Valuation of mining business

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1. Introduction

1.1. The mining industry

The mining industry covers establishments engaged in the extraction of resources like minerals, coal, ores and so on from the Earth. Industry operations affecting performance of mining business include quarrying, digging, maintenance and support operations (like milling, crushing, washing, screening etc.). In mining industry, exploration for and development of mineral properties and services performed in the development are also included. The output of mining industry is a wide range of products for both industrial and consumer use. Mines performs as supporters of manufacturing and energy companies, and producers of materials for further use for precision instruments, electronics, jewelry and related businesses. Mining operations are capital-intensive, with significant amount of fixed operating costs. On the other hand, demand for mining industry products is fluctuating constantly, making prediction hard to do. Fluctuations make whole business very profitable when demand is high, but on the other hand companies from this sector need to adapt very quickly to maintain their market position where demand is lower. This is why Mergers & Acquisitions activity in the sector is also prone to fluctuate. According to Heffernan[1], attaching a price tag to a mine property is not easy even to experts and experienced valuators, because of many variables such as metal prices, expansion potential and environmental issues. Moreover, if the property is at the exploration stage with no history of cash flow or has a significant resource component, the task is even more complicated.

1.2. Challenges to valuators

Given any business we can develop some techniques to calculate its value to further usage in comparison purposes. But while that could be true in case of traditional business, mining ones are different. Obviously, a single mine is a finite business, mining that mineral deposits can contain certain, limited amount of resource, and when mined ore out of the deposit is depleted, a mine business is about to close. This is completely different as opposed to situation of let's say traditional manufacturer, who could adapt to new demands and trends, and stay in business successfully for many years.

[1] Heffernan Virginia, "Mineral Property Valuation" in E&MJ issued in August 2004, p. 21

What's more, there are several features that differs from other businesses, which have a significant impact on valuation challenges. One can mention for instance, that mining assets are controlled by governments, mining itself are capital intensive, finite, their earn return by liquidating assets. Furthermore, they are susceptible to market risks, and one more feature to describe them is transparency of COs and GOVs.

There are many figures, that can be used to value a business. For instance, one can mention price to earnings ratio, price to cash flow, operating margin, net profit margin. All of them can be used to say if a stock of this idiosyncratic stock is relatively cheap or relatively expensive. This sense of price can be also achieved by looking at BV per share, and comparison of things like the profit margin and dividend rate to prevailing interest rates. But in case of mining they are not really helpful. The thing is, that we use them only under background assumption, that considered business will be continuing and performing in similar way for long period of time, generating theoretically earnings and cash flows are for all intents and purposes infinite. For instance, the same value of P/E of traditional manufacturer and mining is not comparable, because mining will operate only in limited period of time – meaning, that the same P/E favors traditional business, which will stay for longer time, thus generating more cash flows. Therefore, the implicit assumption about continuous operation of business is of course not fulfilled in case of minings, therefore some other ways to value them must be found.

It seems, that the very reasonable way to value a mining business is to look at its NPV (Net Present Value) of discounted future cash flow. Discount rate has to represent the geological, political, social and financial risks. But looking at cash flows is not sufficient. Paul van Eeden (2007) says, that we have to take into account not only generated cash flows, but also sustaining costs of capital, like future exploration and development costs, which are necessary for a mine to operate and keeping its production of sufficient and expected level[2]. Given that any suitable cash flow model can be derived for a mine, a simple net present value of future cash flows can be calculated. Sum of all net present values and assets from the balance sheet corrected by any debt from there will give net asset value per share if divided by number of shares. As Paul van Eeden continues, in the real world, "mining stocks almost always trade for more than the net asset value of their constituent mines, and for a

[2] Paul van Eeden "How to value a mining stock", [http://www.paulvaneeden.com/How.to.value.a.mining.stock]

good reason". Mining stocks also offer leverage to commodity prices. Given the margins between final price of one unit of gold and costs of exploring and mining, these margins are basement for net present value of company, which bases of the margin. If market price of one unit of gold increases in ceteris paribus, then any growth in price will effect on leveraged growth of margin, implying that cash flows increase much higher as price of gold increases.

According to van Eeden, if we pay more for mining stocks that they are worth believing, that in future price of underlying commodity will increase, basically speaking we gamble on the commodity price. Fortunately, there is a way to include, quantify and discount premium, which is paid by one to incorporate leverage of underlying commodity. This common formula is known as Black-Scholes Model (Black-Scholes formula). Its general use makes the formula very universal - it is applicable not only to mining case. The model itself can help obtain more realistic asset value per share of mining business, basing on option pricing techniques. What should be done is to calculate the discounted net present value of the all the company's mines and then add the premium option value obtained from the Black-Sholes model. By adding the option value to NPV we can account for the fact that mining shares trade at a premium to their net asset value just because of leverage to the underlying commodities.

This adjusted value in fact can be used to compare different mining companies to each other, and also other businesses from different sectors to mining projects. Van Eeden concludes, that "unfortunately, very few mining analysts employ the Black Sholes model to calculate mining net asset values, so for most people buying mining stocks really comes down to blind speculation on commodity prices".

In this paper I will present different approaches, arose from challenges the mining business presented according to this conceptual framework.

2. Comparison of different methodologies

Ian Campbell[3] in his work "The valuation of mining companies" mentions several different approaches to value a mining business, from which a composite table was created:

	Liquidation Value	Tangible Asset Backing	Multiple of Net Asset Value	Discounted Cash Flow	Multiple of EBITDA	Multiple of Free Cash Flow	Market price / gross cash flow	Multiple of earnings	Comparable transaction prices	Market capitalization per ounce of annual production	Dollars per ounce of reserves	Capitalization per ounce of reserves	Imputed bullion price	Zero discount Net Present Value	Internal Rate of Return Surplus	Dividend Yield	Present Value of Exploration Expenditures	Historic reserves per km of camp structure	Land area	Past Explorations budget	Proximity to Past or Active Mines
Develops																					
Enterprise Value				X	X	X			X	X	X	X	X		X		X	X	X	X	X
Equity Value	X	X	X	X	X	X	X	X	X	X				X		X					
Principally used to develop																					
En Bloc Value	X	X		X	X	X			X						X						
Stock Market Price/Metrics			X	Sometimes	Commonly	Sometimes	Commonly	X	X	X	X	X	X	X		X	X	X	X	X	X
Reliability																					
Little or None			X							X	X	X	X	X			X	X	X	X	X
Some	X	X			X		X	X	X						X	X					
Greatest reliance				X		X															
Information available to Securities Analyst																					
Historic Data	Generally not	Generally not	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prospective Data	N/A	N/A	N/A	Limited	Limited	Limited	Limited	Limited	N/A	N/A	N/A	N/A	N/A	N/A	Yes	No	No	N/A	N/A	N/A	N/A

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[3] Published in Stock Research Portal: [http://www.stockresearchportalblog.com/2008/10/the-valuation-of-mining-companies-%E2%80%93-post-12-of-17/]

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	Liquidation Value	Tangible Asset Backing	Multiple of Net Asset Value	Discounted Cash Flow	Multiple of EBITDA	Multiple of Free Cash Flow	Market price / gross cash flow	Multiple of earnings	Comparable transaction prices	Market capitalization per ounce of annual production	Dollars per ounce of reserves	Capitalization per ounce of reserves	Imputed bullion price	Zero discount Net Present Value	Internal Rate of Return Surplus	Dividend Yield	Present Value of Exploration Expenditures	Historic reserves per km of camp structure	Land area	Past Explorations budget	Proximity to Past or Active Mines
Adopted by																					
Securities Analysts	No	Not Commonly	Commonly	Sometimes	Commonly	Sometimes	Commonly	Commonly	Commonly	Infrequently	Infrequently	Infrequently	Infrequently	Sometimes	Infrequently	Commonly	Infrequently	No	No	No	Sometimes
Corporate Acquirers	No/Limited	Sometimes	No/Limited	Yes	Yes	Yes	Possibly	In Accretion Test	Common	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	Yes	No	Unlikely	Unlikely	Unlikely	Unlikely	Sometimes

based: Ian R. Campbell "The Valuation of Mining Companies"

I will try to discuss several of these frameworks later on.

2.1. Discounted Cash Flow Methodology

This methodology develops either an en bloc enterprise value, or en bloc equity value if interest bearing debt and equivalents and other non-operating liabilities (e.g. unfunded pension obligations, unfunded environmental liabilities, etc.)are deducted from enterprise value. It is the most theoretically sound share and business valuation methodology. Pursuant to this methodology a detailed forecast of revenues, cash operating expenses and required prospective sustaining capital reinvestment, capital invested to support growth assumed in the forecast period, and required working capital changes are discounted to present value by a discount rate which incorporates a blend of what are taken to be appropriate after-tax rates of return on equity and long-term prospective interest rates (in 'finance speak', a 'weighted average cost of capital'). Benefits related to existing future depreciation claims for income tax purposes and redundant assets are added to derive en bloc enterprise value. Interest-bearing debt and equivalents and other non-operating liabilities are deducted to derive en bloc equity value.

Campbell says[4], that DCF methodology is the primary one adopted by Corporate Acquirers in acquisition analysis, and is adopted periodically in stock market pricing and forecasting by Securities Analysts. On the other hand, analysts typically do not have access to all relevant information, which eventually lead to more subjective share trading value and price conclusions derived by DCF than those made by Corporate Acquirers. More than other methodologies, the DCF methodology explicitly considers the cyclical nature of commodity prices.

2.2. Liquidation value

This is the approach, which develops equity value, providing that a business is not going to perform or is deemed. According to principles of this approach, the liquidation value of each tangible and intangible asset is determined by appraisal or otherwise estimated, and those so-called liquidation values are summed up. Next, all the liabilities are deducted. Ian Campbell (2008) claims[5], that this methodology generally is more theoretical than practical. It is seldom if ever adopted in a going concern context by Corporate Acquirers as a risk measurement tool. In Campbell's experience[6] it is rarely used by itself in a stock market context, thus typically not adopted by Securities Analysts. Given that, where a company owns assets redundant to its operations and strategy, we can value these according to liquidation approach on a liquidation value (net of income tax on disposal) basis by both Securities Analysts and Corporate Acquirers. Then we add this to "what otherwise would be either an enterprise value, an en bloc share value, or a "proportionate" per share price"[7].

2.3. Tangible asset backing

This approach also develops an en bloc equity value. The principles of this approach methodology are, that we determine the "value in use" (going concern value) of each tangible and identifiable intangible asset owned by a company. The liabilities of the mining business are deducted. According to Campbell (see previous footnotes) this methodology is theoretically correct in developing net asset value pursuant to peer group analysis. Business

[4] Ian Campbell, *The Valuation of Mining Companies – Post #14 of 17*, retrieved from [http://www.stockresearchportalblog.com/2008/10/the-valuation-of-mining-companies-%E2%80%93-post-14-of-17/]
[5] Ibid, *Post #12 of 17*, retrieved from [http://www.stockresearchportalblog.com/2008/10/the-valuation-of-mining-companies-%E2%80%93-post-12-of-17/]
[6] Ibid
[7] Ibid

owners and Corporate Acquirers who executed confidentiality agreements possibly have data available, to meaningfully adjust reported asset and liabilities from their book values for accounting purposes to "value in use". However, on the other hand Securities Analysts usually do not have the same depth of information (with respect to these things available to them). Campbell further continues sharing his experience, that such comparisons "do not tend to be particularly meaningful, and any such comparisons should be carefully assessed before placing any reliance on them"[8]. The Tangible Asset Backing methodology may be adopted by Corporate Acquirers and their advisers as a risk measurement tool where:

1. the difference between the price of mining company and the underlying tangible asset is taken to be a measure of the "intangible value component" inherent in the purchase price.
2. intangible assets have greater prospective risk than tangible assets do.

Campbell summarizes, that "(…) this methodology generally is adopted in part by Corporate Acquirers as a basis for post-acquisition financial and income tax reporting purposes, but is not widely adopted by Securities Analysts"[9].

2.4. Multiple of Net Asset Value

This approach is typically in use by analysts to develop stock market price estimates, being equity values. The principles of this approach are, that multiples of reported net book value are imputed from what are taken to be "peer group companies". Furthermore, a comparator based stock market price is developed by applying the average, or some other multiple derived from that analysis, to the net book value of the subject company. According to Campbell, "this methodology is widely adopted by Securities Analysts as a primary valuation methodology when valuing mining exploration companies and companies without cash flow and earnings, and is adopted extensively by them as a secondary valuation methodology in other valuation analysis"[10]. So, application of this approach is likely to produce unsound results – hence ought not as a general rule to be considered as reliable one. Campbell continues with following reasons:

[8] Ian Campbell, *The Valuation of Mining Companies – Post #12 of 17*, retrieved from [http://www.stockresearchportalblog.com/2008/10/the-valuation-of-mining-companies-%E2%80%93-post-12-of-17/]
[9] Ibid
[10] Ibid

1. application of generally accepted accounting (GAAP) principles by different companies may result in different reported asset and liabilities values for similar assets and liabilities.
2. particularly, at any given point in time the current values of historically acquired assets may be quite different than the carrying value of those same assets – a great deal of which current information typically is not publicly disclosed – or for that matter known at any point in time by company Boards or Managements pursuant to either appraisal or analysis.
3. much of the detailed data and information required to complete meaningful DCF analysis frequently is not publicly available

Campbell summarizes this approach as being "typically is not adopted or relied on by Corporate Acquirers or their Advisers, other than perhaps as a litmus test in the context of attempting to determine whether the public markets are likely to assess an acquisition as accretive or negative to the Purchasing Company's share price"[11].

2.5. Comparable transactions approach

This commonly adopted methodology can result in the development of either enterprise value or equity value. Developing prospective stock market prices Securities Analysts commonly adopt this methodology by comparing prevailing stock market price metrics for the company they are analyzing to stock market prices prevailing for companies they believe to be "peer group" companies. Assuming proper selection of the 'peer group companies' and appropriate analysis and application of financial and stock price metrics this arguably is a sensible methodology for them to use in their analysis. However, it is a highly subjective methodology and hence each application of it should be reviewed carefully to ensure its application seems sensible. Because of special significance of this technique, I will focus more on this subject in next chapter of this paper.

[11] Ian Campbell, *The Valuation of Mining Companies – Post #12 of 17*, retrieved from [http://www.stockresearchportalblog.com/2008/10/the-valuation-of-mining-companies-%E2%80%93-post-12-of-17/]

3. Market comparables approach

Mining valuation may conveniently be divided into first the study of reserves or assets, and then more variable quantities or possibilities. While an attempt will be made to deal with former one, the latter will only be touched upon sufficiently to set out differences.

In this chapter I would like to deal with compared fundamental and market comparable approach. The thing is, that actually none of them can be discussed separately, what is pointed out by many authors, including Craig Roberts from National Bank Financial in his work. Market comparable approach largely is based upon fundamental data, which is fluently faded into market data and market approach.

Obviously, while many methods to estimate a mining business are available, the value itself is only established through a transaction. Comparable methods allow to benchmark the value of the mining company against different mining projects, which value have been established by the market. In this sense, comparable methods are key tool for ensuring, that the value estimates are congruent with the value, that market would actually pay. Robert Craig says, that market comparable and fundamental (e.g. NPV) approaches if project valuation is taken into account should not be viewed as alternative approaches, but rather as integrated, so as to derive a single value estimated from both market and fundamental data[12]. While fundamental approach estimates value directly from basic project information where values most usually come from calculation of NPV, in market comparable approaches market values for one or more mining projects are applied to project of interest in order to estimate its value. Craig further explains how market comparable approach works in case of mining project for simple, example data. If for instance the project of interest is a gold mining project, having estimated recoverable reserves of 1 million oz, and according to market data in comparable projects average value of reserve oz is worth 50 dollars, then value of interest project can be estimated on the level of 50 million dollars. In the same way, if a business from industrial minerals generates 5 million dollars cash flows annually, and from market data we know, that similar projects from similar sector are worth 5 times annual cash flow, then the value of estimated project will be 25 million dollars. To be utilized

[12] Craig Roberts, National Bank Financial, “The Valuation Of Advanced Mining Projects & Operating Mines:Market Comparable Approaches”, p. 1

in wider context, these values should be normalized, so we can compare them among different projects. To normalize, we express them as division by some fundamental project parameter, say annual cash flow or quantity of reserves. For parameters presented above, we get:

market value (USD) / recoverable reserves (OZ)

or

market value (USD) / annual cash flow (USD)

But saying, that market comparable approach totally differs from fundamental approach and does not take into consideration any of its output would be not true. Generally, investor can assume, that any market value is derivative of many factors. It can be assumed, that market values of the comparable projects take account of all fundamental project information, through investors basing investment decisions on fundamental approaches (net present value of cash flow) and other forms of analysis.

But for the example of gold project mentioned before, the only specific information about the project are reserves of mineable resource. Obviously, one ounce is not equal to another one, meaning that for instance cash cost per ounce may vary from low values in robust projects to higher values in marginal ones. Thus, the success of market comparable approach in valuing the project depends significantly on the question, if comparables (on average) have values per ounce "approximately equal to underlying value of the project being valued"[13].

3.1. Sources of market data

There are many sources from which data can be retrieved for market comparables approach. These include:

1. Value paid in a direct asset transaction
2. Value paid in a corporate acquisition transaction
3. Value implied in a merger transaction
4. Current trading value of a company

[13] Craig Roberts, National Bank Financial, "The Valuation Of Advanced Mining Projects & Operating Mines:Market Comparable Approaches", p. 3

3.1.1. Value paid in a direct asset transaction

The value paid in a direct asset transaction has the advantage that provides a direct measurement of project value, since there are no corporate considerations to impact value. Unfortunately for the valuator, most transactions are at the corporate level, particularly those for which value data is publicly disclosed. Also, as with all transaction data, it is applicable to a particular point in time, and is likely to have diminishedvalidity if market conditions have changed from the date of the transaction. Obviously, the more recent the data the better.

3.1.2. Value paid in a corporate acquisition transaction

The value paid in a corporate acquisition transaction can be almost equivalent to a direct asset transaction in the case of the acquisition of a junior company holding a single significant asset, where the dominant interest of the acquirer is this single asset. Thus more junior companies with fewer or ideally only one project may be better sources of comparable market value data for particular project types, but since these juniors may attract lower market values than more senior companies for a variety of reasons (lower liquidity, market capitalization, etc), market values derived from these companies may be less than the values the same projects would attract in the portfolios of senior companies, unless the market is anticipating an acquisition of the junior company.

For transactions involving the acquisition of larger mining companies, multiple projects may be involved, and these projects are likely to be diverse (e.g. in various geographic locations, open pit, underground, heap leach, milling, etc). While this diversity may limit the comparability to a particular project type, some senior companies, for example some of the large South African gold producers, may have less project diversity and may thus provide valuation data in aggregate that is still applicable to specific project types. For transactions involving larger companies, uncertainty in underlying project value is also more likely to arise because of the impact of corporate level considerations (management, financial structure, etc) on transaction value.

Again, transaction value data may have reduced validity because it is dated and does not fully represent current market conditions.

3.1.3. Value implied in a merger transaction

Often the line between an acquisition and a merger transaction is grey, and many of the comments above regarding project values derived from transaction values apply here as well. In merger transactions, corporate issues may play an even greater role in determining transaction value. Again, transaction date is an issue.

3.1.4. Current trading value of a company

Two key advantages of using the current trading value of a company are that:

1. market value estimates so derived represent current market value
2. the amount of data is greater, with all public mining companies being continually valued in the market through their share price.

Disadvantages include the fact that a current share price represents a marginal market value, which may differ significantly from the total value that would be realised in a full project transaction (by the transaction premium).

3.2. Estimating fundamental & market value

It is useful to start with reviewing how market and fundamental values of both mining projects and mining companies are measured or estimated. Table 1 represent distinction between fundamental and market value, and between project and corporate value:

	Fundamental value	**Market Value**
Project Value	Net Present Value (NPV)	Adjusted Market Capitalization or Enterprise Value or Asset Transaction Price
Corporate Value	Net Asset Value (NAV)	Market Capitalization or Corporate Transaction Price

source: Craig Roberts, The Valuation Of Advanced Mining Projects and Operating Mines: Market Comparable Approaches

The market value of a mining company's project (AMC - adjusted market capitalization) is estimated from the market value of the company that holds the project, or from corporate transaction value (merger or acquisition value), as follows:

	Market value of company (Market capitalization or corporate transaction value)
minus	Working capital
minus	Value of other investments
minus	Value of hedge book
plus	Liabilities
=	**Implied market value of mining project (AMC)**

based on: Craig Roberts, The Valuation Of Advanced Mining Projects and Operating Mines: Market Comparable Approaches

The underlying idea here is that market takes account of corporate items such as working capital, debts, book value, investments and other in process of making investment decision, so not only values of projects held by mining companies. Thus, what is done here is to adjust market value by value of other fundamental items in order to estimate the value attributed by the market to mining. I explicitly assumed, that the mining which value is about to be estimated is advanced operating project, not emerging one. In latter case, we shall also include cost of capital required to achieve production, that would be subtracted from calculated value. This approach however has very significant shortage – it does not take into consideration any of risk, associated with cost of capital – unless the capital risk has been removed, which will further cause a market willing to pay premium.

A mining company's net asset value is calculated from the estimated aggregate net present values of the company's projects, which is actually reversion of above calculations:

	Aggregate net present value of mining company's project
plus	Working capital
plus	Value of other investments
Plus	Value of hedge book
minus	Liabilities
=	**Net asset value of the company**

based on: Craig Roberts, The Valuation Of Advanced Mining Projects and Operating Mines: Market Comparable Approaches

By comparing the implied market value (AMC or EV) to the estimated fundamental value (NPV) of its project, a valuator can assess whether the estimated fundamental values are

above or below the values that would likely be realized in the market. Similarly, by comparing a company's market value (market capitalization) to its estimated fundamental value (NAV), an analyst can calculate the premium or discount the market is paying to a particular fundamental value (NAV) estimate.

Craig argues, that neither of fundamental or market approach should be used standalone, but rather they should be combined and used as 2 legs of analysis. He presents his clues on in following diagram:

Diagram: Hierarchical ordering of comparable market value ratios according to sequence of project net cash flow and NPV estimation

Comparable project parameter	Information about the comparable taken into account	Market valuation ratio of comparable project
Geological resource	Geological delineation	AMC / oz resource
Mineable reserve	Mining recovery, economics, other	AMC / oz reserve
Recoverable metal	Metallurgical recovery	AMC / recoverable oz
Payable metal	Pay factor, unit deductions	AMC / payable oz
Gross revenue	Metal prices	AMC / gross revenue
Net smelter return	Treatment, refining, transport, penalties	AMC / NSR or net revenue
Operating cash flow (= EBITDA)	Operating costs	AMC / operating cash flow or EBITDA
Cash flow after capital (= EBIT)	Capital (initial and sustaining)	AMC / EBIT
Net cash flow (= Earnings)	Interest and taxes	AMC / NCF or earnings
Net present value	Discounting	AMC / NPV

source: Craig Roberts, The Valuation Of Advanced Mining Projects and Operating Mines: Market Comparable Approaches

The first column represents a typical sequence of calculation of mining project's Net Cash Flow and Net Present Value. While moving down the table, increasing amount of project

information is taken into consideration, until the point in which the estimated NPV takes into account all quantifiable data that could possibly affect value. Each line in the cash flow calculation cumulatively incorporates all information in the previous lines. Looking at the corresponding market to fundamental valuation ratios in the right hand column, the ratios lower down in this table include all the information in the higher up (more primitive) ratios, plus information these more primitive ratios do not take into account. For example, an AMC / recoverable oz ratio includes all the information in an AMC / insitu oz ratio, plus additional project information relevant to project value (in this example, metallurgical recovery). These ratios thus become increasingly accurate measures of value as one moves through the sequence of cash flow and NPV calculation. At the bottom, the AMC / NPV ratio incorporates all relevant quantifiable information for each project comparable into a single market to fundamental value ratio for that comparable. If the market comparable approach is used as a stand-alone method, the higher up the market to fundamental value ratio is in this table, the less information is incorporated, and the greater the potential error. Valuing an advanced mining project or operating mine using a comparable method on contained metal ignores the impact of a host of known project specific information.

Thus for each comparable, we have an estimate of market value, of NPV, and of the market to fundamental value ratio. This ratio tells us what the market is willing to pay per dollar of NPV for each comparable project, based on a particular set of economic assumptions (metal prices, discount rate, inflation rate, interest rate, exchange rates, etc).

Roberts further propose an example to illustrate this concept. Let's have an example of a 1 million recoverable oz gold project, given that:

1. the valuator sets up a cash flow model, and based on certain gold price and discount rate assumptions, estimates a project value of $40 million.
2. using the same gold price and discount rate assumptions, the valuator estimates NPV's for each of the comparable projects. Market value (AMC) estimates for each of the comparables are also prepared, and the ratio of market to fundamental value (AMC / NPV) for each of the comparable projects is then estimated and averaged. Assume the average ratio is 1.67.

3. the valuator then applies this “market multiple” to the estimated NPV of the project being valued, resulting in a “market adjusted” value estimate of $67 million

There could be various reasons for the market valuation of the comparable projects being significantly higher than their estimated NPV’s, including that the market is assuming a higher gold price and/or a lower discount rate than the valuator. By applying the AMC / NPV multiple, the valuator is calibrating the measured value to the value the market is attributing to the comparables.

As an alternative to applying the AMC / NPV multiple, the valuator could determine a gold price / discount rate combination such that the estimated NPV’s of the comparables on average equal their estimated AMC’s. This higher gold price and/or lower discount rate could then be used to estimate a revised (higher) NPV for the project being valued. Of course, the number of gold price / discount rate combinations available to yield an average AMC / NPV for the comparables of 1.0 is infinite, and each combination would result in a different revised NPV estimate for the project being valued. Further, it is unlikely that a single gold price / discount rate combination would equalise AMC and NPV for each comparable project. Adjusting the gold price / discount rate assumptions is therefore not necessarily a more accurate method of adjustment than simply applying the estimated AMC / NPV ratio of the comparables to the estimated NPV of the project being valued.

The key point is that any significant difference between the estimated market and fundamental values of the comparables strongly implies that the estimated NPV of the project derived with the same economic assumptions should be adjusted to more accurately estimate the value the market would be willing to pay.

3.3. Selection of market comparables

The selection of closely comparable projects is key to ensuring that the basis for adjusting the estimated NPV of the project being valued (i.e. the estimated market to fundamental ratio of the comparables) is valid. At least two key areas need to be addressed in selecting comparables:

1. the comparability of the projects themselves

2. for comparable projects held within public companies, the impact of corporate level considerations on the estimated market value of the projects.

3.3.1. Project Comparability

Given NPV estimates for a variety of gold projects in a variety of locations, estimated using the same economic assumptions (metal prices, discount rates, etc), the market would not still pay the same or similar value per dollar of estimated NPV for all of these projects. The market may pay a premium for lower cost production, for a more stable political jurisdiction, for a producing asset versus a development asset, etc. I will present some of crucial factors, which may lead to significant differences in the value markets will pay per dollar of estimated project NPV.

Commodity or product

Products that produce marketed products, rather than commodities may attract a different premium or discount to NPV. It is for instance well know (but at the same time less well explainable) that gold projects attract a considerable premium to estimated NPV versus other projects. Generally speaking, comparable projects should produce the same commodities or products as the project being valued.

Location

A market premium or discount may be applied due to political stability and risk, economic stability, environmental sensitivity, etc. Studies of Deutsche Bank Securities indicate that at a 318 USD gold price and a 6% discount rate, senior North American gold producing companies were trading at an average 53% premium to NAV, versus 17% and 19% discounts for senior Australian and South African producers respectively. While these are company values, presumably the conclusion would be similar for the underlying projects. Note that these differences in market valuation may be due to differences in the location of the projects, to the domicile of the companies, or to the location of the markets in which companies are trading. Ideally, the comparables should have operations in proximate locations, have corporate offices in the same jurisdiction, and be valued in the same markets.

Date of the valuation data

If the valuation is based on a merger or acquisition transaction, the premium or discount to estimated fundamental value the market wants to pay is fluctuating over time, even if changes in metal of product price had been adjusted.

Cost of production / grade / margin

Projects with low cost production (high grade) may attract a market premium, it works vice versa.

Reserve size

Projects with larger reserves may attract a market premium. Therefore, it is preferable to have reserves of similar size, at a grade that will result in similar margins.

Capital cost / infrastructure requirements

Projects with lower relative capital costs, typically implying lower infrastructure costs, may attract a market premium, and vice versa.

Deposit type, mining method

The market may pay a premium for particular deposit types. For some time open pit bulk mineable gold deposits were favoured, more recently high grade underground projects are perhaps viewed more positively by the market. It is preferable that comparables have similar deposit types and mining methods.

Process method

Free milling projects, for example, may attract a premium versus refractory projects. Comparables with similar metallurgy and plant design are preferable.

It should also be recognized that in some cases, even the best available comparables may have features that differ significantly enough from the project being valued to make any conclusions drawn from comparable analysis of limited or questionable validity. In such cases, the valuation exercise is obviously more difficult, and the valuator will have to

recognize a greater degree of uncertainty in the derived value estimate. Valuator should include an assessment of the comparability of the projects selected in any valuation report.

The following matrix classifies mining projects according to their relative capital costs and operating margins. The comparables and the project being valued would ideally be similarly categorized.

Project categorization by capital cost and operating margin

	High margin	**Low margin**
Low capital	Low risk - Robust economics	High operational risk, typical of a restart
High capital	High capital risk - Good operational sustainability	Probably not economic

source: Craig Roberts, The Valuation Of Advanced Mining Projects and Operating Mines: Market Comparable Approaches

As illustrated by the above examples, there are many issues to consider in searching for valid comparables. All projects are in some ways unique, and thus there are generally no perfect comparables. A systematic consideration of issues such as those listed above will help to filter-out the best comparables.

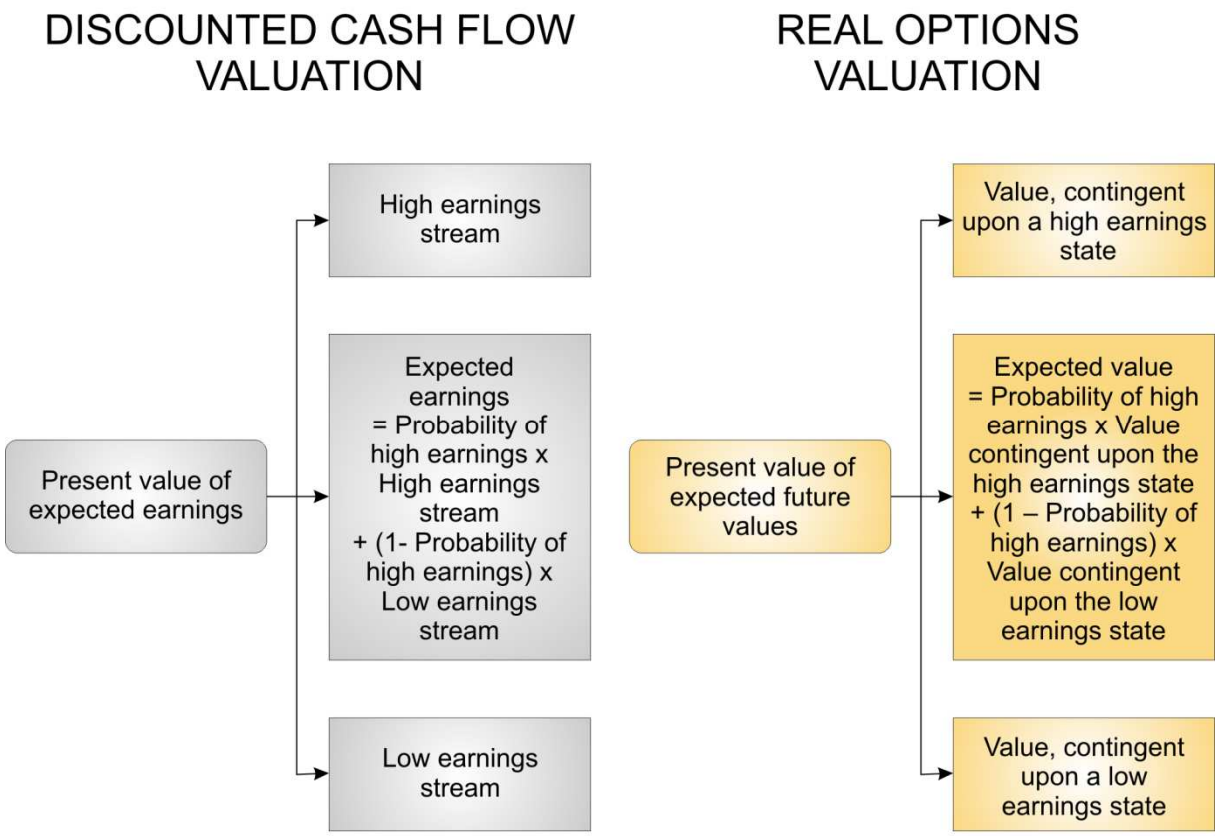
Market comparable approaches to valuation involve estimating the market value of selected comparable projects, relating this estimated market value to a reference fundamental project variable (e.g. ounces In reserve), and then applying this market to fundamental value ratio to the same reference variable of the project being valued. A project's fundamental data can be ordered hierarchically, however, according the how much information it incorporates, with the fundamental value estimate (e.g. NPV) cumulatively incorporating all quantifiable fundamental project information. The ratio of market (e.g. AMC) to fundamental value (e.g. NPV) is thus the most comprehensive value ratio to use, and allows the integration of fundamental and market value estimates into a single combined value

estimate. By estimating both market and fundamental values for the comparables, rather than only the market value of the comparables, the valuator is able assess how the market is really valuing projects relative to their estimated fundamental value. Using a fundamental (e.g. NPV) approach alone will not take account of available market information, and using a market comparable approach alone will not take account of all known specific information regarding the project being valued, except when benchmarked against fundamental value (NPV). In the end, fundamental methods estimate value, but value is established by markets. We therefore need to calibrate fundamental value estimates against values established in actual market transactions. Implementing market comparable analysis involves a number of challenges, for example in selecting valid comparables, and in estimating the market value of comparable projects from the companies that own those projects. Confidence in the project value estimate can be gained through a detailed and documented consideration of comparability, and the recognition of circumstances where comparables are of questionable validity.

4. Option pricing techniques

4.1. Principles

The standard valuation techniques (DCF – discounted cash flows) estimates value of company, basing on future expected cash flows, discounted at any appropriate rate. This approach is applicable in many ways, provided that the investment policy is independent of prices. In reality, management must respond to continuous fluctuations of commodity prices, therefore implementing alteration in investment policy.



based on: Hall Jason, Nicholls Shannon, "Valuation of mining projects using option pricing techniques" p. 2
graphics by Marcin Otorowski

For example, when prices are high production will go up, while if prices fall down the production will go down. As Hall and Nichols note[14], ability to exercise options to alter investment policy is appreciable, as 30% of value of high-growth volatility companies can be

[14] Hall Jason, Nicholls Shannon, "Valuation of mining projects using option pricing techniques" p. 1

attributed to the value of embedded options. This situation applies to case of mining business in Australia. Hall and Nichols further continue, that in foreseeable future option pricing approach is likely to replace Discounted Cash Flow as the standard valuation technique (even today, 30% of listed companies improve decision-making by option pricing approach)[15]. The growing evidence (both theoretical and empirical) is the evidence, that prices that market is willing to pay often exceed valuations deriving from DCF, and this difference can be attributed to option value. Thus, real option valuation of a company can be considered as the value, that includes management's options to change the scale of production in that project. From its assumptions, it will exceed the DCF of this company. The reason of difference is because DCF value is the present discounted value of future expected cash flows, while option techniques involve business value, associated with all possible cash flows. The illustration of the difference would be the model where earnings can continue as a perpetual stream of either high or low cash flows.

Practically, in corporate finance the standard DCF valuation approach is gradually being supported by tools of real options valuation. Hall, Nicholls mention, that the adoption is supported by "a substantial body of evidence which concludes that valuations which incorporate the value of embedded options are a better approximation of transaction prices than DCF valuations". In her work, Kelly (1998) applied a binomial option approach to the investment timing option, relying on data available from futures and spot markets. She further determined the value of the undeveloped gold mine and compared the value derived from the option model to the final offer price of the IPO. The result was, that traditional NPV investment rule would have the firm invest as soon as the price of gold exceeds the development and extraction costs. But in option approach it is not optimal to commence development unless the value of the commodity is high enough to cover both the cost of development and the cost of foreclosing the mine at a later date. Transaction prices approximated valuations which included the value of these embedded options.

Consideration of options valuation is especially crucially important for high-volatility mining sector. The volatility, associated with such things as commodity prices, exchange rates, costs and so on makes managements have to be able to change investments policies and plans in response to changes in these drivers. Hence, the value of the firms' abandonment option is

[15] Ibid

likely to be greater than average. Furthermore, the heightened volatility of revenue streams and margin growth means that their growth options also have above-average value, given that investment policy is expected to change in response to feedback regarding the firm's growth prospects.

Mining stocks almost always trade for more than the net asset value of their constituent mines, and for a good reason. There is a way to quantify the premium that one should pay for a mining stock to incorporate the leverage it has to the underlying commodity price. There is a formula called the Black-Scholes Model that can be used to calculate the "option" value of a mining stock. What should be done is to calculate the discounted net present value of the all the company's mines and then add the "option value" of the mines as calculated by the Black Sholes formula to obtain a more realistic asset value per share. By adding the optionality of mining shares to the net present value of the mines themselves we can account for the fact that mining shares trade at a premium to their net asset value because of their leverage to the underlying commodities.

If we calculate the net asset value of a mining stock as described above we will get a result that can be used to compare different mining companies to each other, and mining companies to investments in other sectors. Unfortunately, very few mining analysts employ the Black Sholes model to calculate mining net asset values, so for most people buying mining stocks really comes down to blind speculation on commodity prices[16].

4.2. Example use of option approach

I will present usefulness of option approach using fictional, simplified example, developed by Hall and Nichols. The first case is, that we value a coal mine, which incorporates two options. One of them is to abandon the project with no costs, but without realization of values of mine. The second one is to invest $200 million in an expansion which will increase production. The assumptions are as follows: A coal mining reports says, that last year revenues from production and sales of 6 million tons at 50 USD per ton were 300 million USD, fixed operating costs were 130 million USD, variable operating costs 22 USD per ton. We assume, that these costs include depreciation, and expenditures for maintenance capital is equal to depreciation. For this example we consider, that mine can be abandoned at any

[16] Paul van Eeden "How to value a mining stock"

time, for any time and for zero price (which is not true in real world, as we should take into account annual maintenance costs, cost of abandoning, cost of restarting and so on). The project itself could be considered as advanced, steady-state. The mine has reserves of 60 million tons, which will be enough for 10 years of life if mining continues at its present rate. The corporate tax rate is 30 percent. If production is expanded to ten million tons per year, additional fixed costs will be $30 million per year. The only risk factor considered in this example would be uncertainty over coal price movement, which was reasonably assumed to be positively associated with overall economic growth. This is both a risk to the viability of the mine, but also a source of value, given that management can alter investment policy in response to information about coal prices. Further, suppose that coal prices can increase by 13 percent in any given year, or decrease by 11 percent provided that coal prices cannot fall below $30 per ton, or rise above $100 per ton. Potential coal price movements of this type are consistent with the distribution of export coal prices reported by ABARE for the most recent 30-year period. For each of these potential future coal prices, there is an associated Free Cash Flow to the Firm, computed as:

FCFF = (Price – Variable Costs) x tones – Fixed Costs x (1 – tax rate)

Distribution of potential coal price movements and associated cash flows is presented on below tables:

Constrained price

0	1	2	3	4	5	6	7	8	9	10
50.00	56.37	63.56	71.67	80.80	91.11	100.00	100.00	100.00	100.00	100.00
	44.35	50.00	56.37	63.56	71.67	80.80	91.11	100.00	100.00	100.00
		39.33	44.35	50.00	56.37	63.56	71.67	80.80	91.11	100.00
			34.88	39.33	44.35	50.00	56.37	63.56	71.67	80.80
				30.94	34.88	39.33	44.35	50.00	56.37	63.56
					30.00	30.94	34.88	39.33	44.35	50.00
						30.00	30.00	30.94	34.88	39.33
						30.00	30.00	30.00	30.94	30.94
							30.00	30.00	30.00	30.00
								30.00	30.00	30.00
									30.00	30.00
										30.00

Expected price

$50.00	**$50.54**	**$51.12**	**$51.75**	**$52.44**	**$53.35**	**$54.15**	**$55.23**	**$56.18**	**$57.42**	**$58.53**

Free cash flow to the firm

0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
27	53	84	118	156	199	237	237	237	237	237
	3	27	53	84	118	156	199	237	237	237
		-18	3	27	53	84	118	156	199	237
			-37	-18	3	27	53	84	118	156
				-53	-37	-18	3	27	53	84
					-57	-53	-37	-18	3	27
						-57	-57	-53	-37	-18
							-57	-57	-57	-53
								-57	-57	-57
									-57	-57
										-57

Expected Free Cash Flow To The Firm

$28.86	**$31.31**	**$33.97**	**$36.85**	**$40.66**	**$44.03**	**$48.58**	**$52.55**	**$57.76**	**$62.43**

source: Ibid

If we now perform discounting according to DCF formula:

$$DCF = \sum_{t=1}^{n} \frac{FCFF_t}{(1+r)^t}$$

Where r is the risk-adjusted cost of capital. We have sufficient information about inputs (see the table below) to perform a DCF valuation, given any specific discount rate (say 15%). Discounting these expected cash flows at 15 percent implies a DCF valuation of 199 million USD.

This is (purposely chosen) a risky project, as two consecutive falls in coal prices will result in negative cash flows. If changes in prices are essentially driven by changes in the economic environment, we apparently have a project, in which the degree of systematic risk is high. This allow to run options model here, because only in the absence of any volatility of potential cash flows, options to expand or abandon would be worthless. If we consider lower right hand part of diagram, we can clearly see that the firm incurs a series of negative cash flows. Clearly, at some point it will be optimal to abandon the project, rather than continue performing and incurring these negative cash flows. If prices are sufficiently low and we don't have any reasonable prospect of recovery in future (meaning, that negative cash flow

in one year does not mean we have to abandon, it's rather a series of negative cash flows) the project should be abandoned. The value created is in the avoidance of negative CF.

The remaining question is, how can we determine the optimal point at which to abandon, having in mind, that one negative ash flow does not automatically exercise abandonment option? First, we work out the value of the project at the end of its life for each possible coal price. If that value is negative, it seems rational to abandon before we incur that negative cash flow. Second, we work out the value of the project in the second-last year, for each possible coal price, given the information about our optimal strategy in the last year. At each node of the valuation tree in year 9, we ask the question, "Is the project worth more to us if we keep operating, or we abandon today?" This requires us to compare two valuations at each node:

1. the value of maintaining production, which is the sum of the discounted expected value at the end of year 10 plus the cash flow received in year 9
2. the value of ceasing production, which we have assumed to be zero in each case.

Diagram 3 shows these potential alternatives. Consider the five situations in which the final year cash flow is negative, ranging from negative $18 million to negative $57 million. The project would be abandoned in those instances because the revenue stream would be insufficient to cover operating costs. Now consider the series of DCF valuations immediately to the left of this final column. In year 9, if the coal price is at an intermediate level of, say, $56.37 per ton, the project is worth $104 million, the sum of $53 million received in year 9, plus the value attributed to the project's potential values next year of $84 million or $27 million. Expressed as an equation, we write:

$$V_{9;56.37} = FCFF_9 + Discounted\ expected\ value\ in\ year\ 10$$
$$= FCFF_9 + \frac{p * V_{10;63.56} + (1-p) * V_{10;50.00}}{1 + r_f} = 53 + \frac{0.47 * 84 + 0.53 * 27}{1.06}$$
$$= 104\ [million\ USD]$$

where:

- $V_{9;56.37}$ - value in year 9 in the case where coal price is 56.37 USD per ton
- $V_{10;63.56}$ - value in year 10 in the case where coal price rises to 63.56 USD per ton

- $V_{10;50.00}$ - value in year 10 in the case where coal price falls to 50.00 USD per ton
- r_f - the risk-free rate of interest

Discounted Cash Flow Valuation

0	1	2	3	4	5	6	7	8	9	10
199	414	594	757	888	967	963	850	670	460	237
	31	193	350	491	606	681	699	632	460	237
		-116	23	158	278	373	431	440	382	237
			-216	-100	16	119	196	237	229	156
				-270	-177	-78	10	75	104	84
					-277	-211	-130	-52	6	27
						-252	-200	-140	-72	-18
							-210	-162	-110	-53
								-163	-112	-57
									-112	-57
										-57

Real option valuation

0	1	2	3	4	5	6	7	8	9	10
252	437	603	759	888	967	963	850	670	460	237
	117	233	365	496	607	681	699	632	460	237
		21	89	184	286	374	431	440	382	237
			0	9	62	134	198	237	229	156
				0	0	0	38	80	104	84
					0	0	0	0	15	27
						0	0	0	0	0
							0	0	0	0
								0	0	0
									0	0
										0

source: Ibid

This diagram shows, that the project would be abandoned in the case where coal price falls to $34.88 in year 3. In real-world terms, there is an 11 percent chance of this occurring and there is around a 40 percent chance that the project will be abandoned at some point within the ten-year forecast horizon. Overall, the real options valuation of the project is $252 million, implying that the option to abandon was worth one-fifth of total project value, when we compare the difference between real options valuation with the DCF valuation. This desegregation is fairly typical of what we observe in the listed equity market. Now consider

the case in which we have the option to expand production to ten million tons per year. This allows us to mine at a faster rate so we receive cash flows sooner. But it comes at an investment cost of 250 million USD, requires an additional 30 million USD per year of fixed costs, and reduces the mine life. This is a negative-NPV project. The DCF of the mine excluding the option to expand was $199 million. Including the option to expand, the DCF valuation of the mine falls to $164 million. However, say we decide to exercise the expansion option only in response to coal price rises. Consider the case where we exercise the option at the end of year 5, which gives us three years of remaining mine life at production of ten million tons per year, rather than 5 years at production of 6 million tons per year. If coal prices are at the highest possible level in our scenarios, exercise of this option is valuable. Project value increases to 1013 million USD at the upper-most node of year 5, from its prior level of $967 million. This means that, conditional upon the coal price having five consecutive increases, it is worthwhile proceeding with the expansion, and the incremental value is $46 million. In all other cases, the expansion does not generate additional value, primarily because we are simply mining the remaining 30 million tons at a faster rate, rather than expanding production in perpetuity. The total project value, which includes both the expansion and abandonment options is now 253 million USD, relative to its DCF valuation of 199 million USD, as shown in Exhibit 4.

Discounted cash flow and real options valuations including the option to expand in year 5

0	1	2	3	4	5	6	7	8	9	10
253 ←	439 ←	607 ←	768	908	1013	1165	843	434	Expansion option exercised – out of reserves	
						845	714	434		
							458	300		
								84		
	117 ←	233 ←	365	496	607	681	699	632	460	237
		21 ←	89	184	286	374	431	440	382	237
			0	9	62	134	198	237	229	156
				0	0	0	38	80	104	84
					0	0	0	0	15	27
						0	0	0	0	0
Abandonment option exercised - negative values not incurred							0	0	0	0
								0	0	0
									0	0
										0

source: Ibid

The option pricing techniques presented lend themselves to use in a number of related contexts – most obviously, to corporations considering when, whether, and how, to develop a given resource; to financial analysts concerned with the valuation of such corporations; and to policymakers concerned with the social costs of layoffs in cyclical industries and with policies to avert them. The techniques are well suited to analysis of the effects of alternative taxation, royalty and subsidy policies on investment, and employment in the mining sector. Ultimately, real options is one of the most important corporate finance decision-making tools to have been introduced in the last 30 or 40 years. It captures the present value of flexibility of managerial decisions at a future date in response to the arrival of new information. Traditional NPV methodology implicitly assumes precommitment – that is, no flexibility. Yet most applications of real options are more realistic and therefore more complicated models of reality.

5. Movements to standardize mineral asset valuation

As attaching the price value to a mining business is seriously complicated (far more than in case of more traditional business) valuations of mineral properties are often overstated or unacceptably variable depending on the methodology or bias of the valuator.

To help address this lack of consistency and introduce some transparency, a movement to standardize the valuation process has arose. There are some jurisdictions developed or revamped own national standards. However, on a much larger and more ambitious scale, several representatives of different countries, including Australia, Canada, South Africa and USA have formed a task to establish some idiosyncratic international code, which can be used by companies regardless of place of their properties. CIMVal in Canada and VALMIN in Australia are examples of such valuation codes. Similar concept is about to work in Poland, there is a movement that drive polish code POLVAL - Mineral Asset Valuation Code[17]. One can hope, it will become a binding standard in valuing mineral asset in Poland.

[17] Kicki Jerzy, Saługa Piotr, "O potrzebie standaryzacji i opracowania polskiego Kodeksu Wyceny Złóż Kopalin" in "Gospodarka surowcami mineralnymi" issue 2008/24 (2/4) p.38

6. Conclusions

Given almost any business, we can use and develop specific (more or less sophisticated) to value it. Valuing mining business gives more challengers to its valuator because of its idiosyncratic features and characteristics. Mining is – no matter how good performance is now – a finite business, meaning it will stop to produce in specific period of time due to no resource to mine. This is completely different as opposed to situation of let's say traditional manufacturer, who could adapt to new demands and trends, and stay in business successfully for many years. Mining assets are controlled by governments, mining itself are capital intensive, finite, their earn return by liquidating assets. Furthermore, they are susceptible to market risks, and one more feature to describe them is transparency of COs and GOVs.

Many figures that are commonly used in case of traditional business do not work effectively in case of mining, just because of those specific features of mining business. For instance, a ratio like P/E is used under background assumption, that considered business will be continuing and performing in similar way for long period of time, generating theoretically earnings and cash flows are for all intents and purposes infinite, which of course is not fulfilled in case of mining project.

It seems, that the very reasonable way to value a mining business is to look at its NPV (Net Present Value) of discounted future cash flow. Discount rate has to represent the geological, political, social and financial risks. But looking at cash flows is not sufficient. Paul van Eeden (2007) says, that we have to take into account not only generated cash flows, but also sustaining costs of capital, like future exploration and development costs, which are necessary for a mine to operate and keeping its production of sufficient and expected level . Given that any suitable cash flow model can be derived for a mine, a simple net present value of future cash flows can be calculated. Sum of all net present values and assets from the balance sheet corrected by any debt from there will give net asset value per share if divided by number of shares.

As it has been observed, mining stocks almost always trade for more than the net asset value of their constituent mines. The difference could be explained from existence of

premium risk. The way to quantify and discount premium is known as Black-Scholes Model (Black-Scholes formula). Its general use makes the formula very universal - it is applicable not only to mining case. The model itself can help obtain more realistic asset value per share of mining business, basing on option pricing techniques. What should be done is to calculate the discounted net present value of the all the company's mines and then add the premium option value obtained from the Black-Sholes model. By adding the option value to NPV we can account for the fact that mining shares trade at a premium to their net asset value just because of leverage to the underlying commodities. Option pricing techniques are very smart, and it seems that in next couple of years they will be widely used in valuing mining business.

But I also discussed the fact, that the value itself is creating on the market. Thus, in chapter 4 I presented range of issues and frameworks concerning market comparable approach, which is slightly more complicated in case of mine as one could expect from another sector business.

Nowadays, there are some movements to standardize process of valuing underlying mineral asset. In last chapter I mentioned some of codes from foreign countries (Australian VALMIN, Canadian CIMVAL) and also Polish code – POLVAL.

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