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THE VALUATION OF LONG LIFE MINES: CURRENT ISSUES AND METHODOLOGIES

CHRIS EVES[1]

ABSTRACT

The past decade has seen an increasing focus on the mining and extractive industries in Australia. The significant increases in both new mines, commodity prices and employment opportunities has lead to considerable discussion on the value of this industry and the contribution that the industry makes to exports, GDP and the public in general. This debate has resulted in the introduction of the Mineral Resources Rent Tax being introduced in 2012. An issue that follows from the introduction of these taxes is the current exposure of property valuers to mine and extractive industry valuations and the most appropriate method that should be employed for valuing long life mines for rating and taxing purposes, finance and accounting purposes.

This paper will provide a detailed review of past and current valuation methods for long life mines and will highlight the current issues and problem facing valuers who are currently working in or intend to carry out valuation work in this industry

Keywords: Mining, extractive industries, mine valuation, valuation methodology

1.0 Introduction

The valuation of long life mines raises a number of valuation issues that are unique to this industry and as such can provide a number of critical concerns and problems facing the valuer when determining the value of a mine for a range of valuation purposes. Foremost in this current situation is the accuracy and appropriateness of current valuation methods for determining both the value of existing mine operations and the feasibility value of a proposed or new mining operation. A better understanding of the existing mine and extractive industries valuation requirements, methods and determination is required for valuers to meet the valuation requirements of mine operators, financial institutions and government bodies. Current mine operators and potential industry participants require valuation methodologies that provide reliable data and figures to assist in the assessment of value at the feasibility stage, as well as at specific points in time of the mine life for reporting purposes. Potential finance providers also require accurate mine and extractive industries valuations for lending security purposes and these need to be consistent and reliable, as well as being able to be carried out by a range of valuation practitioners. The complicated nature of mining, the long term nature of these operations and the difficulties and valuation risks that have been identified as major obstacles for the valuation profession and the ability to supply the mining industry with the most accurate and reliable valuation information and reports. Current valuation methods employed by property and business valuers are based on real property specific methods that are not always transferable to a mining situation, especially a long term mine operation. The nature of real property valuation methods rely on the availability of comparable sales information, readily available access to current property data and very industry specific measures of risk associated with real property ownership and occupation. Many of the economic and industry risks associated with the valuation methods employed in real property valuation are also issues that can impact on mining and extractive industries, but the assessment of risk for real property valuation is based on a single measure determined by a discount or capitalisation rate. Although this is suitable for real property valuation methods, the complexity of mining operations, their long term nature, global perspective and interrelationship between production, commodity, fiancé and political risk, renders current real property valuation methods insufficient for long life mine valuation. Many of these valuation issues also impact on the feasibility assessment of long life mines.

To increase the level of awareness, degree of accuracy and the acceptance of end mine valuation figures it is crucial that all direct and indirect participants in the mining industry have full confidence in the actual valuation methodology and underlying assumptions and guidelines. Currently; there is a certain level of discrepancy between the valuation guidelines issues by mining bodies, the professional practice standards published by valuation boards and the requirements of the mining industry players. In addition, the industry recognises the high level of risk associated with any mining enterprise or project and any valuation method or guidelines that can take the various sources and levels of risk into account in the actual valuation methodology will result in both more accurate and reliable valuations and will also provide a greater level of confidence in the feasibility studies carried out at the mine planning stage.

Paper Scope and Aims

This paper will address these issues by:

- Carryout an extensive literature review to document and understand the current issues relating to mine and extractive industry valuation issues from the perspective of:
    - Real property valuation
    - Current mining boards and authorities
    - Valuation standards and guidelines
- Identifying the major issues that impact on the accuracy and reliability of current real property valuation methods and their implementation in mine valuation

Mining Valuation Standards and Guidelines

This paper and review of mining valuation methodologies and valuation guidelines has been segregated into several research areas. An in-depth reading, data gathering and interpretation found a number of areas of studies in relation to mining valuation and have been identified as follows:

a) International practices of mining valuation which should discuss on the manual, codes and standards that have been applied worldwide in regards to mining valuation;

b) Risk assessment in mining valuation which highlights the common valuation approaches applied in the mining industries; and

c) Alternative approaches that have been suggested and implemented by various scholars and practitioners to determine the value of mining businesses.

A literature review of the above subject areas and the summarisation of the findings are discussed further below.

International Practices of Mining Valuation – Manual, Codes and Standards

International Mining Standards (Mine Valuation)

The peak mining bodies throughout the world have compiled details of the various valuation methods that can be used to determine the value of a mine. Although these codes provide a listing of the valuation methods that can be adopted they don't provide any actual instructions or guidelines on how such valuations should be carried out. The following details the various valuation methods proposed for mine valuation across the main mining countries in the world.

Australia (The Valmin Code, 2005)

This code states that the decisions on the valuation methodology to be used are the responsibility of the expert or specialist depending on:

a. The nature of valuation
b. The development status of the mineral
c. The extent and reliability of information available.

The valuer must state the reason for each methodology used. The Valmin Code does not state any specific method for extractive industry valuation , however does recognise and refer to the MICA website or other website on valuation methodologies. In the MICA website, there are discussion papers on valuation methodology for extractive industries.

The papers highlighted:

a. Income Method: DCF/NPV Method
b. Market Sales Method
c. Cost Method
d. Useful Rating Method
e. Option Theory Method

The first three mentioned valuation approaches are common valuation methods for real property valuation and are suitable the valuation of property where there is an established trading market, a reasonable volume of transaction data and full access to all financial and production data. In the case of mining, many of these criteria are not available. The two remaining mine valuation methods are not commonly used in property valuation and would be unfamiliar to the majority of the profession.

Canada (CIMVal, 2004)

The CIMVal recognises the following valuation methodologies and approaches for mine and extractive industries:

Income Approach

- Discounted Cash Flow (DCF)
- Monte Carlo Analysis

- Option Pricing
- Probabilistic

Market Approach

- Comparable Transactions
- Option Agreement Terms
- Gross “in-situ” metal value
- Net Metal Value or Value Per Unit of Metal
- Value Per Unit Area
- Market Capitalisation

Cost Approach

- Appraised Value
- Multiple of Exploration Expenditure
- Geo-science Factor

Agian, the majority of these reported valuation methods are not always commonly used in property valuation practice, but are more commonly used in mine feasibility studies.

2.1 South Africa (SamVal, 2008)

In South Africa, the accepted valuation methods are Cash Flow Approach, Market Approach and Cost Approach. The valuer must apply at least two (2) methods in the valuation report.

2.2 USA (USPAP)

There are no descriptions about extractive industry valuations in the USPAP even though mineral is classified part of real property. It depends on the purpose of the report:

a. For normal valuation (loan, sales, etc) – reference to the USPAP Standard 1 & 2.

b. For business valuation – reference to the USPAP Standard 9 & 10.

c. Machinery for mining – Fall under “Personal Property” valuation – reference to the USPAP Standard 7 & 8.

According to USPAP Standard 1 & 2, the three (3) valuation methods accepted are DCF, Cost and Sales Comparison methods. USMinval is the proposed valuation standards for extractive industries in US, but still has not been officialised since the last draft in 2003. However, it stated in the draft, the following methods can be considered for mine valuations:

Income Approach

1. Discounted Cash Flow (DCF)
2. Option Pricing
3. Monte Carlo Analysis

4. Probabilistic Method

Cost Approach

1. Appraised Value Method
2. Multiple of Exploration Expenditure
3. Geo-science Factor Method

Market Approach

Comparable Transactions

1. Option Agreement Terms
2. Gross ‘in-situ” value
3. Net Metal Value or Value Per Unit of Metal
4. Value Per Unit Area
5. Market Capitalisation

The draft USMinval adopted the Australian Valmin Code. The Canadian have adopted the USMinval Proposed Code and came out with their own version of CIMVal Code in 2004.

A common issue with all these international standards and guidelines for mine and extractive industry valuations is the fact that although the valuation methods are provided, this guidance is very general and does not provide any formal information on the applicability of process of any of the valuation methods. They all assume that there is adequate market information and data available for each of the valuation methods to be used. In reality this is rarely the case in this particular property and industry sector.

Australian and International Property Valuation Standards

The valuation profession both in Australia and internationally applies valuation standards and guidelines for specific classes of real property. These standards address the valuation method that should be adopted for each class of property and in some cases will also address the main issues that impact on the potential value of those property assets.

In respect to the property valuation profession the overarching principles and guidelines are stated in the International Valuation standards, with each individual country also publishing their own guidance notes and standards that follow the general principles in the International Valuation Standards. The Australian Property Institute and the Royal Institution of Chartered Surveyors are the two main property valuation professional bodies in Australia and both have attempted to provide guidelines and standards for Australian Valuers practising or potentially practising in the area of mine and extractive industry valuation.

International Valuation Standards

IVS (June, 2010) indicates that the IVSB do not approve new funding for extractive valuation standards. Instead, The IVSB needs to collaborate with the extractive industries players in regards to the level of interest in valuation standards for extractive industries. Currently there is no proposed standards or and valuation methods for extractive industries.

However, in 2003 the IVSC has produced a proposed draft of the Guidance Notes for Extractive Industries valuation. The draft indicated that the market valuation of an Extractive Industry Property as Real Property must be based on the Highest and Best Use (HBU) of the property. The draft also stated the three (3) valuation approaches generally available for consideration:

- Income (Capitalisation) Approach including market-related discounted cash flow;
- Sales Comparison Approach (termed Market Approach for Business Valuations) generally by indirect means;
- Cost Approach (term Asset-Based Approach for Business Valuation), including Depreciated Replacement Cost and Equivalent Cost Analysis.

The draft IVS mine valuation guidance notes have since been withdrawn and are to be replaced with Technical information Paper (TAP). As stated in the introduction of this paper, the level of expertise of the typical property valuer is very limited in relation to the understanding and application of valuation methods for the valuation of long life mines. This is further hindered by the very limited information that is contained in the IVS valuation guidelines. As is the case for some of the mining body standards, the valuation methods suggested by the IVS and API are very suitable for commercial, industrial and rural property but due to the nature of mines and extractive industries are not as relevant for this property and business class. Again, the limited number of participants in the market, the small pool of properties or operations, the high production and commodity price risk level of the industry, the long term nature of the operations, the diverse type of operations and the small transaction pool limit the use of traditional valuation methods for this property class.

Royal institution of Chartered Surveyors (RICS)

RICS is the leading international professional body for real property valuers, with a global presence and regional offices in UK, Western Europe, US, Asia and Australia. This professional body also sets standards and guidelines for a range of property sector valuations. In 2011 RICS released valuation guidelines for mineral bearing land and waste management sites.

Like the IVS standards, these RICS valuation guidance notes are produced to provide valuers with the necessary information to undertake the valuation of specific types of property. As stated by the RICS:

"Guidance notes provide advice to RICS members on aspects of their work. Where procedures are recommended for specific professional tasks, these are intended to represent best practice, i.e. procedures which in the opinion of RICS meet a high standard of professional competence"

(RICS, 2011)

This standard lists the various purposes for the valuation of mines and extractive industries including:

- Financial reporting
- Sales and acquisition
- Company mergers
- Public and/or private funding
- Rent or royalty review
- Taxation
- Litigation

- Building and plant and equipment valuation for insurance purposes

Although these RICS guidelines provide some basic information in respect to the complexities of mineral bearing land valuation, such as

- interest being valued – surface, natural resource and/or operation;
- ownership of other minerals and right to disturb
- rights to work and withdraw support;
- tenure – freehold and/or leasehold;
- type of natural resource being extracted;
- annual quantity and quality of materials being, or proposed to be, extracted;
- production yields achieved, or to be achieved, after processing;
- saleable outputs of the operation;
- geology and hydrogeology of the natural resource;
- planning, permitting and licensing relevant to the property;
- financials – ex-pit selling prices, operational costs and/or surplus trading profits (margins);
- market feasibility study for all saleable products;
- rehabilitation/restoration requirements;
- residual income or alternative end use value;
- subsidence or withdrawal of support liabilities; and/or
- discharge liabilities. (RICS, 2011)

There are no substantial RICS definitions of these major issues and no specific information on the valuation methods that should be adopted, nor any actual guidelines on how the valuation should be carried out.

For accurate mine valuations to be carried out by property valuers, it is vital that these valuers have a thorough understanding of the mining industry and the impact of operations on mine value

Review of Valuation Methodologies

The following provides a summary of the current valuation methods employed by valuers in the assessment of mines and extractive industries for a range of valuation purposes. As stated in the previous section the various purposes for carrying out a valuation of a mine or extractive industry is not only for the initial feasibility of the project but also includes:

- Financial reporting
- Sales and acquisition
- Company mergers
- Public and/or private funding
- Rent or royalty review
- Taxation
- Litigation
- Building and plant and equipment valuation for insurance purposes

The purpose of the valuation also an important factor in determining the valuation method that needs to be adopted and the information and data that is required to carry out the valuation. There have been a number of academic and industry papers in relation to the valuation methods that should be adopted for the valuation of mineral bearing land and these are discussed below and a comparative summary is provided in Table 1.

Scott (2010) categorises valuation methodologies based on the following:

- Traditional methodologies (Market comparison approach, cost approach and income approach) including discounted cash flow methodology.
- Alternative valuation methodologies including adjusted present value, certainty equivalents, decision trees and real option valuation.
- Quantitative risk assessment techniques including sensitivity analysis, scenario analysis and monte carlo simulation.

Previously, most authors generally agreed that discounted cash flow analysis should be the principal valuation method. However, some of them dismissed it as not applicable to certain categories of mineral property as follows:

- Bruce et al (1994) states that rigorous, methodical and prescriptive valuations of exploration properties are in general spurious unless the assumptions and the subjective judgements that have been used are fully disclosed.
- According to Lawrence (1994), the expected value method (DCF) has little application in the valuation of exploration mineral assets.
- Butler (1994) considers DCF techniques only applicable when sufficient information is available to quantify, with some confidence most of the parameters affecting the value.
- Edward (1994) views is rather confused. The mining valuer is expected to have undertaken a probability analysis and applied significant discounts to reflect the uncertainty/probability of ultimately recouping the cash flows reflected in the DCF value. Difficulties arise if the DCF methods have been applied to simplistically to exploration properties without due regard to allowing for probability.

McFarlane (2002) agrees that DCF is the best approach of valuation of extractive industries in South Africa, if there is an availability and adequate of data. However, most valuers preferred the so-called technical valuation methods for mineral properties without defining resources where the value is inferred through:

- The exchange value of similar properties, the Comparable Sales method;
- The willingness to pay to participate in a share of expected future returns, the Joint-Venture method;
- Value inferred through prior exploration expenditure, the Multiple of Exploration Expenditure method (Cost Approach); and
- Subjective rating of attributes most frequently requisite to successful mining, the Geoscience Rating method.

According to Lawrence (1994), the valuation methodology chosen to value a mineral asset depends upon the amount of data available on that asset and the reliance that can be placed on the data. In the same vein, commenting on the quality of data and reliability of forecasts used in discounted cash flow calculation, O'Connor and McMahon (1994) warned that it is important not to allow the science of the methodology to dominate the assessment. In other words, subjective judgements are more important than objective valuations.

The Table 1 below shows the Comparison of Valuation Methodologies from international practices:

Table 1: Valuation Methods for Mineral Properties

Valuation Approach	**Valuation Method**	**Method Ranking**	**Comments**
Income	Discounted Cash Flow (DCF)	Primary	Very widely used. Generally accepted internationally as the preferred met
Income	Monte Carlo Analysis	Primary	Less widely used, but gaining in acceptance.
Income	Option Pricing	Primary	Not widely used and not widely understood but gaining in acceptance.
Income	Probabilistic Methods	Not available	Not widely used, not much accepted.
Market	Comparable transactions	Primary	Widely used with variations.
Market	Option Agreement Terms	Primary	Widely used but option aspect commonly not discounted, as it should be.
Market	Gross “in situ” Metal Value	Not available	Not widely used, and not accepted in Canadian mineral valuation.
Market	Net Metal Value or Value per unit of metal	Secondary	Widely used rule of thumb.
Market	Value per Unit Area	Secondary	Used for large Exploration Properties.
Market	Market Capitalisation	Secondary	More applicable to valuation of single property asset of junior companies than to properties.
Cost	Appraised Value	Primary	Widely used but not accepted by all regulators.
Cost	Multiple of Exploration Expenditure	Primary	Similar to the Appraised Value Method but includes a multiplier factor. More commonly used in Australia.
Cost	Geoscience Factor	Secondary	Not widely used.

Source: USMINVAL (2003), CIMVAL (2004) and SAMVAL (2008)

Where DCF is applied there is a disagreement concerning the treatment of risk and the selection of the discount rate:

- Ballard (1994) was satisfied that risk can be accommodated through a discount rate estimated by means of Capital Asset Pricing Model (CAPM).
- O’Connor and McMahon (1994) recognise the deficiencies of CAPM but apply it in the absence of what they termed a better methodology.
- Runge (1994) considers that the uncertainties in mineral valuation are too project specific to be assessed using the CAPM.
- Butler (1994) regards Monte-Carlo simulation as impractical and is happier with the presentation of discrete sensitivities.
- O’Connor & McMahon (1994) point out that NPV is only one input into a mining investment decision and discusses other relevant inputs including the special strategic intervals of the company.

- Runge (1994), Lonergan (1994) and Winsen (1994) insist that managerial flexibility be incorporated into valuation analysis. This is especially relevant to sensitivity analysis as it is commonly applied in which mine management is assumed to blindly follow a fixed operating plan irrespective of what commodity prices are doing.

In valuing exploration tenements, most authors considered it misleading to conduct NPV analysis on speculative data. Sorentino (2000) claims that it is surprising that no attempt has been made to estimate the accuracy of these methods on the basis of statistical analysis or simulation experiments. Valuation of exploration tenements appears well suited to a subjective probability treatment and it is surprising that this approach has not been either attempted more frequently or more strongly advocated by valuers.

Risk Assessment in Mining Valuation: Valuation Approaches

The following section of the paper details and discusses the various mine and extractive industry valuation methods that are currently undertaken to assess mine value. From the previous sections a number of valuation methodologies have been discarded from this overview as they are considered inappropriate methods due to their simplistic approach, lack of comparable evidence or their inability to arrive at a figure that is realistic or supportable. The market based valuation methods such as direct comparison is stated to be an acceptable method by both the mining codes as well as the valuation professional bodies; however, in reality few mines sell on the open market, it is extremely rare for a number of mines to be similar in size, ore quality, reserves, resources and operational requirements. On this basis a direct comparison between the mine being valued and recent sales is not practical or reliable for any valuation purpose. A similar situation exists for valuing a mine or extractive industry on a cost or summation valuation basis. This valuation method does not consider any of the risk factors associated with mining.

Therefore the discussion on mine valuation methods will focus on the various income approaches, especially those valuation methods that consider risk in the valuation calculation. The main factor that contributed to the mining valuation is how the risk was treated. Therefore, many scholars have discussed on the valuation approaches that been used in the market and suggestion of its benefits and weakness.

In risk assessment, the methods being employed are either sensitivity analysis, scenario analysis or probability simulation analysis (Monte Carlo simulation/MCS). The descriptive and explanation of each method as employed by various scholars are as follows:

Sensitive analysis

Torries (1998) mentions that this method involves the variance of a single project parameter to determine the influence that variable has on the potential NPV or IRR of the project. Often assessed at a specified percentage deviation from the base case, commonly ±10%, but the size of the deviation should be indicative of the likely volatility in the variable (Scott, 2010).

Mun (2004) indicates the advantages by using this method which is:

a. They are simple and inexpensive to perform and are easily facilitated through the modelling of probabilistic simulations.
b. Useful in identifying the critical variables to a project's success.
c. The identification provides management with direction as to where limited resources would be best focused to reduce or mitigate uncertainties which have serious consequences on the outcome of a project.

However, the only disadvantage of this methods is it provides little information regarding the risk characteristics of the project but provides no information as to the likelihood of that uncertainty occurring.

Malone et al (2007) further highlighted that the variable assess in mineral project includes size of reserves, commodity price, quantity produced, operating costs, capital costs, exchange rates and discount rate.
According to Stirzaker (1997) and West (2006), sensitivity analysis has been criticised for providing no knowledge of the project's sensitivities. Experienced manager would well aware that a project's NPV is sensitive to the commodity price, the discount rate, operating and capital costs and the production capacity. It was earlier commented by Sorentino and Barnett (1994) that the limitation of the usefulness of this method of analysis is because of the method's simplicity.

This was further explained by Scott (2010) that in practice, project's variables will not fluctuate one at a time, independently of each other at a specified deviation from the base case. It cannot determine the effects of variations in more than one parameter simultaneously.

Scenario Analysis

Torries (1998) describes scenario analysis as the extension of sensitivity analysis which permits multiple project variables to fluctuate simultaneously to determine the combine effect on the outcome of a project.

Scott (2010), Gamble (2007) and Torries (1998) have discussed on 2 common use of scenario analysis:

1. Determine the best case, worst case scenarios that which are used to establish the upper bound and lower bound range of possible project outcomes. Establishing the probable range of the project's outcome identifies the potential magnitude of project uncertainty but reveals no indication of likelihood of occurrence.
2. Used to examine the potential project outcome under the defined 'what if' scenario. This type of analysis will provide information regarding the impact of an event but requires subjective judgement for establishing the probable occurrence of that event.

3 Situations for the use of 'what if' scenarios are as follows:

i. Where a variable exerts a substantially large impact on the outcome of a project and would overpower all other variables examined under probability simulation analysis.
ii. Where there is limited ability to accurately determine the probability distribution for the variable or the probability of occurrence under 'what if' scenario.

iii. Where management has limited ability to control the outcome of such an event but requires an assessment of the impact the event would have on the project's outcome.

In addition, Mun (2004) has mentioned that the inclusion of correlation between project's variables can assist in defining the scenario analysis and help determine critical components of a project's interrelationship that sensitivity analysis unable to identify.

Probability Simulation Analysis (Monte Carlo Simulation/ MCS)

Torries (1998) has identified that MCS is capable of extending the individual uncertainties of each variable to determine their combined effect on the outcome of the model. The process involves the estimation of the expected value for each variable and assigning a probability distribution representing the uncertainty in that estimation.

Mun (2004) has described that Monte Carlo Simulation (MCS) is employed to randomly sample a value from the probability distributions of each variable and combines these values as the inputs for the model to generate a random outcome. The process is repeated many thousands of time to create a probability distribution of the random outcomes from the model.

The underlying principles of MCS are the law of large numbers and the central limit theorem, which state that as the number of simulations approach infinity the generated results will approach an accurate representation of the population. MCS expands the single point estimate of a model into a range of possible outcomes and determines the probability of each outcome occurring.

The probability distribution of generated outcomes for the project can be statistically examined to reveal the expected NPV and risk characteristics of the project. Results from MCS can be used to establish confidence intervals for a defined range of project outcomes including the probability of the project's exposure to negative returns and upside gains. Apart from that, value at risk can be measured through MCS. The accuracy and reliability of MCS results require the correct modelling of the input variable's probability and the establishment of any interrelationships amongst the variable.

Gamble (2007) comments that the representative probability distribution for the variable can be determined from historical data or by employing Delphi Method; which uses expert opinions from managers during risk workshops to determine the appropriate probability distribution for key variables in the model.

The interrelationships between the variables must be established and incorporated into the model's structure or parameters of simulation to ensure accurate MCS result is generated. If relationships are not included, random sampling can combine unrealistic combinations of the variables which will compromise the reliability of the results.

Further explanation by Torries (1998) also discusses that Inclusion of uncertainty in the probability distribution of the model's variables for MCS warrants a reduction in risk-adjusted discount rate employed for the NPV simulation, to avoid the double representation of this risk in the model.

He also explained that in MCS the risk preferences of the decision maker should not be incorporated in the calculation of expected NPV. Instead the probability distribution of possible NPV presents the risk characteristics of the project to the decision maker and their attitude toward risk will influence the decision to invest in project. If the discount rates are chosen correctly then the expected NPV from MCS adjusted for the risk preferences of the decision maker should equal the expected value from NPV scenario analysis.

However, Gamble (2007) mentions that concerns and limitation of MCS are includes difficulties in performing MCS calculation, difficulties in identifying interrelationships between variables, and difficulties in establishing appropriate probability distributions to assign variables. The problems with MCS also highlighted by Torries (1998) that MCS suffers from the inherent limitations of DCF models, including the determination of the appropriate discount rate and the static and inflexible nature of the valuation. Decision makers are also concerned that MCS does not provide a single metric on which to rank projects for investment. However, he also stated that the prime reason as to why MCS has not been widely accepted amongst decision makers as an absence of familiarity with the technique.

Risk Assessment in Mining Valuation: Alternate Valuation Approaches

The researchers have found several alternative approaches that can be used in determining the value of mining businesses. The methods are adjusted present value (APV), certainty equivalents, real options valuation (ROV) and modern asset pricing (MAP) and their discussions are as follows:

Adjusted Present Value (APV)

This method was originally published by Myers (1974). It is an alternative to the WACC discounting under a DCF valuation framework. Represent movement from the use of single “one size fits all” discount rate applied to all the cash flows of an investment, by separating different streams of cash flows resulting from an investment and discounting them separately.

Luehrman (1997) discusses that Traditional APV separates the valuation of cash flows from business operations, which are discounted at the cost of equity from the CAPM model, from the valuation of cash flows generated from the financial structuring of the business, which are discounted at the cost of debt.

The overall value of the business is determined under the principle of value addictively and is equal to the summation of the present value from the business cash flows and the present value of financial side effects, including tax savings, subsidised debt, credit enhancement and hedging risk.

The greatest strength of APV over WACC discounted NPV is the additional information that APV provides through the separation of cash flows which can be used to identified where the value of an asset is generated.

Scott (2010) strengthens opinions on this method by mentioning that this method can be used to separate cash flows of mineral project during evaluation. This separating permits each discounting cash flows by discount rate that are more accurately represents the uncertainty present in that cash flow.

Analysis performed under the APV framework will provide greater information regarding the impact of uncertainty and the value of cash flows compared to standard NPV analysis. The separates analysis of a project’s cash flow represents significant contributions toward modern asset pricing methods.

Certainty Equivalents

Torries (1998) has discussed in detailed regarding this method. A certainty equivalent amount represents the value, known with certainty, that an individual or company would be indifferent about swapping in exchange for a particular risky project. Conventional valuations of risky projects focus on the expected value concept, which weights the outcome of an uncertain event by the probability of occurrence to determine the expected value of the project. This approach fails to adequately capture the magnitude of the capital being exposed to the possibility of loss and assumes that the investor exhibits a neutral toward risk which is not right. It is generally accepted that most investors are risk adverse.

Myers (1968) mentions that the degree to which risk aversion impact the uncertainty equivalent value is determined by the investor’s utility function of possible outcomes and their risk tolerance. The risk tolerance of a risk-adverse investor is defined as the maximum amount the investor is willing to gamble in a lottery that has even chance of winning that amount of money or loosing half of that amount.

Torries (1998) claims this method can be used to create consistent framework in which investment decisions under uncertainty can e analysed. Certainty equivalent valuation using the equal probability method can be employed to analyse probabilistic outcome fom simulation analysis to reach an investment decision that includes the risk preferences of the investor. Analysis of risky project’s certainty equivalent values at differing levels of investment can be used to determine the optimal level of investment in the risky business.

Real Options Valuation (ROV)

Leslie and Michaels (1997) have indicated that real option valuation is the extension of financial option pricing methodology to the valuation of real assets. Under the real options framework, an asset may be viewed as containing an embedded option if, for a fixed price, it provides the owner with a right to make a decision to invest, divest, abandon or delay an opportunity that has the potential to realise future payoffs or limit future liabilities without imposing any obligation to do so. A call option represents the right to buy an asset at the exercise price, while a put option represents the right to sell an asset at the exercise price.

Modern Asset Pricing (MAP)

Real option is included as a form of MAP valuation whereby the policies and strategies of managing the asset are combined towards maximisation of the assets value. MAP differ from DCF valuation since it incorporating the flexibility of future management decisions in the analysis of an assets value and by discounting expected cash flows directly at the source of uncertainty (Laughton, Sagi & Samis, 2000).

Conclusion

Based on the above discussions, it is found that there are several areas of studies that can be highlighted to improve the valuation methodologies of mining/extractive industries. The areas of studies are as follows:

No standardisation or suggestion of valuation methodology to employ in international and countries valuation standards.

In general, every standard has provided suggestions on approaches and methods to be used in mining valuation. However, there has been limited discussion on what is the best method of valuation for different types of mining operations. This leaves room for improvement for the researcher to adapt the valuation methodologies with different implementation of extractive valuation exercise. Suitability of valuation methodologies employ will increase the report credibility and provide accurate valuation.

Traditional valuation methodology, especially DCF lack in addressing risk assessment in mining valuation accurately.

Based on the various scholar opinions, it is found that traditional valuation methodology is not sufficient in assessing the risk in the mining industries. The limitation in DCF implementation was highlighted by most authors, as well as other type of traditional valuation approaches. To date, the improved or alternate valuation methodologies were suggested, not just from the scholars but from the practitioners as well.

Several alternative valuation methodologies were suggested to assess the crucial risk element in mining valuation.

Many valuation methodologies were suggested such as adjusted present value and certain equivalents. However, the gaining popularity of Monte Carlo simulation and real options valuation methodologies has put the valuation of mining industries to the next level, where the simulation or valuation based on actual data assembled is more appreciated. However, the usage of the alternative valuation approach can be confirmed with at least one of traditional approaches, such as cost or direct comparison approach.

The study on the valuation methodologies using alternative approaches should be considered as new paradigm in shifting from old, traditional approaches to more sophisticated, reliable data-based assessment.

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