the front of the workbook with:
 - All auditing notes listed,
 - A list of items to be checked or corrected using a priority colour code noting high, medium and low ranked items (using red, yellow and green cell colouring), and
 - Links to the sections of the model to which that the auditing notes apply.

3.3.10 Graphs

Graphs are recommended as:

1. A quick check for errors in input data, computations and outputs, and
 2. A fast way for others to understand the evaluation.
- Adequate time should be allowed for the evaluation model to graph all key inputs and key outputs as checks on errors and for rapid understanding of the entity. These should include cash flows, NPV, prices, sales volumes, production, grades, saleable product, revenue, capital costs (construction and ongoing), operating costs, taxes.

3.3.11 Helicopter View

The evaluation process should be conducted with regular pauses to understand how the entity looks from a "helicopter view".

- Results and graphs should be viewed and discussed after important stages in the development of the evaluation.

3.3.12 Avoid

- Over-complexity
- black-box spreadsheet functions.
- Black box models and standard template models which claim to cover all evaluations.
- Links to other workbooks: these are dangerous because the other model may be altered without the change being recognised. If used the whole row/column with titles and labels is referenced across so covert changes can be seen.
- Macros that perform calculations: these cannot be readily followed visually nor audited and generally are not trusted.
- Hidden rows, columns or worksheets: the 'Data Group' facility is satisfactory because it marks the collapsed data.
- Spreadsheet functions that have a history of misuse: these are difficult to audit, whereas 'longhand' computations can be followed easily and visually.

3.4 Alternative Evaluation and Assessment Methodologies

Although the DCF approach is the preferred methodology used in the mining industry, numerous other methodologies are available and are increasingly being used on a more regular basis. During the course of developing the AusIMM Guidelines for Modelling and Evaluation the topic of alternative methodologies was raised and discussed. It was deemed prudent to highlight the existence and continuing emergence of these alternate methodologies and to discuss a couple in brief, namely Real Options Valuation (ROV) and Value at Risk (VaR). The AusIMM does not in any way suggest that these methodologies be used in assessing mineral projects, but rather that members keep in mind that alternative tools are available and are being increasingly accepted in conjunction with the traditional DCF approach.

3.4.1 Real Options Valuation (ROV)

What is Real Options Valuation?

The Real Options Valuation (ROV) technique was derived from the Black and Scholes financial option-pricing model developed in 1973. The sequence and timing of decisions can be modelled using ROV thus providing a method which values project flexibility.

When ROV should be applied?

Real Options Valuation is suited to projects with inherent future uncertainties. For a project with little or no uncertainty, ROV can be used; however it will yield the same result as a traditional DCF valuation.

ROV should be used when differing business strategies exist to determine the value of each strategy. Additionally, it can determine at which time a strategy should be acted upon.

Benefits and drawbacks of the method

ROV can accurately value decisions under an uncertain future. However, the accuracy of the valuation depends significantly on the assumptions used to carry out the valuation.

Computing time is dependent of the number of uncertain parameters incorporated into the valuation, thus as ROV complexity increases so too does computing time. To minimise computation time key parameters (i.e. commodity price, recovery and mining rate) need only be included. Computer programs, such as DPL (Decision Programming Language), allow a ROV to be computed in under a minute with as many as ten uncertain input parameters.

One of the greatest benefits of using a real options process is that it can change a decision-maker's way of thinking. The real option way of thinking may see the early abandonment of an uneconomic project as a success. It places importance on the ability to modify a plan rather than to adhere to it and it favours investments that are robust to uncertainty rather than dependent on it.

3.4.2 Value at Risk (VaR)

What is Value at Risk?

VaR is used in finance for measuring and managing risk. When used in portfolio management it is commonly expressed as a probability of making a loss or return below a certain dollar value over a specific time period e.g. an asset portfolio with a one-week 5% VaR of \$10m has a 5% chance of decreasing in value by more than \$10m over the week.

When VaR should be applied?

The VaR method provides an estimated distribution of outcomes. It also allows the management of risk by providing a feel for exposure on the downside and hence provides an opportunity to tailor risk exposure.

Benefits and drawbacks of the method

Application of VaR in the mining industry involves the identification of risks and their interdependencies at all levels. This involves a comprehensive stage of quantifying and considering all the risks reducing the chance of oversights that may occur when using alternative methods.

The identification of risks that are material, understanding their interdependencies, along with the quantification and modelling of probability curves is an involved process that requires gathering a considerable amount of information.

The concept that a statistical approach can be applied for understanding the distribution of value outcomes and that then striking a VaR is applicable to numerous markets holds true. In financial markets, the method is used to make decisions for investing in various markets each with their respective levels of risk, liquidity and volatility. Mining assets demonstrate their own peculiar characteristics around liquidity and volatility, suggesting that concepts inherent in VaR will be used for making longer-term decisions concerning existing and proposed projects rather than, as it is currently used in financial markets, for shorter-term portfolio management.

APPENDIX A – WORKED EXAMPLE

The following example is illustrative, and is not intended to be definitive, of how to structure a model. The analyst should always consider when structuring a model and summary page, it is important to consider the level of detail at which the exercise is to be undertaken, the audience it is intended for, and the information normally expected to be conveyed.

The following worked example was made available as an Excel Workbook to AusIMM Members and participants at the AusIMM MetPlant2011 in Perth in August 2011. It is shown below in PDF.

Worked Example - MetPlant 2011			
Contact			
Peter Card 04 07 508 924			
Purpose			
This 'Worked Example' illustrates the economic evaluation modelling practices recommended by AusIMM It compares a gold mine using existing common technology with a new technology - at concept level			
Warnings			
This example is an illustration. It has not been audited and should be checked before being used			
Audits			
Self audit	P Card	Yet to be completed	
existing case	D Martin	Yet to be completed	
new tech case	G Darwin	Yet to be completed	
taxes	G Wise	Yet to be completed	
external peer	C Casey	Yet to be completed	
Simplified to four cash streams			
Each evaluation is simplified into four streams: Revenue, Operating Costs, Capital Costs and Taxes. Accounting can be derived from these.			
Understanding the colour coding			
13 Aug2011 B White, "Sales Plan for Operations to 2025"			
67.4	Every item of input data is exposed in a cell using blue font on a blue background		
	It has its source, date and person in blue font in the row immediately above. (Not as a hidden cell note)		
67.4	202.2	Any item that is dubious or needing verification is in pink font	
	Every item which is referenced across from another worksheet is in green font on green background.		
recovery	% silver	36%	36%
	The complete row is referenced across including its title in column A as a check that the correct data is being referenced. If a referenced cell is in Column B in the source worksheet then it appears in the same column (B) in this worksheet. (this greatly reduces errors) Therefore if 2013 is in column K in one worksheet then it is in column K in every other worksheet		
134.8	Every algorithm must use cells only from this worksheet. (It does not reference data in another worksheet, nor contain hidden fresh data)		
134.8	Computational algorithms should not change across a row. If there is an exception it should be highlighted with a dark border		
67.4	Some people use italics for nominal terms data and vertical font for real terms data		

Worked Example - MetPlant 2011

Summary

Existing case

existing technology

NPV - Existing Case A\$ 2,007,342

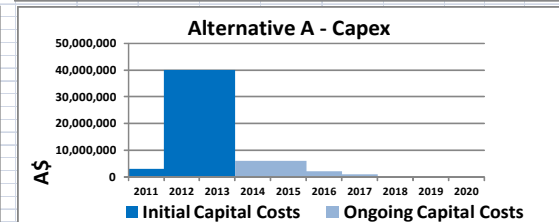
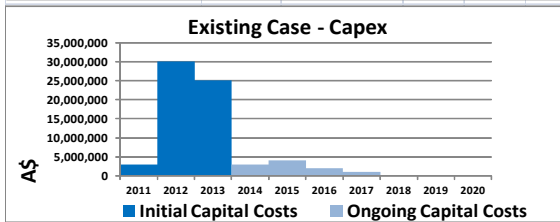
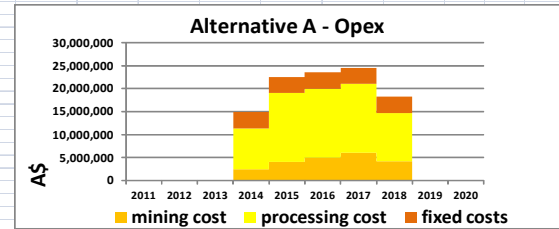
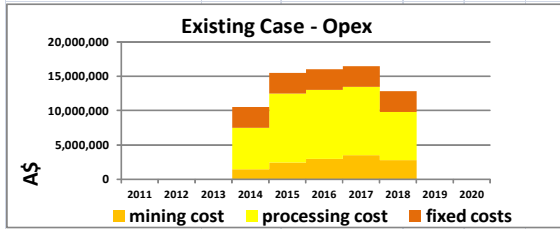
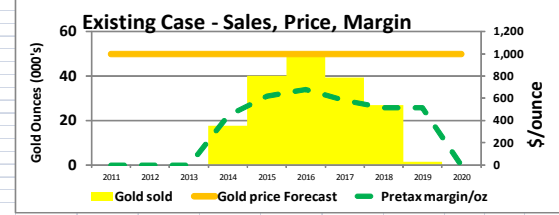
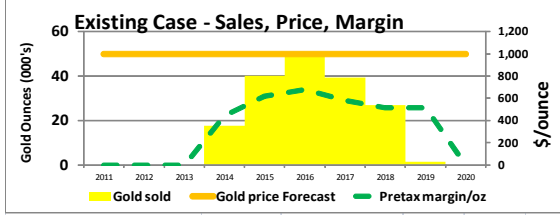
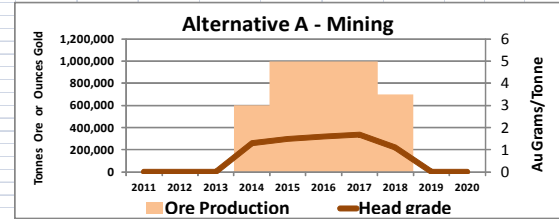
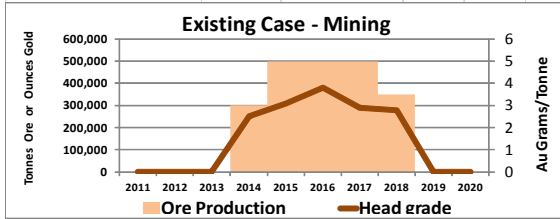
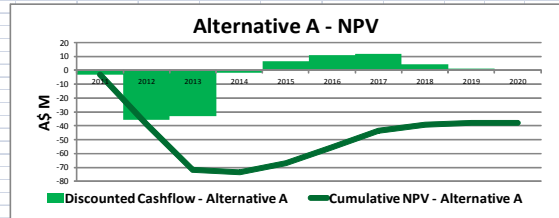
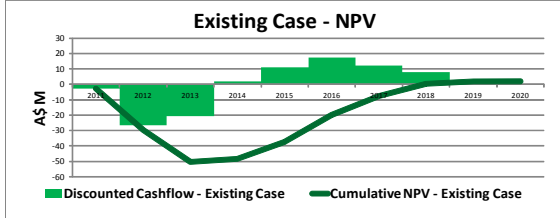
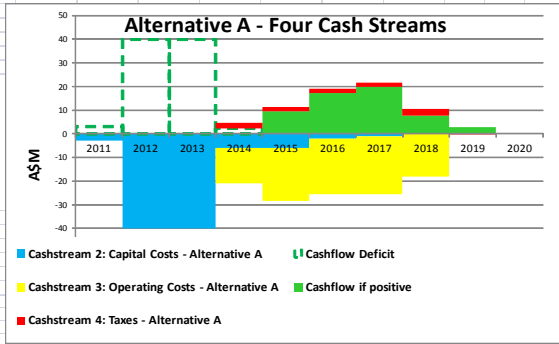
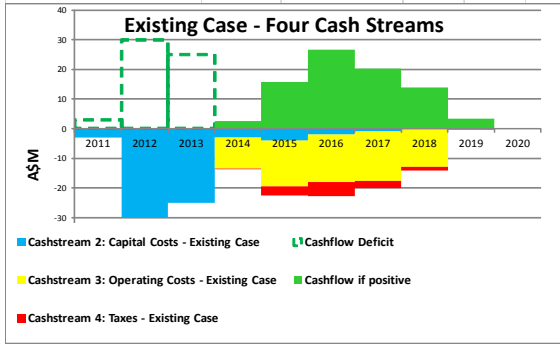
IRR - Existing Case 9.1%

Alternative A

carbon in pulp technology

NPV - Alternative A A\$ -37,833,798

IRR - Alternative A -9.4%



Worked Example - MetPlant 2011

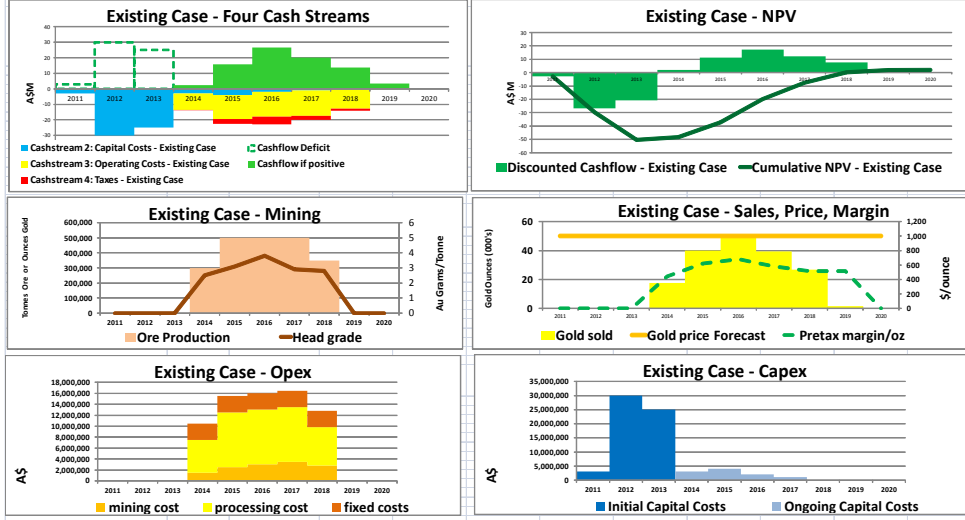
This example is an illustration. It has not been audited and should be checked before being used.

Existing case

Existing Technology

NPV - Existing Case A\$ 2,007,342

IRR - Existing Case 9.1%



Life of Mine	units	Total	2011	2012	2013	2014	2015	2016	2017	2018	2019
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Cashstream 1: Production and Revenue

Production											
10 Aug 11 T Benson mine schedule "Mine Plan 12 June 11"											
Ore Production	tonnes	2,150,000				300,000	500,000	500,000	500,000	350,000	
Head grade	grams/tonne	3.1				2.5	3.1	3.8	2.9	2.8	
Contained gold mined	ounces	213,183	0	0	0	24,116	49,839	61,093	46,824	31,511	0
Processing Recovery	% of contained gold					78%	85%	81%	83%	82%	
Gold produced	ounces	175,736	0	0	0	18,810	41,367	50,707	38,698	26,154	0
Sales											
23 Aug 11 J Gomachie "Sales Plan: July 2011"											
Gold in circuit	weeks	3	3	3	3	3	3	3	3	3	3
Gold in circuit	ounces	0	0	0	0	1,085	2,387	2,925	2,233	1,509	0
Gold sold	ounces	175,736	0	0	0	17,725	40,065	50,169	39,391	26,878	1,509
Revenue											
23 Aug 10 ABC Company Forecast of gold price											
Gold price Forecast	A\$/ounce Real	1,000	1,000	1,000	1,000	1,000	1,050	1,000	1,000	1,000	1,000
Gold Revenue	A\$ Real	175,736,334	0	0	0	17,725,080	40,065,236	50,168,501	39,390,613	26,877,999	1,508,904
Debtors - Closing											
23 Aug 11 J Gomachie "Sales Plan: July 2011"											
Debtors - Closing	A\$ Real	0	30	30	30	30	30	30	30	30	30
Debtors - Closing	A\$ Real	0	0	0	0	1,456,856	3,293,033	4,123,438	3,237,585	2,209,151	0
Cashstream 1: Revenue - Exist	A\$ Real	175,736,334	0	0	0	16,268,224	38,229,059	49,338,096	40,276,467	27,906,433	3,718,055

Cashstream 2: Capital Costs

10 Aug 10 G Dawson "Capital Cost Estimate: Indicative Estimates Version G"											
Initial Capital Costs	A\$ Real	58,000,000	3,000,000	30,000,000	25,000,000						
Ongoing Capital Costs	A\$ Real	10,000,000				3,000,000	4,000,000	2,000,000	1,000,000		
Cashstream 2: Capital Costs - F	A\$ Real	68,000,000	3,000,000	30,000,000	25,000,000	3,000,000	4,000,000	2,000,000	1,000,000	0	0

Tax deductions for Capital Expenditure

3 May 11 E Hermal Assume all capital is deducted in proportion to the gold sold over the life of mine.											
Tax Deduction for Capital Expenditure	% of contained gold					10%	23%	20%	23%	15%	1%
Tax deduction for capital expenditure	A\$ Real	68,000,000				6,858,601	15,900,975	19,412,866	15,241,935	10,400,262	583,860

Cashstream 3: Operating Costs

3 May 11 G Dawson "Operating Cost Estimate: Indicative Estimates." There is no waste to be mined.											
mining cost per tonne	A\$ Real/tonne @	31				5	5	6	7	8	
mining cost	A\$ Real	13,300,000				1,500,000	2,500,000	3,000,000	3,500,000	2,800,000	0
processing cost per tonne	A\$ Real/tonne @	100				20	20	20	20	20	0
processing cost	A\$ Real	43,000,000				4,000,000	10,000,000	10,000,000	10,000,000	7,000,000	0
fixed costs	A\$ Real	15,000,000				3,000,000	3,000,000	3,000,000	3,000,000	3,000,000	0
Cashstream 3: Operating Cost	A\$ Real	71,300,000	0	0	0	10,500,000	15,500,000	16,000,000	16,500,000	12,800,000	0
cost per ounce	A\$/ounce Real					58	375	316	426	489	0

Cashstream 4: Taxes

2 June 11 R Torphy: SA State Royalty is 1% of revenue paid monthly											
State Royalty	% of revenue	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
State Royalty	A\$ Real	1,757,363	0	0	0	177,251	400,652	501,685	393,906	268,780	15,089

Company Income Tax

2 June 11 R Torphy: Company Income tax rate is 30%. The cash payment averages mid year. Assume operating cost cashstream approximates the cost of goods sold.											
Gold Revenue	A\$ Real	175,736,334	0	0	0	17,725,080	40,065,236	50,168,501	39,390,613	26,877,999	1,508,904
less:											
Cashstream 3: Operating Costs - Existing Case	A\$ Real	71,300,000	0	0	0	10,500,000	15,500,000	16,000,000	16,500,000	12,800,000	0
Tax deduction for capital expenditure	A\$ Real	68,000,000	0	0	0	6,858,601	15,900,975	19,412,866	15,241,935	10,400,262	583,860
State Royalty	A\$ Real	1,757,363	0	0	0	177,251	400,652	501,685	393,906	268,780	15,089
Assessable Income	A\$ Real	34,678,971	0	0	0	189,228	8,661,088	14,254,450	7,254,773	3,408,957	909,955
Company Income Tax Rate	% of assessable income	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
Income Tax	A\$ Real	10,403,691	0	0	0	56,768	2,598,483	4,276,335	2,176,432	1,022,687	272,986
Income tax payment	A\$ Real	10,403,691	0	0	0	56,768	2,598,483	4,276,335	2,176,432	1,022,687	272,986
Cashstream 4: Taxes - Existing	A\$ Real	12,161,055	0	0	0	234,019	2,999,135	4,778,020	2,570,338	1,291,467	288,075

Cashflow and NPV

Cashflows											
Cashstream 1: Revenue - Existing Case	A\$ Real	175,736,334	0	0	0	16,268,224	38,229,059	49,338,096	40,276,467	27,906,433	3,718,055
Cashstream 2: Capital Costs - Existing Case	A\$ Real	68,000,000	3,000,000	30,000,000	25,000,000	3,000,000	4,000,000	2,000,000	1,000,000	0	0
Cashstream 3: Operating Costs - Existing Case	A\$ Real	71,300,000	0	0	0	10,500,000	15,500,000	16,000,000	16,500,000	12,800,000	0
Cashstream 4: Taxes - Existing Case	A\$ Real	12,161,055	0	0	0	234,019	2,999,135	4,778,020	2,570,338	1,291,467	288,075
Cashflow - Existing Case	A\$ Real	24,275,280	-3,000,000	-30,000,000	-25,000,000	2,534,205	15,729,924	26,560,076	20,206,129	13,814,966	3,429,979
IRR - Existing Case											9.1%

Discounting

17 July 11 F Green email: discount rate for investment in gold is 8% Real. The base date is 1 July 2011											
Discount Rate	% Real	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
Discount Factor		0.96	0.89	0.82	0.76	0.71	0.65	0.61	0.56	0.52	

Discounted Cashflow - Existing	A\$ Real	2,007,342	-2,886,751	-26,729,179	-20,624,367	1,935,792	11,125,505	17,393,968	12,252,613	7,756,605	1,783,157
Cumulative NPV - Existing Case	A\$		-2,886,751	-29,615,930	-50,240,297	-48,304,505	-37,179,000	-19,785,033	-7,531,420	224,185	2,007,342
NPV - Existing Case	A\$	2,007,342									

Worked Example - MetPlant 2011

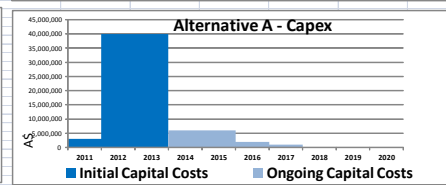
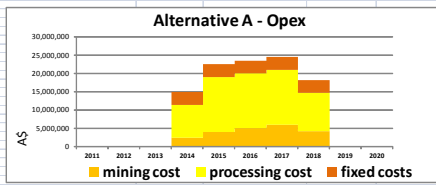
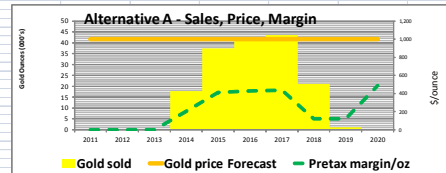
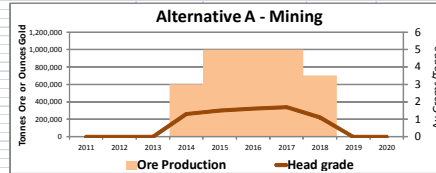
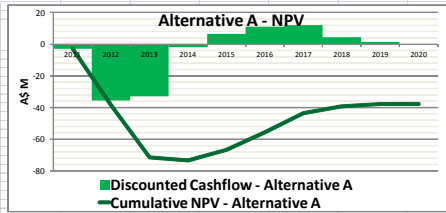
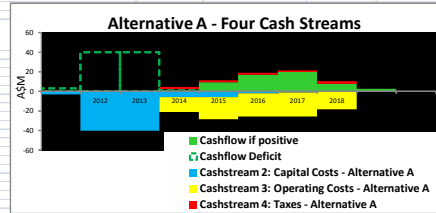
This example is an illustration. It has not been audited and should be checked before being used.

Alternative A

carbon in pulp technology

NPV - Alternative A\$ -37,833,798

IRR - Alternative A -9.4%



Life of Mine	units	Total	2011	2012	2013	2014	2015	2016	2017	2018	2019
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Cashstream 1: Production and Revenue

Production											
13 Aug 11 T Benson mine schedule "Mine Plan for new technology 12 Aug 11"											
Ore Production	tonnes	4,300,000				600,000	1,000,000	1,000,000	1,000,000	700,000	
Head grade	grams/tonne	1.3				1.3	1.3	1.4	1.7	1.1	
Contained gold mined	ounces	204,380	0	0	0	25,080	48,232	51,447	54,662	24,759	0
Processing Recovery	% of contained gold					75%	80%	80%	80%	80%	
Gold produced	ounces	162,090	0	0	0	18,810	38,585	41,158	43,730	19,807	0
Sales											
23 Aug 11 J Gomachie: "Sales Plan: July 2011"											
Gold in circuit	weeks	0	3	3	3	3	3	3	3	3	3
Gold in circuit	ounces	0	0	0	0	1,085	2,226	2,374	2,523	1,143	0
Gold sold	ounces	162,090	0	0	0	17,725	37,444	41,009	43,581	21,187	1,143
Revenue											
23 Aug 10 ABC Company Forecast of gold price											
Gold price Forecast	AS/ounce Real	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Gold Revenue	AS Real	162,090,032	0	0	0	17,725,080	37,444,348	41,009,152	43,581,499	21,187,237	1,142,716
Debtors											
23 Aug 11 J Gomachie: "Sales Plan: July 2011"											
Debtors - Closing	AS Real	0	0	30	30	30	30	30	30	30	30
Cashstream 1: Revenue - A AS Real											
		162,090,032	0	0	0	16,268,224	35,823,587	40,716,154	43,370,073	23,027,861	2,884,133

Cashstream 2: Capital Costs

10 Aug 11 G Dawson email "Capital Cost Estimate: Indicative Estimates for New Technology route"											
Initial Capital Costs	AS Real	83,000,000	3,000,000	40,000,000	40,000,000	6,000,000	6,000,000	2,000,000	1,000,000		
Ongoing Capital Costs	AS Real	15,000,000									
Cashstream 2: Capital Cost AS Real											
		98,000,000	3,000,000	40,000,000	40,000,000	6,000,000	6,000,000	2,000,000	1,000,000	0	0

Cashstream 3: Operating Costs

25 May 11 G Dawson email "Operating Cost Estimate: Indicative Estimates for new technology". There is no waste to be mined.											
mining cost per tonne	AS Real/tonne ore	25				4	4	5	5	6	
mining cost	AS Real	21,600,000				2,400,000	4,000,000	5,000,000	6,000,000	4,200,000	0
processing cost per tonne	AS Real/tonne ore	75				15	15	15	15	15	
processing cost	AS Real	64,500,000				9,000,000	15,000,000	15,000,000	15,000,000	10,500,000	0
fixed costs	AS Real	17,500,000				3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	0
Cashstream 3: Operating C AS Real											
		103,600,000	0	0	0	14,900,000	22,500,000	23,500,000	24,500,000	18,200,000	0
cost per ounce	AS/ounce Real					792	583	571	560	919	0

Cashstream 4: Taxes

Government Royalties											
2 June 11 R Trapp: SA State Royalty is 1% of revenue paid monthly											
State Royalty	% of revenue	0.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
State Royalty	AS Real	1,620,900	0	0	0	177,251	374,443	410,092	435,815	211,872	11,427

Company Income Tax

2 June 11 R Trapp: Company Income tax rate is 30%. The cash payment averages mid year. Assume operating cost cashstream approximates the cost of goods sold.											
Gold Revenue	AS Real	162,090,032	0	0	0	17,725,080	37,444,348	41,009,152	43,581,499	21,187,237	1,142,716
Cashstream 3: Operating Costs - Alternative A	AS Real	103,600,000	0	0	0	14,900,000	22,500,000	23,500,000	24,500,000	18,200,000	0
Tax deduction for capital expenditure	AS Real	88,000,000	0	0	0	10,716,624	22,618,938	24,794,226	26,349,473	12,809,812	690,889
State Royalty	AS Real	1,620,900	0	0	0	177,251	374,443	410,092	435,815	211,872	11,427
Assessable Income	AS Real	41,130,868	0	0	0	-8,008,794	6,009,033	-7,695,166	-7,703,789	10,934,487	440,600
Company Income Tax Rate	% of assessable inc	0.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%
Income Tax	AS Real	-12,339,260	0	0	0	-2,420,638	-2,420,710	-2,308,550	-2,311,137	-3,010,346	132,120
Income tax payment	AS Real	-12,339,260	0	0	0	-2,420,638	-2,420,710	-2,308,550	-2,311,137	-3,010,346	132,120
Cashstream 4: Taxes - Alt A AS Real											
		-10,718,360	0	0	0	-2,243,387	-2,046,266	-1,898,458	-1,875,322	-2,798,474	143,547

Cashflow and NPV

Cashflows											
Cashstream 1: Revenue - Alternative A	AS Real	162,090,032	0	0	0	16,268,224	35,823,587	40,716,154	43,370,073	23,027,861	2,884,133
Cashstream 2: Capital Costs - Alternative A	AS Real	-98,000,000	-3,000,000	-40,000,000	-40,000,000	-6,000,000	-6,000,000	-2,000,000	-1,000,000	0	0
Cashstream 3: Operating Costs - Alternative A	AS Real	-103,600,000	0	0	0	-14,900,000	-22,500,000	-23,500,000	-24,500,000	-18,200,000	0
Cashstream 4: Taxes - Alternative A	AS Real	-10,718,360	0	0	0	-2,243,387	-2,046,266	-1,898,458	-1,875,322	-2,798,474	143,547
Cashflow - Alternative A AS Real											
		-28,791,608	-3,000,000	-40,000,000	-40,000,000	-2,388,388	9,369,853	17,114,612	19,745,395	7,626,335	2,740,585

IRR - Alternative A -9.4%

Discounting

17 July 10 F Green email: discount rate for investment in gold is 8% Real. The base date is 1 July 2011											
Discount Rate	% Real	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
Discount Factor	%	0.96	0.89	0.82	0.76	0.71	0.65	0.61	0.56	0.52	
Discounted Cashflow - Alt A AS Real											
		-37,833,798	-2,886,751	-35,638,906	-32,998,987	-1,824,407	6,627,136	11,208,214	11,973,232	4,281,912	1,424,759
NPV - Alternative A AS											
		-37,833,798	-2,886,751	-35,638,906	-32,998,987	-1,824,407	6,627,136	11,208,214	11,973,232	4,281,912	1,424,759

Financial Analysis

Why and when we should consider financial analysis with economic analysis

DCF analysis concerns itself with cash in and cash out, the timing of these cash flows, and what the net value is in present terms under the desired rate of return set by the investors that provide equity and the lenders that provide debt. The parties providing equity and debt financing will require a return that is commensurate with the level of risk (perceived or real) and these rates determine the discount rate used in DCF analysis.

Although DCF analysis will identify the expected cash flows at the operational level it will not necessarily identify the timing and quantity of returns that the parties providing the equity and debt funding will receive. This is of obvious importance when considering that the parties providing finance will want to know when their payback will be received. Debt holders will require assurance that, under a range of possible scenarios, interest on the loan facility can be covered and that the debt will be paid back. Equity holders will want to understand when payback in the form of dividends will commence and what the return will be over the life of a project. Given that dividends are paid from retained earnings and debt repayment has seniority over equity payouts, the operation needs to be modelled financially. Ultimately it comes down to how providers of capital receive returns based on where they sit, e.g. geographically, in which currency, based on tax regimes that apply, how and when they can access cash returns or earnings, etc.

Publically listed corporations around the world have a statutory requirement to report their results under the respective accounting standards. Hence financial performance is assessed under these accounting measures. It is important to understand that:

- DCF provides a measure of value under an economic approach and tests if the cost of debt and equity is satisfied (etc) over the period of the cash flows, and that
- Financial analysis is a necessary step when gravitating towards the corporate and financial environments and will test, among other things, for the same over more discrete time periods (e.g. if interest payments can be covered each year).

APPENDIX B – INTRODUCTION TO DISCOUNT RATES

This appendix is intended to be a brief introduction to the theory underlying the specification of discount rates. It is assumed that the reader understands the basic principles of the time-value-of-money and the mechanics of conducting a discounted cash flow (DCF) analysis to derive a Net Present Value (NPV): these are not discussed here. Rather, the purpose is to provide background information to the technical-economic analyst who may not have formal training in the field, so that he/she understands what the discount rate is intended to do, how it is likely to have been derived, and most importantly to ensure that the discount rate used and the cash flows to which it is applied are consistent.

It should be noted that the discussion is for typical DCF evaluations. However, many of the principles apply, with variations, to alternative valuation methodologies such as Real Options Valuation (ROV). The discussion is under several subheadings, as follows:

- **Weighted Average Cost of Capital (WACC):** The discount rate typically used in many companies.
- **The Capital Asset Pricing Model (CAPM):** Typically used to determine the rate of return required by shareholders (or equity holders) in a company.
- **Cashflows – Real or Nominal, Before or After Tax:** Any of the four combinations of these parameters could be derived, and different discount rates will be required in each case. Cash flows can also be expressed as “before” and “after” Debt, i.e. excluding or including interest costs that will apply. Cash flows that are after the deduction of interest costs are typically referred to as “geared”. In our coverage of discount rate we will, as is typical in the resources industry, refer to analysis on an ungeared basis, before considering the financing cash flows, hence the “four” possible discount rates rather than the “eight” that are possible if also considering geared cash flow analysis.
- **Additions to the Weighted Average Cost of Capital:** There are two generally accepted approaches for reflecting risk in DCF valuations – via the cash flows or via the discount rate. That is, either the cash flow is reduced or the discount is increased and this results in a lower valuation. In effect, the higher the risk, then the greater the return sought. Many companies add “risk premiums” to the Weighted Average Cost of Capital to account for risks of dealing with different commodities or different countries.

Weighted Average Cost of Capital

To specify a discount rate, it is essential to ask what it is intended to achieve. Clearly this will be the same as what it is intended that the project should achieve. The underlying purpose of any project will typically be at least to return to the investors their capital plus a required rate of return. The mechanics of a typical DCF calculation are such that, if we discount a company’s cash flow at the company’s Weighted Average Cost of Capital (WACC) and get an NPV of zero, we have repaid the capital and delivered the required return. Any positive NPV is the Value Added by the project over and above the repayment of capital and delivery of the required return.

Any venture will be funded by debt, equity, or a mix of the two. The Weighted Average Cost of Capital is the cost to the company of its total debt and equity funding. It is derived from the following formula:

$$WACC = r_E \cdot E/V + r_D \cdot (1-t) \cdot D/V$$

where r_E = return required on equity, or cost of equity

r_D = return required on debt, or cost of debt

E = market value of equity

D = market value of debt

V = E + D

t = tax rate

When discounting a cash flow to calculate an NPV it is important to use a discount rate that is in the same terms as the cash flow. The WACC is applied to ungeared after-tax cash flows and so has a component of “cost of debt” (or interest) and “cost of equity” to suit the fact that the cash flow is available for servicing debt and equity. The cost of debt is paid before tax. Hence, its after tax cost is $r_D \cdot (1-t)$. The “1-t” factor is often referred to as the “tax shield”. Equity holders are paid from retained earnings and the physical cash payment from cash flows after tax. Hence, the cost of equity is already post-tax and does not need to be adjusted for the tax shield – it does not apply.

The variables E and D are sometimes determined from the company’s publicly reported Balance Sheet. The balance sheet figure may be a good representation of the market value for debt whilst the market value of equity for publically listed entities is better represented by the market capitalisation of the firm.

The cost of debt, r_D , is typically relatively easy to determine from the dollar amount and interest rate of each source of debt funding, typically described in detail in the notes to the annual accounts in the company’s annual report. One should also remember to check for any new or retired debt facilities reported by the company since the last reported balance sheet.

The required return on equity capital, r_E , can be derived by various methods: this discussion will cover the Capital Asset Pricing Model (CAPM) approach.

The Capital Asset Pricing Model (deriving the Cost of Equity)

Shareholders receive returns by two means, Dividends and Capital Gains. The rate of return required by shareholders depends on the riskiness of the investment: if high risk, high expected returns are required; if low risk, low expected returns.

While accepting that in reality there is always some risk, there are investments that are considered “risk-free” e.g. government bonds. These provide the Risk-free Return, r_F , and the 10-year government bond rate is most often used.

Investments spread over the total market would face the “market risk”, and would be expected to provide the Market Return, r_M .

Investment portfolios can be built with a lower risk than the market, and these are expected to provide returns between the risk-free and market returns (i.e. greater than r_F and less than r_M). Similarly, investment portfolios can be built with a higher risk than the market, and these are expected to provide returns greater than r_M . Note that returns for investments in non-risk-free assets are average expectations in the long-term, but are not guaranteed in any timeframe, and certainly not in the short-term.

The Capital Asset Pricing Model (CAPM) relates shareholders’ expected return (r_E) to risk by a linear function with a gradient of β , known as the “beta factor” or simply, the “beta”.

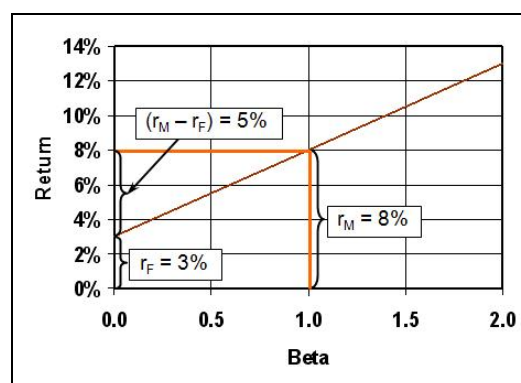
$$r_E = r_F + \beta(r_M - r_F)$$

where β is the ratio of Volatility of Company Returns to Volatility of Market Returns

The beta can be estimated as the Change in Share Price (Adjusted for Dividends) divided by the Change in the Market Accumulation Index for the same time period. To determine a company’s beta, a series of such data points is plotted over time, and the gradient calculated. One could track share prices and market movements oneself, or buy information from specialist market research firms. In a mathematical sense, beta represents a measure of systematic (or non-diversifiable risk) in a portfolio of assets and is measured as the covariance of an asset’s performance relative to the market divided by the variance in performance of the market.

Company betas are quoted on various market web pages, such as the major banks’ share trading websites, and also published by the Australian Graduate School of Management. It is also important to remember that betas can be calculated over various periods (e.g. over 18 months, four years, etc) and there is more than one approach available (but often the Ordinal Least Square method is used). A company’s beta can also change over time more than one figure can be quoted over time.

By definition, the “market” $\beta = 1$ (if $\beta < 1$, the risk is lower than the market, and if $\beta > 1$, higher), and $(r_M - r_F)$ is defined to be the “market risk premium” above the risk-free alternative. The figure below shows these relationships graphically: β is the gradient of the return vs risk line.



When identifying the beta, it is also of some importance to note the statistical “correlation coefficient” for the relationship identified: although a beta value may be determined, it may not be statistically significant. It should also be noted that some companies are “countercyclical” and have negative betas: their returns move in the opposite direction to the overall market.

Accounting for Inflation

Interest rates charged by finance providers, and quoted in the company’s annual report, are used to specify numerically the dollar values of the repayments that will be made in the future, in the money of the time that the payments are made – these are therefore “nominal” rates. Similarly, the rates of return generated to derive r_E are typically based on reported prices over time, without any adjustment for the effects of inflation – these are also therefore “nominal” rates of return. The discount rate formulas quoted above are therefore Nominal Discount Rates, which can only be correctly applied to Nominal Cash Flows.

Inflation erodes the purchasing power of the interest and capital repaid over time. The “real” return is that which is over and above the inflation rate.

If r_N = the nominal rate of return, and
 r_i = the inflation rate,

the real rate of return r_R is NOT given by

$$(r_N - r_i),$$

but rather by the relationship (known as the Fisher equation)

$$1 + r_R = (1 + r_N) / (1 + r_i)$$

i.e. $r_R = [(1 + r_N) / (1 + r_i)] - 1$

Discount Rates and NPVs – Real and Nominal, Before and After Tax

Combining the above, four possible discount rates can be derived and applied. The appropriate one to use will depend on what the cash flows to be discounted are:

Nominal, Before Tax $r_{NBT} = WACC/(1-t) = r_E.E/V / (1-t) + r_D.D/V$

Nominal, After Tax $r_{NAT} = r_E.E/V + r_D.(1-t).D/V$

Real, Before Tax $r_{RBT} = [(1 + r_E.E/V / (1-t) + r_D.D/V) / (1 + r_i)] - 1$

Real, After Tax $r_{RAT} = [(1 + r_E.E/V + r_D.(1-t).D/V) / (1 + r_i)] - 1$

The cost of equity, r_E , is an after tax cost and so the before-tax discount rates have r_E grossed up to a pre-tax basis of $r_E/(1-t)$.

Before and after tax NPVs can be different:

- The after tax discount rate will be lower than the before tax discount rate.

- The points in times at which capital expenditure is incurred and when tax depreciation is realised are different.
- An after tax evaluation may include tax losses carried forward at the start of the project, it is quite possible for the after tax NPV to be greater than the before tax NPV (if a value is not attributed to the tax losses in the before-tax NPV calculation).

NPVs calculated from real and nominal cash flows should be the same if the correct discount rates are used. Mathematically, deflating nominal cash flows to real and applying the real discount rate does in two calculation steps what is done in one step by applying the nominal discount rate to nominal cash flows. Nominal-term calculations may use different inflators for various drivers and components of the cash flow. The effect of these will not necessarily average out to the general inflation rate that may be quoted, but if the overall deflation rate used in the analysis is also used in the Fisher equation for arriving at the real and nominal term discount rates, there should be no difference in NPVs.

Additions to Discount Rates

The discount rates as defined above by the WACC take account of investors' required returns only, and the "systematic" or "market" risk. They do not take account of the "business" risk of dealing with certain commodities or in certain parts of the world.

Many companies add a "risk premium" to the WACC to account for these factors – typically up to several percentage points for some commodities, and for various countries or regions.

"Risk premiums" are rules of thumb that appear to have acquired legitimacy by consensus and long use. The committee developing these guidelines is not aware of any theoretical or evidentiary support for the process itself, nor for the values used for the risk premiums. The committee notes that, while using discount rates that include risk premiums may be satisfactory for comparing alternatives within a particular project, given its location and commodity, there are conceptual difficulties with comparing simple NPVs derived at different discount rates for projects with different commodities and / or in different countries. It is also perhaps worth noting that the company's beta already accounts for its current mix of commodities and countries where it is operating.

Monte Carlo simulation may be a more rigorous way to account for business risk, but only if reliable probability distributions for various data items are available. All key parameters including production rate and mineable resource need to be included: not just the easier-to-quantify parameters of operating costs, capital costs, grades and recoveries, etc. It is suggested without proof that the lowering of the NPV resulting from using a discount rate elevated by the use of a risk premium is perhaps a surrogate for identifying an NPV that has a higher probability (perhaps 90%) of being bettered than the "expected" value that would be derived with no simulation of business risks and discounting at the WACC, which would typically have perhaps a 50% probability of being achieved.

Proponents of other valuation methodologies would also suggest that the use of these would preclude the need to apply such risk premiums. This is discussed briefly in the section "Discount Rates in Other Valuation Methodologies" below in this appendix.

Financing Cash Flows

The financing cash flows – capital repayments, interest, dividends, and the tax effects of interest payments – are accounted for in the discount rates. They are therefore not included in the cash flows for economic evaluations determining project NPV etc for a typical ungeared technical-economic evaluation.

The financing cashflows may however need to be calculated outside the economic evaluation to confirm the ability of the operation to repay loans and meet debt coverage requirements, as may be required by financiers.

Calculation of an “Equity” NPV calculation may be requested, assuming specified debt funding for the project, to determine the return to shareholders. Debt draw-downs, and repayments of capital and interest will then come into the cashflow analysis, and the discount rate to be used will be the required return on equity. This is generally not recommended for the technical-economic evaluation: the project should stand on its own merits, and not depend on the financing arrangements for its viability.

One could also evaluate a project at the equity discount rate with zero debt funding to assess stand-alone viability of project. This would typically be a more conservative approach, as the required equity rate of return would usually be greater than the rate of return for debt.

Discount Rates in Other Valuation Methodologies

As noted in the introduction to this appendix, the preceding discussion is for typical analyses of total net project cash flow with discounting at the company’s WACC, which in essence treats the net cash flow by reference to the company’s overall riskiness as perceived by the market. Risk premiums are used by some companies to account for the additional perceived risks of dealing with certain commodities and/or in certain countries.

Other valuation methodologies, such as Modern Asset Pricing (MAP), Arbitrage Pricing Theory (APT), and Real Options Valuation (ROV) approach the valuation problem from the point of view of identifying and dealing with various risks individually. Some of these methodologies are described in more detail in other sections of these guidelines, but for the sake of completeness in this discussion of discount rates, certain aspects are described here.

Some of these techniques account for the risk associated with individual components of the cash flow. Individual betas are derived for (for example) metal prices and various cost categories, such as labour, consumables, energy, and so on. The techniques used to derive these betas will be similar to those described above for determining the shareholders’ required rate of return. The betas thus derived are applied to the market premium (ie the difference between the market and risk-free rates of return) to derive discount rates relating only to the systematic or market risk of each cash flow item.

Each cash flow item is then discounted at its appropriate discount rate, the resulting cash flows then summed to obtain a total, which is then accounting for all risks. The only other item to then be

accounted for is the time-value-of-money. The total risk-discounted cash flow is therefore then discounted at the risk-free rate of return to account for the effects of timing only.

The betas derived for each cash flow item will automatically account for the risks associated with the commodities and countries involved in the revenue and cost structure of the company and/or project. The result will be a dollar-denominated value, but since the discount rates used have no reference to the costs of debt and equity, there is no guarantee that a positive value implies that debt providers and equity holders can be repaid their investments and paid their required rates of return.

Concluding Comments

It is rarely the task of the engineer or technical analyst to derive discount rates. They are usually specified by the corporate finance department.

Technical-economic analysts should however be familiar with the assumptions underlying their derivation, and ensure that the appropriate rate is applied depending on the cash flows generated: real or nominal, before or after tax.

In particular it should be noted that, while generating a positive NPV using the WACC as the discount rate implies that all providers of funding have received the repayment of their investments plus their required rates of return, this does not, as noted in the body of these guidelines, imply that any particular pattern of finance repayments can be made.

Different projects, companies and industries have different WACCs. There are numerous views on what the applicable WACC is when valuing an investment. The authors make no recommendations regarding these sometimes opposing views except to make readers aware they exist. However, it is recommended that some thought is given to such matters as: from what perspective the valuation is being undertaken, the size of the investment relative to the company, whether it is in an industry with different risks and typical WACCs from the company's investors' perceptions, how it will alter the cost of capital if the transaction proceeds, and having a well-considered and justifiable position. Some of the (conflicting) views that may be encountered are:

- When valuing an investment, the marginal cost of capital is considered relevant. But the WACC can be used if weighted with the additional marginal cost. This ignores issues such as the marginal capital requirements being fully funded using debt and any effects on credit ratings and a possible increase in cost of debt. Many believe, if fully funded by debt, then use the existing WACC at margin. Over time, companies refinance and the marginal cost of capital will cease – hence this lends support to using the current proportion of debt and equity at expected costs of debt and equity.
- When valuing another company for acquisition, use your company WACC as that is what the acquired company's cash flows will be valued at when consolidated.
- When valuing another company for acquisition, use that company's WACC.

- Do both of the above to identify whether you and the other company value it differently, with potential impacts on acquisition costs.
- When valuing a company in the same industry, use the industry WACC – this may be based on the view that an optimal capital structure is obtainable and, given the optimal mix is difficult to observe, one uses the industry average cost of capital instead.
- When valuing a company in a different industry, use the industry WACC with an adjustment for your debt position.
- Business Units within a company each have their own set of risks, hence it is appropriate to use a different cost of capital when ranking opportunities.

APPENDIX C RECOMMENDED READING LIST

Discount Rates

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APPENDIX D TECHNICAL ECONOMIC EVALUATION GUIDELINES

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