WA School of Mines: Minerals, Energy and Chemical Engineering

A Market Risk Premium Problem: How should gold properties be valued on the Australian Securities Exchange?

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Declaration

To the best of my knowledge and belief, this thesis contains no material previously published by any other person except where due acknowledgement has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

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1 Introduction

Valuations of gold mining projects are dependent upon a number of uncertain factors, many of which are subjective in nature. When a company is listed on the Australian Securities Exchange (ASX), public announcements by that company must be made in accordance with the Australian Securities and Investments Commission Act 2001 (Commonwealth), the Corporations Act 2001 (Commonwealth) (Corporations Act), the ASX listing rules, and relevant professional and industry standards. For mining and exploration reporting in Australia, the industry standard is the Australasian Code for Public Reporting of Technical Assessments and Valuations of Mineral Assets (VALMIN 2015), which incorporates the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (JORC 2012). Furthermore, the Australian Securities & Investments Commission (ASIC) provides independent regulatory guidance to Australian corporations and regularly publishes compliance guidance notes for use by mineral asset valuation practitioners (defined as an Expert in the Corporations Act).

Figure 1-1 presents a schematic representation of the regulatory framework applicable to the Market Valuation of mineral assets where the project owners are listed on the ASX.

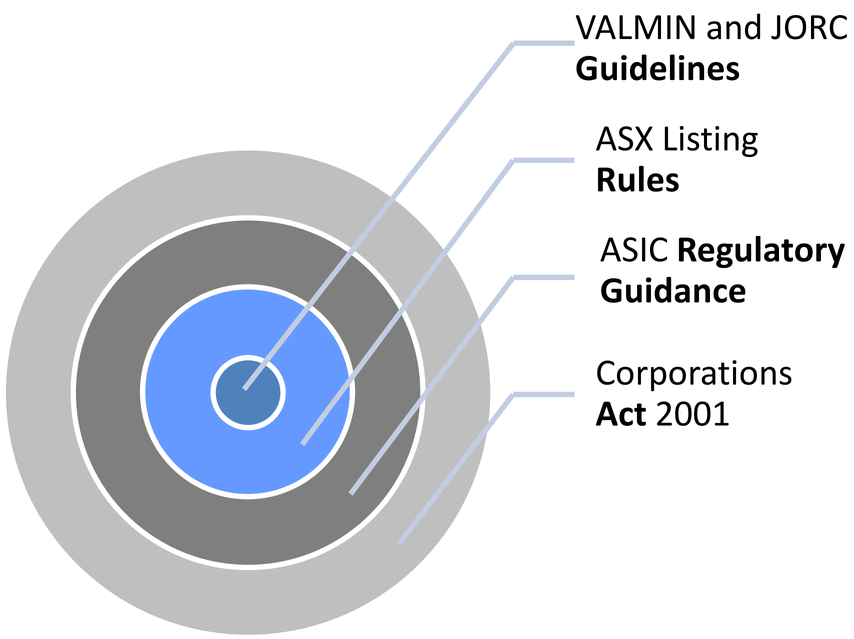


Figure 1-1: The Australian regulatory framework applicable to the research

Specifically, VALMIN (2015) is ‘designed to fit within the Australian regulatory framework comprising the Corporations Act, and various ASIC Regulatory Guidelines and ASX Listing Rules’, and is ‘considered to be broadly consistent in terms of fundamental principles and general approach with relevant international codes, templates, standards and guidelines’. Clause 8.7 of VALMIN (2015) explicitly relates to the market premium or discount, ‘When a premium or discount is used in determining a Market Value, a practitioner must state how these have been taken into account.’ This grants VALMIN (2015) practitioners (Practitioners) the liberty to apply a discretionary market discount or premium to their fundamental valuation based on their perception of the market risk profile at the valuation date. While fundamentally this appears sound, the notion that Practitioners adequately administer this discretion is subjective. The choice of the contributing factors and the quantification and application of those factors is entirely made through discretionary judgement.

Valuations of gold mining projects are very sensitive to metal prices, exchange and discount rates. Industry guidelines as to how to estimate such parameters are currently vague or non-existent. As a consequence, project proponents are relatively free to determine the assumptions to be used in valuing their projects in an unsystematic and at times arbitrary way. This makes it difficult to make realistic comparisons of the value drivers of different projects very unreliable. Realism in project value comparisons is further eroded by evidence that project owners do not adequately price individual risk factors, particularly country risk, in setting the discount rate for each project. There is a clear need for formulating more consistent and systematic evaluation methodologies and industry guidelines to address these critical issues (Guj and Nakamura 2011).

This chapter presents an overview of the research concepts and conceptions on value and market value. Additionally, the research questions addressed in this research are introduced, and an outline of the contributing chapters is provided.

1.1 Motivation

A deeper understanding by investors of the relationship between the fundamental gold project value and the realised market value of these projects on the ASX is needed. Existing asset pricing models such as the Capital Asset Pricing Model (Sharpe 1964, Lintner 1965, Mossin 1966) and the Arbitrage Pricing Theory (Ross 1976) use quantitative inputs and are largely focussed on capital markets theory and the efficient-market hypothesis. Under the efficient-market hypothesis market prices fully reflect all the available information under the assumption that human beings (or at least a statistically significant majority of them) are rational in their decision making (Fama 1970). Such models work on the inference of portfolio diversification where the value of assets can easily be decomposed into a systematic (market) component and an unsystematic (idiosyncratic) component. The unsystematic component can diversified away in a limitless market using the law of large numbers. Such models are not suited to the market valuation of single-asset portfolio's where the unsystematic component cannot be diversified away. Simin (2008) notes the low-forecasting performance of asset returns using these traditional frameworks.

Applied models and concepts are based on the use and application of empirical research together with legislation, industry standards and heuristics. These applied models use both quantitative and qualitative inputs based on valuer judgement and industry forecasting (Lawrence 2001). Efforts to outline practical market-based valuation approaches on mineral properties have not been daring enough to attempt to resolve the investment decision making quandary of valuation as they recognise the limitations of the many and varied methodologies employed. Moreover, such efforts have been limited in their endeavours to include comment on behavioural finance which focuses on the drivers behind investment decisions including information availability and emotion and sets out to disprove the traditional assumptions under capital market theory and the efficient-market hypothesis. Indeed, Davis (2003) notes that in mineral asset valuation it is presumed that project owners are, 'informed and rational, and are not subject to emotional or irrational behaviour'. There is a lack of empirical work that assesses the behavioural aspects of gold project valuation and how these behavioural aspects contribute to realised gold project transaction value.

There is no existing academic literature or practical framework model which addresses the pricing of market factors for single-project transactions on the ASX. The Australian regulatory framework calls for market valuations to include consideration of market factors but does not prescribe what the market is, what the factors are or how the risk attributable to these market factors should be quantified with respect to project valuation. The existing research does not address this problem, leaving marketeers with little guidance on how market factors contribute to realised project transaction values on precise valuation dates. Further, the complimentary roles that traditional capital markets theories and behavioural economics have within gold project valuation praxis has not been addressed in the academic literature.

As such, research is required to identify and quantify the relevant market factors which are not identified for single-asset portfolios using traditional models such as the CAPM or APT, and research is required to assess the role that behavioural economics contribute to realised gold project transaction value. Further, research is required to triangulate the traditional theory with behavioural economics to provide pragmatic guidance for use in research and industry practice through the development of a valuation framework.

1.2 Research outline

The identification and quantification of the market factors relating to Project value is challenging. In research, as well as in practice, many methodologies for the estimation of market risk exist, with notable areas of overlap and knowledge gaps. A definitive framework does not exist. Consequently, there are many estimation concepts and conceptions that have distinct advantages and disadvantages. This leads to the first question that this thesis will address.

Research Question 1: Are there identifiable market factors associated with gold project transactions on the ASX and how are these factors related? The first part of the question requires a review, synopsis and classification of related valuation practice research, including a review of the existing methods used to estimate market factors. The review will assess the character of the knowledge gaps that encumber clarity on estimation methodologies, leading to obvious disparity between the expected and realised market price for an asset, as well as the associated premia. The second part of the question calls for the analysis and assessment of relevant historical market index data and market transaction information to identify the contributing factors, and leads to the second research question to be addressed in this thesis.

Research Question 2: Can an inclusive valuation framework be created from historical transaction data using the identified market factors for gold projects on the ASX? The guidelines for the development of a suitable framework must be established, identifying what the principal components are, and how the factorial relationships should be integrated? The framework (Framework) must be suitable for use by both industry practitioners and marketeers as a tool for forecasting transaction value. Further, the Framework must present a practical and transparent methodology developed within the context of the existing legislation and regulatory controls governing ASX-listed companies that hold gold projects. The use of the Framework should allow Practitioners and marketeers to effectively quantify the market factors (the market component) relating to the valuation of gold projects at the asset level. Additionally, it should temper the storytelling power of mining executives and provide a foundation for discussion on the development of further regulatory guidance.

1.3 Overview and structure

To answer the research questions described in the preceding section, this thesis is structured as follows. The introductory chapter describes the context and rationale for undertaking this research further develops the research questions, presents an overview of the mixed-method approach being used, and provides a layout of the subsequent chapters. The second chapter provides a review of the relevant literature associated with market valuation, including its behavioural aspects. From this review, the most important theoretical and empirical works relating to the mineral resources sector are discussed, with specific reference to gold projects. The literature is classified and critiqued for its suitability to practical application, identifying a number of knowledge gaps, and providing the focus for the research methodology and experimental design.

The third chapter describes the quantitative component of the research study starting with an explanation of the methodology and description of the raw data and analytical techniques to be used. It then describes the formation of both the Dummy and Training Portfolios that will be used in the analysis, as well as the analytical techniques applied to identify the factorial relationships and residual research gaps. The fourth chapter presents the qualitative component of the research which addresses the residual research gaps identified in chapter three, starting with an explanation of the methodology and description of the raw data and analytical techniques to be used. It also describes the analytical techniques applied to identify additional factorial relationships using a quantitative analysis of the qualitative data. The fifth chapter triangulates the results of the quantitative study with the results of the qualitative study in accordance with the principles of a mixed-method sequential explanatory research design and describes the construction of a suitable valuation framework. The sixth and final chapter reviews the merits and limitations of the research and provides suggestions for future research opportunities. An overview of the thesis structure is presented in Figure 1-2.

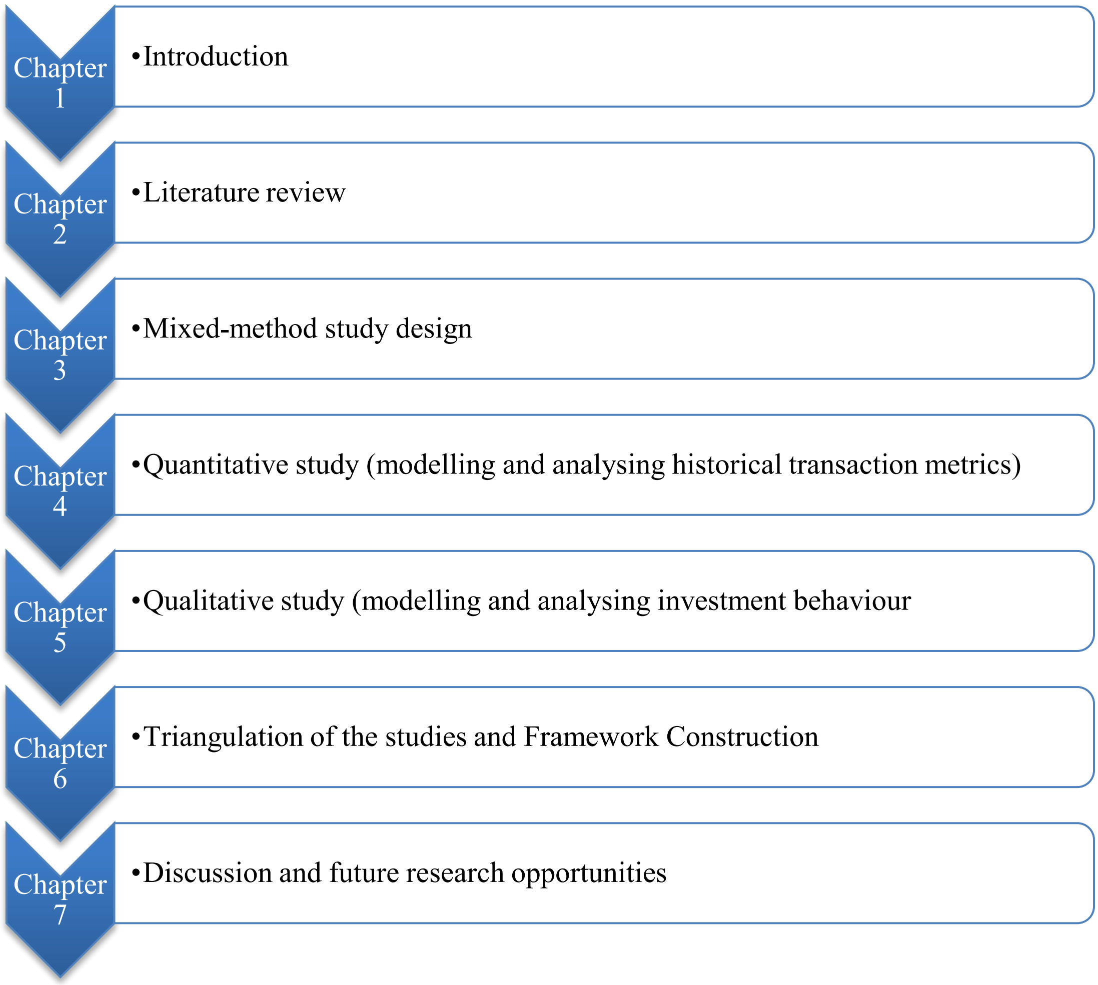


Figure 1-2: Thesis Chapters

1.4 Clarification of terminology

In order to minimise the ambiguity around commonly used lexes that have different contextual meanings, Table 1-1 defines the research terminology and presents a short description of each technical term as used and applied throughout this thesis.

Table 1-1: Glossary of terms and definitions

Term	Definition
Arm's length basis	Describes a transaction where the Project or Property buyer and the Project or Property seller act independently and have no relationship with each other.
Asset Valuation	The process undertaken to determine the value of a Project
ASX	Australian Securities Exchange
Equity Risk Premium	The difference (delta) between the expected return on equity in a stock and the risk-free rate.
Expert	A person whose profession or reputation gives authority to a statement made by him or her in relation to that matter. (*Corporations Act* s9, 2001)
Fundamental Value	An assessment of the future net economic benefit from a mineral asset or project under a set of appropriate assumptions, excluding any premium or discount for market or strategic considerations.

Term	Definition
	Also known as Technical Value.
Gold	Gold metal
Investment Value	‘The value of an asset to the owner or a prospective owner for individual investment or operational objectives’ (IVSC)
IVSC	International Valuation Standards Council
JORC	Joint Ore Reserves Committee
JORC (2012)	The Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves, 2012 Edition.
Market or Market Place	The Australian Securities Exchange (ASX) and its associated stock-indices where buyers and sellers are individuals or companies who exchange shares in gold projects, thus setting their value.
Marketeer	A person or entity which participates in transactions.
Market Risk Premium	The difference (delta) between the expected return on a market portfolio and the risk-free rate,
Market Value	‘The price that would be negotiated in an open and unrestricted market between a knowledgeable, willing but not anxious buyer and a knowledgeable, willing but not anxious seller acting at arm's length for a Mineral Asset’. (VALMIN, 2015)
Mineral Asset	See Project.
Practitioner	‘An Expert who prepares a Public Report on a Technical Assessment or Valuation Report for Mineral Assets or Securities’ (*Corporations Act* (s9 2001)).
Price	See Transaction Price.
Project, Property, Asset or Mineral Asset	Projects or properties in Western Australia (WA) containing potentially economic gold where the Project or Property seller and buyer are listed on the ASX.
Project Seller	Companies that own listed WA gold projects
Project Buyer	Companies that buy listed WA gold projects
Project Transactions	The instance of buying or selling a Project, Property or Asset on the Market.
Technical Value	See Fundamental Value.
Transaction Price	The agreed price paid for a Project or Property.
The VALMIN Committee	‘A joint committee of The Australasian Institute of Mining and Metallurgy, the Australian Institute of Geoscientists and the Mineral Industry Consultants Association with the participation of the Australian Securities & Investment Commission, the Australian Securities Exchange Limited, the Minerals Council of Australia, the Petroleum Exploration Society of Australia, the Securities Association of Australia and representatives from the Australian finance sector’ (VALMIN, 2015)
VALMIN (2015)	Australasian Code for Public Reporting of Technical Assessments and Valuations of Mineral Assets, 2015 Edition.
Valuer	Individuals or companies associated with the market that undertake gold project / property valuations.

2 Literature Review

Two broad modalities of valuation, with notable overlap, were identified in the literature review that are relevant to this research:

1) Financial asset pricing models that typically use quantitative inputs and are based around capital markets theory and the efficient-market hypothesis, and
2) applied models and concepts that are based on the use and application of empirical research together with legislation, industry standards, heuristics and behaviours. These applied models use both quantitative and qualitative inputs based on valuer judgement and industry forecasting (Lawrence 2001).

The purpose of the literature review is not to critique the applicability of existing valuation methodologies or capital markets theory; such critiques are plentiful. Rather, this review highlights the lack of transparency during the calculation of both the technical (intrinsic) and market-related factors in mineral asset valuation, as outlined in equation E2-1.

$$\text{Market Value (MV)} = \text{Intrinsic Value (IV)} + \text{Market-Related Factors (MC)} \quad \textbf{(E2-1)}$$

where:

MV	=	'the price that would be negotiated in an open and unrestricted market between a knowledgeable, willing but not anxious buyer and a knowledgeable, willing but not anxious seller acting at arm's length' (VALMIN, 2015).
IV	=	the underlying (intrinsic or technical) value. It is an assessment of the future net economic benefit from the mineral asset, excluding any market component
MC	=	The Market Component. It can be positive (a premium), negative (a discount) or nil.

2.1 Capital Asset Pricing Model

Much of the theoretical and empirical work on modern valuation theory has been developed in the tradition of the single-factor (single beta) Capital Asset Pricing Model (CAPM). The CAPM was first published by several independent authors during the 1960s (Sharpe 1964, Lintner 1965), Mossin (1966) The CAPM and its variants rely on the premise that investors demand a premium on their return on investment for holding perceived risky securities in their portfolio (in the spirit of the Modern Portfolio Theory introduced by Markowitz (1952)). The model suggests that the expected returns on individual securities are related to a measure of their unsystematic or 'diversifiable' risk within a well-balanced portfolio (the diversification / balance essentially normalises the securities' risk within the portfolio), and systematic or 'non-diversifiable' risk that is caused by factors such as inflation, recessions, and changing interest rates (Ehrhardt and Brigham (2010)).

The basic assertions made by the CAPM are:

1) Investors are risk averse and look to maximise their wealth.
2) Investors make their forecasts at the beginning of a defined investment period
3) Only two parameters position the portfolio: risk and expected return (as represented by the variance of the expected return).
4) Assets in the investment portfolio are perfectly divisible and there are no taxes or transaction costs.
5) The market is atomistic, all investors have the same opportunities, there are no entry or investment barriers, all securities are negotiable, and all information readily available for all investors.
6) Unlimited loans at a risk-free rate of interest are available to each investor.
7) Every investor is homogeneous, therefore, they each have the same perception concerning expected return.

Simplistically, the CAPM is represented in equation E2-2.

$$R_i = R_f + \beta_i (R_m - R_f)$$

(E2-2)

where:

R_i	=	expected rate of return on equity or cost of equity (security).
R_f	=	risk-free rate of return which is arguably the long term (10-year) government bond rate (Schwartz and Trigeorgis (2004).
β_i	=	asset beta (volatility of asset return compared to the expected market rate of return of asset (covariance divided by the variance).
R_m	=	expected market rate of return (typically benchmarked against a 'suitable' index).
$R_m - R_f$	=	market risk premium.

In his review of the CAPM, Don (2007) notes the widely accepted theory that systematic risk exposure (asset beta) can be used as one measure of market risk as it cannot be eliminated through any kind of diversification in the portfolio (as would be true for unsystematic (idiosyncratic) risk using the law of large numbers in a limitless market). The amount of compensation Beta combined with the equity risk premium indicates the amount of compensation investors require for taking on the additional risk by taking equity. Where $\beta = 1$, and the excess return on the market is 5%, the required return would be the risk-free rate of return plus 5%. The Equations given in E2-3 solve the CAPM for beta.

$$\beta_i = (R_i - R_f) / (R_m - R_f)$$

(E2-3a)

and

$$\beta_i = \frac{\sigma_{im}}{\sigma_m^2}$$

(E2-3b)

where:

σ_{im}	=	covariance of the market portfolio and the asset returns
σ_m^2	=	market portfolio variance

Under the Efficient Markets Hypothesis (EMH), which was first stated by Roberts (1967) but widely attributed to Fama (1970), the price of a stock (security) at any time is a good estimate of its intrinsic value in an efficient market. An efficient portfolio modelled using the CAPM can be represented visually using the Security Market Line (SML). The SML plots the expected return of a stock for any given beta coefficient, so that the gradient of the SML is equal to the market risk premium (Figure 2-1).

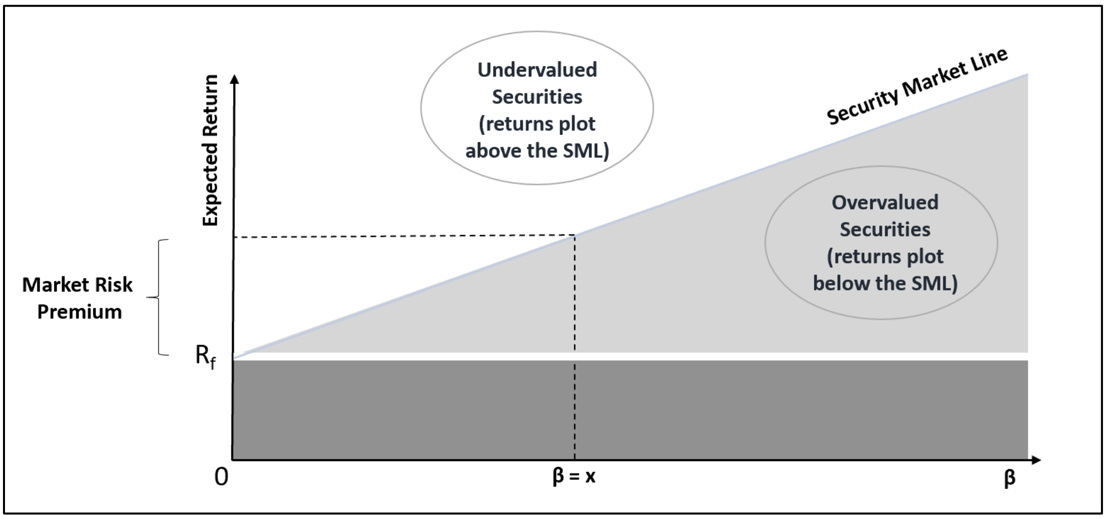


Figure 2-1: The Security Market Line

Jensen's alpha (Jensen 1968) is an objective measure of a securities' market performance. Jensen states that a constrained regression of beta using the CAPM allows the systematic risk to be estimated using the SML for any security.

> "However, we must be very careful when applying the equation to managed portfolios. If the manager is a superior forecaster (perhaps because of special knowledge not available to others) he will tend to systematically select securities which realize a [regression error term (e_i) of greater than zero] ($e_i > 0$). Hence his portfolio will earn more than the 'normal' risk premium for its level of risk." (Jensen (1968)).

Jensen suggests that by removing constraints on the CAPM so that it does not pass through zero an allowance for this forecasting ability is made, i.e. he introduces a non-zero constant alpha, as in E2-4:

$$\alpha_i = R_a - (R_f + \beta_i (R_m - R_f)) \tag{E2-4}$$

where:

α_i	=	Jensen's alpha
R_a	=	actual rate of return
R_f	=	risk-free rate of return
β_i	=	asset beta
$R_m - R_f$	=	market risk premium

Excess returns (outperformance), relative to the market return, plot above the SML and these securities are said to be undervalued (positive Jensen's alpha). Lower returns (underperformance), relative to the market return, plot below the SML and these securities are said to be overvalued (negative Jensen's alpha). For example, an alpha of 1.0 suggests outperformance by 1% and an alpha of -1.0 means underperformance by 1%. The obvious subjectivity arising from the use of a securities' beta to quantify market risk relates to the choice of market and use of a suitable index against which the asset should be compared. Assets may or may not sit within a portfolio of similar assets and the return on those similar assets may or may not be easily comparable to the market returns on a known index (For example, the returns of a company holding gold project assets could be benchmarked against the All Ordinaries Gold Index, the ASX 300 Mining and Metals Index, the ASX 200 Resources Index, or another index).

A significant amount of academic research relating to the estimation of market risk premia uses a critique of the CAPM and its many extensions to form the basis for discussion, though the research is not generally industry specific. Fernandez (2004) argues that while the historical market risk premium is identical for all investors, the required market risk premium, and the concept of the expected market risk premium, are unique to individual investors. Fernandez suggests that the quantification of the required market risk premium to inform the CAPM works for a single investor by asking the investor what he / she requires, and subscribes to the notion that the market risk premium for the total market cannot be determined (notably because if all investors had the same preference, then all investors would have identical portfolios, as would the market and sector indices be identical). Interestingly, he discusses the qualification of the different types of market risk premium (required, historical and expected) and the implications for the misuse of relevant terminology in the CAPM, but does not attempt to suggest a solution to quantify such premia at the investor level.

Harris and Marston (1999) used the back-analysis of historical data over the period between 1982 and 1998 from the Standard & Poor's American 500 market index (S&P 500) to derive an average forecast market risk premium of 7.14% above average bond yield rates across a theoretical pseudo-portfolio. They analysed four specific measures of forecast risk:

1. the yield spread between government and corporate bonds;
2. consumer sentiment about future economic conditions;
3. the average spread of analysts' forecasts on corporate earnings; and
4. the implied S&P 500 volatility derived from options data.

Notably, they found that the market risk premium rates were variable and had a negative correlation with government interest rates, hinting that required returns are more stable than interest rates. They conclude that the market risk premium changes over time and that:

> "A constant risk premium over time is not an adequate explanation of pricing in equity versus debt markets...our research does not resolve the answer to the question, what is the right market risk premium? We hope that future research will harness ex ante data to provide additional guidance to best practice in using a market premium to improve financial decisions". (Harris and Marston (1999)).

Mayfield (2004) suggests that while many research efforts have demonstrated that 'expected' returns vary with time, the method most used to calculate this expected return in practice is the averaging (arithmetic or geometric) of excess historical stock returns using either a geometric or arithmetic averaging method. He suggests that a statistically significant positive correlation between expected stock returns and market volatility is not demonstrable and proposes that market risk should be estimated using an equilibrium relationship between market volatility and expected returns. He assumes a two-state Markov process where the economy is either in a period of low volatility (ex-post returns are high) or a period of high volatility (ex-post returns are low) but leaves significant subjectivity on the timing of the switch.

Han (2011) and others, such as Bali (2008) and Urbański (2012), recognise that the CAPM variant, the Intertemporal Capital Asset Pricing Model (ICAPM) developed by Merton (1973), provides insight into the estimation of the market risk premium in a dynamic setting by incorporating a global market risk input variable (compensation for direct and indirect exposure to foreign currency exchange rates) into the CAPM calculation. Simplistically, the ICAPM is calculated as in equation E2-5

$$R_i = R_f + \beta\,(R_m - R_f) + (F_c * P_{fc}) \qquad \textbf{(E2-5)}$$

where:

R_i	=	Expected rate of return
R_f	=	Risk-free rate of return
β	=	Asset beta
R_m	=	Expected rate of market return
F_c	=	Sensitivity to foreign currency real exchange level
P_{fc}	=	Exposure to foreign currency

Like Mayfield (2004), Han (2011) acknowledged that the underlying theoretical CAPM is somewhat objective in that it either assumes that the market rate of return and market volatility have some sort of positive relationship, or that investors are ill-considered in their expectation of a logarithmic relationship between the two. To address this quantification uncertainty, several authors have proposed frameworks for the estimation of the market risk premium on investments that are not industry specific. Han (2011) recognises that the empirical evidence for the relationship between the market risk premium and market systematic risk using volatility measures is conflicting. He suggests a volatility framework where the components of systematic risk and market volatility are considered to have only a partial relationship, and that the market volatility component is stochastic. Han proposes that the results of his analysis, 'readily explain the market risk and return puzzle'. Han admits that there are some difficulties in calculating the market premium using his stochastic volatility framework in a continuous-time setting and readily acknowledges that the framework implicitly assumes that the risk-free rates are constant. This framework does not appear to explain the market risk and return puzzle, given that the framework does not accommodate bull or bear markets.

While the CAPM and its variants are used to value equity-funded corporate assets, there is demonstrable subjectivity around the quantitative inputs to it and similar frameworks. Indeed, in his review of capital asset pricing models, Don (2007) concludes that:

> "There is no consensus in the literature as to what a suitable measure of risk is, and consequently, as to what is a suitable measure for evaluating risk-adjusted performance. So, the quest for a robust asset pricing model continues".

In his recent work, Fernandez (2015) not only comments on the 'absurdity' of the CAPM with respect to its 'real world value', he also summarises existing literature on the subject and comments on its invalidity. Table 2-1 presents Fernandez's view of the CAPM.

Table 2-1: The CAPM according to Fernandez (2015)

CAPM	Real World
Homogeneous expectations. All investors have equal expectations about asset returns.	Heterogeneous expectations. Investors do not have equal expectations about asset returns.
Investors only care about expected returns and volatility of their investments.	Investors also care about jumps, crashes and bankruptcies.
All investors use the same beta for each equity share.	Investors use different betas (required betas) for each share.
All investors hold the market portfolio.	Investors hold different portfolios.
All investors have the same expected market risk premium.	Investors have different expected market risk premia and use different required market risk premia.
The market risk premium is the difference between the expected return on the market portfolio and the risk-free rate.	The market risk premium is not the difference between the expected return on the market portfolio and the risk-free rate of return.

More recently, Lilford, Maybee et al. (2018) critique the functionality of the CAPM as a single-period pricing model. They suggest that this single period is not appropriate for resource sector projects given the dynamic nature of their life cycle with respect to capital structure and changes in the operating environment that lead to contraction or expansion of production levels. This paper warrants further discussion and provides some useful work that will be investigated later in this research.

2.2 Arbitrage pricing theory

The arbitrage pricing theory (APT) was first introduced by Ross (1976) as an alternative to the CAPM. It uses a multi-factor (multi-beta) approach to describe the correlation between systematic risk and return. The APT (equation E2-6) is based on the 'no arbitrage' argument, which states that capital markets exist in a state of competitive equilibrium and that unsystematic risk (the error term, ε_i) can be diversified away using the law of large numbers in a limitless market.

$$R_i = R_f + \beta_1 * RP_1 + \beta_2 * RP_2 + ... + \beta_n * RP_n + \varepsilon_i$$

(E2-6)

where:

R_i	=	expected rate of return
R_f	=	risk-free rate of return (no exposure to systematic factors)
$\beta_{1..n}$	=	asset beta in relation to the specified systematic factor (1…n)
$RP_{1..n}$	=	risk premium of the specified systematic factor (1…n), i.e. the additional return that is expected for taking on the associated risk
ε_i	=	unsystematic risk component (diversifiable)

The APT implicitly argues that the SML does not govern whether a security is underpriced or overpriced, because each security is exposed to a set of different risk factors, or the same factors in different proportions, as represented by the unique betas. This allows for flexibility in the choice of systematic factors used by the modeller. Also, the model requires the regression analysis of historical returns to determine the relevant systematic factors. Ross advocates for the use of several systematic factors which he states to be most reliable as price indicators in an empirical setting: sudden changes in inflation, corporate bond premia and shifts in the yield curve (of interest rates paid on bonds of different maturities), though he does acknowledge that the selection of systematic factors is discretionary and highly subjective.

As with the CAPM theory for single-factor models, several multi-factor models that allow the quantification of systematic risk have been developed under the APT framework. Perhaps the most popularised multi-factor model is the Fama and French (1993) three-factor model (TFM) presented in equation E2-7. Fama and French added two explanatory variables (factors) to the CAPM to reflect a portfolio's exposure to those two factors, namely small capitalisation stocks, and stocks with a high book-to-market value ratio. Fama and French postulate that in the long term, smaller capitalised companies tend to see higher returns than their larger peers, and that value companies (book-to-market value ratio is high) tend to see higher returns than growth companies (book-to-market value ratio is low). Two additional factors (investment and profitability) were added to the TFM by Fama and French (2015). This new model was published as their five-factor model (FFM) as in equation E2-8, though the explanatory power of these two additional variables is considered to be low (Jiao and Lilti 2017).

$$R_i = R_f + \beta_1 (R_m - R_f) + \beta_2 (SMB) + \beta_3 (HML) + \varepsilon_i$$

(E2-7)

$$R_i = R_f + \beta_1 (R_m - R_f) + \beta_2 (SMB) + \beta_3 (HML) + \beta_4 (RMW) + \beta_5 (CMA) + \varepsilon_i$$

(E2-8)

where:

R_i	=	expected rate of return
R_f	=	risk-free rate of return
R_m	=	expected market rate of return
SMB	=	Factor 2: (Size): Small minus Large (historical excess market returns of small-capitalised companies minus historical excess market returns of large-capitalised companies)
HML	=	Factor 3 (Value): High minus Low (historical excess returns of value companies (book-to-price ratio is high) minus historical excess returns of growth companies (book-to-price ratio is low)
RMW	=	Factor 4 (Operating Profitability): Robust minus Weak (historical excess returns of more profitable companies minus historical excess returns of less profitable companies)
CMA	=	Factor 5 (Investment): Conservative minus Aggressive (historical excess returns of more conservative companies minus historical excess returns of more aggressive companies)
β_1	=	sensitivity (volatility) compared to the expected rate of return of the market / sensitivity to market risk
β_2	=	sensitivity of the asset's returns to SMB
β_3	=	sensitivity of the asset's returns to HML
B_4	=	sensitivity of the asset's returns to RMW
B_5	=	sensitivity of the asset's returns to CMA
ε_i	=	unsystematic risk component

2.3 Unification model

Khan and Sun (1996) argue that the CAPM neglects the unsystematic risk factor (ε_i) accommodated by the APT portfolios (acknowledging that ε_i is usually indiscriminately small in limitless markets with limitless diversification opportunity), whereas the APT neglects the essential risks accommodated by the CAPM (where essential risk is determined on a whole but limited market (finite number of assets) and normalised co-variance with this essential risk used to derive β). They note that different sets of risks are captured by the two theories and that the two theories, 'address different aspects of the premium-awarding scheme for taking such risks.' They attempt to combine the CAPM and APT with the presentation of their unification model. In this model, the overall risk is separated into a systematic and an unsystematic component (as in the APT), with a further decomposition of the systematic component into an essential and an inessential fraction (with reference to the CAPM). However, the authors acknowledge that their model still requires a large but limited number of assets in the portfolio. The implication is that the model's use is constrained to portfolio-based valuation rather than single-asset valuation:

> "Even in the presence of many sources of industry-wide or market-wide factors risks, there is only a unique source of risk, characterised by one random variable, that is rewarded by the market, and the risk premium assigned to that particular factor only reflects the role of that factor in the definition of essential risk." (Khan and Sun 1996).

2.4 Physical gold as a safe haven investment

Investment in physical gold is colloquially referred to as a hedge or safe haven investment. That is, an investment in physical gold serves as a form of insurance against market shocks (unpredictable fluctuations) because gold is traditionally known as a store of intrinsic value due to its relative inelasticity of supply. McCown and Zimmerman (2006) refer to physical gold as a zero-beta asset. A number of studies spanning across time from Shisko (1977) to Li and Lucy (2017) have demonstrated empirical proof of the safe haven concept by examining the role of physical gold in the global financial markets.

Faff and Chan (1998) tested the sensitivity (and therefore hedging ability) of Australian gold equity returns to a gold bullion price factor in the period between 1979 and 1992. They cite the work by Blose and Shieh (1995) and Larsen and McQueen (1995) amongst others who suggest that the purchases of stocks of gold companies attract a unique premium due to their sensitivity to the gold price. Faff and Chan (1998) demonstrated that the market returns of companies in the natural resources and mining sectors show a higher positive sensitivity to gold price movements than companies in other sectors. Additionally, they found that these sensitivities had time variance correlating with macroeconomic events (shocks), such as the October 1987 global stock market crash.

Baur and McDermott (2010) investigated the role of physical gold investment in a number of financial markets, including the ASX. They tested the validity of the safe haven, hedge and zero-beta assumptions using the empirical analysis of monthly, weekly and daily continuously compounded stock market returns and gold bullion prices in United States dollars per troy ounce. Their analysis identified a time- and market shock-variable gold beta coefficient against a market capitalisation weighted world index and against many emerging and developed markets, including the United Kingdom of Great Britain and Northern Ireland market and the United States of America market, but not the Canadian or Australian markets. In the Australian and Canadian markets, the physical gold price was found to generally co-move with the weekly and monthly markets, with a negative beta coefficient in some extreme market conditions.

These findings imply that an investment in physical gold in Australia is neither a safe haven nor a hedge.

Baur (2014) reports the results of his study into the exposure of S&P/ASX All Ordinaries Gold Index (XGD) listed mining companies to changes in the gold price over the period January 1980 to December 2010 (41 gold mining firms), and builds on a number of earlier research efforts including Twite (2002), Chan and Faff (1998) and Faff and Chan (1998). Baur (2014) reports that while the average beta over the long twenty-year time period studied was around 1.0, the variance is significant. Baur notes the theoretical 'negative asymmetrical exposure to gold yielding higher returns' for investors in gold mining firms when compared to those investing in physical gold. Baur (2014) explains that this asymmetrical exposure is due to the investment giving exposure to a unit of gold plus a share in the future production of the gold mining company. Further, the future production can be classed as a real option as it can be increased or decreased in accordance with the flexibility afforded by commercial management.

2.5 Industry practice

The VALMIN Code (2015) outlines the main industry accepted practical valuation approaches for the assessment of Market Value (the market approach, the income approach and the cost approach). The applicability of these valuation approaches varies according to the stage of exploration or study development (maturity) of the mineral asset, the resource or reserve (un)certainty and the amount, quality and transparency of the information available on the potential of the mineral assets. The Market Approach is primarily based on the theory of substitution. Here, the mineral asset being valued is compared with the similar mineral assets which have been transacted by a willing buyer and a willing seller in an open market and where the transaction metrics are publicly available and transparent. Valuation methods utilising this information under the Market Approach include peer trading multiples such as enterprise value or market capitalisation per ounce of gold, or the transaction value per ounce of gold. The Income Approach utilises methods which estimate the income or cash flow generating potential of the mineral asset. The Income Approach is commonly adopted for assessing project value where technical studies have been undertaken to a level that allows forecast prices and costs to be reasonably estimated. Other methods used under the Income Approach include Monte Carlo analysis using probabilistic ranges on the input variables to the discounted cash flow (DCF) and real options valuation. The Cost Approach is used when studies are not mature enough to allow cash flow projections to be modelled and is commonly used to value early exploration stage mineral assets. Methods used include the calculation of multiples of exploration expenditure, where expenditures are analysed for their contribution to the exploration potential of the mineral asset.

Most fundamental analysis begins when mineral assets (properties or projects) are in the production or development stage (Davis 2003). As such, the literature review and research focus is limited to the market valuation of projects where Mineral Resource or Ore Reserve estimates have been reported to the ASX under JORC (2012) guidelines and where the reporting of technical information for the project is likely to allow the reasonable application of an Income Approach to market valuation. This focus removes the subjectivity around the quantification of contained (in-ground) gold for valuation purposes and also removes the qualitative assessment of contribution to value required by the Cost Approach.

2.5.1 Income based methods

The Discounted Cash Flow (DCF) method is the most common income based method used by Practitioners and their stakeholders in the valuation of both mature mineral asset portfolios and mature stand-alone mineral assets. Rudenno (2012) reports that the DCF approach is the dominant primary valuation methodology used by Australian analysts and financiers across all industry types. The DCF method of asset or firm valuation was first noted by Fisher (1930) and in its current form by Ward (1978). The DCF method derives a net present value (NPV) by projecting future cash flows and discounting them using an estimated cost of capital as in equation E2-9 (Ehrhardt and Brigham 2010).

$$NPV = -Initial\ Investment + \sum_{t=1}^{T} \frac{Net\ Cash\ Flow_t}{(1+i)^t}$$

(E2-9)

where:

t	=	Number of time periods
T	=	life of the project
i	=	discount rate

Although several methods of discounting can be employed, discounting the free cash flows by the Weighted Average Cost of Capital (WACC) based on the CAPM is most frequently used by both academic and industry practitioners to derive and report a NPV (Ruback 2002). Miller (2009) notes that a WACC is typically used as the discount, or 'hurdle', rate in situations where a company (firm) uses more than one source of capital. The WACC can be calculated on either a pre-tax or post-tax basis. A pre-tax WACC (equation E2-10) is applied as a hurdle rate when the DCF model accommodates tax shielding from interest payments. A post-tax WACC (equation E2-11) is applied as a hurdle rate when the DCF model does not accommodate tax shielding from debt service payments. Here, the valuer is expected to allocate a risk premium in addition to the risk-free rate, which is informed by the CAPM market risk premium, β. Like the CAPM and APT, there is much debate regarding the validity and complexities in using the WACC.

$$WACC = W_dR_d + W_eR_e$$

(E2-10)

$$WACC = W_dR_d\,(1\text{-}t) + W_eR_e$$

(**E2-11**)

where:

Wd	=	weighted proportion of debt
We	=	weighted proportion of equity
Rd	=	interest rate on debt based on a market rate
Re	=	risk-free rate plus a risk premium based on the CAPM, β
t	=	effective tax rate, not the income tax rate (Fernandez 2010)
1	=	Wd + We

Fernandez (2010) demonstrates the limitations with respect to the use and misuse of the WACC calculation, particularly the specious ways valuation practitioners use substitution on key variables to arrive at a WACC value, which is then misrepresented (e.g. using the wrong tax rate or assuming an incorrect capital structure such as book values of equity and debt rather than valuations undertaken by an independent contractor or consultant). Fernandez suggests that practitioners should further consider the definition of WACC:

> "The WACC is just the rate at which the Free Cash Flow (FCF) must be discounted to obtain the same result as the valuation using Equity Cash Flows. The WACC is neither a cost nor a required return: it is a weighted average of a cost and required return. To refer to the WACC as the "cost of capital" can be misleading" (Fernandez 2010) .

Mitra (2011) discusses the requirement for the WACC to be calculated separately for each project within a portfolio. Citing a 1993 survey (Bierman 1993), Mitra notes that 93% of Fortune 500 firms, out of a survey population of 100 firms, used a constant company-wide WACC to value projects. Cacciafesta (2015) agrees that a firm's WACC varies with the addition of new projects and that warnings to use non-existing market values of debt and equity rather than book value are inapplicable for new projects. Cacciafesta suggests that the cash flow a new project generates should be discounted at a rate lower than the rate used for the debt of the new project.

Risk-adjusted discount rates

Gilbertson (1980) made early recognition that there are a number of complications associated with the application of traditional CAPM theory at the asset level and presents a method to adjust the discount rate for specific asset-level risk. Gilbertson arrives at a risk-adjusted discount rate (RADR) by suggesting first that the risk-free rate should be represented by a government bond rate that matches the discounting life of the asset, and second that the forecasting of dividends or earnings for a 'large number' of individual share prices and regressing them against the market beta allows for a least-squares estimate of the risk premium. Importantly, Gilbertson recognised that additional difficulties arise when forecasting dividends or earnings on gold stocks as these forecasts are sensitive to the assumed gold price. Furthermore, Gilberston does not make comment in relation to a suitable index and uses the Johannesburg Stock Exchange Actuaries All Market Index in the presentation of his research.

Smith (2003) suggests a summation approach to the calculation of a suitable discount rate for mining projects, in which three components are used: Mineral Project Risk, Country Risk and the Project-specific Discount Rate (equation E2-12). Smith suggests that Country Risk should be the only macroeconomic factor considered in the derivation of a RADR, given that this factor accommodates, where relevant, taxation risk. Smith recognises the challenges of quantifying the Project-specific Discount Rate and suggests that NPV variations of up to 50% can be estimated due to differences of opinion relating to the calculation of the discount rate.

$$d = Rd + Rp + Rc$$

(E2-12)

where:

d	=	project-specific, constant dollar, 100% equity, discount rate
Rd	=	real, risk-free, long-term interest rate
Rp	=	risk portion of the project-specific discount rate
Rc	=	risk increment for country risk.

The number of risk factors available to choose from when developing a project-specific RADR is substantial. Davis (2003) re-presents an analysis of major American gold property acquisitions during the 1990s undertaken by Ludeman (2000). The work indicated that a significant premium was paid for operating mines, where both Ore Reserve estimate and cost uncertainty had been reduced, and that assets with undeveloped Ore Reserves traded at a 44% discount to operating stage assets. Furthermore, mineral assets that had Mineral Resource estimates reported (with no reported Ore Reserve estimates) traded at an 83% discount to operating (production) stage assets.

Davis agrees that the quantification of the correct RADR to use for mineral asset valuation is difficult. He argues that, 'as the consideration of risk is used to derive and report an Ore Reserve estimate, no additional discounting or application of a premium to the risk-free discount rate should apply'. Davis suggests that this is not what happens in practice and that perceived Ore Reserve risk is highly penalised by investment decision-makers in a systematic manner. He proposes that observed trading multiples (which he calls market factors) may be correcting for optimism bias in Mineral Resource and Ore Reserve estimation as, 'geologists tend to be optimists regarding the mineral potential of a property in its early phase'.

Lilford, Maybee et al. (2018) in their resource sector-specific work, suggest several inconsistencies in the calculation of WACC as applied to RADR for resource projects:

1. WACC accommodates a single-period pricing model whereas resource sector projects use multi-period cash flows.
2. Betas vary over time as the market varies.
3. The company's explicit debt level varies over time.
4. The cost of debt varies as interbank offer rates vary.
5. The unlevered and then re-levered beta should be adjusted as debt levels change.
6. The debt-to-equity ratio changes over time due to debt repayments or further drawdowns, impacting the weightings in the WACC.
7. The overall capitalisation of the company changes over time, which impacts the weightings of debt and equity to the overall capital of the company.
8. The quantification of a dynamic project risk profile is excluded from the WACC.

Lilford, Maybee et al. (2018) propose a scenario driven WACC calculation to accommodate their noted inconsistencies and derive variable and periodised RADRs based on these dynamic factors. They acknowledge that the discount rate used in NPV calculations on resource sector projects usually include an underived premium to the WACC using technical and techno-economic uncertainties to arrive at a premium, Xr, where the basic form is usually RADR = WACC + Xr. Whilst the authors remark that no two practitioners can be expected to provide the same Xr, they acknowledge that the contributing factors are not only difficult (or impossible) to derive, but that they are usually justified based on the experience of the valuation practitioner, 'or as a technical or economic uncertainty or risk addition'. They note that this quantification presents a research opportunity and concur with Davis (2003) in their statement that one should not necessarily use higher discount rates for more marginal projects.

Real options

There is industry-wide recognition that uncertainty around market events leaves investors and project owners with the need for a scenario-based investment strategy, and significant academic attention has been given to Real Options Analysis (ROA) to assist with the valuation of resource sector projects (Real Options Valuation (ROV)). ROA was first postulated by Myers (1977) who suggested that business opportunities could be viewed as options (the right but not the obligation to make a business decision), and that the valuation of these options could add significant flexibility to an asset when considered as part of the capital budgeting decision-making process. Myers coined the phrase 'real option', as the options refer to real assets or non-financial instruments.

The problem lies in the quantification of the value of the flexibility (real option), given that traditional NPV analysis does not account for this value, and scenario-driven deterministic financial modelling often attempts to value the flexibility using a constant discount rate, leading to valuation errors. Trigeorgis (1993) and Dixit and Pindyck (1994) suggest that ROV is 'superior to the deterministic approach because the deterministic approach only accommodates 'irreversible' investments'. Davis (2003), while not advocating explicitly for the employment of ROV, suggests that ROV may explain the 'puzzling differences between fundamental asset valuation at the level of the project and equity valuation in the market'. A number of authors have proposed valuation frameworks for real options, with many using an extension of either the Black-Scholes stock option pricing model (Black and Scholes 1973) or one of its variants, the Cox-Ross-Rubenstein Binomial Option Pricing Model (Cox, Ross et al. 1979) as a foundation. Both models assume a constant risk-free rate of return, a perfect (no arbitrage) market exists in which the underlying asset pays no dividends, that there are no taxes or transaction costs, that the portfolio components are perfectly divisible, and that pricing is achieved through constant negotiation. A surfeit of plausible alternative models, including Schwartz (1977), Hilliard and Schwartz (1996) and Brennan and Turner (2010), provide extensions or variations to the ROA and ROV pricing theories. For the sake of brevity, a detailed exposition is not given here, rather high-level summaries of the Black-Scholes Model and the Cox-Ross-Rubenstein Binomial Option Pricing Model are given.

The Black-Scholes Model

The Black-Scholes Model (BSM) prices a European-style option (i.e. one which gives the owner the option to exercise only at expiration). The BSM assumes that the underlying stock price is lognormally distributed and that the price follows a continuous-time stochastic (Weiner) process with constant drift and variance. Here, the call option price is calculated as the discounted future value of the option if the stock price is above the strike price (how far into the money it will be), multiplied by the risk-adjusted probability that the stock price will be at or above the strike price at expiration (equation E2-13).

$$C = SN(d_1) - Ke^{-Rft}N(d_2)$$

(E2-13)

where:

C	=	call premium
S	=	current underlying stock price
T	=	time until expiration
K	=	option striking price
Rf	=	risk-free interest rate (assumed to be constant)
N(x)	=	cumulative standard normal distribution (average = 0, standard deviation = 1)
e	=	Euler's number, exponential term (2.1828)
d_1	=	first probability factor, which represents the conditional risk-adjusted probability that the present value of the contingent receipt of the stock will exceed the current stock price, i.e. N(d_1) represents the future value of the stock if (and only if) the stock price is above the strike price and including the probability that it will be in the money
d_2	=	second probability factor, where N(d_2) represents the risk-adjusted probability that the option will be exercised, i.e. the risk-adjusted probability that the stock price will be at or above the strike price at expiration.

where:

$$d_I = d_2 + \sigma\sqrt{t}$$

$$d_2 = \frac{ln(K/S) - \left(r - \frac{1}{2}\sigma^2\right)t}{\sigma\sqrt{t}}$$

σ	=	volatility of the underlying asset (represented by the standard deviation of the daily logarithmic returns)
ln	=	Naperian logarithm

Therefore, at expiration, the exercise value of the call option with strike price, *K*, can be defined in equation E2-14:

$$C = max[0, S_t - K]$$

(E2-14)

The Cox-Ross-Rubenstein Binomial Option Pricing Model

The Cox-Ross-Rubenstein (CRM) binomial option pricing model (equations E2-15a, E2-15b, E2-16 and E2-17) is a variation on the BSM. The CRM assumes that the underlying stock price, S, follows a multiplicative binomial process over discrete time periods, where the underlying price only has two possible movements per time period: up or down. As such, the CRM prices either a European-style option or an American-style option (i.e. one which gives the holder the option to exercise at any time prior to expiration). First, size (magnitude) of the share price movement in each time period is assigned using the historical volatility, σ. A probability, p, is also assigned to each movement (to satisfy the no arbitrage condition, $dS < R_f < uS$).

$$uS = e^{\sigma\sqrt{t/n}}$$

(E2-15a)

$$dS = e^{-\sigma\sqrt{t/n}} \text{ or } \frac{1}{uS}$$

(E2-15b)

where:

uS	=	size or magnitude of an uptick
dS	=	size or magnitude of a downtick
t	=	time until expiration (in years)
n	=	number of binomial periods

The value of the underlying asset is derived for each earlier time period using an equivalent replicating portfolio where the risk-neutral equivalent portfolio produces the same cash flow as the call option. Therefore, at time *n* the value is defined using equation E2-16

$$S_n = S_0 \times uS^{N_{uS} - N_{dS}}$$

(E2-16)

where:

N_{uS}	=	number of upticks
N_{dS}	=	number of downticks

At expiry, a call option value is expressed as Max [S_n – K, 0] and a put option value is expressed as Max [K – S_n, 0], where S_n is the spot price of the underlying asset in the n[th] period and K is the strike price of the option. An *n* period option model is defined in equation E2-17.

$$C = \frac{1}{R_f^n}\left[\sum_{j=a}^{n}\left(\frac{n!}{j!\,(n-j)!}\right) q^j (1-q)^{n-j}\left[uS^j dS^{n-j} S - X\right]\right]$$

(E2-17)

where:

a	=	minimum number of upticks to exceed K (call finishes in the money).

The application of ROA to the natural resources sector on this basis is widely attributed to Tourinho (1979), through his unpublished PhD thesis, *The Valuation of Reserves of Natural Resources: An Option Pricing Approach*, although Brennan and Schwartz (1985) is recognised as the first peer reviewed journal article to present a mathematical model for the valuation of natural resource assets using the BSM as a foundation. Brennan and Schwartz acknowledged the significant price swings in the natural resources sector, stating:

> "Under such conditions the practice of replacing distributions of future prices by their expected values is likely to cause errors in the calculation both of expected cash flows and of appropriate discount rates and thereby lead to suboptimal investment decisions."

Their model showed that optimal guidelines for decision making on developing, managing and abandoning mining projects could be developed using 'the techniques of continuous time arbitrage and stochastic control theory', where, under the no arbitrage assumption, Brennan and Schwartz create a risk-free equivalent portfolio by taking a position in the physical mining project as well as in the metal futures market. They then calculate the value of the mining project without the real option. The difference between the two values is the value of the real option. Taking motivation from Tufano (1998), Colwell, Henker et al. (2002) developed a model based on Brennan and Schwartz (1985) to empirically value Australian gold mines. They modelled the real option ownership value using a methodology analogous to the valuation of an American call option using CRM. The risk-free portfolio is developed by hedging production with gold futures, where the strike (exercise) price is equal to the extraction cost of gold plus the associated development costs. As with the financial options theory, the gold price in ROA is assumed to follow a Weiner process, with constant drift and variance (a standard Brownian motion), and the futures price is informed by the convenience yield of holding gold.

In their critique of the DCF approach and advocacy for the use of ROA in gold project valuation, Colwell, Henker et al. (2003) suggest that the DCF approach undervalues gold projects:

> "The lower valuations are due to the inability of the DCF technique to adjust for the volatility of gold prices, the stochastic nature of the gold price, and the value of the embedded real options. A further disadvantage of the DCF approach is the need to obtain a subjective discount rate, which is not required for the real options model."

Guj and Garzon (2007) support the notion that ROA is superior to DCF analysis for natural resource sector projects, stating:

> "DCF analysis also applies a single RADR to both the revenue and costs functions of the financial model of a mining project, irrespective of the revenue being much more risky than the costs, mainly because of the high volatility of commodity prices."

The ROA approach gives the Practitioner the ability to evaluate the opportunity cost of operational flexibility (expansion, abandonment, deferral suspension or closure) as well as a scenario-based evaluation of changes to the capital structure, but the DCF method remains favoured by industry practitioners. Ampofo (2017), in his unpublished PhD thesis, *Reasons why Real Options Analysis (ROA) is not widely accepted in the minerals industry*, documents the history and misuse, challenges and opportunities of the application of ROA. His mixed-methods research supports the now widely recognised view that the practical acceptance in the mining industry for real options has been slow, not because of the opportunities it provides, but because of its perceived 'computational complexity'. In Ampofo's survey of 14 industry experts, the participants noted a lack of trust in the ROA method, a lack of education on the method, poor communication of analysis results, the absence of software packages that allow ROA and the industry's inability to adopt innovation, as the main reasons the practical implementation of ROA in the minerals industry is deficient.

Decoupled Net Present Value

Since 2013, a number of authors have discussed the concept of the decoupled NPV (DNPV), where project risk is separated from the time-value of money to allow the derivation of a risk premium that can be added to the risk-free rate. The theory argues that fine-tuning the CAPM, the use of ROV, and methodologies accounting for scenario-based cash flows such as probabilistic Monte Carlo simulations, all double count risk. This agrees with the notion that all risk should be appropriately accommodated in the choice of the RADR.

Espinoza and Morris (2013) and Espinoza (2014) first introduce the DNPV concept to the valuation of infrastructure projects using valuation concepts originating in the insurance industry, commenting that, 'The practice of using a single parameter to account for two inherently different variables, i.e. the time value of money and risk, weakens the investor's ability to consistently correlate a rate of return with a project's given risks'. More recently, Espinoza and Rojo (2018) have applied the concept to the valuation of investment opportunities in the mining sector. They suggest that each of the key risks associated with the mining project should be evaluated and then assigned a (heuristic based) synthetic insurance premium (a premium that would be demanded by a risk-neutral insurance company, if one exists). Each synthetic insurance premium (cost of risk) is then subtracted from the expected cash flows of the project. This separates the expected cash flows from the risk-free rate, leaving 'virtually riskless' expected cash flows. These riskless cash flows are then discounted at the risk-free rate to arrive at the project value.

2.5.2 Market based methods

Efforts to outline market-based valuation approaches on mineral properties have not been daring enough to attempt to resolve the investment decision making quandary as they recognise the limitations of the many and varied methodologies employed. Such efforts have been limited in their endeavours to include comment on behavioural finance and the fact that mainstream economics 'ignores the entrepreneur' (Ibrahim and Vyakarnam 2003).

The comparable sales approach to market valuation is not only widely used throughout the minerals industry, but it is often used as a primary valuation method when the availability of suitable data allows. Here, practitioners compile and use hedonic analysis on transactions involving projects of a similar technical and operating regime with a view to establishing a range of values that the market is likely to pay for equity in a comparable project. Historical transaction values are typically normalised (equation E2-18) for real metal prices at the effective date of the valuation, as this is seen to provide a proxy for the market sentiment at the time of the transaction and accounts for the premium (or discount) the market placed on the transaction at the time the transaction took place.

$$Normalisation\ Factor = \frac{Metal\ Price\ at\ time\ of\ transaction}{Metal\ Price\ at\ date\ of\ valuation}$$

(E2-18)

Another market-based method used to benchmark companies against each other is an assessment of the corporate enterprise value divided by JORC Code reported ounces (EV/JORC). Rudenno (2012) comments that the EV/JORC approach does not consider the market risk profile at all. Other market-based methods include an assessment of earnings multiples (for example, the price to earnings ratio) and the Metal Transaction Ratio (MTR) analysis. All market-based approaches are open to the same subjectivity and test of transparency on the deterministic calculation of a market risk profile. Indeed, Maybee (2010) states that many of the risk factors that influence a mining project are qualitative in nature, and do not easily lend themselves to numerical evaluation.

2.6 Behavioural finance

The field of behavioural finance developed through empirical work in the 1990's is summarised in the seminal book by Cambell, Lo and MacKinlay (1996). The field of behavioural finance focuses on the drivers behind investment decisions and sets out to disprove the traditional assumptions under capital market theory and the efficient-market hypothesis. Davis (2003) eloquently describes the market premium problem attached to the valuation of mineral assets and notes that while the use of fundamental analysis and capital markets theory to predict discounted earnings is the valuation methodology recommended by economists, mineral asset valuers are faced with the same paradigm that all valuers are faced with: the presumption that owners are 'informed and rational, and are not subject to emotional or irrational behaviour'. He comments that economic theories 'assume away the vagaries of Fair Market Value and therefore finds no difference between fundamental and Fair Market Value'. Furthermore, Davis suggests that economists create assumptions to force this parallel. In acknowledging that value is not always equivalent to transaction price, Lawrence (2001) suggests that:

> "The consideration of the financial motives, capabilities, the special interest of the purchaser and the state of the market at the valuation date are not necessarily included in the price paid for an asset. Indeed, the quantification of contingent payments, strategic motives, future royalty streams and project specific risks are innately subjective in this regard."

Simin (2008) notes the low-forecasting performance of asset returns using traditional frameworks under the efficient-market hypothesis of capital markets theory. Under the efficient-market hypothesis market prices fully reflect all the available information under the assumption that human beings (or at least a statistically significant majority of them) are rational in their decision making (Fama 1970). Baker and Wurgler (2007) propose that sentiment is relevant in asset pricing and that it is a priced systematic market risk factor. They make comment regarding two strands of behavioural finance research. The first focuses on the notion that rational managers make decisions based on behaviourally biased investors. The second strand considers the notion that the managers themselves may be irrational in their decision-making due to overconfidence in their ability, or aversion to loss. Lawrence (2001) comments that:

> "Because of the diversity of situations in which a valuation might be required, no simple formulas (or recipes) can be used in mineral asset valuations. It also explains why the competence, judgement and repute of the valuer is the critical factor in valuation practice since all valuations are time and circumstance specific."

Valuations are limited by the knowledge and the experience of the valuation practitioner and the knowledge and experience of the marketeer. As such, project valuation outcomes that are used to inform negotiations leading to realised transaction values can be easily manipulated.

2.6.1 Basis of value

The Australian regulatory framework allows some degree of investor protection at the market valuation level. There is a requirement for an Independent Expert Report (IER) to be published alongside documentation relating to proposed material transactions where companies are listed on the ASX. Here, the role of the Independent Expert is to provide an objective, impartial analysis of a proposed transaction and to give an opinion on the fairness and reasonableness of the transaction for voting shareholders. This opinion is typically supported by a mineral asset market valuation prepared by a VALMIN Practitioner (Independent Specialist).

So far this literature review has focused on the concept of market value and an assessment of the related risk premium, where:

> "Market Value is the estimated amount (or the cash equivalent of some other consideration) for which a Project should exchange on the date of Valuation between a willing buyer and a willing seller in an arm's length transaction after appropriate marketing where the parties had each acted knowledgeably, prudently and without compulsion." (VALMIN 2015).

This term has the same intended meaning as that of the International Valuation Standards Committee's (IVSC 2012) with the same name, and the same meaning as Fair Value in the ASIC Regulatory Guide (RG) 111. However, it is an assessment of Investment Value that is usually the focus of the individual marketeer or potential investor. The term Technical Value under VALMIN (2015) has an intended meaning that is similar to the IVSC term Investment Value. Under IVSC (2012), the definition of Investment Value is 'the value of an asset to a particular owner or prospective owner for individual investment or operational objectives', whereas, Technical Value is defined under VALMIN (2015) as 'an assessment of a Mineral Asset's future net economic benefit at the Valuation Date under a set of assumptions deemed most appropriate by a Practitioner, excluding any premium or discount to account for market considerations'.

Indeed, it is possible that confusion around the basis of value, confusion around the valuation assessment framework, and confusion arising from unconscious or conscious behaviours and biases has contributed to the academic debate on preferred valuation methods. Clarity here could provide some direction for future discussion on the matter: given the governance provided by the Australian regulatory framework, there is an assumption by marketeers that realised transaction values are appropriately negotiated and appropriately transacted on a fair and reasonable basis. It is assumed that behavioural elements do not play a part in the preparation of market valuations. It is also assumed that shareholders consider the content of valuation reports judiciously and vote on proposed transactions without compulsion or bias.

Both historical and contemporary research on the matter of gold asset pricing is limited to econometric analysis using only quantitative data. That is, the research ignores the behavioural aspects of asset pricing where qualitative analysis may explicate some of the observed variance in the quantitative outcomes.

2.6.2 Practitioner behaviour

When investors lack complete information regarding their investment, they are believed to be making their choices based on unreasonable or irrational behaviour and personal considerations (Rao and Moseki 2009). Lawrence (2002) suggests that this theory also holds for Practitioners undertaking valuation assessments. He suggests that:

> "Valuation is a rather subjective process that heavily relies upon the repute and competence of the valuer. A true market will not be influenced for long (if at all) by spurious mineral property values. This is where responsible and informed media and brokers/analysts fulfil their proper role, otherwise they become part of the problem not the solution."

Damoradan (2001) suggests that it is not a lack of understanding of the principles of valuation or a lack of access to good data that causes spurious valuations or a wide variance in valuation outcomes. The wide variance in valuation outcomes is due to bias by those preparing the valuations (Practitioners): Practitioners are biased and are averse to admitting this fact. They fear uncertainty, making efforts to evade fear or hide from it. Damoradan also suggests there is a Practitioner expectation that economic models will make their decisions for them. If these behaviours unconsciously inform a market valuation prepared by a Practitioner, then the problem of shareholders and new investors being biased in their decision making can be compounded by this Practitioner bias. One could therefore argue that Lawrence's assertion that true markets will not be influenced for long (if at all) by spurious mineral property values commands further enquiry. Practitioner bias can be expressed in a multitude of forms, from bias in identifying and quantifying the unsystematic aspects of a project, through to bias in the selection of the systematic factors to be considered in the cash flow analysis and the selection of scenarios (what-if analysis) to present to marketeers.

The real estate industry and the resources industry share a hedonic valuation function and valuations in the two industry sectors both rely on Practitioner judgement. In the gold sector of the natural resources industry the hedonic valuation method decomposes the expected value of a project by pricing factors such as the project's size and grade in grams of gold per tonne (g/t) of material mined, Mineral Resource and Ore Reserve estimates, and maturity with respect to its development stage by their desirability. Klamer (2017) summarises the academic literature relating to real estate valuer judgement and the recognised biases discussed in 32 academic studies dating from the early 1990s. No such formal synopsis has been identified for the resources industry sector. The salient observations made by Klamer include concerns over the ethical standards of valuation Practitioners, together with the prevalence of heuristic behaviours leading to biased valuation outcomes:

- There are concerns over the ethical standards of information intermediaries such as valuation Practitioners leading to advice which may not always be independent of client attachment: the timely delivery of valuation reports under fee-for-service agreements leads to a subconscious client attachment;
- A moral hazard can exist for valuers with regard to deciding on an appropriate market value estimate;
- Suggestions by a client to reconsider an estimated value can pressure a valuer to use their discretionary power to allow potential loss of revenue to prevail over principle (sub-optimal decision making);
- Positive reinforcement feedback from clients to valuation Practitioners triggers Practitioners to perceive themselves as providers of objective market value estimates, whereas negative feedback stimulates a perception of playing a price validation role;
- Uncertainty in valuation decision-making processes is related to information ambiguity and lack of market transparency caused by data deficiencies (incomplete information) and the absence of a central trading market place;
- The use of incomplete data leads to the application of heuristic behaviour (cognitive shortcuts) such as anchoring bias – even for educated and trained practitioners; and
- Evidence of reference point anchoring (use of third-party value estimates and pending sales information in lieu of comparable sales data) exists where valuation Practitioners provide valuation estimates in non-familiar geographic settings.

Parallels can be drawn between the observations presented by Klamer and valuation practice in the resources industry. Practitioner bias in valuation is a systematic factor that is not currently considered by marketeers when making their investment decisions with respect to gold projects.

2.6.3 Project owner behaviour

The principal role of the mining executive is to add shareholder value through the appropriate development, implementation and communication of strategic plans, including the execution of project transactions. Naturally, when mining executives become the champions of proposed transactions, the communication of the perceived merits and risks of those proposed transactions are typically communicated via an announcement on the ASX market platform and then via investor presentations and major shareholder meetings prior to the publication of the IER and transaction closure.

Under the Australian regulatory framework, project owners are required to provide Practitioners all information that could be considered material to the preparation of a valuation whether this is public information or not. This provision requires the project owner to demonstrate good ethical practice. It also requires project owners to have a thorough understanding of the valuation process and the effects of information asymmetry and bias. Objective information reporting, while concurrently gaining the attention of potential investors and holding the attention of existing investors, is a difficult task for even the most seasoned mining executive.

A large and growing body of literature has investigated the role of narrative and storytelling in consumer decision making as well as strategy formulation and implementation. Connecting with the literature on the travel industry, Adaval and Wyer Jr (1998) undertook a thought-provoking experiment to assess the role of narrative in choice-driven decisions. The study concluded that travel destinations were viewed more favourably when the communication of the salient aspects of each destination were presented in narrative rather than list form. The experiment essentially disproved earlier work on consumer integration theory (Anderson 1981). Consumer integration theory asserted that when people evaluate products, they examine each piece of information separately and then form an opinion by averaging their observations on each unique aspect. A second, and arguably more important observation from Adaval and Wyer's work was that unfavourable information, when presented in narrative form, had less of an impact in the choice decision outcomes than when information was presented in list form. That is, unfavourable information or information that is inconsistent with the story is apparently diluted when presented in narrative form. If humans use holistic rather than piece-meal processing to assess the importance of new information, then storytelling by mining executives could influence investment choices and therefore influence transaction values.

O'Shea (2008) suggests that mining firms use positive language in disclosures as a vehicle for self-promotion. Bird, Grosse et al. (2013) moved by the findings of Ferguson and Scott (2011), studied the ASX market response to announcements relating to technical information prepared under JORC guidelines. Their event study found that significantly positive abnormal returns of between 2.05% and 3.24% are experienced by mining companies making these announcements, and that larger positive abnormal returns in the period from 10 trading days before the announcement to 20 trading days after the announcement were related to the use of positive adjectives in the headlines of the announcements.

2.6.4 Investor behaviour

To recapitulate, the expected market risk premium reflects the difference between the expected return on a risky asset and the expected return on a riskless asset. The willingness to pay for this market risk premium reflects an investor's degree of risk aversion. Thus, if investor judgement on the risk profile of a gold project is clouded by Practitioner or owner bias (either subconsciously or consciously), then the ability of the investor to suitably quantify the expected market risk premium becomes problematic. Investor behaviour and the question of whether investors make rational or irrational choices has long been the subject of academic debate, a debate that goes beyond the scope of this research. Al Mamun, Abu Syeed et al. (2015) provide a debate summary (Table 2-2) and note the admission by many capital markets theorists that markets are not entirely efficient, and that investors are not entirely rational. It is assumed that professional ethics prevail during the presentation of an investment business case, whether this is a public presentation that is formally reported to the ASX platform, or a private presentation in a closed market. Notwithstanding anything to the contrary, the risks and opportunities for each project are not presented using identical language in an identical form and context within ASX market announcements, given the lack of regulation on this.

Table 2-2: Behavioural bias by investors (summarised from Al Mamun, Abu Syeed et al. (2015)).

Bias Type	**Description**
Representativeness	Under uncertainty, investors believe that historical performance is representative of general performance.
Cognitive Dissonance	People tend to ignore, reject, or minimise information that conflicts with a particular belief. Cognitive dissonance results in investors attempting to avoid or discount a conflicting belief and seeking out support for the preferred belief.
Familiarity	Investors prefer familiar investments and believe that they are less risky than other investments or even safer than a diversified portfolio. Representativeness bias can be compounded by familiarity bias.
Mood and Optimism	More optimistic judgements are made when investors are in a good mood. Investors are more critical when they are in a bad mood.
Overconfidence	Investors are usually overconfident about their ability to pick good investments. They believe their knowledge is more accurate that it really is. Overconfident investors believe more strongly in their valuation of a stock and concern themselves less about the beliefs of others. Overconfidence causes investors to take too much risk, resulting in paying too much for investments and increasing their susceptibility to large losses.
Endowment Effect	Investors demand much more to sell something than they would be willing to pay to buy it. People do not overvalue the things they own as much as they are affected by the pain associated with giving them up.
Status Quo	The tendency by investors to do nothing when faced with choices. Additionally, people prefer to hold investments they already own as making a change implies that the previous purchase decision was a poor one.

Bias Type	Description
Reference Points and Anchoring	Investor fixation (anchoring) on a specific price (reference point). The brain's choice of reference point determines whether the investor feels the pleasure of obtaining a profit or the pain of experiencing a loss.
Law of small numbers	Investors believe that a small sample represents the population. They make faulty predictions on the future by basing their decisions on a limited reference period (current trends).

2.7 Synopsis

In this chapter, different valuation methodologies and extensions of those methodologies are discussed. Additionally, behavioural finance is introduced as a complementary, but significant, research field that could explicate some of the challenges experienced during the assessment of market value. While the presented models propose partial solutions for the quantification of market value in a theoretical sense, it remains recognisably difficult to evaluate, validate and apply these models. There appears to be a dearth of literature providing a pragmatic solution for use by industry practitioners and other marketeers. Table 2-3 presents a synopsis of the existing literature surrounding the market premium problem as applied to this research.

Table 2-3: Literature review summary

Model	Summary
CAPM	Widely accepted theory that beta (β) is a measure of sensitivity to general market movements (systematic risk) and can be used as one measure of market risk as it cannot be eliminated through any kind of diversification in the portfolio. A single-period model assuming a perfect, limitless market.
WACC	Used widely as a proxy for a project's investment hurdle rate in DCF analysis, the WACC model is informed by the CAPM to quantify the equity component of market risk. Has recently been extended to allow time -series assessment.
RADR	Used informally to discount project-level cash flows based on the application of discretionary risk factors, usually applied as an extension to the WACC model. Not yet fully explored; remains a focus for academia and marketeers.
APT	Models expected returns as a linear function of various factors or market indices and beta coefficients. Provides a useful multi-factor extension to the CAPM; however, the selection and number of factors is ambiguous. APT has some similarities with the RADR method.
Unification model	Attempts to combine the CAPM with the APT. Overall risk is separated into a systematic and an unsystematic component (as in the APT) and the systematic risk is further broken down into an essential and inessential part (with reference to the CAPM). Uses calculus on a portfolio that includes a large but finite number of assets, rendering it impractical for use by industry Practitioners on single-asset valuation.
Real options analysis	Allows the impact of management flexibility to be quantified through an extension of the financial options theory, which relies heavily on perfect markets and rational investors.
Behavioural finance	A paucity of literature on behavioural finance in the resources sector, and no relevant literature for project-level gold transactions. Some useful insights for further evaluation.

2.8 Character of knowledge gaps and research methodology

The literature review supports the notion that the assessment of gold project market value is multi-factorial. The review assisted in identifying and characterising the knowledge gaps that encumber clarity on the estimation of realised transaction value. The CAPM, APT and their extensions rely on the efficient-market hypothesis (Fama 1965), where calculations are typically used in a forecasting capacity to derive a required return of equity on a single-period investment in a limitless market. Used widely as a proxy for a project's investment hurdle rate in DCF analysis, the WACC is informed by the CAPM to quantify the equity component of market risk. As an alternative to the use of the WACC, RADRs are used informally to discount project-level cash flows based on the application of discretionary risk factors. The identification and sensitivity of realised Project transaction value to these risk factors remains a focus for academia and marketeers, and there is a gap in the literature on this subject.

The efficient market hypothesis asserts that the market is perfect and that investors are rational in their decision making. The field of behavioural finance focuses on the drivers behind investment decisions and sets out to disprove traditional assumptions such as the efficient market hypothesis. The second gap in the literature is the lack of empirical work that assesses the behavioural aspects of gold project valuation and how these behavioural aspects contribute to realised gold project transaction value.

There is a lack of clarity surrounding market factors that contribute to the value of gold projects at the project transaction level (limited market), and the sensitivity of the realised gold project transaction value to those factors. There is also a lack of empirical work that assesses the behavioural aspects of gold project valuation and how these behavioural aspects contribute to realised gold project transaction value. This thesis will address these knowledge gaps and answers the questions identified during the literature review:

1. Are there identifiable market factors associated with gold project transactions on the ASX and how are these factors related?
2. Can an inclusive valuation framework be created from historical transaction data using the identified market factors for gold projects on the ASX?

The research methodology has been designed to contextualise the market value of gold projects through the identification of the salient and substantial non-salient variables using an inclusive, interdisciplinary approach under a mixed-method framework. Literature describing mixed-method research methodologies in the economics field is limited (Jefferson, Austen et al. 2014). In their journal article, *The use of mixed methods across seven business and management fields*, Cameron and Molina-Azorin (2010) suggest an emerging acceptance level in the use of mixed methodologies in business academia, notably amongst research students. A mixed-method sequential explanatory design (QUAN→qual) was adopted to appropriately address the research questions in this thesis without restricting the analysis (Figure 2-2).

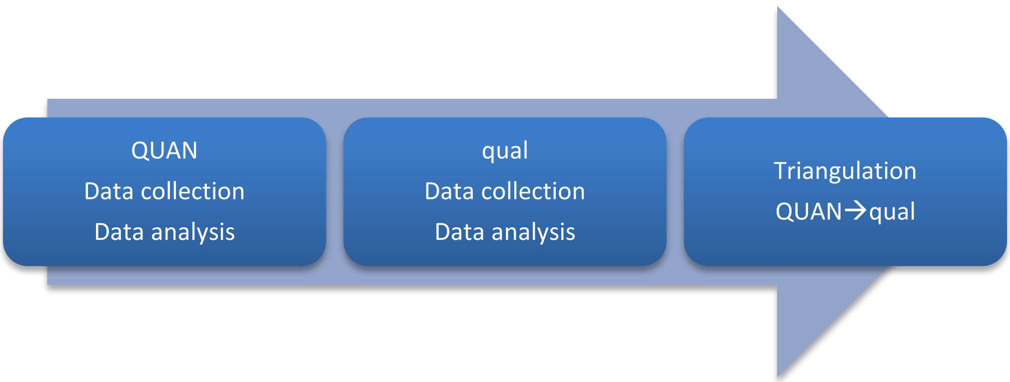


Figure 2-2: Sequential explanatory design

In consideration of the research questions, data were first collected in a quantitative strand. These quantitative data related to the historical performance of the market indices, geopolitical time-series data and gold price data. Noting the decomposition assumption that the variance of any feasible portfolio is attributable to a systematic (market component) and an unsystematic (diversifiable or idiosyncratic component) risk component, the ASX All Ordinaries Gold Index was selected as a dummy portfolio (Dummy Portfolio) to allow for this decomposition and eliminate confounding variables for the period between January 2011 and October 2017. The knowledge gained from the decomposition and analysis of the Dummy Portfolio was then applied to the analysis of historical gold project transaction data for the period from January 2011 to October 2017 (Training Portfolio). Second, a qualitative data strand relating to the Training Portfolio was collected and then analysed using quantitative methods 'to obtain different but complementary data on the same topic' (Morse 1991) in Creswell and Clark (2007). The quantitative and qualitative studies were then triangulated to allow some explication of the quantitative study outcomes through the development of causal stories using the analysis of the qualitative data. This triangulation also allowed the derivation of a framework to answer the research questions.

3 Quantitative Study (QUAN)

The Quantitative Study was designed to identify and assess the systematic and unsystematic factors relating to gold project transactions on the ASX through the development and decomposition of two portfolios. The systematic component was assessed using the historical returns on a proxy market portfolio (Dummy Portfolio). Here, the historical returns of the ASX All Ordinaries Gold Index (XGD) over a seven-year period from 2011 to 2017 (Research Period) were used to calculate an implied market risk premium and then assessed for their relationship with the gold price and a number of geopolitical variables using backwards stepwise ordinary least squares multiple (OLS) regression analysis. The unsystematic (diversifiable) component was assessed using a portfolio of historical transactions made by ASX listed companies over the Research Period (Training Portfolio). Experimental modelling was undertaken using iterative OLS multiple regression analysis to assess the sensitivity of the realised transaction values to a number of project-specific factors.

3.1 Dummy Portfolio Development

To develop the Dummy Portfolio, an assessment of the returns (Rm) on the XGD, the calculation of the implied market risk premium (Rm – Rf), and the classification of the monthly and quarterly XGD market sentiment over the research period was made. Historical index prices for the XGD, the Australian Dollar Spot Gold Price (XAU.AX) and the Australian Government Bond Rates were sourced from the subscription database, Barchart Premier (Barchart 2019). Data on geopolitical risk indicators were sourced from the Australian Bureau of Statistics (ABS 2019) and the Reserve Bank of Australia (RBA 2019) websites. Table 3-1 presents a comprehensive list of the quantitative data used in the development of the Dummy Portfolio and includes the definitions given by the sources noted in the table.

Table 3-1: Geopolitical data

Indicator	Measure	Code	Source	Definition
Gross domestic product	A$B	GDP	Australian Bureau of Statistics	Sum of the gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. The data are in billion local currency units using current prices.
Consumer price index (CPI)	Index points	CPI	Australian Bureau of Statistics	Measures the changes in the cost of a basket of goods and services consumed by the average urban household.
Investment Factor	A$B	IF	Australian Bureau of Statistics	Gross fixed capital formation, including land improvements, plant, machinery and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings,

Indicator	Measure	Code	Source	Definition
				and commercial and industrial buildings.
Economic growth	Percentage	EG	Australian Bureau of Statistics	The per cent change in the GDP from the same quarter in the previous year using constant prices.
Current account balance	A$M	CAB	Australian Bureau of Statistics	The sum of net exports of goods and services, net primary income, and net secondary income.
Exports	A$M	EX	Australian Bureau of Statistics	All transactions of goods and services (sales, barter, or gifts or grants) from residents of a country to non-residents.
Foreign direct investment	A$M	FDI	Australian Bureau of Statistics	Direct investment equity flows in the reporting economy – the sum of equity capital, reinvestment of earnings, and other capital. Direct investment is a category of cross-border investment associated with a resident in one economy having control or a significant degree of influence on the management of an enterprise that is located in another economy. Ownership of 10 per cent or more of the ordinary shares of voting stock is the criterion for determining the existence of a direct investment relationship.
Foreign exchange reserves	A$B	RE	Reserve Bank of Australia	Foreign currency, deposits denominated in foreign currency, Monetary Gold, Special Drawing Rights (SDRs) and Reserve position in the International Monetary Fund (IMF). Foreign exchange reserves are held in monetary form to finance trade imbalances, check the impact of foreign exchange fluctuations and address authorities' other issues under the purview of the central bank.
Government expenditure	A$B	GE	Australian Bureau of Statistics	Total spending by all levels of government but excluding public enterprises.
Budget balance	A$M	BB	Australian Bureau of Statistics	Revenue minus expenditure of the consolidated government.
Labour cost	Index points	LC	Australian Bureau of Statistics	Reflects the level of the total compensation of employees in the economy.
Inflation, monthly	Percentage	IN	Australian Bureau of Statistics	The percentage change in the CPI from one month to the next.
Exchange rate	A$ units to US$	FX	Google Finance	The amount of A$ units that can be exchanged for one US$.

Indicator	Measure	Code	Source	Definition
Government debt	A$M	GD	Australian Bureau of Statistics	General government gross debt, also known as public debt, is the nominal (face) value of total gross debt outstanding at the end of the period and consolidated between and within the government subsectors.
Cash Target Interest rate	Percentage	CTI	Reserve Bank of Australia	Overnight money market interest rate charged to commercial banks by the Reserve Bank of Australia for overnight loans.

Historical share price information for each buyer company was downloaded from Yahoo Finance (Yahoo Finance 2019) using the open-source, bulk-download software from InvestExcel (InvestExcel 2019). Data relating to the capital structures and other financial metrics of the ASX-listed companies involved in the transactions in the Training Portfolio were sourced from the Morningstar DatAnalysis Premium database via the Curtin University subscription (Morningstar 2019). The databases from which the raw quantitative information was obtained are considered to have an appropriate degree of face validity as instruments to underpin the data analysis. No material content errors were identified during the validation process of the downloaded information. The validation process involved manual quality assurance and quality control (QAQC) checks to ensure sample reliability and to ensure that the experiments underpinning the research questions could be performed without the need for additional quantitative data sources – in other words, the samples were fit for purpose and the input criteria were met.

XLSTAT statistical analysis software (XLSTAT 2019) was used to prepare the data and to identify the explanatory variables contributing to the dependent XGD market price. This was first done using co-integration tests on time-series variables and then stepwise multiple regression analysis to allow the preliminary decomposition given in equation E4-1.

$$E(\gamma) = \beta_0 + \beta_1 (X_1) + \beta_2 (X_2) + \beta_3 (X_3) + \beta_4 (X_4) \ldots\ldots \beta_n (X_n) + \varepsilon_i$$

(E4-1)

3.1.1 Choice of Market Index

Given the research focus is on ASX-listed gold equities, the XGD was deemed to be a feasible dummy market portfolio against which to design and run experiments. This index includes companies within the Global Industry Classification Standard (GICS) gold sub-industry of the All Ordinaries Index of the ASX. The index is constructed using a base-weighted aggregate methodology. The index value is the quotient of the weighted total available market capitalisation of the index's constituents at the valuation date (numerator) and the weighted total available market capitalisation of the index's constituents at the index base date of 2006, adjusted for changes to the constituents' share capital, including rights issues, share buybacks and spin-offs to ensure continuity in the index values (divisor). Essentially, the time-series of the divisor reflects the sum of the adjustments (S&P 2019). The weight assigned to each company in the index is proportional to that company's capitalisation (larger companies are assigned greater portfolio weighting). Being assigned a greater portfolio weighting results in having a greater impact on index values. Changes in the value of the index therefore reflect changes in the aggregate capitalisation of the index constituents as their share prices change rather than as their capitalisation changes.

3.1.2 Choice of Risk-Free Rate of Return

To derive the theoretical rate of return for a riskless asset two conditions are assumed – first, there is no risk of default, and second, reinvestment is permitted at the same rate. Under these two assumptions government bond yields are usually selected as the best proxy for a riskless asset within asset pricing models to derive the cost of equity capital (Mukherji 2019). Short-term government bond rates are arguably less risky than long-term government bonds (as there is a lower probability that interest rates will rise within a shorter time period). However, cash flow models for projects in the Australian gold industry are typically constructed to include discounting over a 10-year to 20-year time period. As such, the Australian Government 10-year bond price was used as a proxy for the risk-free rate of return (Rf) for the development of the dummy portfolio.

3.1.3 Implied XGD ex-post market risk-premium

The implied XGD historical (ex-post) market risk premium (Table 3-2 and Figure 3-1) was defined as the difference between the historical XGD arithmetic return (Jacquier, Kane et al. 2003) (equation E4-2) and the risk-free rate (R_f) calculated on a quarterly basis for the research period (equation E4-3), where the risk-free rate is calculated as the yield minus inflation.

$$Rmi = \frac{C_i - C_{i-1}}{C_{i-1}}$$

(E4-2)

where:

Rmi = arithmetic quarterly return

C_i = closing price on quarter, i

and

$$MP_i = R_{m_i} - R_{f_i}$$

(E4-3)

where:

MP_i = market risk premium (historical rather than expected)

Rmi = XGD return on quarter, i

Rfi = 10-year bond return on quarter, i.

The key observation made from the results of the implied XGD historical market risk premium calculations is that, in 17 out of the 30 quarterly periods assessed, the implied XGD historical market risk premium was negative (Rm-Rf<0). Of course, this calculation was undertaken using ex-post returns data rather than forecast (ex-ante) data as is required by the capital markets theory and its extensions such as the CAPM (Table 3-2 and Figure 3-1). While ex-post negative premia are mathematically possible, they challenge the most fundamental assertion of capital markets theory: that investors demand a premium on their return on investment for holding perceived risky securities (there is positive expected premium for β risk (Fama and French 1996). Investors would not want to hold the risky asset if its return is less than the risk-free return (Zhang and Wihlborg 2010).

Söderlind (2009) comments that, "there are several reasons to believe that moments of historical data can be quite poor approximations of investors' expectations". Söderlind cites work by Thaler (2000) and Giordani and Söderlind (2003) who found evidence to suggest that investors are poor at estimating the volatility (uncertainty) of the risk factors relating to equity returns. This may be due to distorted expectations such as investor overconfidence as noted in Hirschleifer (2001). Jacobsen and Zhang (2018) suggest that observed negative market risk premia are due to investors systematically seeking risk at these times. They reference Boudoukh, Richardson et al. (1993) who found that negative market risk premia are more likely to be observed when short-term government bond rates are high or when the term structure of interest rates is downward sloping (interest rates are expected to fall as short-term bond yield rates are higher than long-term bond yields, meaning that yields and maturities are negatively inverted).

Table 3-2: Implied XGD historical market risk premium

Date	10-year bond rate (Rf)	XGD Index Returns	Implied XGD Market Risk Premium
1/04/2010	5.11%	17.00%	11.89%
1/07/2010	4.99%	18.10%	13.12%
1/10/2010	5.52%	7.52%	2.01%
1/01/2011	5.51%	-3.56%	-9.07%
1/04/2011	5.24%	-8.21%	-13.45%
1/07/2011	4.25%	-6.65%	-10.90%
1/10/2011	3.80%	-10.69%	-14.49%
1/01/2012	4.08%	1.07%	-3.01%
1/04/2012	3.09%	-20.77%	-23.85%
1/07/2012	3.04%	27.77%	24.72%
1/10/2012	3.29%	-20.66%	-23.94%
1/01/2013	3.43%	-14.50%	-17.93%
1/04/2013	3.77%	-50.70%	-54.47%
1/07/2013	3.90%	26.15%	22.25%
1/10/2013	4.24%	-27.11%	-31.35%
1/01/2014	4.10%	17.21%	13.11%
1/04/2014	3.55%	2.19%	-1.35%
1/07/2014	3.48%	-7.51%	-10.99%
1/10/2014	2.83%	-2.65%	-5.48%
1/01/2015	2.33%	21.45%	19.12%
1/04/2015	2.99%	0.10%	-2.89%
1/07/2015	2.60%	1.68%	-0.92%
1/10/2015	2.89%	4.54%	1.65%
1/01/2016	2.49%	28.10%	25.61%
1/04/2016	2.01%	41.64%	39.63%
1/07/2016	1.97%	0.72%	-1.25%
1/10/2016	2.77%	-15.59%	-18.37%
1/01/2017	2.72%	7.96%	5.24%
1/04/2017	2.60%	-1.35%	-3.95%
1/07/2017	2.84%	0.41%	-2.43%
1/10/2017	2.66%	12.74%	10.08%

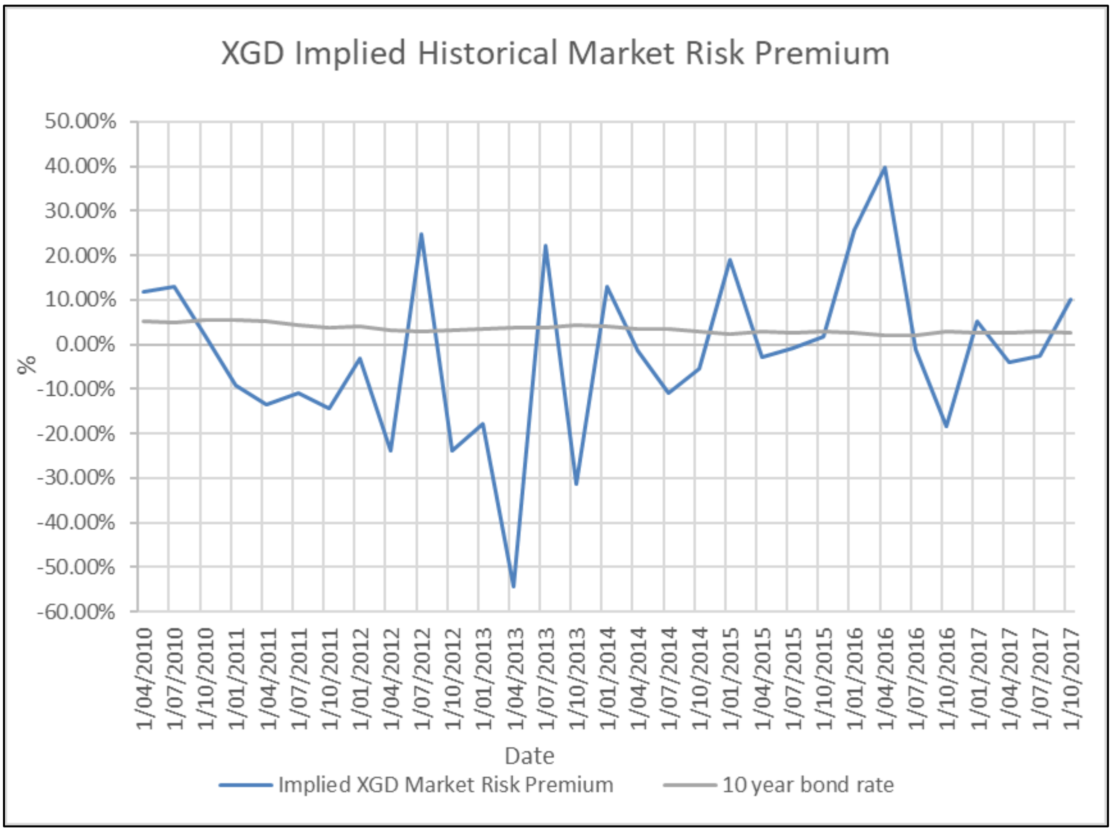


Figure 3-1: Implied XGD historical market risk premium

Encouraged by this conception, the yield curves for the Australian Government 2-year and 10-year bond yield rates were compared with the implied historical XGD market risk premium (Figure 3-2). The significant observation from an assessment of Figure 3-2 is that the historical XGD positive market risk premia are generally observed (A-A[1], C-C[1], D-D[1], E-E[1], F-F[1],G-G[1]) when the term structure is upward (short-term bond yield rates are lower than long-term bond yields, meaning that yields and maturities are positively inverted and interest rates are expected to rise). This observation is concordant with the findings of Boudoukh, Richardson et al. (1993). However, the term structure of the Australian Government bond yield rates (Figure 3-2) was upward in the period between September 2012 and October 2013 and the ex-post premia in this period were volatile. Both significantly negative (1, 2) and significantly positive (B-B[1]) premia were observed in this period, indicating a period of XGD market uncertainty. During this period, the gold price fell from A$1,707/oz to A$1,346/oz, implying a correlation between the term structure and the gold price (Gp-G1p) in this period (Figure 3-3). Although this is a research contribution a further assessment of the underlying data and a causality analysis is warranted before this can be considered to be significant. However, this finding is tangential to the research questions. As such, the finding will not be explored further in this thesis and provides a future research opportunity which is discussed in Chapter 6.

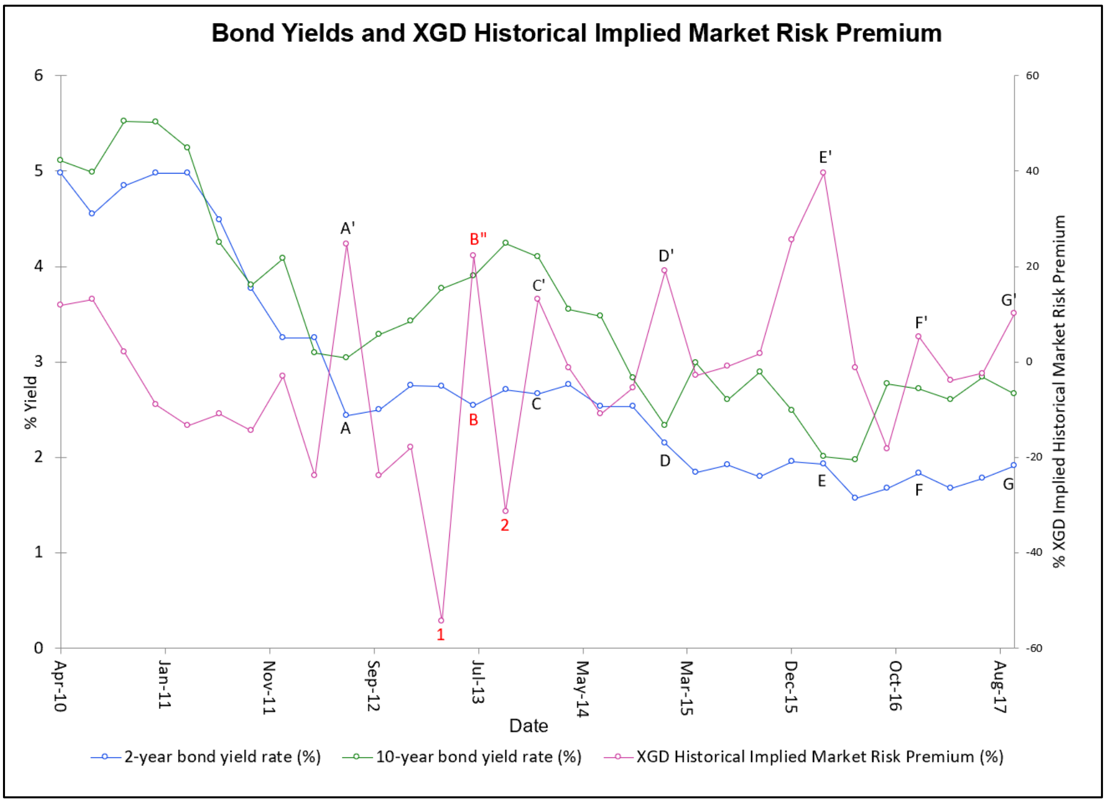


Figure 3-2: Implied XGD historical market risk premium and bond yields

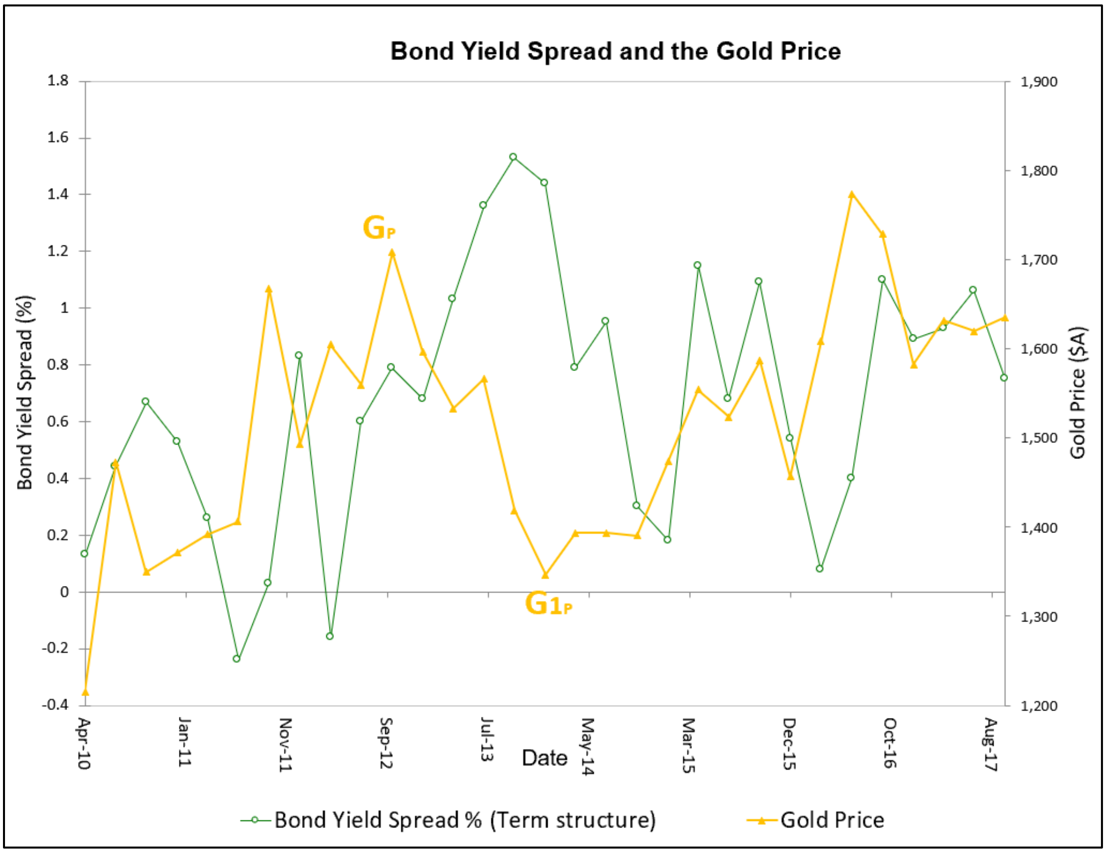


Figure 3-3: Australian Government Bond term structure and gold price history

3.1.4 Geopolitical Variables

Australian Government geopolitical time-series data for the study period were collected (Table 3-1) to allow the interconnectedness between the XGD market valuation, the gold price and these geopolitical (rational) factors to be analysed. Historical monthly (or quarterly where monthly data were unavailable) data were collected, and currency information was collected in Australian dollar terms (A$). An augmented Dickey-Fuller test (Dickey and Fuller 1979) was undertaken to check for stationarity (unit root). The test showed that the time-series data are non-stationary; that is, each series has means and variances that change over time following a random walk (stochastic process). To this end, stationary transformation of the non-stationary data was undertaken using Box-Cox log transformations (Box and Cox 1964) to reduce non-normality and eliminate the incorrectly specified regression modelling that would be achieved through conventional methods (Murray 1994). The Box-Cox log transformation stabilises the variance and eliminates heteroscedasticity in the time-series data by identifying an appropriate exponent (λ), and then uses this exponent to transform the data.

3.1.5 Co-integration tests of time-series variables

Co-integration tests were performed on the geopolitical and gold price data to test for variable redundancy. Table 3-3 provides the correlation matrix and Table 3-4 provides the multicollinearity statistics. Yoo, Mayberry et al. (2014) discuss the redundancy of data where collinearity exists; in their words, 'what a regressor explains about the response is overlapped by what another regressor or a set of other regressors explain'. They suggest that the commonly used cut-offs for collinearity are correlation coefficients between 0.7 and 0.9. The R^2, Tolerance and Variance Inflation Factor (VIF) for each geopolitical predictor variable (Figure 3-4 and Table 3-5) were calculated to allow a more informed decision to be made regarding which variables should be included for further analysis in accordance with the philosophy of O'brien (2007). Tolerance is described as $1 - R_i^2$, or the proportion of the variance of independent variable (i) that is not related to the other independent variables, where a tolerance of zero indicates linear dependence of (i) on the other independent variables. The VIF is the reciprocal of the tolerance, $\frac{1}{(1-R_i^2)}$, which postulates an indication of the effects of collinearity on the variance.

Table 3-3: Correlation matrix

Variable	GP	BB	GE	FX	IF	IN	CAB	FDI	CTI	GDP	CPI	RE	LC	EG	GD	EX
GP	**1.000**	-0.136	0.589	0.324	0.425	-0.027	0.051	0.194	-0.478	0.544	0.529	0.414	0.556	0.167	0.590	0.431
BB	-	**1.000**	-0.379	-0.175	-0.283	0.086	0.059	0.009	0.347	-0.354	-0.371	-0.418	-0.393	0.223	-0.388	-0.304
GE	0.589	-0.379	**1.000**	0.691	0.705	0.025	0.029	0.337	-0.856	0.931	0.880	0.829	0.882	-0.208	0.868	0.720
FX	0.324	-0.175	0.691	**1.000**	0.232	0.149	0.080	0.130	-0.832	0.660	0.766	0.794	0.759	-0.451	0.718	0.503
IF	0.425	-0.283	0.705	0.232	**1.000**	-0.035	0.185	0.556	-0.525	0.760	0.618	0.549	0.628	0.124	0.668	0.440
IN	-	0.086	0.025	0.149	-0.035	**1.000**	0.033	-0.330	-0.165	-0.012	0.109	0.081	0.099	-0.245	0.056	-0.018
CAB	0.051	0.059	0.029	0.080	0.185	0.033	**1.000**	0.073	-0.056	-0.033	0.063	-0.046	0.088	0.195	0.101	-0.523
FDI	0.194	0.009	0.337	0.130	0.556	-0.330	0.073	**1.000**	-0.235	0.427	0.308	0.336	0.307	0.071	0.340	0.194
CTI	-	0.347	-0.856	-0.832	-0.525	-0.165	-0.056	-0.235	**1.000**	-0.882	-0.961	-0.924	-0.963	0.391	-0.938	-0.687
GDP	0.544	-0.354	0.931	0.660	0.760	-0.012	-0.033	0.427	-0.882	**1.000**	0.933	0.885	0.929	-0.179	0.921	0.793
CPI	0.529	-0.371	0.880	0.766	0.618	0.109	0.063	0.308	-0.961	0.933	**1.000**	0.937	0.997	-0.278	0.987	0.728
RE	0.414	-0.418	0.829	0.794	0.549	0.081	-0.046	0.336	-0.924	0.885	0.937	**1.000**	0.933	-0.285	0.915	0.751
LC	0.556	-0.393	0.882	0.759	0.628	0.099	0.088	0.307	-0.963	0.929	0.997	0.933	**1.000**	-0.253	0.993	0.707
EG	0.167	0.223	-0.208	-0.451	0.124	-0.245	0.195	0.071	0.391	-0.179	-0.278	-0.285	-0.253	**1.000**	-0.192	-0.276
GD	0.590	-0.388	0.868	0.718	0.668	0.056	0.101	0.340	-0.938	0.921	0.987	0.915	0.993	-0.192	**1.000**	0.689
EX	0.431	-0.304	0.720	0.503	0.440	-0.018	-0.523	0.194	-0.687	0.793	0.728	0.751	0.707	-0.276	0.689	**1.000**

Table 3-4: Multicollinearity statistics

Statistic	GP	BB	GE	FX	IF	IN	CAB	FDI	CTI	GDP	CPI	RE	LC	EG	GD	EX
R^2	0.781	0.674	0.918	0.849	0.960	0.761	0.843	0.636	0.979	0.988	0.997	0.950	0.999	0.683	0.999	0.924
Tolerance	0.219	0.326	0.082	0.151	0.040	0.239	0.157	0.364	0.021	0.012	0.003	0.050	0.001	0.317	0.001	0.076
VIF	4.570	3.070	12.254	6.624	25.035	4.192	6.367	2.751	47.822	83.417	383.226	20.144	1571.940	3.158	839.118	13.104

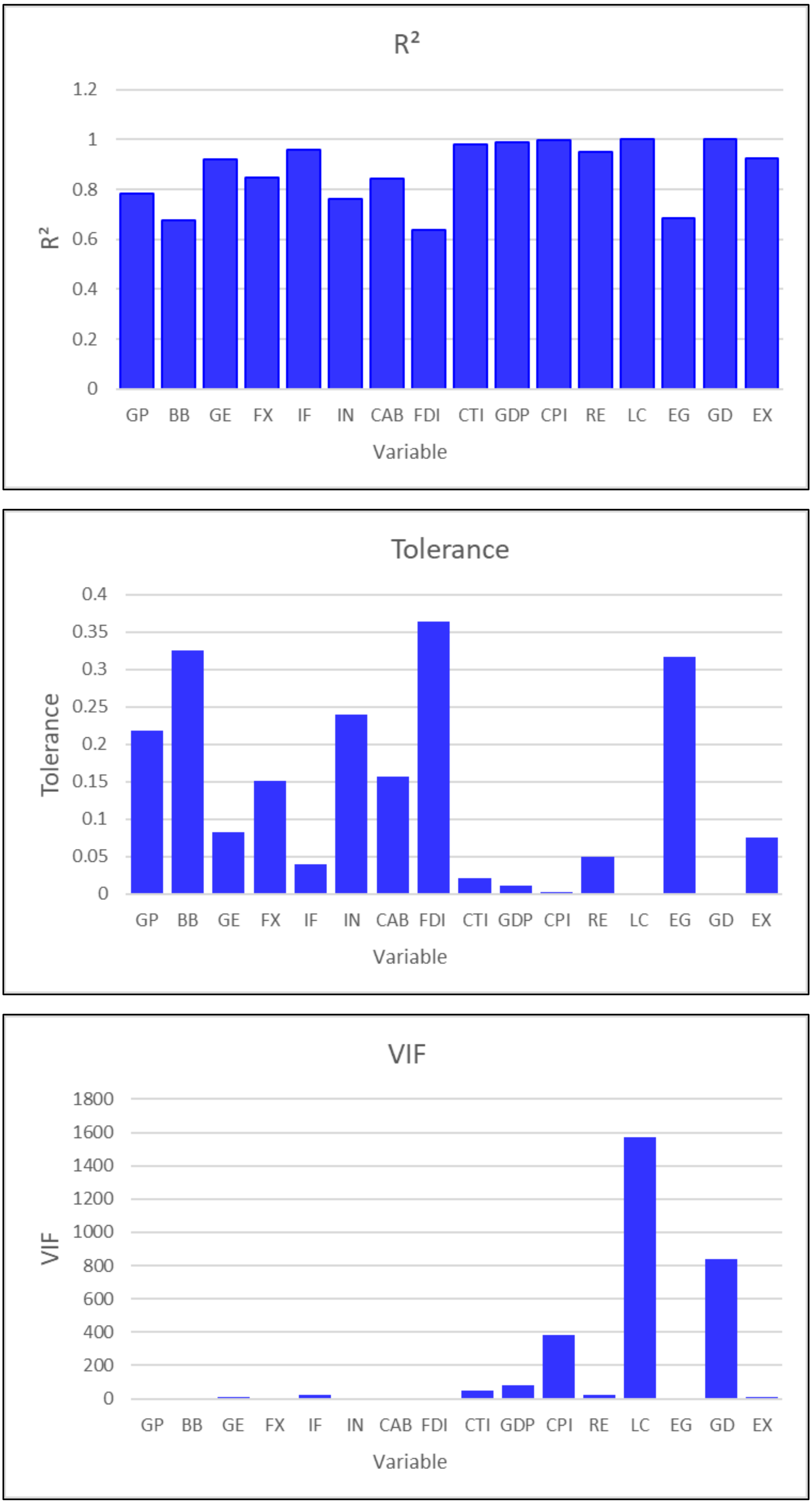


Figure 3-4: Computation of R2, Tolerance and VIF

O'brien (2007) discusses the existing academic debate on collinearity thresholds, including the use and misuse of 'rules of thumb'. O'Brien's research does not entertain further debate in this matter and, having considered the discussion, a VIF of 50 was selected as the exclusion threshold. Given this collinearity threshold exclusion criterion, the variables representing the historical time-series data for government expenditure, exports, foreign exchange reserves, GDP, CPI, government debt and labour costs were removed from the geopolitical dataset (Table 3-5).

Table 3-5: Computation of R^2, Tolerance and VIF

Variable	R^2	Tolerance	VIF	Interpretation
FDI	0.636	0.364	2.751	In
BB	0.674	0.326	3.070	In
EG	0.683	0.317	3.158	In
IN	0.761	0.239	4.192	In
GP	0.781	0.219	4.570	In
CAB	0.843	0.157	6.367	In
FX	0.849	0.151	6.624	In
GE	0.918	0.082	12.254	In
EX	0.924	0.076	13.104	In
RE	0.950	0.050	20.144	In
IF	0.960	0.040	25.035	In
CTI	0.979	0.021	47.822	In
GDP	0.988	0.012	83.417	Out
CPI	0.997	0.003	383.226	Out
GD	0.999	0.001	839.118	Out
LC	0.999	0.001	1571.940	Out

3.1.6 Geopolitical Factor Regression

A backward stepwise multiple regression analysis (MRA) was undertaken on the pared quarterly data (n=31), where the best fit regression model gives $R^2 = 0.753$ and Adjusted $R^2 = 0.706$ (where the Adjusted R^2 is an adjustment of R^2 based on the number of independent variables in the model). This suggests that approximately 75% of the variability in the XGD market index price over the research period can be explained by the independent predictor variables selected (Table 3-6).

Table 3-6: Best Fit model stepwise variables

Model ID	Number. of variables	Variables	Variable In/ Out	Status	MSE	R^2	Adjusted R^2
1	9	GP, GE, IF, FX, BB, EG, CAB, IN, FDI	n=9	In	0.069	0.771	0.677
2	8	GP, GE, IF, FX, BB, EG, CAB, IN	FDI	Out	0.066	0.770	0.690
3	7	GP, GE, IF, FX, BB, EG, CAB	IN	Out	0.064	0.767	0.699
4	6	GP, GE, IF, FX, BB, EG	CAB	Out	0.063	0.765	0.708
5	5	GP, GE, IF, FX, BB	EG	Out	0.063	0.753	0.706

The best fit model (Model ID 5) criterion is displayed in bold. Using the unstandardised and standardised beta coefficients given in Table 3-9Table 3-7 and Table 3-8, the equations of the XGD geopolitical factor regression model are given in equations E4-4. The unstandardised beta coefficients represent the slope of the correlation between the dependent XGD index value and the independent variable. This is the amount of change in the XGD index value due to a change in one unit of the independent variable. The standardised beta coefficients compare the strength of the effect of each of the independent variables to the XGD index value. The standardised beta coefficient refers to the number of standard deviations that the XGD index value will change for a single standard deviation change in the value of each independent variable. The model form is given in equation E4-4a. The unstandardised model is given in equation E4-4b, and the standardised model is given in equation E4-4c.

$$\hat{y} = b0 + b1\,(x1) + b2(x2) - \ b3(x3) - \ b4(x4) + b5(x5) + \varepsilon i$$

(E4-4a)

$$\widehat{XGD}_P \ = -5.05 + 1.960(GP) + 3.072(GE) - 4.580\ (IF) - 2.572(FX) + 0.241(BB) + \varepsilon \mathrm{i}$$

(E4-4b)

$$\widehat{XGD}_P \ = 0.367(GP) + 0.761(GE) - 0.982\ (IF) - 0.755(FX) + 0.341(BB) + \varepsilon i$$

(E4-4c)

Table 3-7: Unstandardised beta coefficients

Source	Beta coefficient	Standard error	t	P	Lower bound (95th Percentile)	Upper bound (95th Percentile)
Intercept	-0.505	4.231	-0.119	0.906	-9.203	8.193
GP	1.960	0.659	2.974	0.006	0.605	3.315
GE	3.072	0.991	3.101	0.005	1.036	5.109
IF	-4.580	0.741	-6.177	< 0.0001	-6.104	-3.056
FX	-2.572	0.542	-4.742	< 0.0001	-3.687	-1.457
FDI	0.000	0.000				
BB	0.241	0.076	3.177	0.004	0.085	0.397
CAB	0.000	0.000				
IN	0.000	0.000				
EG	0.000	0.000				

Table 3-8: Standardised beta coefficients

Source	Beta coefficient	Standard error	t	P	Lower bound (95th Percentile)	Upper bound (95th Percentile)
GP	0.367	0.123	2.974	0.006	0.113	0.620
GE	0.761	0.245	3.101	0.005	0.256	1.265
IF	-0.982	0.159	-6.177	< 0.0001	-1.309	-0.655
FX	-0.755	0.159	-4.742	< 0.0001	-1.082	-0.428
FDI	0.000	0.000				
BB	0.341	0.107	3.177	0.004	0.120	0.562
CAB	0.000	0.000				
IN	0.000	0.000				
EG	0.000	0.000				

The standardised model given in equation E4-4c implies that the Investment Factor (IF) has the strongest inverse relationship with the XGD market price and the A$ to US$ Exchange Rate (FX) has the second strongest inverse relationship.

3.1.7 Market sentiment classification

In recent years, volatility indices have been used as a measure of market or investor sentiment – a fear gauge where extreme readings indicate a forecast price reversal (Shaikh and Padhi 2015). Here, time-series data are used to analyse market sentiment using methods such as the Autoregressive Conditional Heteroscedasticity (ARCH) and Generalised ARCH (GARCH) modelling approaches, which both describe the error term on the variability of returns on a time-series period as a function of the error term on the previous period. An ARCH model is used when an autoregressive model for the error term is assumed and a GARCH model is used when an autoregressive moving average model is assumed for the error term.

In Australia, the S&P/ASX 200 volatility index (A-VIX) estimates the implied volatility of the S&P/ASX 200 index option prices with 30-day expiries by aggregating the weighted prices of the puts and calls over a wide range of strike prices (the mid-point of the bid-ask spread) in real time. A volatility index relating to the XGD has not, to the author's knowledge, been developed using a similar approach, although the methodology could be applied to any market index or investment portfolio.

Rao and Moseki (2009) advocate for a classification approach to the measurement of relative market sentiment rather than the traditional approach based on time-series. Here, the market is said to be in one of seven states – depressed, bearish, downward, tranquil, upward, bullish or bubble – according to the observed variance in returns for a given market in a specified sample period. This approach has been further discussed and accepted by Rao and Ramachandran (2014) and Rao and Moseki (2009). As the development of the valuation framework in this research is centred around the use of practical econometrics rather than quantitative finance or pure mathematical finance, a modified Rao and Moseki approach is used to create a sentiment variable for the XGD during the period covered by this research. The XGD daily market returns were used to inform the weekly return definition ($\bar{\boldsymbol{r}}_{\boldsymbol{w}}$). Substituting simple arithmetic returns for the logarithmic returns used by Rao and Moseki, the average arithmetic weekly returns (where $\boldsymbol{n}_{\boldsymbol{w}}$ represents the number of trading days in the week) are defined for each week as in equation E4-5.

$$\bar{r}_w = \frac{1}{n_w}\sum_{t=1}^{n_w} r_t$$

(E4-5)

The variance of the XGD for each weekly sample ($\boldsymbol{S}_{\boldsymbol{w}}^{\boldsymbol{2}}$) is defined as in equation E4-6.

$$S_w^2 = \frac{1}{(n_w - 1)}\sum_{t=1}^{n_w}(r_t - \bar{r}_w)^2$$

(E4-6)

As in Rao and Moseki, the market returns of the XGD come from a population with a finite mean and variance so that the Z statistic defines the classification rules as in equation E4-7.

$$Z = \frac{(\bar{r}_w - \mu)}{\sigma}\sqrt{n_w}$$

(E4-7)

where:

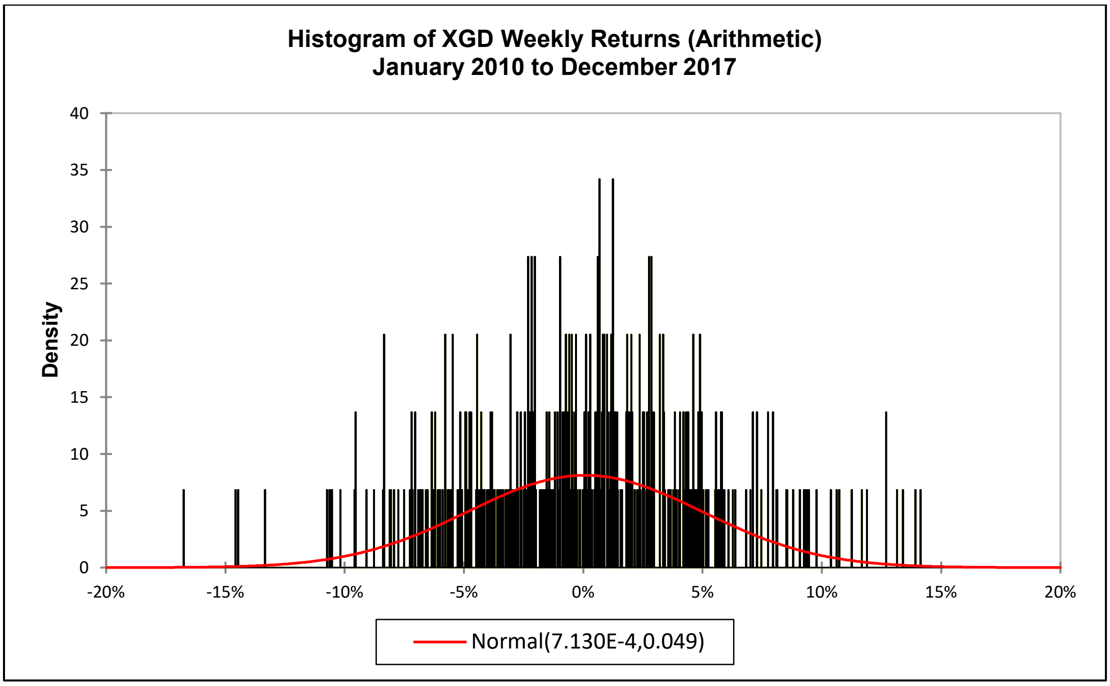
Z = Z-score

μ = population mean

σ = population standard deviation

r_t = trading day returns

The XGD market for the research period could then be classified as being in one of the seven states as defined by the Z score based upon its weekly returns. The XGD market arithmetic returns followed a normal Gaussian distribution around three standard deviations in accordance with the assumption for the Rao and Moseki model (Figure 3-5).



Observations	Minimum	Maximum	Mean	Standard deviation
364	-16.7%	14.1%	0.1%	0.49%

Figure 3-5: XGD arithmetic weekly returns during the research period

The seven classification states are defined by the equations in E4-8.

$$XGD_{s1} = \bar{r}_{w+1} < \hat{\mu} - 3\frac{\sigma}{\sqrt{n_w}}$$

$$XGD_{s2} = \hat{\mu} - 3\frac{\hat{\sigma}}{\sqrt{n_w}} \leq \bar{r}_{w+1} < \hat{\mu} - 2\frac{\hat{\sigma}}{\sqrt{n_w}}$$

$$XGD_{s3} = \hat{\mu} - 2\frac{\hat{\sigma}}{\sqrt{n_w}} \leq \bar{r}_{w+1} < \hat{\mu} - \frac{\hat{\sigma}}{\sqrt{n_w}}$$

$$XGD_{s4} = \hat{\mu} - \frac{\hat{\sigma}}{\sqrt{n_w}} \leq \bar{r}_{w+1} < \hat{\mu} + \frac{\hat{\sigma}}{\sqrt{n_w}}$$

$$XGD_{s5} = \hat{\mu} + \frac{\hat{\sigma}}{\sqrt{n_w}} \leq \bar{r}_{w+1} < \hat{\mu} + 2\frac{\hat{\sigma}}{\sqrt{n_w}}$$

$$XGD_{s6} = \hat{\mu} + 2\frac{\hat{\sigma}}{\sqrt{n_w}} \leq \bar{r}_{w+1} < \hat{\mu} + 2\frac{\hat{\sigma}}{\sqrt{n_w}}$$

$$XGD_{s7} = \bar{r}_{w+1} > \hat{\mu} + 3\frac{\hat{\sigma}}{\sqrt{n_w}}$$

(E4-8)

These classification states are described in Table 3-9 and Rao and Moseki (2009). The resulting XGD classification is presented in Table 3-10 and Figure 3-6.

Table 3-9: Rao and Moseki (2009) sentiment classification scheme

Class	Name	Criterion	Description
S1	Depressed/ fear sentiment	Week+1 returns are less than the mean returns minus three times the standard deviation divided by the square root of the number of trading days in the week.	The equity index witnesses a sharp fall, enough to cause panic to a seller holding stocks. This may lead to distress selling and shatter investor confidence. This sentiment may also lead to eventual bankruptcy or consolidation or regulatory intervention. Raising funds from the capital market may be extremely difficult.
S2	Bearish sentiment	The mean returns minus three times the standard deviation divided by the square root of the number of trading days in the week are less than or equal to week+1 returns and less than the mean returns minus two times the standard deviation divided by the square root of the number of trading days in the week.	The equity index witnesses a significant downward trend, enough to cause frustration to a seller holding stocks. This may lead to an offloading exercise of stocks and undermine investor confidence. Raising funds from the capital market may be adversely affected.
S3	Downward sentiment	The mean returns minus 2 multiplied by the standard deviation divided by the square root of the number of trading days in the week are less than or equal to week+1 returns and less than the mean returns minus the standard deviation divided by the square root of the number of trading days in the week.	The equity index witnesses a gradual fall, enough to sound a warning to an investor. This may lead to an offloading exercise of stocks and may dent investor confidence. Sustained attempts may be needed to raise funds from the capital market.
S4	Tranquil sentiment	The mean returns minus the standard deviation divided by the square root of the number of trading days in the week are less than or equal to week+1 returns and less than the mean returns plus the standard deviation divided by the square root of the number of trading days in the week.	The equity index witnesses normal swings. The investor continues to be an active player in the stock market. This state may also be called 'range bound' or 'uncertain'.
S5	Upward sentiment	The mean returns plus the standard deviation divided by the square root of the number of trading days in the week are less than or equal to week+1 returns and less than the mean returns plus two times standard deviation divided by the square root of the number of trading days in the week.	The equity index witnesses a gradual upward swing, enough to cause a feeling of encouragement to an investor. The environment for fund raising may be encouraging.
S6	Bullish sentiment	The mean returns plus two times the standard deviation multiplied by the square root of the number of trading days in the week are less than or equal to week+1 returns and less than the mean returns plus three times standard deviation divided by the square root of the number of trading days in the week.	The equity index witnesses a significant upward swing, propelling speculation by a seller holding stocks. Raising funds from the capital market may be easy.
S7	Greed/ bubble sentiment	Week+1 returns are greater than the mean returns plus three times the standard deviation divided by the square root of the number of trading days in the week.	The equity index witnesses a sharp rise, enough to prompt a seller either to dispose of their load or to hold on in the hope of further appreciation leading to a bubble-like condition. This state assures the seller of massive gains for having waited. Raising funds from the capital market may be spontaneous.

Table 3-10: Weekly XGD sentiment classification

	2011	2012	2013	2014	2015	2016	2017
Week 1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Week 2	4	6	5	6	7	3	4
Week 3	2	4	4	5	6	5	5
Week 4	3	6	4	4	3	4	3
Week 5	5	4	4	6	6	7	6
Week 6	4	4	2	7	4	7	5
Week 7	5	4	1	4	4	4	5
Week 8	4	5	4	4	5	7	4
Week 9	5	3	4	6	1	4	1
Week 10	2	3	4	4	1	4	3
Week 11	4	3	4	1	5	4	7
Week 12	6	2	1	1	5	1	4
Week 13	5	4	1	4	4	5	4
Week 14	6	2	5	7	4	6	7
Week 15	3	5	1	2	4	4	4
Week 16	4	3	5	4	4	5	2
Week 17	3	2	1	3	4	6	1
Week 18	2	4	7	4	3	6	3
Week 19	3	3	1	4	6	6	6
Week 20	4	2	4	3	4	2	4
Week 21	4	4	4	2	4	3	4
Week 22	4	4	1	4	3	4	4
Week 23	3	5	2	5	4	7	5
Week 24	3	4	1	7	4	4	4
Week 25	4	2	1	4	3	6	4
Week 26	5	4	7	5	3	5	3
Week 27	5	6	7	6	4	7	3
Week 28	5	1	2	4	5	3	4
Week 29	4	5	7	2	1	3	4
Week 30	3	5	2	4	4	5	4
Week 31	3	4	3	5	3	5	5
Week 32	5	5	7	4	4	3	6
Week 33	4	5	6	3	7	3	4
Week 34	4	7	4	4	2	2	4
Week 35	4	1	2	1	4	2	6
Week 36	5	6	2	4	4	4	4
Week 37	3	7	7	2	7	3	2
Week 38	1	5	1	4	4	6	3
Week 39	2	4	3	3	4	4	4
Week 40	5	4	2	2	7	1	4
Week 41	4	3	4	4	7	4	5
Week 42	1	4	6	4	2	6	4
Week 43	5	2	1	1	1	3	4
Week 44	4	4	3	1	3	7	5
Week 45	5	4	4	5	2	2	4
Week 46	3	1	1	6	5	1	4
Week 47	2	5	2	5	3	3	4
Week 48	7	4	2	4	4	3	4
Week 49	2	2	6	5	6	4	3
Week 50	2	4	4	4	5	1	4
Week 51	4	1	4	4	5	6	5
Week 52	2	4	7	7	4	7	5

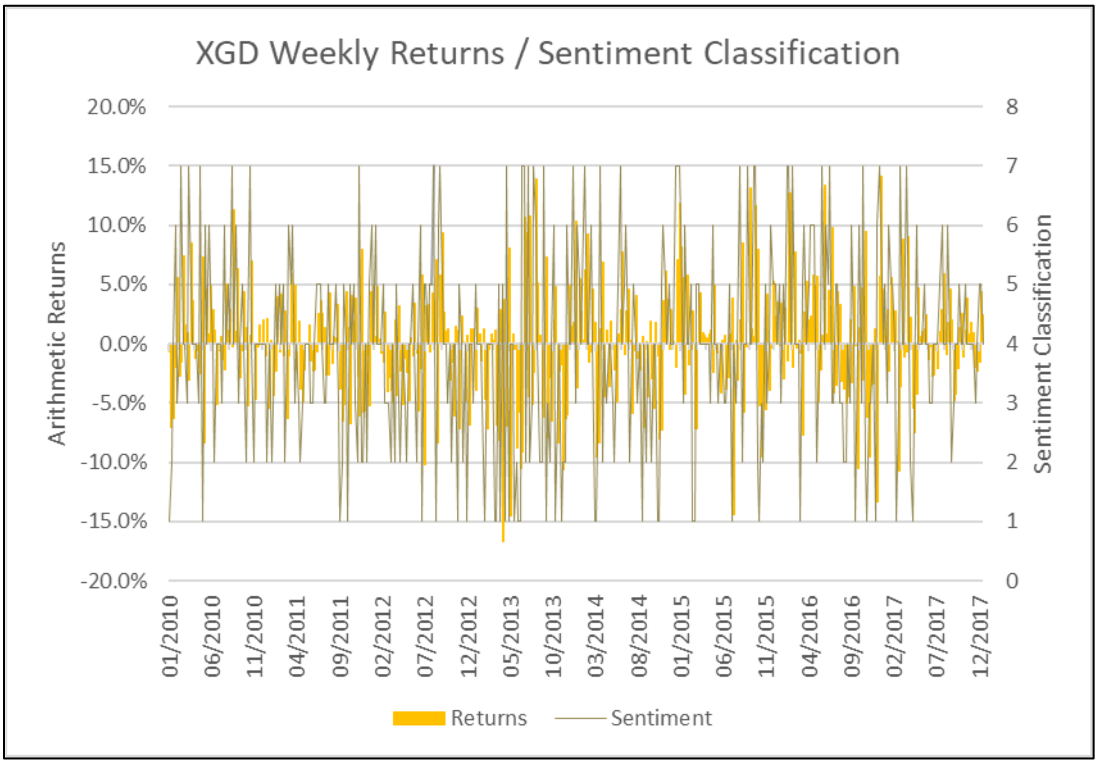


Figure 3-6: XGD weekly market returns and sentiment classification

Given the time-series geopolitical data are based on quarterly data, the modified Rao and Moseki classification was also applied on a quarterly basis, where arithmetic average quarterly returns on the XGD (where $\boldsymbol{n_q}$ represents the number of trading days in the quarter) were defined as in equation E4-9.

$$\bar{r}_q = \frac{1}{n_q}\sum_{t=1}^{n_q} r_i$$

(E4-9)

The quarterly market for the study period was then classified (Table 3-11 and Figure 3-7) as being in one of the seven states described earlier in equation E4-8. This classification represents the trailing quarterly XGD market sentiment and will be used to inform the quantitative modelling presented in Chapter 4.2 of this thesis.

Table 3-11: Quarterly XGD sentiment classification

	2011	2012	2013	2014	2015	2016	2017
Quarter 1	1	1	1	5	4	7	2
Quarter 2	2	7	5	1	7	1	6
Quarter 3	1	5	1	7	4	4	7
Quarter 4	4	5	7	7	7	6	5

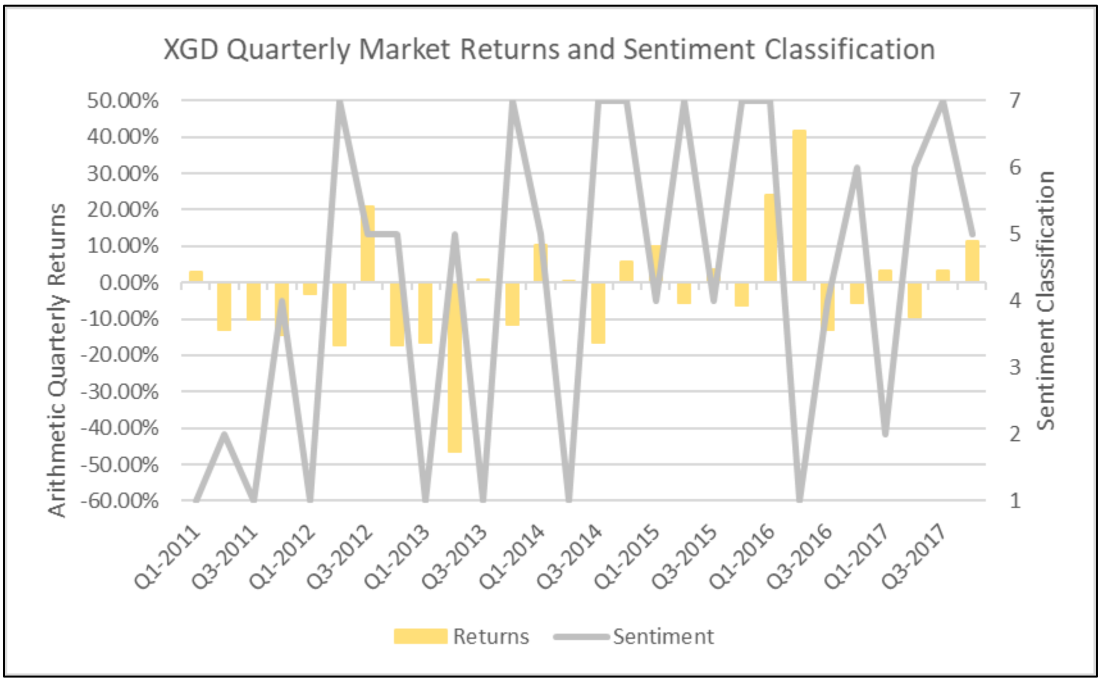


Figure 3-7: XGD quarterly market returns and sentiment classification

3.2 Training Portfolio development

The historical XGD returns and the market valuation of the XGD were derived previously. Additionally, the geopolitical factors contributing to the variability in the XGD market valuation were determined. The weekly and quarterly market sentiment for the research period were then classified using a modified Rao and Moseki (2009) methodology on the periodic XGD market returns. These data relate to the historical XGD market valuation within the Dummy Portfolio. The analytical challenge is to derive a model to explain the market factors (independent systematic variables) contributing to the valuation of gold projects. This work is guided and informed by the results and findings of the XGD market valuation analysis and an assessment of the historical transaction data in the Training Portfolio. Iterative, scenario-based experimental modelling is undertaken on the Training Portfolio to further identify significant relationships and answer the first of the research questions: Are there identifiable market factors associated with gold project transactions on the ASX and how are these factors related?

3.2.1 Transaction selection

To eliminate selection bias, data were collected from all gold project transactions (N=273) listed on the subscription-based S&P Global Market Intelligence Platform database for the period January 2011 to October 2017. Transactions that did not involve gold-only Australian projects transacted by a company listed on the ASX were excluded so that n=170. The following transactions were also excluded:

- Transactions involving farm-in arrangements, where the present value of the transaction at the transaction completion date could not be calculated with confidence because of a lack of transparency on contingent payments;
- Transactions where the only compensation was to a state government mining department for a previously vacant, expired or surrendered title; and
- Transactions deemed not to have been undertaken on an arm's length basis and between related parties.

Further manual validation was undertaken so that the total number of transactions in the training set was reduced to 100 (Table 3-12).

Table 3-12: Transaction selection

Dataset	Metric	Number	Comment
All transactions	All transactions	273	Total number of transactions
	Buyer listed on ASX	170	Used in analysis
	Buyer not listed on ASX	103	Not used in analysis
	Buyer listed on ASX	170	Total number of transactions
ASX listed buyers	Invalid after QAQC check	70	In specie, not arm's length or other
	Valid after QAQC check	100	Transactions valid for use in analysis

3.2.2 Categorical assignment

Each transaction was categorically assigned using the VALMIN Code (2015) guideline (Table 3-13 and Table 3-14) to assess the maturity level of each project in the Training Portfolio. Descriptive statistics were then generated for the training portfolio (Table 3-15).

Table 3-13: VALMIN Code (2015) Project maturity classification

Classification	Description
Early-Stage Exploration Projects	Tenure holdings where mineralisation may or may not have been identified, but where Mineral Resources have not been identified.
Advanced Exploration Projects	Tenure holdings where considerable exploration has been undertaken and specific targets identified that warrant further detailed evaluation, usually by drill testing, trenching or some other form of detailed geological sampling. A Mineral Resource estimate may or may not have been made, but sufficient work will have been undertaken on at least one prospect to provide both a good understanding of the type of mineralisation present and encouragement that further work will elevate one or more of the prospects to the Mineral Resources category.
Pre-Development Projects	Tenure holdings where Mineral Resources have been identified and their extent estimated (possibly incompletely), but where a decision to proceed with development has not been made. Properties at the early assessment stage, properties for which a decision has been made not to proceed with development, properties on care and maintenance and properties held on retention titles are included in this category if Mineral Resources have been identified, even if no further work is being undertaken.
Development Projects	Tenure holdings for which a decision has been made to proceed with construction or production or both, but which are not yet commissioned or operating at design levels. Economic viability of Development Projects will be proven by at least a Pre-Feasibility Study.
Production Projects	Tenure holdings – particularly mines, wellfields and processing plants – that have been commissioned and are in production.

Table 3-14: Categorical assignment

Assigned VALMIN Code Class	Count (n)	Valuation Multiple
Early-Stage Exploration Projects	30	Land Area
Advanced Exploration Projects	17	Resource or Reserve Estimates
Pre-Development Projects	37	Resource or Reserve Estimates
Development Projects	0	Resource or Reserve Estimates
Production Projects	16	Resource or Reserve Estimates

Table 3-15: Arithmetic descriptive statistics

Statistical analysis	Transaction Value (A$)	Area Multiple (A$/km^2)	
Categorical Variable: Early-Stage Exploration Transactions (n=30)			
Minimum	0.95	2,103.99	
Median	138,000.00	3,404.76	
Mean	776,391.50	12,990.61	
Maximum	3,699,896.40	80,000.00	
Standard Deviation	1,149,874.27	21,929.68	
Categorical Variable: Advanced Exploration Stage Transactions (n=17)			
Minimum	75,000.00	1.41	0.89
Median	1,450,000.00	4.81	4.42
Mean	18,576,025.54	10.63	62.57
Maximum	225,000,000.00	50.35	548.71
Standard Deviation	59,602,582.39	14.76	149.57
Categorical Variable: Pre-Development Stage Transactions (n=37)			
Minimum	175,000	0.71	0.71
Median	4,050,197	10.23	10.32
Mean	11,883,624	54.18	53.95
Maximum	150,000,321	1,176.17	1,153.41
Standard Deviation	26,117,679	199.07	195.12
Categorical Variable: Development Stage Transactions (n=0)			
Categorical Variable: Production Stage Transactions (n=16)			
Minimum	120,000	1.61	3.12
Median	15,460,000	38.34	51.66
Mean	72,279,233	55.14	2,774.59
Maximum	745,195,000	161.28	40,715.47
Standard Deviation	181,622,181	55.85	10,140.27

3.2.3 Outlier testing

A simple OLS regression analysis (Figure 3-8A) was undertaken for all transaction values where Mineral Resources were reported against the deposit size (number of reported ounces acquired) to test for the presence of outlier observations (n = 60, Adjusted R^2 = 0.324). A visual analysis of the residuals' plot (Figure 3-8B) and a Cook's distance test (Figure 3-8C) indicated that some observations (n=4) were likely to be outlier observations, and this was confirmed using the Dixon test (Figure 3-8D). These outlier observations (z >2, n=4) were flagged for future analysis.

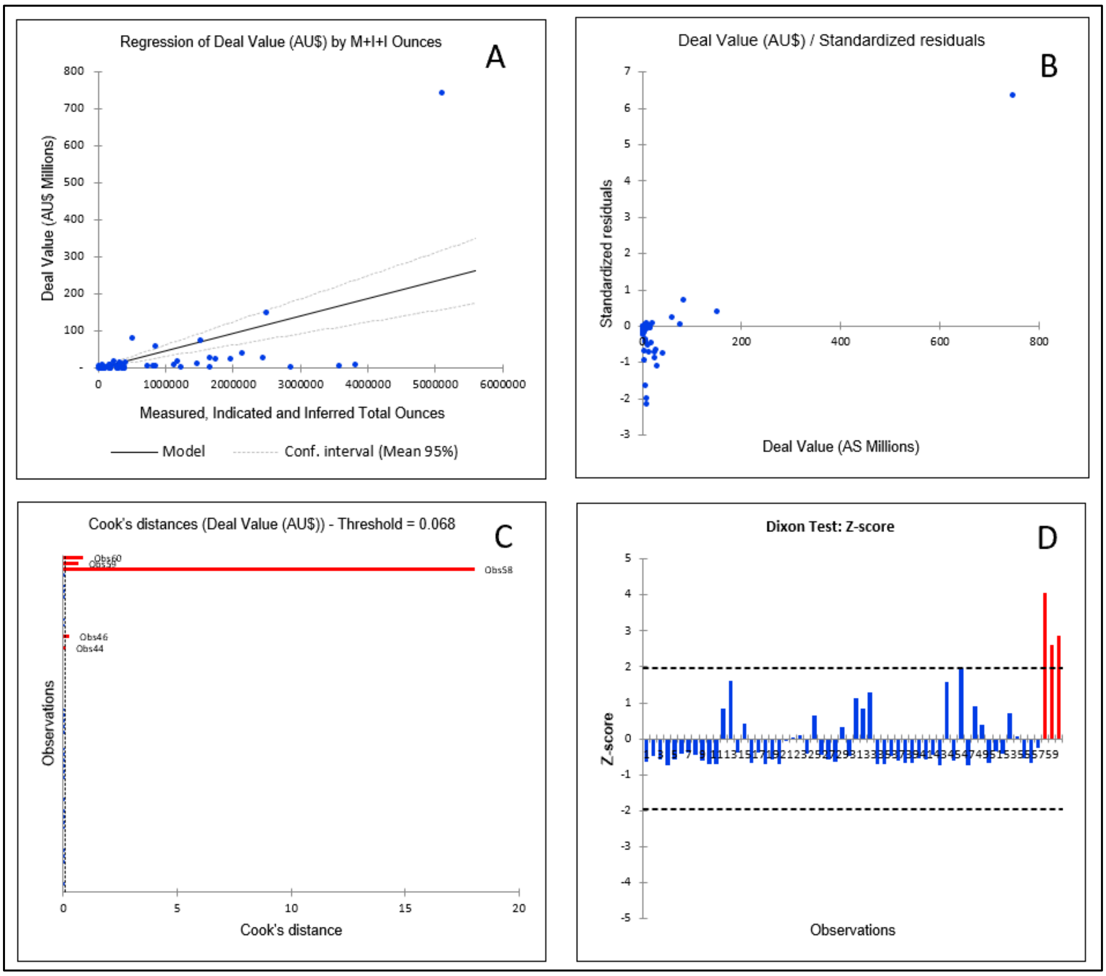


Figure 3-8: OLS regression and outlier identification tests

3.2.4 Experimental modelling

It has been established (Section 4.1.4) that the variability in the XGD market valuation has a significant relationship to the gold price and the systematic market factors of government expenditure, the investment factor, the foreign exchange reserves, the cash target interest rate and the Australian dollar to United States dollar exchange rate. The relationship between these factors, additional idiosyncratic (unsystematic) factors and the market valuation of the gold projects in the Training Portfolio was tested using regression analysis to develop a pricing model.

Technical Value assignment

The focus of this research is to assess the market component of gold project transaction values and to address the research questions that relate to the quantification of the market premium – it is not to enter the long-standing debate on how to assess Technical Value. As such, each transaction in the Training Portfolio was allocated a unique but controlled Technical Value. A Technical Value was approximated for each transaction using the contained value of acquired gold (number of ounces multiplied by the spot gold metal price (Perth Mint closing price at the transaction date)), and then multiplied by a yardstick factor (modified from Lawrence 1994). These yardstick factors are based on the VALMIN Code Classifications and

Mineral Resource Classifications presented in Table 3-16.

Table 3-16: Yardstick factors applied to assign Technical Value

VALMIN Class	Measured (2-5%*)	Indicated (1-2%*)	Inferred (0.5-1%*)
Advanced Exploration	2.00%	1.00%	0.50%
Pre-Development	3.00%	1.33%	0.67%
Development	4.00%	1.66%	0.83%
Production	5.00%	2.00%	1.00%

*Calculated as a percentage of the spot gold price (Perth Mint) at the transaction close date

Using the reported realised transaction price and assigned Technical Value, test premia were derived for each transaction in the Training Portfolio (Table 3-17). The test premia reflect the percentage difference between the Technical value and the Realised Transaction Value. It is not suggested by this derivation that the test premia reflect the market risk premium; it is simply an observed value to be used in experimental relationship modelling.

Table 3-17: Test premia for each transaction in the Training Portfolio

Transaction Identification	VALMIN Class	Technical Value (A$)	Realised Transaction Value (A$)	Test premium or discount (%)
3	Advanced Exploration	12,081	75,000	621
5	Advanced Exploration	237,717	4,500,000	1,893
7	Advanced Exploration	563,932	919,132	163
18	Advanced Exploration	2,188,159	1,866,200	-85
20	Advanced Exploration	2,129,461	300,000	-14
23	Advanced Exploration	1,840,960	350,000	-19
28	Advanced Exploration	959,912	441,000	-46
31	Advanced Exploration	6,096,227	1,450,000	-24
34	Advanced Exploration	6,904,164	1,500,000	-22
37	Advanced Exploration	6,372,458	1,750,000	-27
50	Advanced Exploration	20,933,098	3,250,000	-16
3	Advanced Exploration	12,081	75,000	621
1	Pre-Development	103,960	5,900,000	5,675
4	Pre-Development	371,552	580,000	156
6	Pre-Development	362,018	198,540	-55
8	Pre-Development	815,637	175,000	-21
9	Pre-Development	210,455	1,256,064	597
12	Pre-Development	174,136	229,306	132
13	Pre-Development	1,497,517	2,500,000	167
14	Pre-Development	1,644,809	2,904,900	177

Transaction Identification	VALMIN Class	Technical Value (A$)	Realised Transaction Value (A$)	Test premium or discount (%)
15	Pre-Development	2,126,951	870,000	-41
17	Pre-Development	1,467,627	4,050,197	276
19	Pre-Development	3,428,167	10,125,150	295
21	Pre-Development	1,202,126	850,000	-71
22	Pre-Development	112,493	1,500,000	1,333
24	Pre-Development	3,370,815	8,000,000	237
25	Pre-Development	4,194,918	7,800,000	186
27	Pre-Development	4,932,974	7,500,000	152
29	Pre-Development	6,281,903	3,000,000	-48
30	Pre-Development	3,236,593	2,578,000	-80
32	Pre-Development	4,617,078	15,221,360	330
35	Pre-Development	6,600,693	3,000,000	-45
36	Pre-Development	6,000,838	1,500,000	-25
38	Pre-Development	2,016,825	275,000	-14
40	Pre-Development	9,440,130	4,957,160	-53
41	Pre-Development	5,269,771	5,847,000	111
43	Pre-Development	2,588,000	6,200,000	240
44	Pre-Development	900,776	10,235,000	1,136
46	Pre-Development	41,751,744	3,500,000	-8
47	Pre-Development	12,374,273	12,471,200	101
49	Pre-Development	30,321,727	27,280,000	-90
52	Pre-Development	39,428,989	23,760,000	-60
53	Pre-Development	36,652,543	40,000,377	109
54	Pre-Development	38,398,039	27,895,028	-73
2	Production	454	120,000	26,439
10	Production	168,213	9,000,000	5,350
11	Production	1,272,889	1,539,000	121
26	Production	216,074	18,850,000	8,724
33	Production	272,421	14,094,360	5,174
39	Production	6,372,043	15,460,000	243
42	Production	17,462,099	60,000,000	344
45	Production	20,013,821	17,720,000	-89
48	Production	40,632,094	74,999,912	185
51	Production	25,103,575	25,000,268	100
55	Production	42,794,338	4,600,270	-11
56	Production	53,870,800	7,699,784	-14
57	Production	43,218,947	8,313,000	-19

Regression Analysis Scenario Modelling

The assignment of Technical Value explicitly excludes any premium or discount for market considerations, though it does consider an assessment of a Mineral Asset's future net economic benefit (VALMIN 2015). For the purpose of this study the test premia will reflect not only the market considerations but also the marketeers' willingness-to-pay (WTP) for the implied future earnings and risk-reward profile of the unsystematic risk component of the project's value (risk preference under the willing buyer-willing seller assumption). Here, the traditional assumption that the unsystematic risk component of valuation is diversified away in a limitless market using the law of large numbers does not hold in a single asset portfolio or in a portfolio with a limited number of securities or where the return on the various portfolio securities are positively correlated. Each transaction in the Training Portfolio was then coded for the dependent variable 'realised transaction value (TR_v)' and for the independent variables presented in Table 3-18. Further detail is given in Appendix A.

Table 3-18: Training Portfolio regression analysis variable coding

Variable Type	Variable Code	Variable Description
Dependent	TR_v	Realised transaction value
Independent	TE_v	Implied technical value ($AUD)
Independent	MR_g	Average Mineral Resource Grade acquired (g/t)
Independent	MR_o	Number of Mineral Resource ounces acquired
Independent	R_{OR}	Ore Reserve reported (Yes=1, No=0)
Independent	V_{AE}	Advanced Exploration VALMIN Class
	V_{PD}	Pre-Development VALMIN Class
	V_{PN}	Production VALMIN Class
Independent	S_1	Prevailing XGD Sentiment Class 1 (depressed/fear)
	S_2	Prevailing XGD Sentiment Class 2 (bearish)
	S_3	Prevailing XGD Sentiment Class 3 (downward)
	S_4	Prevailing XGD Sentiment Class 4 (tranquil)
	S_5	Prevailing XGD Sentiment Class 5 (upward)
	S_6	Prevailing XGD Sentiment Class 6 (bullish)
	S_7	Prevailing XGD Sentiment Class 7 (greed/bubble)

Given that the VALMIN Code classification and XGD sentiment classification are categorical ordered polytomous variables, disjunctive tables were created for these factors to allow them to be coded as dummy variables (using the *n-1* rule) for use in regression analysis and also uniquely coded as qualitative variables for use in Analysis of Variance (ANOVA) testing to develop a model to predict TR_v in the form:

$$E(\gamma) = \beta 0 + \beta 1\ (X1) + \beta 2(X2) + \beta 3(X3) \ldots \beta n(Xn) \ldots + \varepsilon i$$

(E4-10)

First, the relationship between TE_v and TR_v was tested using OLS linear regression (Scenario 1). A probability value (p) below 0.05 is taken to be indicative of statistical significance. For n=56, the regression indicates that approximately 27% of the variability in TR_v is explained by TE_v, where the standardised beta ($\beta 1$) coefficient for TE_v is 0.519 and the unstandardised beta co-efficient (model parameter) (b_1) for TE_v is 0.502. Given the p-value (<0.001) of the F statistic computed in the ANOVA table, the information derived from the TR_v is significantly better than would be derived from a basic γ mean. Using unstandardised beta coefficients given in Table 3-19, the equation of the model is given in equation E4-11.

$$\hat{\gamma} = b_0 + b_1(x_1) + \varepsilon i$$

where:

$$\widehat{TR}_v = 4094295.905 + 0.502(TE_v) + \varepsilon i$$

(E4-11)

Table 3-19: Unstandardised beta coefficients – Scenario1

Source	Value	Standard error	t	P	Lower bound (95th percentile)	Upper bound (95th percentile)
Intercept	4094295.905	2003472.367	2.044	0.046	77575.651	8111016.159
TE_v	0.502	0.113	4.458	< 0.0001	0.276	0.727

Next, the explanatory power of the VALMIN Code classification on TR_v was considered as Scenario 2. Here, V_{AE} was used as the control dummy variable. For n=56, the regression indicates that approximately 35% of the variability in TR_v is explained by TE_v and the VALMIN Code classification (model P<0.001). The variable, V_{PN} (VALMIN Code production class) brings additional significant information (V_{PN} p 0.02) to explain the variability in TR_v. The variables V_{AE} (VALMIN Code Advanced Exploration Class and dummy intercept) and V_{PD} do not provide significant information to explain the variability in TR_v. Using unstandardised beta coefficients given in Table 3-20, the equation of the model is given in E4-12.

$$\hat{\gamma} = b_0 + b_1(x_1) + b_2(x_2) + b_3(x_3) + \varepsilon i$$

where:

$$\widehat{TR}_v = -258863 + 0.399(TE_v) + 4435819.155(V_{PD}) + 12341900.168(V_{PR}) + \varepsilon i$$

(E4-12)

Table 3-20: Unstandardised beta coefficients – Scenario 2

Source	Value	Standard error	t	P	Lower bound (95th percentile)	Upper bound (95th percentile)
Intercept	-258,864	3608347.713	-0.072	0.943	-7499543.394	6981815.427
TE_v	0.399	0.116	3.430	0.001	0.166	0.632
V_{PD}	4435819.155	4168321.755	1.064	0.292	-3928530.376	12800168.687
V_{PN}	12341900.168	5155846.467	2.394	0.020	1995937.328	22687863.007

The equation for each VALMIN Code Class under Scenario 2 is given in Table 3-21.

Table 3-21: Scenario 2 Model

VALMIN Code Class	Equation of the model
Advanced Exploration	$\hat{y} = b_0 + b_1(x_1) + \varepsilon i$
Pre-Development	$\hat{y} = (b_0 + b_2(x_2)) + b_1(x_1) + \varepsilon i$
Production	$\hat{y} = (b_0 + b_3(x_3)) + b_1(x_1) + \varepsilon i$

Next, the number of ounces of gold acquired in the transaction was considered as a third explanatory variable on TR_v. (Scenario 3). For n=56, the regression indicates that approximately 45% of the variability in TR_v is explained by TE_v, the VALMIN Code classification and the number of ounces acquired in the transaction (model p <0.001, MR_o p 0.003). Using unstandardised beta coefficients given in Table 3-22, the equation of the model is given in E4-13.

$$\hat{y} = b_0 + b_1(x_1) + b_2(x_2) + b_3(x_3) + b_4(x_4) + \varepsilon i$$

where:

$$\widehat{TR}_v = 602673.123 + 1.302(TE_v) + 3468369.636(V_{PD}) + 13472607.090(V_{PR}) + 13472607.090(V_{PR}) - 15.674(MR_o) + \varepsilon i$$

(E4-13)

Table 3-22: Unstandardised beta coefficients – Scenario 3

Source	Value	Standard error	t	P	Lower bound (95th percentile)	Upper bound (95th percentile)
Intercept	602673.123	3354902.943	0.180	0.858	-6132575.577	7337921.823
$\boldsymbol{TE_v}$	1.302	0.311	4.185	0.000	0.677	1.926
$\boldsymbol{V_{PD}}$	3468369.636	3874810.007	0.895	0.375	-4310636.048	11247375.320
$\boldsymbol{V_{PN}}$	13472607.090	4791125.142	2.812	0.007	3854022.013	23091192.167
$\boldsymbol{MR_o}$	-15.674	5.066	-3.094	0.003	-25.845	-5.503

The equation for each VALMIN Code Class under Scenario 3 is given in Table 3-23.

Table 3-23: Standardised beta coefficients – Scenario 3

VALMIN Code Class	Equation of the model
Advanced Exploration	$\hat{\boldsymbol{\gamma}} = \boldsymbol{b_0} + \boldsymbol{b_1}(\boldsymbol{x_1}) + \boldsymbol{b_4}(\boldsymbol{x_4}) + \boldsymbol{\varepsilon i}$
Pre-Development	$\hat{\boldsymbol{\gamma}} = (\boldsymbol{b_0} + \boldsymbol{b_2}(\boldsymbol{x_2})) + \boldsymbol{b_1}(\boldsymbol{x_1}) + \boldsymbol{b_4}(\boldsymbol{x_4}) + \boldsymbol{\varepsilon i}$
Production	$\hat{\boldsymbol{\gamma}} = (\boldsymbol{b_0} + \boldsymbol{b_3}(\boldsymbol{x_3})) + \boldsymbol{b_1}(\boldsymbol{x_1}) + \boldsymbol{b_4}(\boldsymbol{x_4}) + \boldsymbol{\varepsilon i}$

The average resource grade (in grams per tonne) acquired in the transaction was considered as the fourth explanatory variable on TR_v. (Scenario 4). For n=56, the regression indicates that the variable MR_g does not bring additional significant information (p 0.771) to the variability in TR_v. Further, the addition of the variable, MR_g, shows that the goodness of fit statistics on the P<0.001 model (Table 3-24) are reduced. The predicted residual error sum of squares (PRESS) statistic is approximately 8% higher when the variable MR_g is added. As such, the variable MR_g was not included in the model.

Table 3-24: Goodness of fit statistics –Scenario 3 and Scenario 4 comparison

Item	Value without MRg	Value with MRg
Observations	56.000	56.000
DF	51.000	50.000
R^2	0.449	0.450
Adjusted R^2	0.406	0.395
MSE	120498259553167.000	122697346499191.000
RMSE	10977169.925	11076883.429
MAPE	471.965	494.369
DW	1.581	1.582
Cp	5.000	6.000
AIC	1820.431	1822.335
SBC	1830.558	1834.487
PC	0.659	0.682
Press	10996738508583300.000	11956757460908100.000
Q^2	0.014	-0.072

Next, whether Ore Reserves (R_{OR}) are reported for the project considered in each transaction (1=yes, 0=no) was considered as the fourth explanatory variable on TR_v. (Scenario 5). For n=56, the regression indicates that approximately 59% of the variability in TR_v is explained by TE_v, the VALMIN Code classification, the number of ounces acquired in the transaction and the reporting of an Ore Reserve estimate (model p <0.001, R_{OR} p 0.000).

Table 3-25 shows that R_{OR} appears to be a positive confounding variable with V_{PN}. As a result of the addition of the variable, R_{OR}, the statistical significance of the variable, V_{PN}, decreases from p0.005 to p0.498. A test regression (Scenario 6) was run to determine the effect on the Goodness of fit statistics when the VALMIN Code classification is removed from the regression given that only the VALMIN Code production class (V_{PN}) contributed statistical significance in Scenario 3.

Table 3-25: Unstandardised beta coefficients – Scenario 5

Source	Value	Standard error	t	P	Lower bound (95th percentile)	Upper bound (95th percentile)
Intercept	362151.275	2914695.085	0.124	0.902	-5492186.096	6216488.647
TE_v	1.083	0.275	3.938	0.000	0.531	1.636
V_{PD}	1691209.391	3392293.518	0.499	0.620	-5122412.666	8504831.449
V_{PN}	3291864.232	4817705.872	0.683	0.498	-6384782.797	12968511.262
MR_o	-11.781	4.498	-2.619	0.012	-20.815	-2.748
R_{OR}	15940232.359	3800187.591	4.195	0.000	8307330.946	23573133.772

Scenario 6 provides notably better Goodness of Fit statistics than Scenario 5 (Table 3-26), indicating that it is the reporting of an Ore Reserve estimate rather than the VALMIN Code production class which contributes a greater significance to the variation in $\boldsymbol{TR_v}$.

Table 3-26: Goodness of fit statistics Comparison (Scenarios 3, 5 and 6)

Item	Scenario 3	Scenario 5	Scenario 6	Comment
Observations	56.000	56.000	56.000	
Sum of weights	56.000	56.000	56.000	
DF	51.000	50.000	52.000	
R^2	0.449	0.592	0.588	Down 0.4
Adjusted R^2	0.406	0.552	0.565	Up 1.3
MSE	120498259553167.0	90915722194032.90	88257747805099.70	Down 3
RMSE	10977169.925	9534973.634	9394559.479	Down 1
MAPE	471.965	441.776	460.591	Up 4
DW	1.581	1.565	1.583	Up 0.018
Cp	5.000	6.000	4.000	
AIC	1820.431	1805.547	1802.082	Down 0.2
SBC	1830.558	1817.699	1810.183	Down 0.4
PC	0.659	0.506	0.475	Down 7
Press	10996738508583300.0	8469863211804670.0	8066601216390760.0	Down 5
Q^2	0.014	0.240	0.277	Up 15

Under the principle of parsimony (Seasholtz and Kowalski 1993), Scenario 6 provides a simpler model than Scenario 5. Scenario 6 was therefore selected as the scenario on which to undertake further analysis. Using the unstandardised beta coefficients shown in

Table 3-27, the equation of the model is given in E4-14.

$$\hat{y} = b_0 + b_1(x_1) - b_4(x_4) + b_5(x_5) + \varepsilon i$$

where:

$$\widehat{TR_v} = 1630942 + 1.078(TE_v) - 11.361(MR_o) + 17154097.772(R_{OR}) + \varepsilon i$$

(E4-14)

Table 3-27: Unstandardised beta coefficients – Scenario 6

Source	Value	Standard error	t	P	Lower bound (95th percentile	Upper bound (95th percentile)
Intercept	1630942.7	1620073.617	1.007	0.319	-1619972.815	4881858.281
TE_v	1.078	0.267	4.029	0.000	0.541	1.614
MR_o	-11.361	4.286	-2.651	0.011	-19.960	-2.761
R_{OR}	17154097.7	3129009.186	5.482	< 0.0001	10875281.485	23432914.058

Table 3-28 presents the equations of the models with and without Ore Reserve estimates.

Table 3-28: Models Derived from Scenario 6

Status	Equation of the model
No Ore Reserve estimate	$\hat{y} = b_0 + b_1(x_1) - b_4(x_4) + \varepsilon_1$
Ore Reserve estimate	$\hat{y} = (b_0 + b_5(x_5)) + b_1(x_1) - b_4(x_4) + \varepsilon_1$

The result of this analysis is that two populations are now defined within the Training Portfolio; Population 1 (Ore Reserve estimate reported, n=12), and Population 2 (No Ore Reserve estimate reported, n=44). Next, the significance of the XGD market sentiment was tested on the TR_v for the two populations when controlling for TE_v. and MR_o.and R_{or}.

Population 1: Ore Reserve estimate reported

For Population 1 transactions (Ore reserve estimate reported, n=12), the regression indicates that approximately 94% of the variability in TR_v is explained by TE_v, MR_o, R_{or} and the XGD sentiment classification (Table 3-29). Given the sentiment classification is categorical, disjunctives tables were created and the variable representing XGD Sentiment Class 1 (S1) was used as the dummy variable represented by the intercept. The variable representing XGD Sentiment Class 5 (S5) brings significant information (S5 p0.035) to explain the variability in TR_v (Table 3-29). Under the Mao and Rosecki (2009) classification, S5 represents 'A gradual upward swing enough to cause a feeling of encouragement to an investor. The environment for fund raising may be encouraging'.

Table 3-29: Unstandardised beta coefficients – Population 1

Source	Value	Standard error	t	P	Lower bound (95th percentile	Upper bound (95th percentile)
Intercept	6557643.919	5209460.657	1.259	0.264	-6833700.239	19948988.078
TE_v	2.972	0.576	5.156	0.004	1.490	4.453
MR_o	-33.382	10.696	-3.121	0.026	-60.876	-5.887
S4	8498416.706	9345311.438	0.909	0.405	-15524469.726	32521303.138
S5	21476573.247	7506256.337	2.861	0.035	2181128.177	40772018.317
S6	-10296327.389	8131071.638	-1.266	0.261	-31197911.229	10605256.450
S7	-825627.124	6752856.087	-0.122	0.907	-18184395.310	16533141.062

Population 2: No Ore Reserve estimate reported

The results of the OLS regression on Population 1 do not hold for the same OLS regression on Population 2. For Population 2 transactions (No Ore Reserve estimate reported, n=44), the regression indicates that approximately 28% of the variability in TR_v is explained by TE_v, MR_o and R_{or} and the XGD sentiment classification (Table 3-30). The variable representing XGD Sentiment Class 1 (S1) was used as the dummy variable represented by the intercept.

Table 3-30: Unstandardised beta coefficients – Population 2

Source	Value	Standard error	t	P	Lower bound (95th percentile)	Upper bound (95th percentile)
Intercept	3351219.505	2520843.394	1.329	0.192	-1761287.859	8463726.870
TE_v	0.299	0.203	1.469	0.150	-0.114	0.711
MR_o	-1.468	3.150	-0.466	0.644	-7.856	4.920
S2	-2276994.495	3581698.721	-0.636	0.529	-9541016.184	4987027.194
S4	-919561.613	3109232.723	-0.296	0.769	-7225377.846	5386254.619
S5	-1911777.642	3387813.019	-0.564	0.576	-8782580.902	4959025.618
S6	2413950.742	3531230.454	0.684	0.499	-4747716.557	9575618.040
S7	360419.648	2974659.125	0.121	0.904	-5672468.678	6393307.974

Given the weak positive linear correlation coefficient determined for Population 2, further quantitative analysis on this population was undertaken. A simple OLS regression of TR_v by MR_o suggests that there are three relatively discrete sub-populations within Population 2 (Figure 3-9):

Population 2A (high value, low ounces),
Population 2B (moderate value, moderate ounces), and
Population 2C (low value, high ounces).

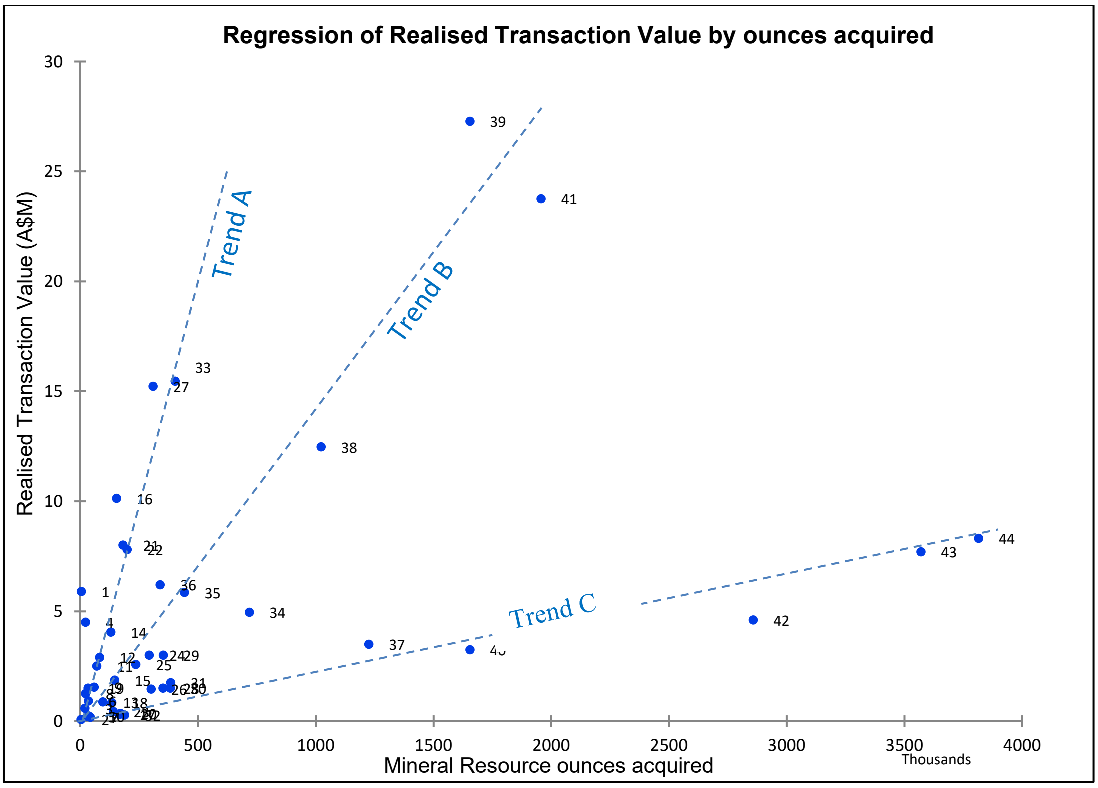


Figure 3-9: Simple OLS regression for Population 2

The arithmetic descriptive statistics for the three sub-populations are presented in Table 3-31. OLS regression analysis was undertaken on each of the three sub-populations using the previously described explanatory variables (Table 3-18).

Table 3-31: Population 2 – Arithmetic descriptive statistics

Statistical analysis	Transaction Value (A$)	Technical Value (A$)	Ounces Acquired	M+I Resource Multiple (A$/Resource Ounce) *
Sub-population A (n=18)				
Minimum	75,000	12,081	4,289	2
Median	4,275,099	1,482,572	77,366	35
Mean	5,566,013	6,376,082	381,708	104
Maximum	23,760,000	42,794,338	2,858,888	1,153
Standard Deviation	5,966,616	12,867,353	771,899	265
Sub-population B (n=10)				
Minimum	850,000	1,202,126	96,466	2
Median	3,000,000	4,253,182	316,887	11
Mean	4,499,540	8,508,742	688,413	10
Maximum	12,471,200	43,218,947	,815,608	18
Standard Deviation	3,718,031	12,630,411	1,130,165	4
Sub-population C (n=16)				
Minimum	175,000	174,136	33,647	1
Median	1,475,000	6,048,533	326,819	4
Mean	4,084,914	11,682,628	669,582	7
Maximum	27,280,000	53,870,800	,570,074	38
Standard Deviation	7,342,093	16,401,066	943,230	9

*M+I represent material classified as Measured and Indicated Mineral Resource

Population 2A

For Population 2A transactions (No Ore Reserve estimate reported, high value, low ounces, n=18), the regression (model p0.001) indicates that approximately 87% of the variability in TR_v is explained by the variables TE_v, MR_o and the XGD sentiment classification (XGD_s); however, some collinearity is noted between the variables of TE_v and MR_o . The variable representing XGD Sentiment Class 1 (S1) was used as the dummy variable represented by the intercept (Table 3-32)

Table 3-32: Unstandardised beta coefficients – Population 2a

Source	Value	Standard error	t	P	Lower bound (95th percentile)	Upper bound (95th percentile)
Intercept	1501006.243	2765350.346	0.543	0.599	-4660578.283	7662590.769
TE_v	1.889	0.369	5.125	0.000	1.068	2.711
MR_o	-27.576	6.131	-4.498	0.001	-41.236	-13.915
S2	-226874.013	3388056.825	-0.067	0.948	-7775935.034	7322187.007
S4	2003358.997	3139413.331	0.638	0.538	-4991689.795	8998407.789
S5	4258823.200	3387965.893	1.257	0.237	-3290035.210	11807681.611
S6	13548563.373	3919818.771	3.456	0.006	4814662.905	22282463.842
S7	2023588.309	3004722.632	0.673	0.516	-4671350.906	8718527.524

Population 2B and Population 2C

For Population 2B (n=10) and Population 2C (n=16), the model p values (0.647 and 0.396 respectively) indicate that the explanatory variables do not bring significantly more information to the model than a basic mean would bring (Table 3-33 and Table 3-34).

Table 3-33: Analysis of variance – Population 2b

Source	Degrees of freedom	Sum of squares	Mean squares	F	P
Model	6	74980576424120.400	12496762737353.400	0.758	0.647
Error	3	49433215339879.600	16477738446626.500		
Corrected Total	9	124413791764000.000			

Table 3-34: Analysis of variance – Population 2c

Source	Degrees of freedom	Sum of squares	Mean squares	F	P
Model	7	415250118720204.000	59321445531457.700	1.207	0.396
Error	8	393344878082382.000	49168109760297.700		
Corrected Total	15	808594996802586.000			

3.3 Quantitative Study Summary

The purpose of the quantitative study was to identify and assess the systematic and unsystematic factors relating to gold project transactions on the ASX. To allow this decomposition, two portfolios were developed. First, an assessment of the systematic component was made using a proxy market portfolio (Dummy Portfolio). Here, the historical returns of the XGD over a seven-year period from 2011 to 2017 were used to calculate an implied market risk premium and then assessed for their relationship with the gold price and a number of geopolitical variables using backwards stepwise OLS multiple regression analysis. The analysis resulted in a co-efficient of determination (denoted by R^2) of 0.753. This indicates that the majority of the variation in the XGD price (approximately 75%) can be explained by the variation in the gold price and the retained geopolitical variables of government expenditure, the United States of America to Australian dollar exchange rate, the budget balance and the investment factor (a measure of the gross fixed capital formation). The XGD was then classified for its relative sentiment state (depressed, bearish, downward, tranquil, upward, bullish or bubble) using a modified Rao and Moseki (2009) approach as discussed in Chapter 4.1.7.

Next, an assessment of the unsystematic component was made using a portfolio of historical gold project transactions made by ASX listed companies over the same seven-year period between 2011 and 2017 (Training Portfolio). Experimental modelling was undertaken using iterative OLS multiple regression analysis to assess the sensitivity of the realised transaction values to a number of project-specific factors including the implied technical value ($AUD) using yardstick factors, the average Mineral Resource grade (g/t), the number of Mineral Resource ounces acquired in the transaction, whether or not an Ore reserve estimate had been publicly reported for the Project considered in the transaction and the classification of project maturity made in accordance with the guidelines of the Valmin Code (2015 edition). Interestingly, the average Mineral Resource grade or Valmin Classification was not statistically significant to the analysis (P 0.771 for the average Mineral resource grade and P>0.400 for all Valmin classes). The analysis resulted in a co-efficient of determination of 0.588 for Projects which had an Ore Reserve estimate publicly reported at the time the transaction was finalised (Population 1 transactions), indicating that approximately 59% of the variability in realised transaction values for Population 1 transactions can be explained by the unsystematic independent variables.

To test the conception of Baker and Wurgler (2007) who proposed that sentiment is relevant in asset pricing and that it is a priced systematic market risk factor, the relative sentiment of the XGD was used then used as an additional independent variable in the analysis. This resulted in a co-efficient of determination of 0.943, indicating that approximately 94% of the variance in the realised transaction values for Population 1 transactions can be explained by the retained independent explanatory variables of the implied technical value and the number of Mineral Resource ounces acquired in the transaction as well as the XGD relative market sentiment classification (particularly S_5 (Upward) and S_6 (Bullish)). This finding supports the conception of Baker and Wurgler (2007) and is a significant research contribution as presented in Figure 3-10.

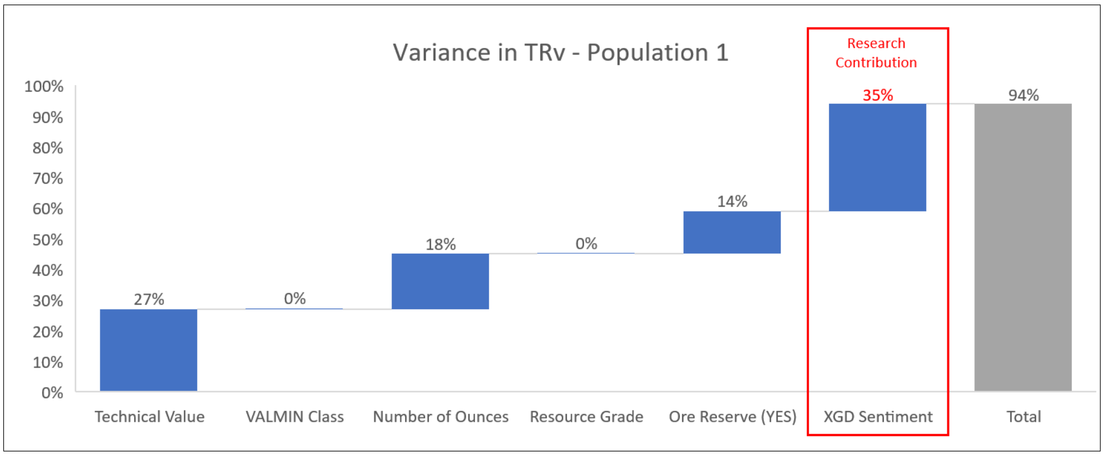


Figure 3-10: Explanation of realised transaction values - Population 1

Where the transactions in the Training Portfolio considered Projects that did not have a reported Ore Reserve estimate, three relatively discrete sub-populations were identified.

The regression on Population 2A (high value, low ounces) transactions resulted in a coefficient of determination of 0.874. This indicates that approximately 87% of the variability in the realised transaction value for Population 2a transactions can be explained by the retained unsystematic explanatory variables of the implied technical value and the number of Mineral Resource ounces acquired in the transaction and the XGD sentiment variable (particularly S_6 (Bullish)) as presented in Figure 3-11. Notable collinearity between the implied technical value and the number of ounces acquired was observed in this analysis. This suggests that the reported Mineral Resource confidence category (Measured, Indicated or Inferred) does not contribute statistical significance to the realised transaction value for Population 2a transactions (no Ore Reserve reported and a high realised transaction value for the number of Mineral Resource ounces reported).

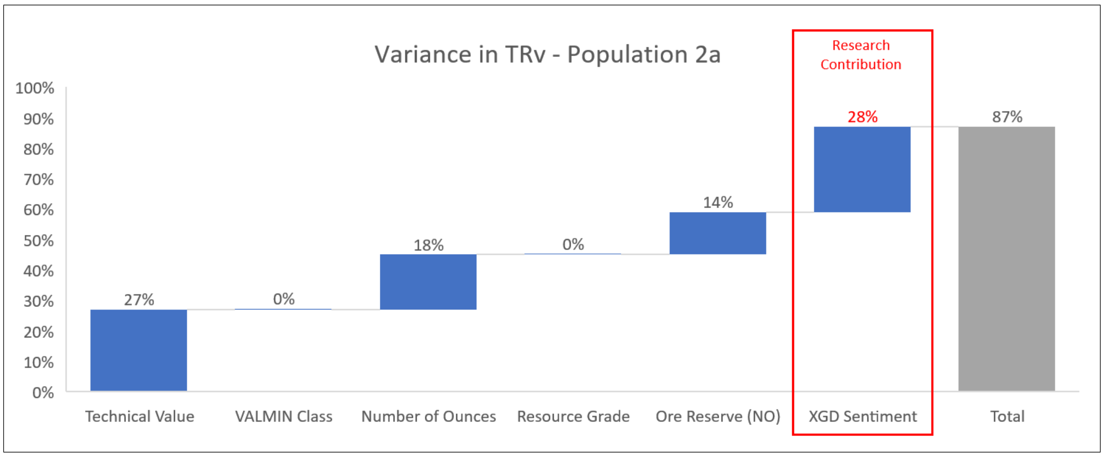


Figure 3-11: Explanation of realised transaction values - Population 2a

The results of the analysis on Population 2B (moderate value, moderate ounces) and Population 2C (low value, high ounces) transactions are not as encouraging. None of the explanatory variables (including technical value, ounces acquired and market sentiment) proved to be statistically significant. These results indicate that the explanatory variables that describe the variance in the realised transaction value of Projects where no Ore Reserve estimates had been reported have not been fully recognised in the quantitative analysis. The results of the quantitative analysis provide a useful base for further discussion and an interesting dataset for use in the qualitative study.

4 Qualitative Study (qual)

Motivated by modern behavioural economic theory, a second study was designed to analyse investment behaviour using a quantitative analysis of qualitative data. The purpose of the qualitative study was to explicate some of the variance in the realised transaction values in the Training Portfolio which was not explained in the quantitative study (QUAN). Qualitative data were collected for each transaction in the Training Portfolio (n=56) to allow the construction of an augmented Training Portfolio. The buy-side ASX market announcement relating to each transaction in the Training Portfolio was imported into NVivo11 Software (QSR International, Melbourne, Australia) (NVivo) for coding and analysis. A qualitative scorecard was developed for each transaction using an assessment of sentiment polarity (TS_x) and strategic and entrepreneurial content (SE_x). Inspired by the suggestion of O'Shea (2008) that mining firms use positive language in disclosures as a vehicle for self-promotion and the event study of Bird, Grosse et al. (2013) noted in the literature review, a sentiment content analysis was undertaken. To test the significance of the use of sentiment polarity in the narrative of these ASX market announcements each ASX market announcement was coded for the NVivo sentiment lexicon. Within this lexicon each word containing sentiment was coded according to its polarity of sentiment. If the word was preceded by a modifying word, that is, one which intensified the sentiment (for example, *very* or *fairly*) then the coding of the word was changed to suit the modifier. If a sentiment word was considered to be neutral, then it was not coded. Words were coded as being either very negative, moderately negative, neutral, moderately positive or highly positive (Figure 4-1).

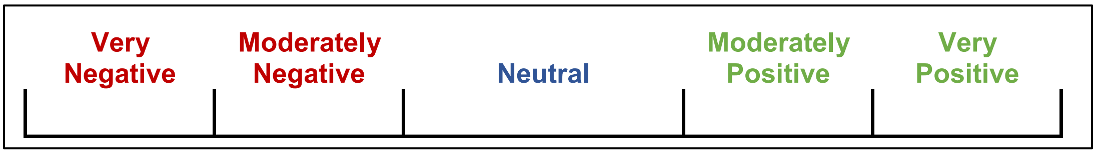


Figure 4-1: Sentiment codes

Source: QSR International, Melbourne, Australia

A summative content analysis was then performed using the percentage coverage by character count (density) as the unit of measurement. That is, a quantitative analysis of qualitative data was performed (Morgan 1993). The results of the summative content analysis are presented in Table 4-1 and Figure 4-2.

Table 4-1: Sentiment by percentage coverage (density)

% Coverage	Very Positive	Moderately Positive	Moderately Negative	Very Negative	TS_x Total Density
Population 1 - Ore Reserve Reported	3.2%	1.1%	0.7%	2.2%	7.1%
Population 2a - No Ore Reserve Reported, High Value, Low Ounces	3.3%	0.8%	0.3%	1.7%	6.1%
Population 2b - No Ore Reserve Reported, Moderate Value, Moderate Ounces	3.0%	0.9%	0.2%	0.1%	4.1%
Population 2c - No Ore Reserve Reported, Low Value, High Ounces	8.6%	0.6%	0.2%	3.9%	13.2%

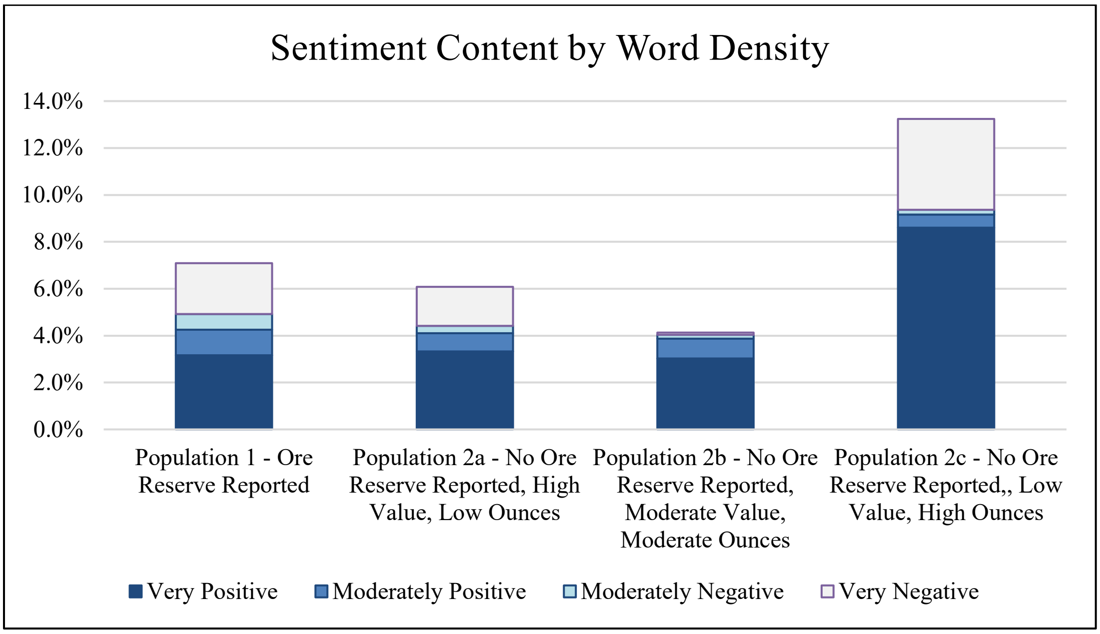


Figure 4-2: Sentiment by percentage coverage (density)

There appears to be a curious connection between the density of sentiment words (TS_x) and the moderation of the polarity of the sentiment words with respect to the realised transaction value per reported Mineral Resource Ounce (TR_v/oz). Higher TR_v/oz values are observed where the sentiment content is high, but the polarity is moderated (Population 1 and Population 2a); and lower TR_v/oz values are observed where the sentiment content is low and the polarity is not moderated (Population 2c).

Explicitly, Population 2c announcements (No Ore Reserve reported; low value, high ounces) contain:

- Substantially more sentiment coverage by word density (TS_x) than any other population;
- The lowest moderated and highest polarised sentiment content by word density than any other population; and
- 300% more highly positive sentiment content by word density than all the other populations.

A possible explanation for these findings supports the notion that rational investors recognise irrational behaviour by project owners. That is to say that investors recognise and penalise overconfidence (represented by polarised sentiment content e.g., "extremely favourable geological setting" rather than "favourable geological setting") by Project owners by paying less for Projects where Project owners are perceived to be overconfident. This finding supports the belief that overconfidence is linked to non-optimal outcomes (Gloede, Menkhoff et al. (2011), Invernizzi, Menozzi et al. (2017). A second explanation for this finding could be that rational investors have recognised an arbitrage (rational choice) opportunity with respect to the technical value of the Project (in the spirit of a positive Jensen's alpha, Jensen 1968), and, using superior negotiation and forecasting skills has purchased an undervalued Project.

The alternative explanation of course is that irrational investors do not recognise the overconfidence irrationality by Project owners and simply participate in the transaction via an alternative motivation such as the irrational belief that any favourable historical performance of a Project owner (seller) is representative of the future performance of that seller (representativeness bias (Chen, Kim et al. 2007) or group feel (Nur and Aren 2019). A longitudinal study following both the purchasing and selling managers performance as well as the realised transaction value of the Project as it transacts between different parties over time would be an interesting undertaking, and one which is beyond the scope of this research. Such research is likely to be challenged by the subjective complexities involved in the measurement and assessment of overconfidence and other behavioural biases such as optimism (Smith, Caputi et al. 2012), and the illusion of knowledge (Avhustiuk, Pasichnyk et al. 2018) notwithstanding ethics, morality and hubris (Park, Kim et al. 2018). Moreover, the correlation between overconfidence, strategic intent and entrepreneurship has received substantial attention in the literature, with mixed findings (Covin and Wales 2012). As such, a second content analysis was designed to test whether any correlation between the sentiment content findings and the strategic and entrepreneurial content of the ASX market announcements exists to support the overconfidence – irrationality construct.

The praxis of open coding (Hsieh 2005) using a special-purpose coding dictionary was adopted to allow a user guided approach to a summative content analysis. To ensure the strategy and entrepreneurial content was assessed with functional validity (Krippendorff 2008), a thematic approach was taken to develop the codebook in two stages. First, the AutoCoding feature in NVivo was used to identify the global themes and then these global themes were manually pared and assigned to the categorical lexes presented in Figure 4-3.

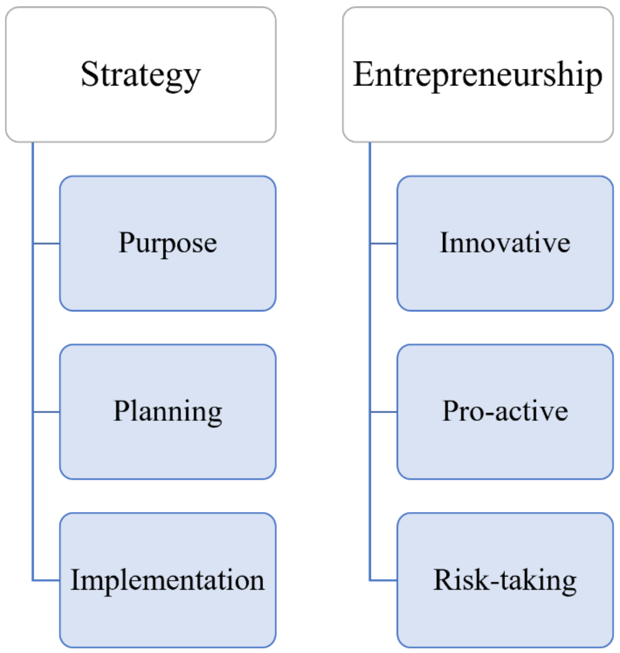


Figure 4-3: Categorical Lexes – Strategy and Entrepreneurship

The development of a strategy lexicon was guided by the early definition of strategy by Alfred Chandler (Chandler 1962),"Strategy is the determination of the basic long-term goals of an enterprise, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals". The development of the entrepreneurship lexicon was guided by the work of Miller (1983) and Covin and Slevin (1991), who suggest that, "entrepreneurial orientation is a firm's behavioural tendency, managerial philosophy, or decision-making practice that is characterised by innovativeness, proactiveness and a willingness to take risks". The functionality within the NVivo11 software package allowed for coding to be undertaken using lexicon synonyms as well as exact word matches. Scores were given to each ASX market announcement using two metrics: the number of observations and the word count density using the strategy and entrepreneurship lexes (SE_x). Table 4-2 and Figure 4-4 present the scorecard relating to the strategy and entrepreneurial lexicon coding.

Table 4-2: Strategy and Entrepreneurship Score Summary

Population	Average Observation Count	Average Total Word Count	Average SE_x Density
Population 1 - Ore Reserve Reported	36.6	6,778	0.54%
Population 2a - No Ore Reserve Reported, High Value, Low Ounces	16.4	1,726	0.95%
Population 2b - No Ore Reserve Reported, Moderate Value, Moderate Ounces	18.2	1,820	1.00%
Population 2c - No Ore Reserve Reported, Low Value, High Ounces	25.9	3,408	0.76%

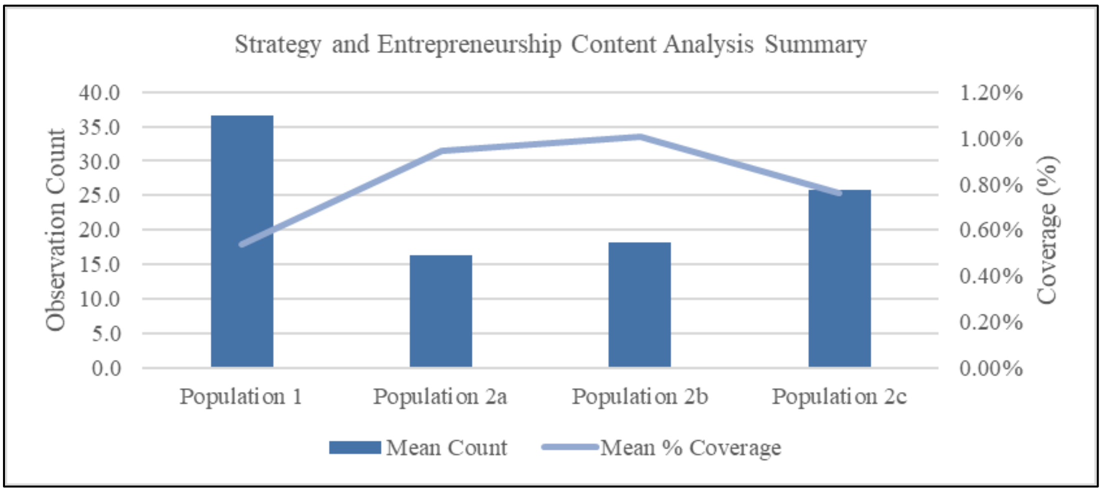


Figure 4-4: Strategy and Entrepreneurship Content Analysis Summary

The substantive observation which is made from this analysis is that while Population 1 announcements are longer than Population 2 announcements, Population 1 announcements contain less strategy and entrepreneurship words than Population 2 announcements. Explicitly, Population 1 announcements contain less strategy and entrepreneurship words by word density than Population 2 announcements (41% less than Population 1a, 46% less than Population 2b and 22% less than Population 2c). Whilst there is not a great variance in the density of the strategy and entrepreneurship content (SE_x) between the Population 2 sub-populations, it is the 2a (high value, low ounces) and 2b (moderate ounces, moderate value) sub-populations which have the highest (SE_x). Explicitly, Population 2c announcements (No Ore Reserve reported; low value, high ounces) contain less strategy and entrepreneurship coverage by word density (SE_x) than any other Population 2 sub-population.

Figure 4-5 presents a schematic representation of the key observed relationship between the realised transaction value (TR_v/oz) and density of the polarised sentiment and strategy and entrepreneurship words in the ASX market announcements relating to the transactions in the Training Portfolio as observed during the two content analyses. Where no Ore Reserves are reported, higher TR_v/oz are realised where the polarised sentiment content is moderated and the percentage of strategy and entrepreneurship content is higher. Moreover, Population 2a announcements (high value, low ounces, no Ore Reserve reported) contain similar content to Population 1 (Ore Reserve reported) announcements with respect to the polarised sentiment and strategy and entrepreneurship word density.

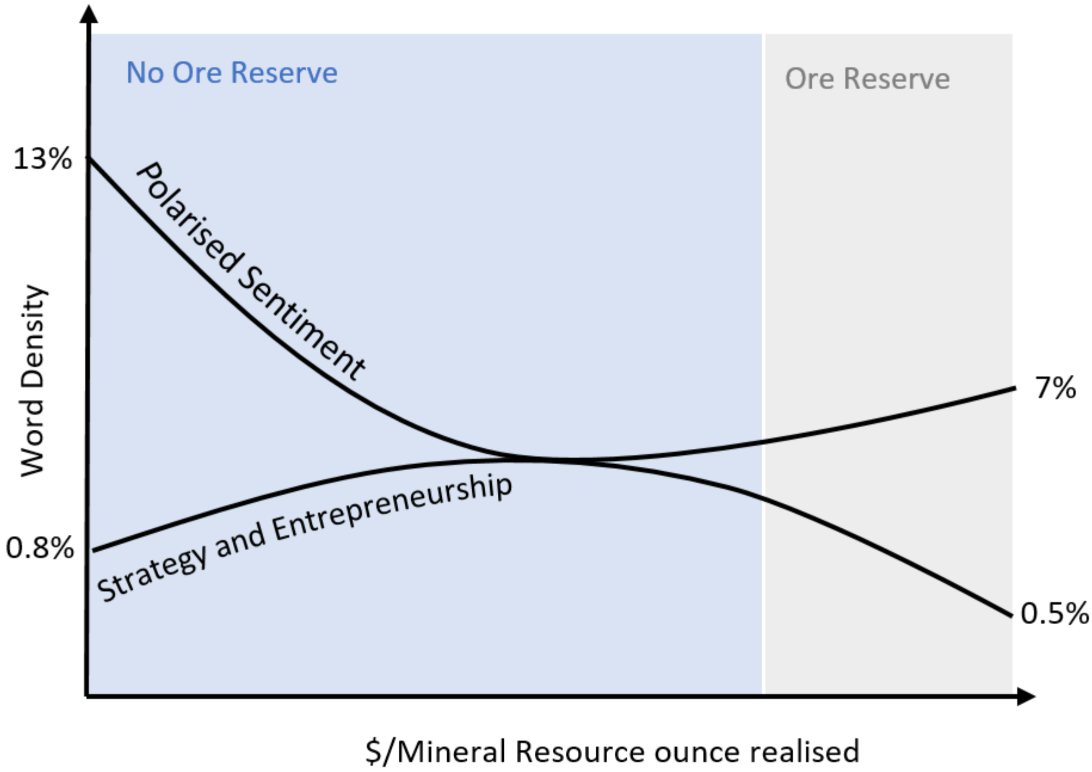


Figure 4-5: Schematic relationship summary – Content Analysis Summary

It is proposed that the sentiment and strategy and entrepreneurship content of the ASX market announcements relating to the transactions in the Training Portfolio reflects behavioural 'posturing' and strategic and entrepreneurial orientation of the companies making those announcements. In turn, TRv/oz is a function of this posturing, where moderated sentiment and higher densities of strategy and entrepreneurship content are related to higher TRv/oz. This proposition has potentially significant implications for both Project proponents and owners as well as marketeers and the wider investment community as it supports the overconfidence-irrationality construct. This irrationality results in poor realised market valuation outcomes for early-stage (No Ore Reserves reported) Projects in the Training Portfolio.

5 QUAN ←→ qual Triangulation

The research presented in this thesis was designed to capture several dimensions of realised gold project transaction value using a mixed-method approach. The results of the quantitative study (QUAN) suggest that a statistically significant part (94%) of the variability in TR_v for Projects where Ore Reserve estimates had been reported (Population 1 transactions) can be explained by independent variables representing the implied technical value (TE_v), the number of Mineral Resource ounces acquired in the transaction (MR_o) and the quarterly trailing All Ordinaries Gold Index (XGD) sentiment classification (S_x). For transactions relating to Projects where no Ore Reserves had been reported (Population 2 (early-stage) transactions), three sub-populations were identified: Population 2a (high value, low ounces), Population 2b (moderate value, moderate ounces), and Population 2c (low value, high ounces). For Population 2a, a statistically significant part (87%) of the variability in TR_v can be explained by independent variables representing the implied technical value (TE_v), the number of Mineral Resource ounces acquired in the transaction (MR_o) and the quarterly trailing All Ordinaries Gold Index sentiment classification (XGD_s). For Populations 2b and 2c, the results of the quantitative study indicate that the variability in TR_v is not explained statistically by the independent variables selected for the quantitative analysis.

The qualitative study (qual) was designed to explicate some of the variance in the realised transactions in the Training Portfolio which was not explained in the quantitative study, with a particular focus on transactions which involved early-stage Projects. The qualitative study used a content analysis of the ASX market announcements relating to the project transactions and introduced two further explanatory variables to the decomposition of TR_v, transaction sentiment (TS_x) and strategy and entrepreneurship (SE_x). The results of the qualitative study suggest that the content of the ASX market announcements may reflect priced risk factors relating to emotional disposition as demonstrated through the use of word sentiment and strategic and entrepreneurial orientation (using subconscious posturing or otherwise) by Project owners and Project investor's interpretation of these orientations. The conception that there is a relationship between sentiment, strategic and entrepreneurial content in the ASX market announcements relating to the realised transactions in the Training Set and the realised transaction values per reported Mineral Resource ounce has validity. The most thought-provoking finding of this research is that sentiment is a priced systematic risk factor as well as a priced unsystematic risk-factor:

(1) The quantitative study demonstrated that XGD market sentiment is a priced systematic risk factor in the valuation of the Projects included in the Training Portfolio, supporting the ideation of Baker and Wurgler (2007) who proposed that sentiment is relevant in asset pricing and that it is a priced systematic market risk factor.

(2) The qualitative study then demonstrated that there is an additional component of unique sentiment risk, or at least the perception of unique (idiosyncratic) sentiment risk that is a priced risk factor. Where Projects are less mature in their formally reported technical confidence level higher realised gold project transaction values are realised when both the positive and negative sentiment is moderated in ASX market announcements. It is postulated that investors perceive polarised positive sentiment in ASX market announcements to be a demonstration of overconfidence (irrationality) by mining executives and that this perception leads to realised gold project transaction values being penalised (a cost of overconfidence). Where technical uncertainty prevails (early-stage Projects) single-asset valuation has an element of, "feelings over fundamentals".

The idiosyncratic sentiment risk identified in the qualitative study can be included as a sensitivity (beta) measure within a single-project valuation framework. The willingness-to-pay (or unwillingness-to-pay) for the perceived irrationality is included as a function of the realised transaction value (TR_v) for those projects where the expected realised transaction value is not equal to the realised transaction value ($\widehat{TR}_v \neq TR_v$) using the multi-beta model developed during the quantitative research study (Population 2b and 2c).

5.1 Valuation Framework for Projects with Ore Reserves

Approximately 94% of the variance in the realised transaction values for Population 1 transactions (Ore Reserves reported) can be explained by the implied technical value, the number of Mineral Resource ounces acquired in the transaction and the XGD relative market sentiment classification (particularly S_5 (Upward) and S_6 (Bullish)). Approximately 75% of the variance in the XGD market price can be explained by the trailing gold price, government expenditure, the investment factor, the United States dollar to Australian dollar foreign exchange rate and the budget balance. The XGD relative market sentiment is a function of the variance in returns of the XGD and the research contribution is the classification and use of the XGD market sentiment to explain approximately 35% of the variance in TR_v for Projects where Ore reserves have been reported, as presented in Figure 5-1. These findings were made during the quantitative study which is presented in Chapter 4 of this thesis.

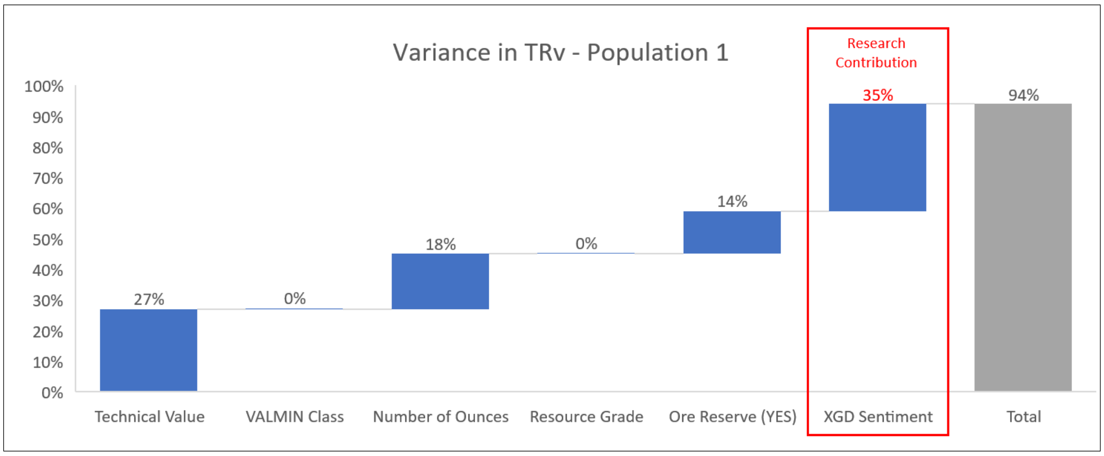


Figure 5-1: Valuation of Projects which have Ore Reserves reported

The research and resulting valuation framework for these Projects demonstrates that the expected realised transaction value $(\widehat{TR}_v)$ for Projects has both a systematic component and an unsystematic component. The systematic component is attributable to the market sentiment classification (XGD_{sx}) which is a function of the market returns as defined by the equations in E5-1

$$
\begin{aligned}
XGD_{s1} &= \bar{r}_{w+1} < \hat{\mu} - 3\frac{\sigma}{\sqrt{n_w}} \\
XGD_{s2} &= \hat{\mu} - 3\frac{\hat{\sigma}}{\sqrt{n_w}} \leq \bar{r}_{w+1} < \hat{\mu} - 2\frac{\hat{\sigma}}{\sqrt{n_w}} \\
XGD_{s3} &= \hat{\mu} - 2\frac{\hat{\sigma}}{\sqrt{n_w}} \leq \bar{r}_{w+1} < \hat{\mu} - \frac{\hat{\sigma}}{\sqrt{n_w}} \\
XGD_{s4} &= \hat{\mu} - \frac{\hat{\sigma}}{\sqrt{n_w}} \leq \bar{r}_{w+1} < \hat{\mu} + \frac{\hat{\sigma}}{\sqrt{n_w}} \\
XGD_{s5} &= \hat{\mu} + \frac{\hat{\sigma}}{\sqrt{n_w}} \leq \bar{r}_{w+1} < \hat{\mu} + 2\frac{\hat{\sigma}}{\sqrt{n_w}} \\
XGD_{s6} &= \hat{\mu} + 2\frac{\hat{\sigma}}{\sqrt{n_w}} \leq \bar{r}_{w+1} < \hat{\mu} + 2\frac{\hat{\sigma}}{\sqrt{n_w}} \\
XGD_{s7} &= \bar{r}_{w+1} > \hat{\mu} + 3\frac{\hat{\sigma}}{\sqrt{n_w}}
\end{aligned}
$$

(E5-1)

The market returns are a function of the market price and the market price is a function of the gold price, government expenditure, the investment factor, the Australian dollar to United States dollar exchange rate and the budget balance as presented in equation E5-2.

$$XGD_p = \beta 1(GP) + \beta 2(GE) + \beta 3(IF) + \beta 4(FX) + \beta 5(BB) + \varepsilon_i$$

(E5-2)

The unsystematic component is attributable to the implied technical value (TE_v), and number of gold ounces acquired in the transaction (MR_o).

Figure 5-2 summarises the valuation framework for Projects with reported Ore Reserve estimates.

$$R_{or} = YES$$

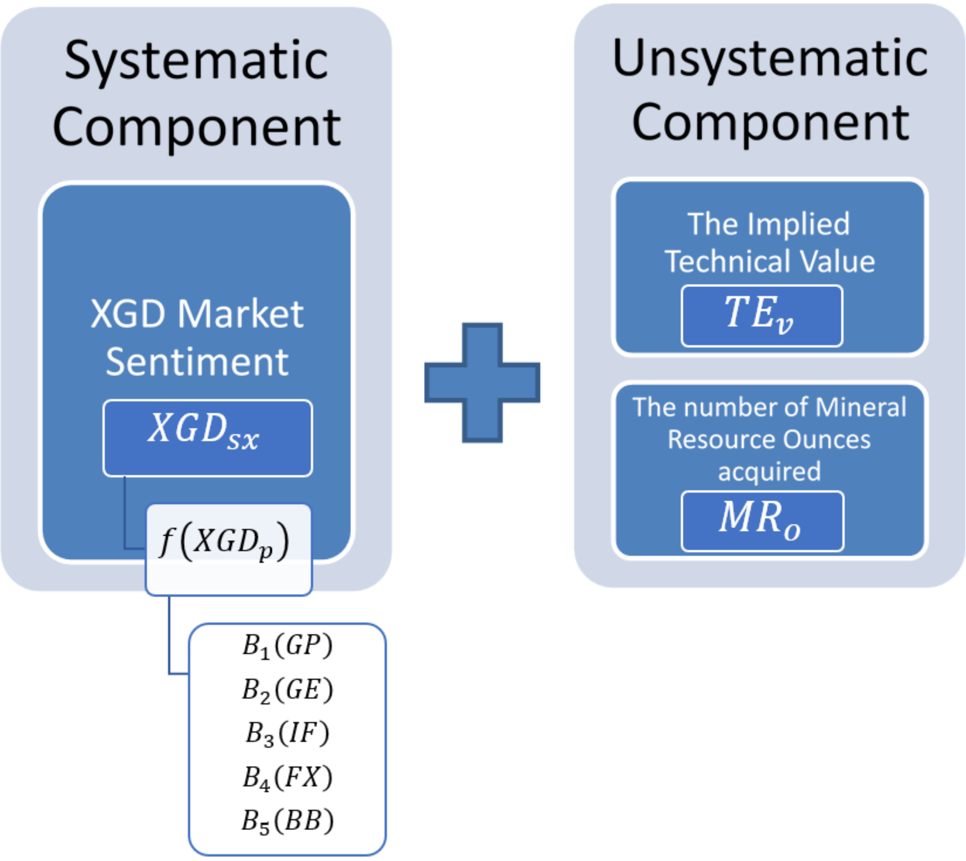


Figure 5-2: Valuation Framework for Projects with Ore Reserve Estimates

5.2 Valuation Framework for Projects without Ore Reserves

For those Projects within the Training Portfolio that do not have the geological confidence or maturity of technical studies to support an Ore Reserve estimate the valuation framework is extended. For these early-stage Projects, technical uncertainty (risk) prevails and this uncertainty brings additional idiosyncratic sensitivities to the valuation framework. The research found that sentiment is a priced systematic risk factor as well as a priced unsystematic risk-factor for this population and the research contribution is the analysis of the content of

ASX market announcements as epistemology (theory of knowledge) within the field of early stage Project valuation.

Figure 5-3 summarises the valuation framework for Projects without reported Ore Reserve estimates.

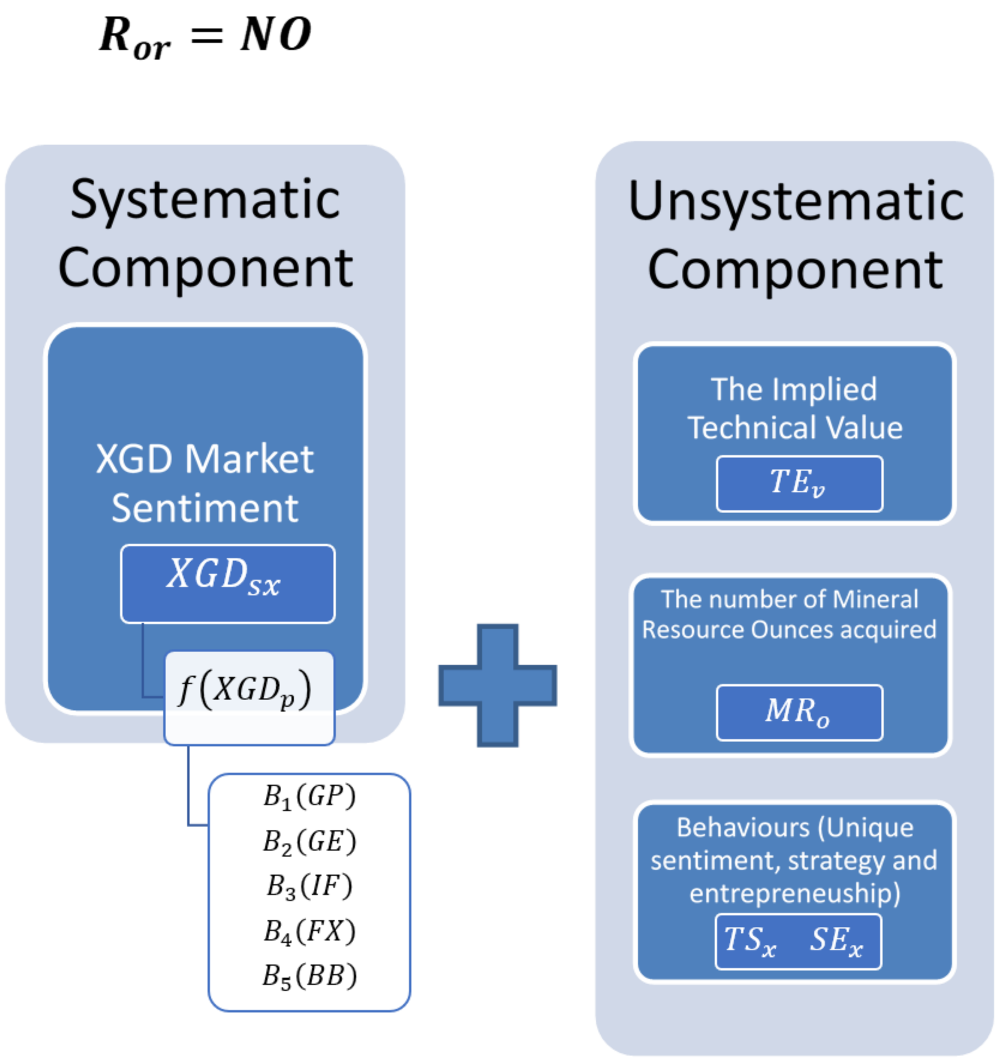


Figure 5-3: Valuation Framework for Projects with Ore Reserve Estimates

6 Discussion and Research Conclusions

6.1 Research Questions

There were two research questions posed in Chapter 1 of this thesis:

1) Are there any identifiable market factors associated with gold project transactions on the ASX and how are these factors related?"
2) Can an inclusive valuation framework be created from historical transaction data using the identified market factors for gold projects on the ASX?

The research questions were answered fruitfully using a mixed-method study approach (QUAN ←→ qual) on data sourced for the research period between January 2011 to October 2017. Under traditional capital markets theory there is an assumption that the variance of any feasible portfolio is attributable to a systematic (market component) and an unsystematic (idiosyncratic) risk component. This unsystematic risk can be diversified away in a limitless market. The challenge was to decompose the market component for single gold project transactions over the research period (a limited market). Two separate portfolios were developed: a proxy market portfolio and a portfolio of transaction data.

The ASX All Ordinaries Gold Index was selected as a feasible proxy market portfolio (Dummy Portfolio). The quantitative component of the research found a statistically significant correlation between the market price of the XGD and the gold price, Australian government expenditure, the Investment Factor, the Australian dollar to United States dollar exchange rate and the Budget Balance. Using OLS multiple regression analyses, approximately 75% of the variability in the XGD price can be explained by these independent predictor variables over the research period. The Investment Factor (IF) has the strongest inverse relationship with the XGD market price and the A$ to US$ Exchange Rate (FX) has the second strongest inverse relationship. The investment factor is measured in A$ Billions and represents the gross fixed capital formation which includes land improvements, plant, machinery, and equipment purchases; as well as the construction of roads, railways, schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. When the IF is high there is an expectation of future economic expansion and business confidence, when the IF is low there is an expectation of future economic recession or business uncertainty. Indeed, a low FX suggests the need for economic stimulation. The inverse relationship between the IF and FX factors and the XGD index price (IF and FX down, XGD up) may represent some safe haven effect for the XGD. Government expenditure (GE) had a very strong positive relationship with the XGD over the research period. Measured in A$ Billions, government expenditure represents the total spending by all levels of government (excluding public enterprise). A high GE suggests economic stimulus by the government. The budget balance (BB) and the Perth mint spot gold price (GP) both had a moderate positive relationship with the XGD over the research period. The budget balance, measured in A$ Millions, is calculated as the revenue minus the expenditure of the consolidated government, where a high BB may arguably help economic growth. The positive relationship between the GE and BB factors, the GP and the XGD index value may suggest that marketeers recognise these periods of economic growth and that a safe haven investment in gold or a gold index is not required, as seen by a fall in the gold price and the XGD index price.

The significance of the XGD market price (and therefore the market factors contributing to the variance in the XGD market price) on gold project transaction value was then assessed. An XGD market sentiment factor was developed by using the market returns to classify the market's sentiment over the research period. A statistically significant relationship between the XGD market sentiment and the realised transaction value per Mineral Resource ounce for the project portfolio (Training Portfolio) was found. Notably:

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1) Higher realised Project transaction values per Mineral Resource ounce are achieved for mature stage Projects (Ore Reserves reported) when the XGD is classified as being in an "upward" state (S_5), Rao and Moseki (2009) classify the "upward" state as, "A gradual upward swing, enough to cause a feeling of encouragement to an investor. The environment for fund raising may be encouraging", and
2) Higher realised Project transaction values per Mineral Resource ounce are achieved for more speculative or early stage Projects (No Ore Reserves reported) when the XGD is classified in as being in a "bullish" (S_6), or "bubble" (S_7) state. Rao and Moseki (2009) classify the "bullish" state as, "A significant upward swing, propelling speculation by a seller holding stocks. Raising funds from the capital market may be easy". They classify the "bubble" state as, "A sharp rise, enough to prompt a seller either to dispose of their load or to hold on in the hope of further appreciation leading to a bubble-like condition. This state assures the seller of massive gains for having waited. Raising funds from the capital market may be spontaneous".

Given that an investment in a gold Project is inherently risky due to technical and commercial uncertainty, these finding are not surprising. As the level of technical confidence increases and the commercial uncertainty decreases, the perception of investment risk decreases. It is postulated that marketeers are more likely to pay a premium to invest in mature stage Projects when they feel encouraged by a rising market price. Further, marketeers wait until they are assured of the continuity and trajectory of the rising market before paying a premium for early-stage Projects as these Projects are, by their nature, more speculative and difficult to value.
Further OLS regression analyses on the Training Portfolio allowed the statistical significance of the idiosyncratic component of Project transaction value to be evaluated. The research found

that for mature stage Projects approximately 94% of the variability in the realised transaction value of the Projects considered in the research can be explained by the XGD market sentiment classification, the additional idiosyncratic independent predictor variables of the number of Mineral Resource ounces, and the implied technical value of the gold in the ground. For more speculative Projects, the XGD market sentiment classification and the same idiosyncratic variables offered a partial explanation of the variability in the realised transaction value of the Projects considered in the research. For all Projects in the Training Portfolio, the grade (g/t) and the VALMIN classification were not statistically significant explanatory variables. The lack of statistical significance of the VALMIN classification is an understandable finding. While VALMIN Practitioners are familiar with the objective categorical classification, marketeers are likely to see Project maturity along a spectrum of maturity. In turn, the research finding that the grade is not a statistically significant explanatory variable is more surprising.

Some of the variance in the realised transaction values involving projects at a relatively low level of techno-economic confidence was then explicated using behavioural factors in a qualitative study. The results of the qualitative study suggest that investors may recognise and penalise behavioural posturing and storytelling, and reward rational and transparent reporting. This finding suggests that sentiment is not only a priced systematic factor, but it is also a priced unsystematic risk factor. This conception fits with the suggestion by Li and Yang (2013) that a significant contributor to the investment decision-making process is the way the investment is presented to the decision maker.

In answering the research questions, the transaction values in the Training Portfolio were successfully decomposed into an idiosyncratic component and a market component. The market factors contributing to the market component were identified and the relationships between the factors were assessed using OLS regression analyses. The idiosyncratic component was also decomposed to allow an inclusive valuation framework to be developed. The key research finding that sentiment is a priced factor at the systematic and idiosyncratic level provides an important implication for future valuation practice. There is an opportunity for astute Project owners to use this finding to their advantage. Further, it warrants an addition to the comment made by Lawrence (2002) and noted in the literature review (Chapter 2):

> "Valuation is a rather subjective process that heavily relies upon the repute and competence of the valuer. A true market will not be influenced for long (if at all) by spurious mineral property values [or emotive storytelling]. This is where responsible and informed [Project owners] media and brokers/analysts fulfil their proper role, otherwise they become part of the problem not the solution."

6.2 Research Summary

Table 6-1 provides a summary of the research presented in this thesis.

Table 6-1: Research Summary

Item	**Comment**
Research Questions	Question 1: Are there any identifiable market factors associated with gold project transactions on the ASX and how are these factors related?" Answer 1: Yes, the research found a statistically significant correlation between the market price of the Australian Securities Exchange All Ordinaries Gold Index (XGD) and the gold price, Australian government expenditure, the Investment Factor, the Australian dollar to United States dollar exchange rate and the Budget Balance over the research period (January 2011 to October 2017). In turn, an XGD market sentiment factor was developed to test the statistical significance of the XGD market sentiment on realised Project transaction values per Mineral Resource ounce for Projects transacted over the research period. A statistically significant relationship between the XGD relationship between the XGD sentiment was found (sentiment is a priced systematic risk factor). Furthermore, sentiment was also found to be a priced unsystematic (idiosyncratic) risk factor.
	Question 2: Can an inclusive valuation framework be created from historical transaction data using the identified market factors for gold projects on the ASX? Answer 2: Yes, an inclusive valuation framework was created using a mixed-method approach which triangulated the results of a quantitative and a qualitative study.
Limitations and future research opportunities	Opportunity 1: The decomposition of the XGD market price was necessarily limited by the Project transaction data set and therefore only considered only econometric data during the research period. The decomposition of the XGD market price over a longer time period to allow testing for stationarity and structural breaks may reveal further insights into the statistical significance of the bond yield rates and the physical gold price on the XGD market price and the possible safe-haven effect of investment in the XGD.
	Opportunity 2a: The Project transaction data considered in the research represented single snapshots in time. The development of a longitudinal study which assesses the statistical significance of the XGD systematic sentiment and the idiosyncratic sentiment as each Project transacts under maturing technical confidence levels and different ownership and management over time would be an interesting undertaking. Opportunity 2b: The opportunity noted in 2a could be complimented by an event study using on firm's financial performance against the XGD performance (covariance) to test the relationship and significance of behavioural economics on valuation praxis in the gold sector in further detail.
Research Contributions	Contribution 1: The finding that positive XGD market premia are observed when the term structure is upward (interest rates are expected to rise) and that the XGD market premia are volatile (both positive and negative) when the term structure is downward (interest rates are expected to fall), suggesting uncertainty whether investment in the XGD offers a safe-haven.
	Contribution 2: The classification of the quarterly XGD market sentiment and the assessment of its statistical significance of the at the single-Project portfolio market transaction level which found that the XGD market sentiment is a priced systematic risk factor at the single-Project portfolio market transaction level
	Contribution 3: The analysis of the content of ASX market announcements as epistemology (theory of knowledge) within the field of early stage Project valuation and the finding that sentiment is a priced idiosyncratic risk factor (as well as a priced systematic risk factor)

6.3 Research Contributions, Future Research and Limitations

The research presented in this thesis makes several new contributions in the related fields of mineral and mining economics, econometrics, corporate finance and behavioural economics. The first research contribution was unexpected and challenges the Capital Asset Pricing Theory with respect to the negative ex-post market premia calculated for the All Ordinaries Gold Index over the research period. An assessment of the Australian Government bond yield rates suggests that positive XGD market premia are observed when the term structure is upward (interest rates are expected to rise) and that the XGD market premia are volatile (both positive and negative) when the term structure is downward (interest rates are expected to fall). During this downward period, the gold price fell from A$1,707/oz to A$1,346/oz, implying a correlation between the term structure and the gold price (the safe haven effect). As noted in Chapter 4, this was a research finding tangential to the research questions in this thesis, which deserves further assessment of the underlying data. Is it that investors are uncertain whether investment in the XGD represents a safe haven as this investment does not give the convenience yield of owning physical gold, that they are risk-seeking during periods of negative market premia as in Jacobsen and Zhang (2018), or is the XGD's volatility related to other factors yet to be identified? The econometric model for the XGD market price developed in this thesis was limited by the time-series of geo-political and economic input data used to answer the research questions using the available Project transaction data. In order to be used as a forecasting tool for the XGD market price, the econometric model requires geo-political and economic input data covering a much longer time-series. Testing for stationarity and structural breaks over a longer time period may reveal additional insights into the statistical significance of the bond yield rates and the physical gold price on the XGD index price and test for the possible safe-haven effect of the XGD. The development of this longitudinal study and resulting econometric model offers a future research opportunity that is outside the scope of this thesis.

The second research contribution is the classification of the quarterly XGD market sentiment using a modified Rao and Moseki (2009) approach and the subsequent assessment of its statistical significance at the single-Project portfolio market transaction level (limited market). The XGD market sentiment was found to be a priced systematic risk factor at this transaction level. This is the first time that the XGD market sentiment has been classified in this way and it is the first time that the sentiment classification has been used to explain some of the variance in the transaction price of Projects at different stages of technical uncertainty. A complementary future research undertaking would be the development of a longitudinal study that assesses the statistical significance of the XGD systematic sentiment and the idiosyncratic sentiment as each Project transacts under maturing technical confidence levels, Board of Management changes or liquidity events and different ownership and management over time.

This opportunity, whilst well beyond the scope of this research, could be complimented by an event study to test the covariance of the firm's financial performance against the XGD performance.

The third contribution made by the research is the analysis of the content of ASX market announcements as epistemology (theory of knowledge) within the field of early stage Project valuation, and the finding that sentiment is both a priced systematic risk factor and a priced idiosyncratic risk factor. It is proposed that the sentiment and strategy and entrepreneurship content of the ASX market announcements relating to gold project transactions reflects behavioural 'posturing' and strategic and entrepreneurial orientation of the companies making those announcements. This proposition has potentially significant implications for both Project proponents and owners as well as marketeers and the wider investment community as it supports the overconfidence-irrationality construct. Irrationality results in poor realised market valuation outcomes for early-stage Projects. As such, the careful crafting of ASX market announcements that target the rational investor rather than the arbitrageur offers an opportunity to optimise Project value, particularly for Projects at an early stage of technical study. The education of mining executives in the art of objective, yet transparent storytelling within the Australian regulatory framework to allow accretive shareholder value is required.

The research contributions presented in this thesis are significant in that they give insight into the complimentary roles that traditional capital markets theories and behavioural economics have within gold project valuation praxis. The framework developed in this research provides pragmatic guidance for use in research and industry practice.

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APPENDIX A

Regression Analysis Scenario Modelling Detail

The assignment of Technical Value explicitly excludes any premium or discount for market considerations, though it does consider an assessment of a Mineral Asset's future net economic benefit (VALMIN (2015). It is proposed that the test premia reflect not only the market considerations but also the marketeers' willingness-to-pay (WTP) for the implied future earnings and risk-reward profile of the unsystematic component (risk preference under the willing buyer-willing seller assumption). Here, the traditional assumption that the unsystematic component of valuation is diversified away in a limitless market using the law of large numbers does not hold in a single investment portfolio. Each transaction in the Training Portfolio was coded for the dependent variable 'realised transaction value (TR_v)' and for the following independent variables:

- The implied technical value (TE_v)
- The Mineral Resource ounces acquired in the transaction (MR_o)
- The average Mineral Resource grade acquired in the transaction (MR_g)
- The assigned VALMIN Code classification
    - Advanced Exploration (V_{AE})
    - Pre-Development (V_{PD})
    - Production (V_{PN})
- The reporting of an Ore Reserve estimate (R_{OR})
- The prevailing XGD sentiment classification at the transaction announcement date
    - Sentiment Class One (S_1)
    - Sentiment Class Two (S_2)
    - Sentiment Class Three (S_3)
    - Sentiment Class Four (S_4)
    - Sentiment Class Five (S_5)
    - Sentiment Class Six (S_6)
    - Sentiment Class Seven (S_7).

Given that the VALMIN Code classification and XGD sentiment classification are categorical ordered polytomous variables, disjunctive tables were created for these factors to allow them to be coded as dummy variables (using the *n-1* rule) for use in regression analysis and also uniquely coded as qualitative variables for use in Analysis of Variance (ANOVA) testing to develop a model to predict TR_v in the form given in Equation A-1:

$$E(\gamma) = \beta 0 + \beta 1\ (X1) + \beta 2(X2) + \beta 3(X3) \dots \beta n(Xn) \dots + \varepsilon i$$

(A-1)

First, the relationship between TE_v and TR_v was tested using ordinary least squares (OLS) linear regression (Scenario 1). A probability value (p) below 0.05 is taken to be indicative of statistical significance. For n=56, the regression indicates that approximately 27 of the variability in TR_v is explained by TE_v, where the standardised beta ($\beta 1$) coefficient for TE_v is 0.519 and the unstandardised beta co-efficient (model parameter) (b_1) for TE_v is 0.502. Given the p-value (<0.001) of the F statistic computed in the ANOVA table, the information derived from the TR_v is significantly better than would be derived from a basic γ mean, so that in the form given in Equation A-2:

$$\hat{\gamma} = b_0 + b_1(x_1) + \varepsilon i$$

(A-2)

Scenario 1 indicates the relationship given in Equation A-3 and presented in Figure A-1 and Table A-1

$$\widehat{TR_v} = 4094295.905 + 0.502(TE_v) + \varepsilon i$$

(A-3)

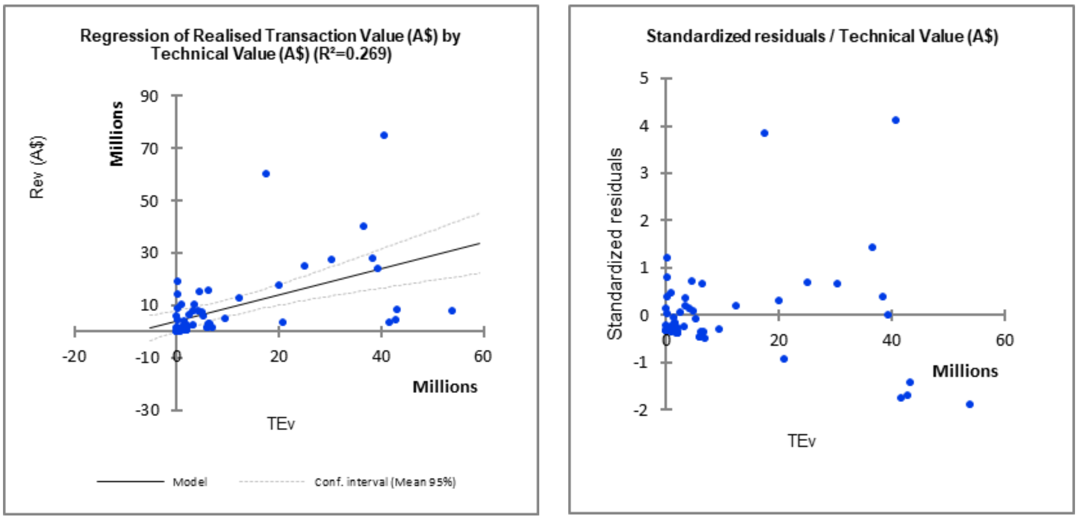

Figure A-1: Regression – Scenario 1

Table A-1: Goodness of fit statistics Scenario 1

Item	Value
Observations	56.000
Sum of weights	56.000
Degrees of Freedom (DF)	54.000
Coefficient of Determination (R^2)	0.269
Coefficient of Determination adjusted for the number of predictor variables (Adjusted R^2)	0.255
Mean Square Error (MSE)	150930763588092.000
Root Mean Square Error (RMSE)	12285388.215
Mean Absolute Percent Error (MAPE)	504.811
Durbin Watson Statistic (DW)	1.648
Mallows Statistic (Cp)	2.000
Akaike Information Criterion (AIC)	1830.243
Beyesian Information Criterion (SBC)	1834.293
Amemiya's Prediction Criterion (PC)	0.785
Predicted Residual Error Sum of Squares (Press)	9511258698513450.000
Stone-Geisser-Criterion (Q^2)	0.147

Table A-2: Analysis of variance – Scenario 1

Source	Degrees of freedom	Sum of squares	Mean squares	F	P>F
Model	1	2999419722717870.00	2999419722717870.00	19.873	< 0.0001
Error	54	8150261233756970.00	150930763588092.00		
Corrected Total	55	11149680956474800.00			

Table A-3: Type III sum of squares analysis – Scenario1

Source	Degrees of freedom	Sum of squares	Mean squares	F	P>F
TE_v	1	2999419722717870.00	2999419722717870.00	19.873	< 0.0001

Table A-4: Unstandardised beta coefficients – Scenario1

Source	Value	Standard error	t	P > |t|	Lower bound (95%)	Upper bound (95%)
Intercept	4094295.905	2003472.367	2.044	0.046	77575.651	8111016.159
TE_v	0.502	0.113	4.458	< 0.0001	0.276	0.727

Table A-5: Standardised beta coefficient – Scenario 1

Source	Value	Standard error	t	P > |t|	Lower bound (95%)	Upper bound (95%)
TE_v	0.519	0.116	4.458	< 0.0001	0.285	0.752

Next, the VALMIN Code classification was considered as a second explanatory variable on TR_v. (Scenario 2). Here, V_{AE} was used as the control dummy variable. For n=56, the regression indicates that approximately 35 of the variability in TR_v is explained by TE_v and the VALMIN Code classification (model P<0.001). The variable, V_{PN} (VALMIN Code production class) brings additional significant information (V_{PN} p 0.02) to explain the variability in TR_v. The variables V_{AE} (VALMIN Code Advanced Exploration Class and dummy intercept) and V_{PD} do not provide significant information to explain the variability in TR_v.

In the form given in Equation A-4:

$$\hat{y} = b_0 + b_1(x_1) + b_2(x_2) + b_3(x_3) + \varepsilon i$$

(A-4)

Scenario 2 indicates the relationship given in Equation A-5 and Figure A-2.

$$\widehat{TR_v} = -258863 + 0.399(TE_v) + 4435819.155(V_{PD}) + 12341900.168(V_{PR}) + \varepsilon i$$

(A-5)

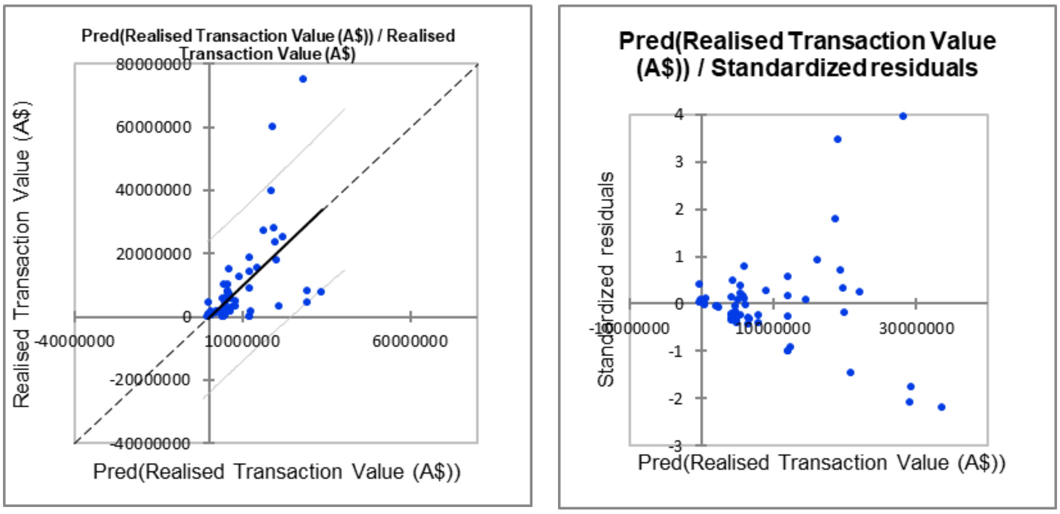

Figure A-2: Regression – Scenario 2

The equation for each VALMIN Code Class under Scenario 2 is given in Table A-6.

Table A-6: Scenario 2 Model

VALMIN Code Class	Equation of the model
Advanced Exploration	$\hat{y} = b_0 + b_1(x_1) + \varepsilon i$
Pre-Development	$\hat{y} = (b_0 + b_2(x_2)) + b_1(x_1) + \varepsilon i$
Production	$\hat{y} = (b_0 + b_3(x_3)) + b_1(x_1) + \varepsilon i$

The detailed statistics for Scenario 2 are given in Tables A-7 to A-12.

Table A-7: Multicollinearity statistics – Scenario 2

	Technical Value (A$)	Pre-Development	Production
Tolerance	0.870	0.589	0.529
VIF	1.149	1.698	1.891

Table A-8: Goodness of fit statistics – Scenario 2

Item	Value
Observations	56.000
Sum of weights	56.000
DF	52.000
R²	0.345
Adjusted R²	0.308
MSE	140359049011526.000
RMSE	11847322.441
MAPE	449.248
DW	1.395
Cp	4.000
AIC	1828.063
SBC	1836.164
PC	0.755
Press	9317856495721760.000
Q²	0.164

Table A-9: Analysis of variance – Scenario 2

Source	Degrees of freedom	Sum of squares	Mean squares	F	P>F
Model	3	3851010407875480.000	1283670135958490.000	9.146	< 0.0001
Error	52	7298670548599360.000	140359049011526.000		
Corrected Total	55	11149680956474800.000			

Table A-10: Type III sum of squares analysis – Scenario 2

Source	Degrees of freedom	Sum of squares	Mean squares	F	P>F
TE_v	1	1651418336305040.000	1651418336305040.000	11.766	0.001
V_{PD}	1	158951858849431.000	158951858849431.000	1.132	0.292
V_{PN}	1	804274913823015.000	804274913823015.000	5.730	0.020

Table A-11: Unstandardised beta coefficients – Scenario 2

Source	**Value**	**Standard error**	**t**	**P > |t|**	**Lower bound (95%)**	**Upper bound (95%)**
Intercept	-258,864	3608347.713	-0.072	0.943	-7499543.394	6981815.427
TE_v	0.399	0.116	3.430	0.001	0.166	0.632
V_{PD}	4435819.155	4168321.755	1.064	0.292	-3928530.376	12800168.687
V_{PN}	12341900.168	5155846.467	2.394	0.020	1995937.328	22687863.007

Table A-12: Standardised beta coefficients – Scenario 2

Source	**Value**	**Standard error**	**t**	**P > |t|**	**Lower bound (95%)**	**Upper bound (95%)**
TE_v	0.413	0.120	3.430	0.001	0.171	0.654
V_{PD}	0.156	0.146	1.064	0.292	-0.138	0.449
V_{PN}	0.369	0.154	2.394	0.020	0.060	0.679

Next, the number of ounces of gold acquired in the transaction was considered as a third explanatory variable on TR_v. (Scenario 3). For n=56, the regression indicates that approximately 45 of the variability in TR_v is explained by TE_v, the VALMIN Code classification and the number of ounces acquired in the transaction (model p <0.001, MR_o p 0.003).

In the form given in Equation A-6:

$$\hat{y} = b_0 + b_1(x_1) + b_2(x_2) + b_3(x_3) + b_4(x_4) + \varepsilon i$$

(A-6)

Scenario 3 indicates the relationship given in Equation A-7 and Figure A-3

$$\widehat{TR}_v = 602673.123 + 1.302(TE_v) + 3468369.636(V_{PD}) + 13472607.090(V_{PR}) + 13472607.090(V_{PR}) - 15.674(MR_o) + \varepsilon i$$

(A-7)

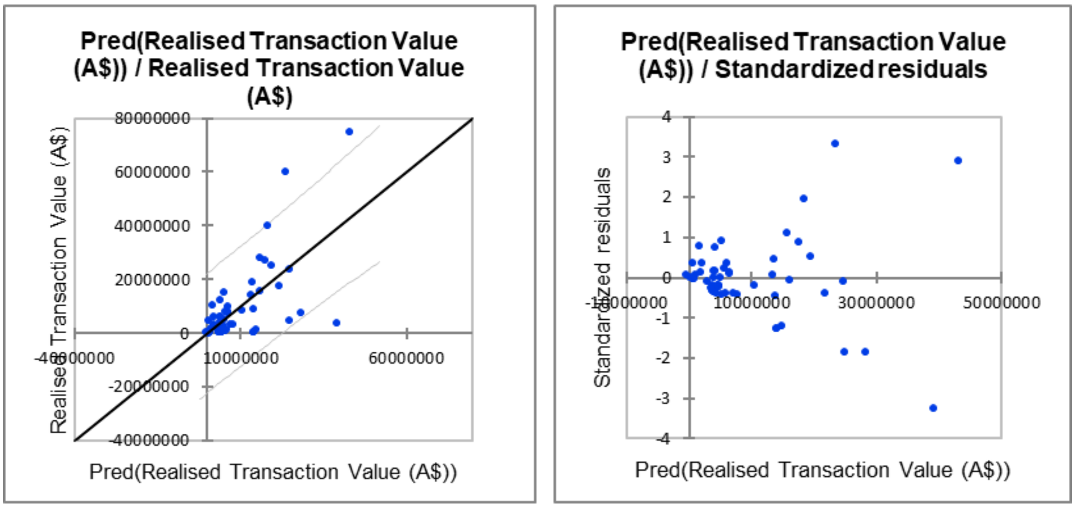

Figure A-3: Regression – Scenario 3

The equation for each VALMIN Code Class under Scenario 3 is given in Table A-13.

Table A-13: Standardised beta coefficients – Scenario 3

VALMIN Code Class	Equation of the model
Advanced Exploration	$\hat{y} = b_0 + b_1(x_1) + b_4(x_4) + \varepsilon i$
Pre-Development	$\hat{y} = (b_0 + b_2(x_2)) + b_1(x_1) + b_4(x_4) + \varepsilon i$
Production	$\hat{y} = (b_0 + b_3(x_3)) + b_1(x_1) + b_4(x_4) + \varepsilon i$

The detailed statistics for Scenario 3 are given in Tables A-14 to A-19.

Table A-14: Multicollinearity statistics – Scenario 3

	Technical Value (A$)	Pre-Development	Production	Ounces acquired
Tolerance	0.105	0.585	0.526	0.103
VIF	9.569	1.709	1.902	9.749

Table A-15: Goodness of fit statistics – Scenario 3

Item	Value
Observations	56.000
Sum of weights	56.000
DF	51.000
R^2	0.449
Adjusted R^2	0.406
MSE	120498259553167.000
RMSE	10977169.925
MAPE	471.965
DW	1.581
Cp	5.000
AIC	1820.431
SBC	1830.558
PC	0.659

Item	Value
Press	10996738508583300.000
Q²	0.014

Table A-16: Analysis of variance – Scenario 3

Source	Degrees of freedom	Sum of squares	Mean squares	F	P>F
Model	4	5004269719263310.00	1251067429815830.0	10.382	< 0.0001
Error	51	6145411237211530.00	120498259553167.0		
Corrected Total	55	11149680956474800.0			

Table A-17: Type III sum of squares analysis – Scenario 3

Source	Degrees of freedom	Sum of squares	Mean squares	F	P>F
TE_v	1	2110413541640040.000	2110413541640040.000	17.514	0.000
V_{PD}	1	96545202920644.000	96545202920644.000	0.801	0.375
V_{PN}	1	952815983087113.000	952815983087113.000	7.907	0.007
MR_o	1	1153259311387830.000	1153259311387830.000	9.571	0.003

Table A-18: Unstandardised beta coefficients – Scenario 3

Source	Value	Standard error	t	P > |t|	Lower bound (95%)	Upper bound (95%)
Intercept	602673.123	3354902.943	0.180	0.858	-6132575.577	7337921.823
TE_v	1.302	0.311	4.185	0.000	0.677	1.926
V_{PD}	3468369.63	3874810.007	0.895	0.375	-4310636.048	11247375.320
V_{PN}	13472607.0	4791125.142	2.812	0.007	3854022.013	23091192.167
MR_o	-15.674	5.066	-3.094	0.003	-25.845	-5.503

Table A-19: Standardised beta coefficients – Scenario 3

Source	Value	Standard error	t	P > |t|	Lower bound (95%)	Upper bound (95%)
TE_v	1.346	0.322	4.185	0.000	0.700	1.991
V_{PD}	0.122	0.136	0.895	0.375	-0.151	0.394
V_{PN}	0.403	0.143	2.812	0.007	0.115	0.691
MR_o	-1.004	0.325	-3.094	0.003	-1.656	-0.353

Next, the average acquired resource grade (in grams per tonne) acquired in the transaction was considered as a fourth explanatory variable on TR_v. (Scenario 4). For n=56, the regression indicates that the variable MR_g does not bring additional significant information (p 0.771) to the variability in TR_v. Further, the addition of the variable, MR_g, shows that the goodness of fit statistics on the P<0.001 model (Table A-20) are lowered. The predicted residual error sum of squares (PRESS) statistic is approximately 8% higher when the variable MR_g is added. As such, the variable MR_g was not included in the model.

Table A-20: Goodness of fit statistics –comparison between Scenario 3 and Scenario 4

Item	Value without MRg	Value with MRg
Observations	56.000	56.000
Sum of weights	56.000	56.000
DF	51.000	50.000
R²	0.449	0.450
Adjusted R²	0.406	0.395
MSE	120498259553167.000	122697346499191.000
RMSE	10977169.925	11076883.429
MAPE	471.965	494.369
Cp	5.000	6.000
SBC	1830.558	1834.487
PC	0.659	0.682
Press	109967385085833300.000	119567574609081000.000
Q²	0.014	-0.072

Next, whether Ore Reserves (R_{OR}) are reported for the project considered in each transaction (1=yes, 0=no) was considered as a fourth explanatory variable on TR_v. (Scenario 5). For n=56, the regression indicates that approximately 59% of the variability in TR_v is explained by TE_v, the VALMIN Code classification, the number of ounces acquired in the transaction and the reporting of an Ore Reserve estimate (model p <0.001, R_{OR} p 0.000, Figure A-4).

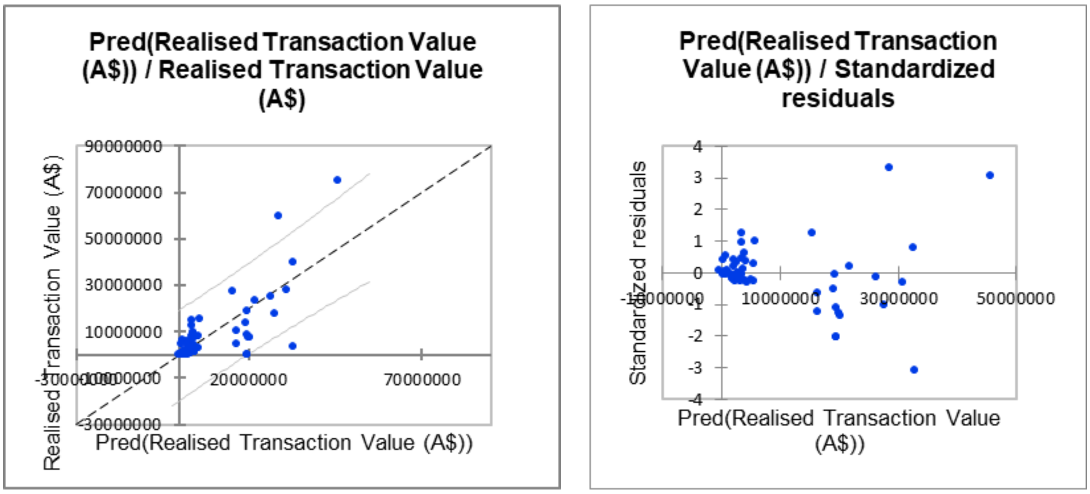

Figure A-4: Regression – Scenario 5

The detailed statistics for Scenario 5 are given in Tables A-21 to A-26.

Table A-21: Multicollinearity statistics – Scenario 5

	Technical Value (A$)	Pre-Development	Production	Ounces acquired
Tolerance	0.101	0.576	0.392	0.098
VIF	9.924	1.736	2.548	10.183

Table A-22: Goodness of fit statistics – Scenario 5

Item	Value
Observations	56.000
Sum of weights	56.000
DF	50.000
R^2	0.592
Adjusted R^2	0.552
MSE	90915722194032.90
RMSE	9534973.634
MAPE	441.776
DW	1.565
Cp	6.000
AIC	1805.547
SBC	1817.699
PC	0.506
Press	8469863211804670.0
Q^2	0.240

Table A-23: Analysis of variance – Scenario 5

Source	Degrees of freedom	Sum of squares	Mean squares	F	P>F
Model	5	6603894846773200.000	1320778969354640.000	14.528	< 0.0001
Error	50	4545786109701640.000	90915722194032.900		
Corrected Total	55	11149680956474800.000			

Table A-24: Type III sum of squares analysis – Scenario 5

Source	Degrees of freedom	Sum of squares	Mean squares	F	P>F
TE_v	1	1410200495892060.000	1410200495892060.000	15.511	0.000
V_{PD}	1	22596798398663.000	22596798398663.000	0.249	0.620
V_{PN}	1	42446536483139.000	42446536483139.000	0.467	0.498
MR_o	1	623822567448258.000	623822567448258.000	6.862	0.012
R_{OR}	1	1599625127509890.000	1599625127509890.000	17.595	0.000

Table A-25: Unstandardised beta coefficients – Scenario 5

Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)
Intercept	362151.275	2914695.085	0.124	0.902	-5492186.09	6216488.64
TE_v	1.083	0.275	3.938	0.000	0.531	1.636
V_{PD}	1691209.39	3392293.518	0.499	0.620	-5122412.66	8504831.44
V_{PN}	3291864.232	4817705.872	0.683	0.498	-6384782.79	12968511.26
MR_o	-11.781	4.498	-2.619	0.012	-20.81	-2.748
R_{OR}	15940232.35	3800187.591	4.195	0.000	8307330.94	23573133.77

Table A-26: Standardised beta coefficients – Scenario 5

Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)
TE_v	1.120	0.284	3.938	0.000	0.549	1.692
V_{PD}	0.059	0.119	0.499	0.620	-0.180	0.298
V_{PN}	0.098	0.144	0.683	0.498	-0.191	0.388
MR_o	-0.755	0.288	-2.619	0.012	-1.334	-0.176
R_{OR}	0.464	0.111	4.195	0.000	0.242	0.686

R_{OR} appears to be a positive confounding variable with V_{PN}. As a result of the addition of the variable, R_{OR}, the statistical significance of the variable, V_{PN}, decreases from p0.005 to p0.498. A test regression (Scenario 6) was run to determine the effect on the Goodness of fit statistics when the VALMIN Code classification is removed from the regression given that only the VALMIN Code production class (V_{PN}) contributed statistical significance in Scenario 3. Scenario 6 provides notably better Goodness of Fit statistics than Scenario 5 (Table A-27, Figure A-5 and Tables A-28 to A-33), indicating that it is the reporting of an Ore Reserve estimate rather than the VALMIN Code production class which contributes a greater significance to the variation in TR_v.

Table A-27: Goodness of fit statistics Comparison (Scenarios 3, 5 and 6)

Item	Scenario 3	Scenario 5	Scenario 6	Comment
Observations	56.000	56.000	56.000	
Sum of weights	56.000	56.000	56.000	
DF	51.000	50.000	52.000	
R^2	0.449	0.592	0.588	Down 0.4
Adjusted R^2	0.406	0.552	0.565	Up 1.3
MSE	120498259553167.0	90915722194032.90	88257747805099.70	Down 3
RMSE	10977169.925	9534973.634	9394559.479	Down 1
MAPE	471.965	441.776	460.591	Up 4
DW	1.581	1.565	1.583	Up 0.018
Cp	5.000	6.000	4.000	

Item	Scenario 3	Scenario 5	Scenario 6	Comment
AIC	1820.431	1805.547	1802.082	Down 0.2
SBC	1830.558	1817.699	1810.183	Down 0.4
PC	0.659	0.506	0.475	Down 7
Press	10996738508583300.0	8469863211804670.0	8066601216390760.0	Down 5
Q^2	0.014	0.240	0.277	Up 15

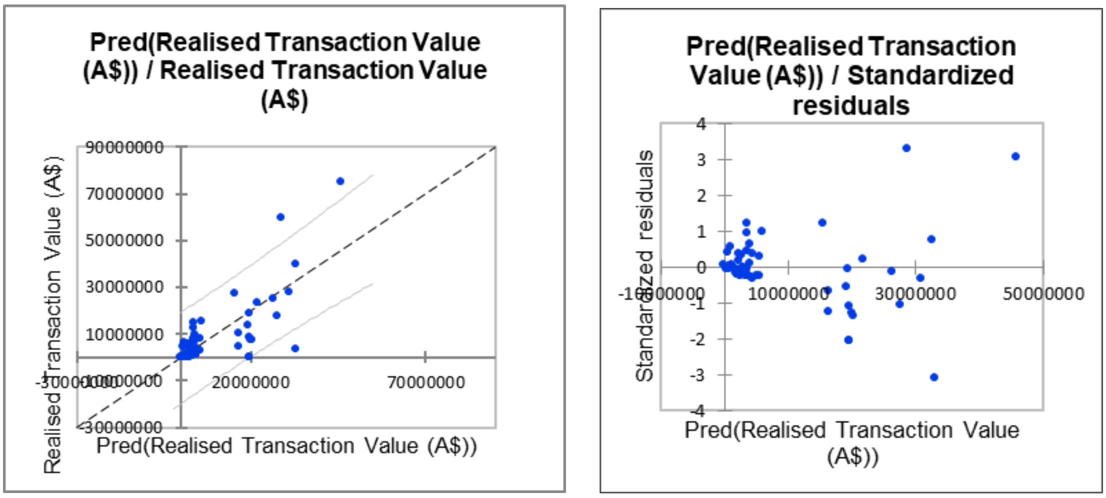

Figure A-5: Regression – Scenario 6

Table A-28: Multicollinearity statistics – Scenario 6

	Technical Value (A$)	Pre-Development	Production	Ounces acquired
Tolerance	0.104	0.105	0.956	0.104
VIF	9.659	9.524	1.046	9.659

Table A-29: Goodness of fit statistics – Scenario 6

Item	Value
Observations	56.000
Sum of weights	56.000
DF	52.000
R^2	0.588
Adjusted R^2	0.565
MSE	88257747805099.700
RMSE	9394559.479
MAPE	460.591
DW	1.583
Cp	4.000
AIC	1802.082
SBC	1810.183
PC	0.475
Press	8066601216390760.000
Q^2	0.277

Table A-30: Analysis of variance – Scenario 6

Source	Degrees of freedom	Sum of squares	Mean squares	F	P>F
Model	3	6560278070609660.00	2186759356869890.00	24.777	< 0.0001
Error	52	4589402885865180.00	88257747805099.70		
Corrected Total	55	11149680956474800.0			

Table A-31: Type III sum of squares analysis – Scenario 6

Source	Degrees of freedom	Sum of squares	Mean squares	F	P>F
TE_v	1	1432948951804500.000	1432948951804500.000	16.236	0.000
MR_o	1	620236491876504.000	620236491876504.000	7.028	0.011
R_{OR}	1	2652619308598450.000	2652619308598450.000	30.055	< 0.0001

Table A-32: Unstandardised beta coefficients – Scenario 6

Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)
Intercept	1630942.733	1620073.617	1.007	0.319	-1619972.815	4881858.281
TE_v	1.078	0.267	4.029	0.000	0.541	1.614
MR_o	-11.361	4.286	-2.651	0.011	-19.960	-2.761
R_{OR}	17154097.772	3129009.186	5.482	< 0.0001	10875281.485	23432914.058

Table A-33: Standardised beta coefficients – Scenario 6

Source	Value	Standard error	t	P > |t|	Lower bound (95%)	Upper bound (95%)
TE_v	1.114	0.277	4.029	0.000	0.559	1.669
MR_o	-0.728	0.275	-2.651	0.011	-1.279	-0.177
R_{OR}	0.499	0.091	5.482	< 0.0001	0.316	0.681

Under the principle of parsimony (Seasholtz and Kowalski (1993)), Scenario 6 provides a simpler model than Scenario 5. Scenario 6 was therefore selected as the scenario on which to undertake further analysis. So that in the form given in Equation A-8, Scenario 6 indicates the relationship given in Equation A-9.

$$\hat{y} = b_0 + b_1(x_1) - b_4(x_4) + b_5(x_5) + \varepsilon i$$

(A8)

$$\widehat{TR}_v = 1630942 + 1.078(TE_v) - 11.361(MR_o) + 17154097.772(R_{OR}) + \varepsilon i$$

(A9)

The equations of the model for projects with and without reported Ore Reserve estimates are presented in Table A-34.

Table A-34: Models Derived from Scenario 6

Status	**Equation of the model**
No Ore Reserve estimate	$\hat{y} = b_0 + b_1(x_1) - b_4(x_4) + \varepsilon_1$
Ore Reserve estimate	$\hat{y} = (b_0 + b_5(x_5)) + b_1(x_1) - b_4(x_4) + \varepsilon_1$

Two populations are now defined within the Training Portfolio; Population1 (Ore Reserve estimate reported), and Population 2 (No Ore Reserve estimate reported). Next, the significance of the XGD market sentiment was tested on the TR_v for the two populations when controlling for TE_v. and MR_o.and R_{or}.

Population 1: Ore Reserve estimate reported

For n=12, the regression indicates that approximately 94% of the variability in TR_v is explained by TE_v, MR_o, R_{or} and the XGD sentiment classification. The variable representing XGD Sentiment Class 5 (S5) brings significant information (S5 p0.035) to explain the variability in TR_v. Under the Mao and Rosecki classification, S5 represents 'A gradual upward swing enough to cause a feeling of encouragement to an investor. The environment for fund raising may be encouraging'. The analysis summary is presented in Figure A-6 and Tables A-35 to A-40, where the S1 class observations are the control group represented by the intercept.

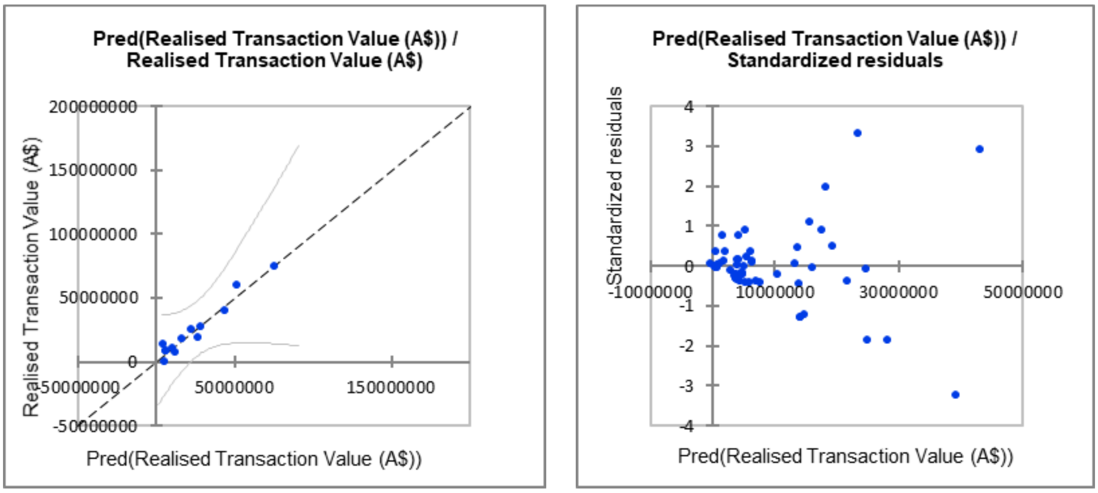

Figure A-6: Regression – Population 1

Table A-35: Multicollinearity statistics – Population 1

	Technical Value (A$)	Ounces acquired	Sentiment 4	Sentiment 5	Sentiment 6	Sentiment 7
Tolerance	0.064	0.062	0.795	0.677	0.577	0.523
VIF	15.589	16.037	1.258	1.476	1.732	1.911

Table A-36: Goodness of fit statistics – Population 1

Item	Value
Observations	12.000
Sum of weights	12.000
DF	5.000
R^2	0.943
Adjusted R^2	0.874
MSE	63616461305664.600
RMSE	7975992.810
MAPE	409.771
DW	1.721
Cp	7.000
AIC	384.901
SBC	388.295
PC	0.217
Press	1316940947526060.000
Q^2	0.763

Table A-37: Analysis of variance – Population 1

Source	Degrees of freedom	Sum of squares	Mean squares	F	P>F
Model	6	5246881430511000.000	874480238418501.000	13.746	0.006
Error	5	318082306528323.000	63616461305664.600		
Corrected Total	11	5564963737039330.000			

Table A-38: Type III sum of squares analysis – Population 1

Source	Degrees of freedom	Sum of squares	Mean squares	F	P>F
TE_v	1	1691359513316240.000	1691359513316240.000	26.587	0.004
MR_o	1	619661305392242.000	619661305392242.000	9.741	0.026
S4	1	52608751324105.000	52608751324105.000	0.827	0.405
S5	1	520778084502111.000	520778084502111.000	8.186	0.035
S6	1	102009030342207.000	102009030342207.000	1.604	0.261

S7	1	950960379757.000	950960379757.000	0.015	0.907

Table A-39: Unstandardised beta coefficients – Population 1

Source	**Value**	**Standard error**	**t**	**P > |t|**	**Lower bound (95%)**	**Upper bound (95%)**
Intercept	6557643.91	5209460.65	1.259	0.264	-6833700.239	19948988.078
TE_v	2.972	0.576	5.156	0.004	1.490	4.453
MR_o	-33.382	10.696	-3.121	0.026	-60.876	-5.887
S4	8498416.7	9345311.43	0.909	0.405	-15524469.726	32521303.138
S5	21476573.24	7506256.33	2.861	0.035	2181128.177	40772018.317
S6	-10296327.38	8131071.63	-1.266	0.261	-31197911.229	10605256.450
S7	-825627.124	6752856.08	-0.122	0.907	-18184395.310	16533141.062

Table A-40: Standardised beta coefficients – Population 1

Source	**Value**	**Standard error**	**t**	**P > |t|**	**Lower bound (95%)**	**Upper bound (95%)**
TE_v	2.177	0.422	5.156	0.004	1.092	3.262
MR_o	-1.336	0.428	-3.121	0.026	-2.437	-0.236
S4	0.109	0.120	0.909	0.405	-0.199	0.417
S5	0.372	0.130	2.861	0.035	0.038	0.706
S6	-0.178	0.141	-1.266	0.261	-0.540	0.184
S7	-0.018	0.148	-0.122	0.907	-0.398	0.362

Population 2: No Ore Reserve estimate reported

The results of the OLS regression on Population 1 do not hold for the same OLS regression on Population 2. For n=44, the OLS on Population 2 regression indicates that approximately 28% of the variability in TR_v is explained by TE_v, MR_o and R_{or} and the XGD sentiment classification. The analysis summary is presented in Figure A-7 and Tables A-41 to A-46 where the S_1 class observations are the control group represented by the intercept. There were no observations made for S_4, which represents the 'uncertain' state.

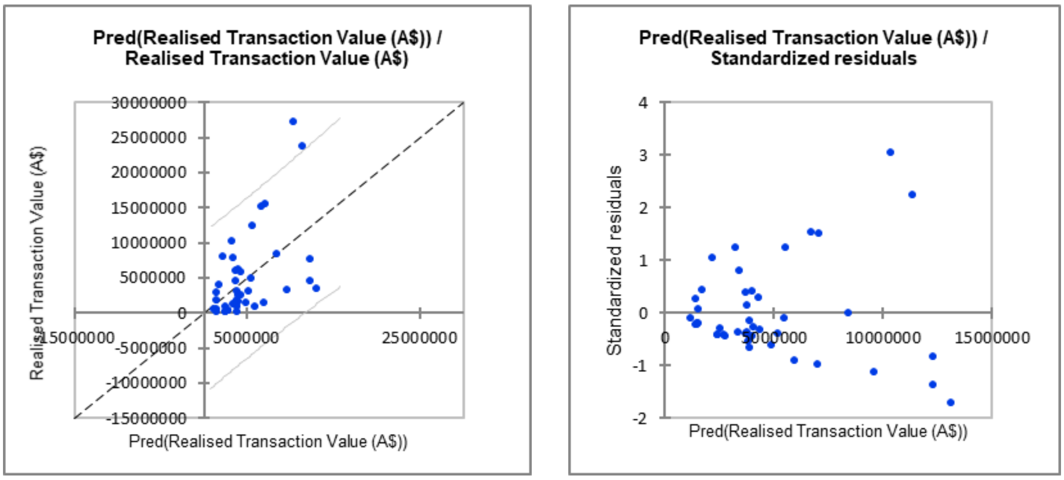

Figure A-7: Regression – Population 2

Table A-41: Multicollinearity statistics – Population 2

	Technical Value (A$)	Ounces acquired	Sentiment 2	Sentiment 4	Sentiment 5	Sentiment 6	Sentiment 7
Tolerance	0.088	0.087	0.547	0.390	0.523	0.562	0.402
VIF	11.345	11.458	1.829	2.566	1.913	1.778	2.485

Table A-42: Goodness of fit statistics – Population 2

Item	Value
Observations	44.000
Sum of weights	44.000
DF	36.000
R^2	0.282
Adjusted R^2	0.142
MSE	31081801030548.900
RMSE	5575105.473
MAPE	292.802
DW	2.393
Cp	8.000
AIC	1374.147
SBC	1388.420
PC	1.037
Press	2310277303961020.000
Q^2	-0.483

Table A-43: Analysis of variance – Population 2

Source	Degrees of freedom	Sum of squares	Mean squares	F	P>F
Model	7	438908972038671.000	62701281719810.200	2.017	0.080
Error	36	1118944837099760.000	31081801030548.900		

Corrected Total	43	1557853809138430.000			

Table A-44: Type III sum of squares analysis – Population 2

Source	Degrees of freedom	Sum of squares	Mean squares	F	P>F
TE_v	1	67110773799136.500	67110773799136.500	2.159	0.150
MR_o	1	6754405769909.620	6754405769909.620	0.217	0.644
S2	1	12561804604685.700	12561804604685.700	0.404	0.529
S4	1	2718700603422.690	2718700603422.690	0.087	0.769
S5	1	9897877333174.750	9897877333174.750	0.318	0.576
S6	1	14524823412266.300	14524823412266.300	0.467	0.499
S7	1	456298121267.687	456298121267.687	0.015	0.904

Table A-45: Unstandardised beta coefficients – Population 2

Source	Value	Standard error	t	P > |t|	Lower bound (95%)	Upper bound (95%)
Intercept	3351219.5	2520843.394	1.329	0.192	-1761287.859	8463726.870
TE_v	0.299	0.203	1.469	0.150	-0.114	0.711
MR_o	-1.468	3.150	-0.466	0.644	-7.856	4.920
S2	-2276994.4	3581698.721	-0.636	0.529	-9541016.184	4987027.194
S4	-919561.61	3109232.723	-0.296	0.769	-7225377.846	5386254.619
S5	-1911777.6	3387813.019	-0.564	0.576	-8782580.902	4959025.618
S6	2413950.7	3531230.454	0.684	0.499	-4747716.557	9575618.040
S7	360419.6	2974659.125	0.121	0.904	-5672468.678	6393307.974

Table A-46: Standardised beta coefficients – Population 2

Source	Value	Standard error	t	P > |t|	Lower bound (95%)	Upper bound (95%)
TE_v	0.699	0.476	1.469	0.150	-0.266	1.664
MR_o	-0.223	0.478	-0.466	0.644	-1.193	0.747
S2	-0.121	0.191	-0.636	0.529	-0.509	0.266
S4	-0.067	0.226	-0.296	0.769	-0.526	0.392
S5	-0.110	0.195	-0.564	0.576	-0.507	0.286
S6	0.129	0.188	0.684	0.499	-0.253	0.511
S7	0.027	0.223	0.121	0.904	-0.425	0.479