The Valuation of Gloucester Coal – An Expanded Net Present Value Approach

Brett Diedrich September 2012

Master of Science in Economics and Business Administration

Specialising in Finance and Strategic Management

Supervisor: Peter Staudt, Dong Energy

Characters & Page numbers: 181,772 STU; 79.9 pages

Executive Summary

A well-constructed corporate valuation is an arduous task requiring detailed analysis, cogent assumptions and executed in a clear, synthesised manner. Traditional DCF analysis, whilst used by the majority of the investment community has its weaknesses. The ability for the model to incorporate future flexibility is limited. The valuation of a company is a subjective process that needs to incorporate future expectations in an uncertain environment. The DCF model is presented on the proviso that investment decisions are fixed, naturally assuming that management take a passive role. This however is contradictory to the philosophy of management and the expectations of the investment community. Real option valuation (ROV) allows for flexibility. Building upon the DCF model, ROV recognises that uncertainty isn't merely represented by downside risk. The ability for corporations to adjust future investments decision when faced with a dynamic environment leads to lower downside risk and the ability to capture increased upside potential.

The thesis is presented in three parts. The first section provides a theoretical framework, highlighting the main characteristics of the present value technique and juxtaposing this with ROV. The theory is then implemented in part two of the thesis through a valuation of a case company. Gloucester Coal, an Australian based coal mining company is the focus of this piece. An overview of the coal industry and Gloucester Coal is presented. The valuation is then executed in three parts. Firstly the DCF valuation assuming no flexibility is presented, secondly the terminal value as represented by exploration activities is discussed. A ROV building upon the inherent flexibility in the operating mines is then incorporated. This process involved volatility estimation, Monte Carlo simulation and payoff structure analysis. A binomial lattice model is used to model the option to expand or abandon the production assets. Finally, a comparison to analyst valuations and concluding remarks are provided.

The valuation resulted in a fair value of $8.02 AUD per share. The incorporation of a ROV framework resulted in a 14% increase in Enterprise Value assuming no flexibility. The valuation and financial model incorporated throughout the body of this text is presented in the first three parts of the appendix. The thesis demonstrates that there is value in uncertainty and management does have the ability to react to new information.

The utilisation of ROV provides the ability for the investment community to recognise the strategic options management carry and assess their performance in execution. Building upon a fully developed DCF valuation of Gloucester Coal, a pragmatic approach is demonstrated with the aim of transcending the academic realm to provide the reader with a palpable valuation tool.

List of Abbreviations

ABARE: Department of Agriculture, Fisheries & Forestry

B-S: Black Scholes Model

DCF: Discounted Cash Flow

DTA: Decision Tree Analysis

FCF/FCFF: Free cash flow/to firm

IEA: International Energy Agency

JORC: Joint Ore Reserves Committee

MCS: Monte Carlo simulation

MRP: Market Risk Premium

NOPLAT: Net operating profit less adjusted tax

NPV: Net Present Value

ROV: Real Option Valuation

ToE: Tonnes of oil equivalent

WACC: Weighted Average Cost of Capital

WEC: World Energy Council

EX: Exercise price

UAV: Underlying Asset Value

Contents

List of Figures

Introduction

1.1 Background

The valuation of a company is a subjective process, riddled with difficulty. Thankfully, stock markets provide investors with relative asset valuations and efficient price formation. However, how does the market reach consensus on a company's valuation and what tools are employed to reach this valuation? There is growing theoretical evidence that company valuations exceed that of conventional valuation methods (Discounted Cash Flow) and this difference can be attributed to option premiums (Copeland & Keenan, 1998; Munn, 2002). A mining company provides a clear example of the difficulty of employing conventional models to ascertain the value of its assets. Mining projects comprise of several factors making real option valuation applicable. Firstly, investments are partially reversible; mining companies have the ability to salvage assets and cancel investments. Secondly, there is a high degree of uncertainty around the mineral deposit, price evolution of the commodity and variability of operating costs. Lastly, there is a degree of leeway in which management can actively respond to new information (Shafiee, Topal, & Nehring, 2009).

1.2 Problem Identification

Capital budgeting is the process of allocating limited firm resources towards long-term investments. This involves forgoing current consumption in order to receive a long-term return (Trigeorgis, 1996). The capital budget process is an evolving one; according to Seitz and Ellison (1995) in a study spanning forty-years, prior to 1988 payback period and accounting rate of return were the preferred decisions method. After this period, the use of the discounted cash flow approach grew. Accordingly, over 75% of companies were using this approach (Seitz & Ellison, 1995). This was also confirmed in a study carried out by Graham & Campbell (2002), of 392 completed CFO surveys, 74.9% of respondents always or mostly use the Net Present Value (NPV) method of project valuation.

However, the NPV approach has been grounded in academic literature for some time. The field first came about through the work of Irving Fisher (1907) in the field of capital, investments and interest rates. However, the valuation technique was formalised through his later work (Fisher I. , 1930) and through contributions from Williams (1930) in the field of intrinsic value (the discounted dividend model). The problem as alluded to by Myers (1984) is that a valuation tool needs to be introduced that links the inherent gap between strategic planning and corporate budgeting. Myers referred to this as, "two cultures looking at the same problem" (1984, p. 130).

These concerns have been further raised by Trigeorgis (1996) and Munn (2002). Conventional valuation tools (DCF) fail to capture the inherent uncertainty and management flexibility in long-term capital budgeting decisions and the firm's assets. Traditionally uncertainty has been viewed as a variable that increases the risk characteristics of a project, and therefore, increases the required return on an investment.

Conventional valuation tools have penalised projects with a high degree of uncertainty and lead to myopic decisions. However, uncertainty creates options; a valuation-tool incorporating management flexibility and uncertainty provides a more suitable method of valuation. Trigeorgis (1996) and Munn (2002) describe this valuation tool as the Expanded (strategic) Net Present Value (eNPV):

$$\text{eNPV} = \text{NPV} + \text{Option Value}$$

Expanded Net Present Value (eNPV or NPV*) = the static base case NPV + the option premium (as represented by the strategic options of active management).

The NPV process assumes that all investments decisions are known and management's role in the investment process is passive. This irrevocable investment strategy is inconsistent with the ideals, function and active nature of management. The eNPV method therefore is not a substitute to NPV; it's a complimentary tool incorporating the use of real option valuation (ROV). "It's paramount that the practitioner first understand that ROA is not a substitute for but a supplement to DCF" (Kodukula & Papudesu, 2006, pp. 65-66). Management adjust capital plans, investment decisions and strategic objectives in the face of new information. This thesis therefore aims to provide a valuation incorporating management flexibility in an uncertain operating environment.

1.3 Problem Statement

This thesis will utilise practical tools available in academic literature to provide a sophisticated valuation tool. This exploratory valuation will be executed through a company case study. The aim of the paper is to bridge the gap between management flexibility, as represented by strategic options and that of the conventional valuation tool: NPV analysis.

Utilising ROV will determine the value uplift of active management and coincidently, provide a comparison benchmark to the market valuation. This driving philosophy yields the following problem statement:

What is the fair value of the case study company using the expanded net present value approach and what is the value of management flexibility inherent in the available strategic options?

1.4 Research Questions

In order to predefine the parameters of this investigation and to provide focus throughout the thesis, the following research questions have been included. By systematically working through the research questions, the thesis in turn will be able to achieve its overall objective of addressing the central problem statement:

- What are the various valuation tools, how are they grouped and where does DCF valuation fit?
- What are the main limitations of the DCF method and does ROV help to alleviate some of these limitations?

- What are real options, how do they relate to financial options and what are the main variables driving the value of these options?
- What are the main ROV techniques?
- What is the base value of the case company?
- What strategic options are available to management?
- How much is management flexibility (ROV) worth?
- How does this compare to market value and analyst valuations?

1.5 Relevance

The thesis aims to bridge the gap between conventional DCF valuation and ROV. Real option literature dates back to the late 1970s though it is yet to transcend the realm of academic literature to an easily applied state in the broader investment community. This inertia was also demonstrated through the long lag between DCF valuation academic literature and its practical uptake in the broader investment community. The relevance of this thesis is centred in three primary goals.

Firstly, to see if the application of the theory highlights additional value that is not being taken into consideration by the market, or a decomposition of the attributed value of flexibility. Secondly, the utilisation of a case study aims to further bridge the gap between theoretical concept and practical application. The thesis will provide a detailed application and therefore serve as a useful aid to practitioners. Lastly, utilisation of ROV further demonstrates the value management flexibility carries. Highlighting this places further emphasis on strategic planning; understanding what options are available to management and the importance of reassessing strategic options when new information is available. Quite often, the financial community provide a mark-up on a DCF valuation to capture value associated with flexibility (Krychowski & Quelin, 2010). The paper provides a solid tool to explaining this value. Copeland and Antikarov (2003) provide a good explanation to this, stating that the NPV method 'systematically' undervalues everything due to its inability to capture flexibility, and most often the price that is paid for this flexibility exceeds its value. This makes it quite pertinent to employ methods that correctly capture this uncertainty.

1.6 Target Audience

The thesis at its centre provides the application of a modified valuation tool. Therefore the paper provides a useful reference for both management and investors. The ability to provide a sharpened valuation tool demonstrates the value that strategic options carry. This obviously carries significance to the broader investment community. In addition, ROV carries significance for management on a project valuation level. Furthermore, utilising ROV highlights the possibility of unlocking additional value though greater information sharing. Information asymmetry may mean the market does not completely understand the strategic options that management possess.

1.7 Structure

The thesis will be presented in three parts. Firstly, the theoretical overview will be presented. This will establish the framework for the case. The next section will present the case study. This will be broken down into six chapters covering four main sections. Lastly, the result will be discussed and compared to analyst reports and a conclusion will be presented.

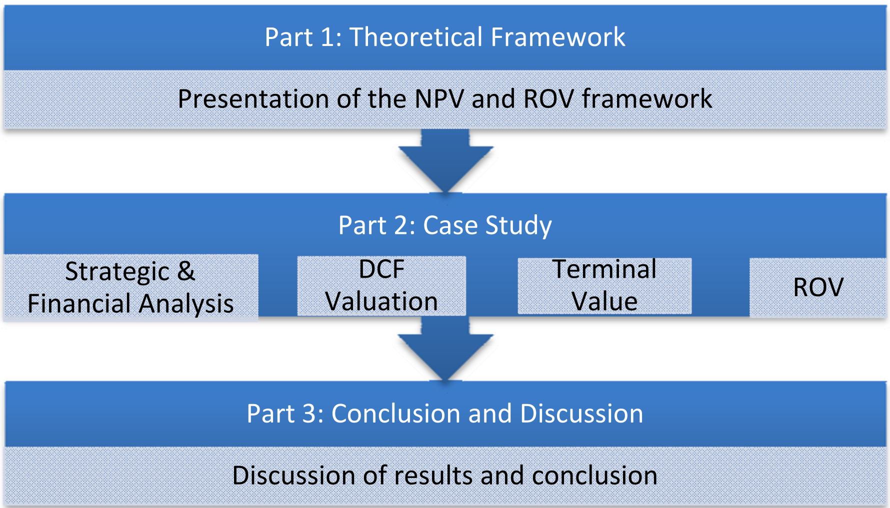


Figure 1: Overview of structure

1.8 Case Study

A case study has been chosen to showcase the theoretical tools. A case approach is one of the principal methods of inquiry in the social science field (Thomas, 2001) . Simons (2009), in her review of a number of case study definitions, postulates that a case study is a method of study that attempts to engage real life complexity through an in-depth exploration involving a multitude of perspectives. The study utilises an abductive research approach. Abductive reasoning proposes problematic reasoning by finding a causal relation among the facts. The aim is to provide a cogent justification of the factors driving the valuation; the objective is not to influence them. The paper is an inquisition into the drivers of value. However, whilst the paper aims to be objective, valuation is not a science. Incomplete information and asymmetry leads to deviations in outcomes.

This case study hopes to overcome a typical misunderstanding that generalisations cannot be formed from a single-case study (Flyvbjerg, 2006). Rather, in line with Kuhn (1987), an area of study that lacks production of case studies is without consummate examples. Without exemplary studies, the area lacks depth and fails to transcend theoretical bounds.

The paper utilises a real life case study and therefore is subject to the associated complexities. An attempt to best apply the theoretical teachings has been put forward; in doing so, some areas of study must be delimited. This will be discussed in the following section.

1.9 Case Company: Gloucester Coal

The case study wanted to focus on a company where the application of the eNPV was relevant. Brenan and Schwartz in 1985 applied ROV to natural resources. Natural resources are suitable to such a framework due to the high degree of uncertainty in mine planning and commodity prices. Samis and Poulin (1998) and Trigeorgis (1996) found that the application of ROV extended the valuation further through its ability to introduce management flexibility.

Slade (2001), Moel and Tufano (2002), Colwell, Henker, & Ho (2003) and Kelly (2004) valued management flexibility in a study of 21 Canadian copper mines, 285 American gold mines, 27 Australian gold mines and 41 further Australian gold mines respectively. Each of the studies found flexibility in mining projects is significant.

The case study wanted to focus on a company that focused on one particular commodity. Initially coal was thought to be a less obvious choice due to the lack of academic articles focusing on coal mine optionality. However, traditionally volatility in coal prices has been quite low, making this area less subject to real option theoretical frameworks. Though recent volatility, caused by supply and demand imbalances, the rise of the seaborne coal market and supply inelasticity has meant coal prices have become much more volatile. In addition, the increased degree of commodities trading has led to further coal price volatility.

The recent business headlines reflect management flexibility being exercised in the coal sector. In April 2012, due to rising costs, BHP decided to close its most costly coal mine in Queensland[1]. Furthermore, and on the more extreme side, Patriot Coal in the US decided in the second half of 2012 to close several mines and place the company under Chapter 11 bankruptcy protection[2]. This is juxtaposed by plans to expand capacity at Abbot Point terminal in North Queensland[3]. These decisions represent strategic flexibility.

Coal is one of Australia's largest export resources; it was for this reason and the interests of the native Australian author that coal companies in Australia were reviewed. There were very few listed pure play coal companies. The industry of late has come under a tremendous degree of consolidation. Gloucester coal was a prime choice as the company had several years of historical data and was a pure play coal company. The

---

[1]http://www.theaustralian.com.au/business/mining-energy/bhp-billiton-to-close-norwich-park-mine/story-e6frg9df-1226323935644

[2] http://in.reuters.com/article/2012/07/13/us-patriot-bankruptcy-idINBRE86C16U20120713

[3] http://www.theaustralian.com.au/business/state-proposes-6bn-coal-port-expansion/story-e6frg8zx-1226067493717

company sells its coal to the export market and relies on spot prices to establish contract prices, therefore being subject to coal price volatility.

The company has been analysed in the 2012 FY and all amounts, if otherwise indicated, are presented in Australian dollars (Approximately: 1AUD/6.2DKK). The second half-year 2012 results have been incorporated into the valuation model. Prices and costs have been estimated in data that was established in the March 2012 quarter. The options model relies on yearly data and therefore the options are prices as at June 2012. The valuation has been provided as at June 2012.

Whilst writing this thesis the company was subject to a takeover offer and subsequently merged with Yancoal. The takeover has not been taken into account when writing this paper. The company has been valued on a standalone basis and therefore Yancoal is not mentioned in the valuation nor does the value reflect any control premiums.

As explained in the options section of the paper, the business has been modelled on a company level. The use of production process optimisation and temporary closure has not been modelled. The valuation utilises the expected recoverable reserve body. Due to technical uncertainty and specialist mining knowledge, changes to the reserve body have not been estimated. It is also assumed that any expansion adjustments are geographically feasible. The exploration assets will be modelled using relative valuation; this is an academically justifiable method. Whilst a fundamental analysis would provide a greater insight (including real options based analysis) into the exploration based activities, due inherent limits of the paper and also a greater need for technical understanding the exploration assets will in effect be recognised as the terminal value, representing the future growth possibilities available to Gloucester Coal.

The mineral resource rent tax (MRRT) has been explained in the industry challenges section of the paper. This is not taken into account in the valuation. A review of big four accounting literature was conducted and it appeared quite obvious that the exact impact of the tax (taking into account credits on state royalties paid) is not clear. In addition, due to the generous asset valuation allowance the exact impact of the change in the tax on mining assets is unknown. It's for this reason that the MRRT is not elaborated upon in the valuation. Furthermore, the Australian government is in the process of introducing a tax on the largest Australian carbon dioxide producers. Gloucester Coal has not advised on the effect of this tax. It is noted that some companies are given allowances and in addition the leader of the opposition (The Hon. Tony Abbott) has made it clear that the tax will be repealed if the coalition government gains power. The impact of a carbon tax is therefore discussed on a general level and will be incorporated into the sensitivity analysis.

The thesis has been written from an outside perspective. All information attained on Gloucester Coal is from public sources and therefore this thesis is based on the same sources available to investors. A great deal of secondary data was used in the construction of this paper. Whilst all due care was exercised, the valuation of the options available to the company would grow with primary input, or an insider's understanding of the firm's capital budgeting process.

The next section will provide a theoretical overview of the fundamental valuation models.

Part I – Theoretical Framework

2. Financial Theory and Valuation Models

This section will provide an overview of common fundamental valuation tools and also establish the theoretical framework behind the case study. An overview of discounted cash flows, decision tree analysis and real option valuation will be provided. These models have been assessed under four criteria, fundamentals, uncertainty, flexibility & usability. The recapitulation will provide a high level comparison of the models and then finally outline the valuation approach that will be used in part II of the paper.

The Role of Valuation

Valuation is at the heart of corporate finance; it drives investment decisions, leading managers to invest in growth opportunities and in turn drives analysts to hunt for mispricing in corporate valuations (Damodaran, 2005). Investment professionals need to utilise a valuation tool that will capture the idiosyncratic value of a corporation's opportunities though on the whole be easily applied to a broad cross-section of companies.

According to Petersen & Plenborg (2012), valuation can be classified into four categories. The first, is present value based techniques, this encompasses discounted cash flow valuation, which estimates the value of an asset to the present value of expected cash flows. The second is relative valuation, using firm based ratios these are compared to a set of company comparable peers in order to establish a consensus valuation based upon established market prices. The third technique, liquidation, values a firm based upon the value of the individual assets of the business, this is either achieved through an orderly or distressed sale – depending upon the context of the valuation. Lastly, contingent claim analysis, uses option-based analysis to value a firm, this is generally referred to as real option valuation (ROV).

This section will focus upon two of these branches, present value based techniques and real options valuation. Liquidation and relative valuation will not be focused upon. This is due to the fact that liquidation value fails to recognise the inherent value of a business being ran as a going concern (Damodaran, 1996), or put simply – the upside potential. The primary focus of this section is to assess tool and techniques that are able to value uncertainty and management flexibility. Liquidation will be incorporated in a contingent based analysis through modelling options such as, the ability to abandon an investment. Secondly, relative valuation is widely used – estimates suggest that 92% of practitioners use the method (95% using present value techniques – i.e., NPV) (Petersen & Plenborg, 2012). This paper will rely on relative valuation to value the exploration activities of Gloucester coal, though the focus of this section is to juxtapose Present Value techniques with that of ROV.

Evaluation Criterion for Financial Valuation Models

Prior to introducing the valuation tools, a criteria needs to be established in order to objectively review the models at hand. According to Petersen & Plensborg (2012) a valuation model needs to provide a balance between value attributes and user attributes. This essentially means that the model needs to make realistic assumptions and provide a fair degree of precision whilst still being easy to use and providing comprehendible output. Four key criteria have been used to assess each of the models: fundamentals, market uncertainty, flexibility and usability. These criteria will in effect give an overview of the model, how uncertainty is handled – meaning the ability for the model to take into account events occurring in the future, the ability for the model to incorporate management's response to uncertain events and lastly the general usability of the model.

Fundamentals	**Uncertainty**
A discussion of the characteristics and structure of the model. In addition an understanding of the background and origin of the model.	Ability to capture the uncertain nature of cash flows and market risk.
Flexibility	**Usability**
The model's ability to capture and incorporate management flexibility. This includes the model's ability to handle a range of outcomes and secondly given that outcome how management would react.	An understanding of the model's use by the broader investment community.

Figure 2: Analytical framework used in theoretical section

2.1 Net Present Value

Fundamentals

There are many discount cash flow models; however these are essentially all derivations involving the calculation of the Net Present Value (NPV) (Kodukula & Papudesu, 2006). The NPV model is used to calculate the present value of a stream of cash flows. These cash flows are discounted at an appropriate risk adjusted rate. Therefore, the value of the firm is driven by the asset's ability to generate cash flow. This philosophy was developed over a long period, originally tracing back to the classic Greeks. Irving Fisher was credited with moving the theory into modern finance, through his early work '*The Rate of Interest: Its Nature, Determination and Relation to Economic Phenomena* (1907)'. This was later added to by the publication of '*The Theory of Interest: As Determined by Impatience to Spend Income and Opportunity to Invest It* (1930)'. It was in his second book that he introduced the inter-temporal trade-off of exchange and production. In doing this, he also justified the maximisation of present value as the production goal (Rubinstein, 2003). However, it was only after the 1950s that the method grew in acceptance.

Utilising the DCF, the valuation of a firm is typically expanded into two parts: the forecasted cash flows plus the terminal value. The forecasted cash flow is established by estimating the free cash flow available to the firm over a set period. The terminal value is the projection of the final forecasted cash flow, using the Gordon growth model (Gordon, 1959). The terminal value is used when it is safe to assume the firm has entered a steady state, taking into account a fixed growth rate (Damodaran, 1996). This is therefore effectively a stream of cash flows into perpetuity. The discounted value of the cash flows establishes the value of the operating assets of the firm. This essentially means that items such as cash need to be added to the value to establish the total enterprise value. (Damodaran, 2005) .

Uncertainty

Uncertainty is taken into account through selecting an appropriate discount rate, such as the weighted average cost of capital (WACC). This and the underlying assumptions behind its use are shown in the appendix. The WACC is calculated by summing the proportional cost of equity and after tax cost of debt. The cost of equity is generally found using the Capital Asset Pricing Model (CAPM) though other models do exist, such as, Arbitrage Pricing Theory which is essentially a multi-index model (Elton, Gruber, Brown, & Goetzmann, 2003). There has been some debate over the predictive powers of CAPM. Fama & French (1992) concluded that their tests do not support the assumption that stock returns are positively related to market betas. However other studies have concluded that expected returns do compensate for Beta risk (Kothari, Shanken, & Sloan, 1995). Therefore For the purposes of this paper, the CAPM will be used to calculate the cost of equity.

There are two sources of risks: firm specific risks and non-diversifiable market based risk (Damodaran, 1996). According to CAPM theory, investors are only compensated for incurring market-based risk. It is assumed that investors hold the market portfolio and therefore firm specific risks are diversifiable (Elton, Gruber, Brown, & Goetzmann, 2003). The CAPM is based on the assumption that investors demand a higher return for taking on additional risk, as shown by the linear relationship above. The premium is known as the excess market return. The degree of additional risk is determined by beta, which measures the company's return relative to the return of the overall market. When calculating beta it is important to make the necessary adjustments for leverage, which is often forgotten when comparing the beta of peer companies (Fernandez & Bilan, 2007). The cost of debt is calculated depending on the quality of the debt. If a company has issued investment grade debt, then typically the calculated yield to maturity (YTM) can be used as the opportunity cost of capital. If the debt is below investment grade then expected YTM (taking probability of default into account) should be used over the headline YTM (Koller, Goedhart, & Wessels, 2010).

The DCF model, as shown, treats uncertainty as a risk factor. It does not incorporate upside risk. Uncertainty is only viewed in terms of downside risk, and estimated through the calculation of WACC. This bias can lead to systematic undervaluation due to a high degree of uncertainty (Kodukula & Papudesu, 2006).

Flexibility

The NPV method takes a deterministic view, basing the value on a single set of cash flows. Therefore the model does not take flexibility into account. The NPV approach assumes a fixed, predetermined path; there is no ability to factor in contingent decisions. Munn (2006) defines this as an 'all or nothing strategy', whereby management has no ability to alter the course of an investment. The model takes the assumption that management makes the decisions now and then passively manages into the future. However, this is not the case in the real world – in the case of a coal mining company, it is clear that management do exercise flexibility over the operation of the mine: the investment strategy is not fixed. Though there are methods employed, that provide a range of valuations, as discussed below.

Scenario and sensitivity analysis

A rigorous DCF analysis will always be supplemented with scenario and sensitivity analysis. Essentially this is assessing forecasting risk and identifying the key variables driving the valuation model (Ross, Westerfield, & Jordan, 2006). Scenario analysis is concerned with establishing likely outcomes; being determined by events such as: worst case, expected case and best case. The problem however is that scenario analysis demonstrates various outcomes though it doesn't give any indication as to how likely these outcomes are. Providing an outcome based valuation will therefore provide investors with a valuations range however the practical application in the investment community is partly irrelevant in determining whether a stock is a good investment or not (Damodaran, 2010).

Sensitivity analysis highlights the key variables and their effect upon the valuation and is useful in identifying the most crucial value drivers. If the movement of a key variable results in a significant change to the valuation of the firm, this may warrant further investigation in order to reduce the uncertainty surrounding the expected value (Ross, Westerfield, & Jordan, 2006). The key downside however is sensitivity analysis does not take into account correlation between variables, one variable is moved and the others are held constant; this is quite unlikely in the real world (Mun, 2006). One way to overcome this is through the use of Monte Carlo simulation, which takes interdependency of variables into account. A Monte Carlo simulation therefore provides a range of values; however it's not without floors, according to Myers (1976), "If NPV is calculated using an appropriate risk adjusted discount rate, any further adjustment for risk is double-counting."

Therefore, the ability to build flexibility into a DCF valuation figure is limited. Whilst there are techniques to model possible values, it doesn't provide a concrete single valuation figure and or the ability to include management responses to uncertainty mid-way through the valuation model. The model is unable to capture contingent actions resulting from the development of events over time, this lie a major floor in the use of the DCF model (Kodukula & Papudesu, 2006).

Usability

The DCF model is intuitive to use and the results are easy to communicate, making the model widely accepted in the business community. However, whilst the results are easily interpreted, the model lacks the ability to incorporate upside potential associated with uncertainty and management's ability to change strategy mid-way. According to Munn (2006), the utilisation of DCF alone is incomplete as it fails in valuing the strategic options available to management. The traditional DCF model assumes a single decision pathway with fixed outcomes; all decisions are made in the present and there is no ability to alter the planned course of action. Furthermore, taking strategic flexibility into account provides valuation upside and reduced downside risk. This is quite intuitive; if market developments were to be unfavourable then naturally management would adjust its investment decisions. Similarly, if market developments were positive, management would either continue with a chosen investment strategy or choose to increase their investment therefore producing further upside. This should be reflected in valuation outcomes.

This may be partly the reason why Asquith, Mikhail and Au (2005) found that only 13% of analyst justified their recommendations utilising a DCF model. This was based on a study of approximately 1,200 top-rated US analyst reports (based on Institutional Investor). This appears to be consistent with earlier analyst studies, concluding that few analysts use present value techniques, opting for ratio based analysis (Bradshaw, 2002; Block S. B., 1999). The results on the surface appear to be quite puzzling; Munn (2006) suggests that DCF models are relatively easy to apply, widely taught and generally an accepted valuation tool. However, according to Hall (2005), 30% of the value of high growth, high volatility firms can be attributed to real options. Therein appears to be the problem, DCF models are unable to account for this, using a DCF model can lead to incorrect 'gross-ups' in order to include these hidden options (Hall & Nicholls, 2007). This violates the principles of the DCF method. According to Davis (1996), mineral assets consistently trade at values above that of their DCF value – the premium is due to the fact that a DCF model cannot take into account uncertainty and the potential upside resulting from this.

2.2 Decision Tree Analysis

Fundamentals

Decision tree analysis (DTA) provides the ability to map out various scenarios over the course of time; helping to identify the strategic options available (Mun, 2006). The scenarios effectively involve contingent decisions; involving various outcomes. The projected valuation is calculated by using the expected value approach (Kodukula & Papudesu, 2006). The benefit of this approach is it forces all strategic choices to be brought to the surface, providing a more dynamic valuation model (Trigeorgis, 1996). In order to calculate the expected value, the value of each decision must be calculated. As this value is based upon options available at a later stage, the decision tree must be calculated by rolling-back the expected value, starting with the most distant nodes. According to Damodaran (2010) there are four types of nodes. The root node represents the beginning of the decision tree; this is the ultimate value of the decision tree. Event nodes present possible outcomes, each carrying a specific probability; the various events are determined by the user and the likely probability of the event is calculated based on forecasts, historical patterns or management inference. Decision nodes represent a point in which a course of action must be chosen, this decision is driven by the expected value. Lastly, end nodes represent the final outcome.

Uncertainty

DTA is able to capture both upside and downside risk, thereby recognising management's ability to respond to external events. DTA accounts for risk in two ways: through probabilistic outcomes and a discount rate (Kodukula & Papudesu, 2006). DTA breaks down decisions into discrete stages, allowing for the correct response given the situation (Damodaran, 2010). However, quite often a constant discount rate is used when applying DTA, this however assumes incorrectly that the risk borne in each period remains constant (Trigeorgis, 1996). According to Mun (2006) there are two major floors in utilising DTA. Firstly, subjective probability is used in determining the event nodes and secondly the risk structure of the project changes throughout the decision tree, requiring recalculation of the correct rate. Quite often the errors resulting from these two issues compound over time, leading to incorrect valuations. This can be overcome by utilising a replicating portfolio approach; this is done by constructing a combined portfolio of a risk-free asset and an identical twin market security (Copeland & Antikarov, 2003). However this process is quite cumbersome as the portfolio must be reweighted at each node of the lattice (Brandão, Dyer, & Hahn, 2005).

Flexibility

DTA fully incorporates management flexibility in discrete time through the application of decision nodes (Brandão, Dyer, & Hahn, 2005). The introduction of DTA forced what was an implicit assumption around operating strategy into the open. Therefore DTA assists managers in finding the best strategy given uncertainty. DTA laid the basis for real option analysis; the binomial lattice model is an application of DTA

(Brealey, Myers, & Allen, 2008). However, DTA assigns probabilities to different outcomes, which can often be manipulated to fit the situation (Kodukula & Papudesu, 2006).

Usability

DTA analysis provides a tool to model investment flexibility. Whilst DTA lays the ground work for ROV, the model itself should be used with caution. The DTA approach tends to overestimates the value of flexibility, as the incorrect discount rate is often used (Copeland & Antikarov, 2003). Proponents of DTA tend to use the DCF discount rate which inevitably leads to an overvaluation of flexibility as the risk of an option should always be greater than that of the underlying asset (Koller, Goedhart, & Wessels, 2010). In addition, incorporating options, which is the primary reason of using DTA, means a fixed discount rate is not appropriate as the risk structure is constantly changing. According to Trigeorgis (1996), DTA provides the ability to model flexibility however is economically flawed, due to the discount dilemma; option based models provide a solution to this problem. Option based solutions may be harder to calculate though the evolution of computer based solutions has provided much support to practitioners.

Leuhrman (1997) suggests that the growth of technological based solutions is making, what use to be, more academically exhaustive methods of valuation, common practice. This is starting to show inside the boundaries of corporations, a study of large Australian listed firms found that one-third utilised option pricing techniques to improve decision-making (Truong, Partington, & Peat, 2005). In addition Block (2007), found that 14.3% of respondents from U.S. Fortune 1000 companies utilised real options and well over half of the nonusers are considering adopting ROV in the future; whilst lower than the Australian study it highlights a promising trend. Natural inference then would suggest that market valuations will in time move to include more comprehensive valuation techniques. Munn (2006) and Brandão, Dyer, & Hahn (2005) suggests that DTA should be incorporated into a ROV. Working with a binomial lattice model avoids the issues associated with the correct discount rate, the results from a binomial lattice ROV can then be presented in a decision tree framework. This highlights the strategic options available to management whilst applying an academically correct valuation technique.

2.3 Real Options Valuation

Fundamentals

A ROV expands upon the traditional DCF model; it's important to understand that a ROV is not independent of a DCF analysis but complimentary as the DCF valuation forms the underlying asset value. A detailed recount of the main academic contributions to the field is provided in the appendix.

Variable	Call	Put
Underlying Asset Value (UAV) ↑	↑	↓
Exercise Price (EX) ↑	↓	↑
Time to expiration (t)* ↑	↑	↑
Volatility (σ) ↑	↑	↑
Risk-free rate (r) ↑	↑	↓
Dividends (D)	↓	↑
*American options may on rare occasions not be affected by changes in time e.g., if underlying stock price on an American call is trading close to zero.		

Figure 3: Key variables affecting option price

Sourced from (Hull, 2008, p. 210)

A financial option is a contract giving the buyer the right, not the obligation, to buy (call) or sell (put) an underlying asset at a pre-specified exercise price (EX) at a specific date (European option) or within a predefined period (American option). The payoff structure is determined by the price of the underlying asset value (UAV). A call option will be exercised if UAV > EX; a put option will be exercised if UAV < EX. Therefore the value of a call option is MAX [0, UAV-EX], and the value of a put is MAX [0, EX-UAV]. The asymmetric payoff structure therefore highlights that an option value will capture all the upside due to favourable movements in X, however will never be worth less than zero (Hull, 2008, pp. 213-217). Table 4.1 highlights the six determinants of options prices.

Options can be classified into two broad categories, financial and real – the classification is determined by the underlying asset. Brennan and Schwartz (1985) were the first to recognise the applicability of options theory in the natural resource field; valuing the uncertain cash flows of a copper mine, they found that ROV was especially valid due to: the volatility of commodity prices, the difficulty of determining an optimal discount rate, and the inability to allow for management flexibility. Similarly Shafiee, Topal and Nehring (2009) found that ROV provided a modern valuation tool that provides the ability to adapt and revise mining projects and variables. Real options carry most value when there is a high degree of managerial flexibility combined with a high degree of uncertainty (Kodukula & Papudesu, 2006, p. 59); if management has a low degree of flexibility or if the investment outcome is certain, ROV will equal that of a base case DCF valuation. Therefore ROV should be thought of as an extension to traditional DCF valuation (Trigeorgis, 1996; Mun, 2006; Kodukula & Papudesu, 2006). The table below highlights the link between financial option parameters and those of real options:

Parameter	Financial option	Real option
Underlying asset value (UAV)	Current stock price	(Gross) PV of expected cash flows
Option price (OV)	Fixed in financial market	Initial project investment – paid to acquire, create or keep alive
Exercise price (EX)	Exercise price	Investment cost to realise option
Time to Maturity (T)	Times to expiration	Time until opportunity disappears, in some cases this must be approximated based on market conditions
Volatility σ	Volatility of stock price	Volatility of project value
Increase in T	Value increases (↑)	Value increases (↑) in practice however might decrease if competition enters before option exercised
Increase in σ	Value increases (↑)	Value increases (↑)
Ability for option holder to influence option value	None	Proper management action can increase the option value while limiting the downside potential.
Liquidity and tradability of the option	Liquid and tradable in financial markets	Most often neither liquid nor tradable.
Rationality behind the exercise decision	Most rational; dictated by the numerical difference between the underlying asset (stock) value and exercise price	Exercise decision may have political and emotional implications (e.g., abandonment of a long-term project with a large team).

Figure 4: Linking financial options to real options
Sourced from (Trigeorgis, 1996, p. 125; Kodukula & Papudesu, 2006, pp. 6-7)

However there are some limitations in the options analogy as highlighted by Kester (1993). Financial options are proprietary; the owner of the option has the exclusive right to exercise. A real option may be shared by many companies, if one company decides to move first this may either lead to the option disappearing or an erosion of the UAV. The erosion of the underlying asset is similar to when a dividend is paid on a stock. Though, calculating the erosion of a real asset requires a higher degree of computation than calculating the present value of dividend payments. A typical example of UAV erosion is winner take all markets; this is why companies may choose to exercise an option early, even though they may prefer to wait for more information. Secondly, financial options may be traded, in a manner similar to the stock in which it relates to. Real options on the other hand may be inseparable from the underlying asset and therefore in order to realise the value of an option it may need to be exercised by the underlying owner of the asset. Lastly, exercising (not trading) a financial option results in the owner taking ownership in the underlying asset. Real options however don't always follow this simple logic. In some situations exercising a real option leads to further discretionary investments: other real options. These are known as options on options, or compound options. Further difficulties in bridging the gap between financial options and real options are investigated by Adner & Levinthal (2004). They posit that, the ability for the owner of real options to affect the underlying value of the real asset and the inability to observe the market price of the option make it more problematic to apply the option framework.

This imperfect analogy between financial and real options is also cited as basis for implementation difficulties by Krychowski & Quelin (2010). They also argue that more needs to be done to bridge the gap between the qualitative and quantitative aspect of real options. However, this being said, in order to combine these two aspects it is important to understand what are the types of real options available to corporations.

Types of Real Options

As discussed, holding an option gives the owner the right, not the obligation, to either buy (call) or sell (put) the underlying asset at a predetermined price. This being said, it's important that this has temporal application and therefore it is important to review key literature (Trigeorgis, 1996; Kodukula & Papudesu, 2006; Mun, 2006) in order to ascertain the key strategic options available to corporations. The table below summarises the common strategic real options.

Category	Description	Type of option
Option to defer	The ability to wait for more information before proceeding.	call
Option to alter	Ability to alter operating scale: expand due to growing market or downsize in unfavourable market conditions.	call/put
Time to build	This refers to breaking projects down into stages. Each stage in effect is an option.	call/put
Option to abandon	The ability to exit an investment if market conditions warrant the project obsolete.	put
Option to switch	Management can either change: the output, input or a combination of the two.	call/put
Growth option	An initial investment made in order to secure a future growth opportunity.	call/put

Figure 5: Common real options

Source: (Trigeorgis, 1996, pp. 2-3) with information from Kodukula & Papudesu (2006) & Mun (2006)

Essentially there are two basic categories of options: simple and compound options. Simple options derive their value directly from the UAV. The value of a compound option is derived from the value of another option. Both time to build and growth options are compound options (Kodukula & Papudesu, 2006). Compound options can either be sequential or parallel (simultaneous). This means either a company must exercise an option to create another, or the options run alongside each other – the independent option has a life equal to or longer than the dependent option. In addition, there is one more type of option which is called a rainbow option. A Rainbow option can either be a simple option or a compound option. Traditionally options have one source of uncertainty; this is the volatility of the underlying asset. Rainbow options may have multiple sources of uncertainty or there may be changes in the uncertainty over the life of the option (Kodukula & Papudesu, 2006).

Requisites to applying Real Option Valuation

According to Munn (2006) there are five primary requirements that need to be satisfied in order for real options to be used. A base case financial model must exist, without a base valuation then real options cannot be utilised. There must be some degree of uncertainty, in order to model options then there must be some degree of unknown in the future – the higher the degree the greater the benefit of ROV. These uncertainties must affect the decisions management will make when actively managing the project and management's actions must also have a financial impact. Even if uncertainty exists, management must be able to highlight the strategic flexibility they are able to employ. Lastly, management must have the competency to execute these options when optimal to do so. The value of real options analysis, as shown below, is dependent upon the degree of receiving new information and the ability of management to respond to this.

Room for managerial flexibility	Low — Likelihood of receiving new information	High
High	Moderate flexibility value	High flexibility value
Low	Low flexibility value	Moderate flexibility value

Figure 6: Real option valuation matrix

Source: (Koller, Goedhart, & Wessels, 2010, p. 683)

The criterion of an option needs to be well defined and in a manner that can be acted upon. In recent study, academics have found that the abandonment options may in fact destroy value when assumed assumptions about abandonment flexibility are wrong. This is because exit criteria may not be self-evident, leading to the systematic underutilisation of the option (Adner & Levinthal, 2004). Copeland & Tufano (2004) acknowledge this is a problem, though they provide three remedies. Firstly, correctly rewarding the people who make these decisions, it may be an extremely hard decision to close down a plant though this in effect may create a large degree of value for the company – a correctly applied incentive structure is key. Secondly, creating well-defined option trigger prices, and subsequently reviewing employee performance by the time lag between exercising the option and the defined trigger. Thirdly, in some cases it may be beneficial to share these trigger points with investors and analysts. The benefit of this of course must be weighed against the risk. Finding a compromised solution can in effect increase the degree of management accountability.

General Assumptions underlying real options valuation

The application of option based pricing requires the absence of arbitrage opportunities. This is known as the Fundamental Theorem of Asset Pricing (Arnold & Schockley, 2010). Essentially this requires the ability to construct a portfolio of traded securities which replicate the payoff structure of the option. As real options relate to untraded securities it is argued that this rule is invalid, therefore rendering real option theory unusable (Trigeorgis, 1996). However, according to Arnold & Schockley (2010), if the assumptions surrounding the acceptability of the DCF (including NPV) approach are considered valid, then by default, a real options approach is also valid. DCF valuation is a tool used to value an illiquid stream of cash flows. The cash flows are valued using a 'twin traded' security with the same risk characteristics. This is essentially the application of the CAPM; used to establish an appropriate discount rate, which fixes a marketable investment to an underlying stream of cash flows. This method is considered valid assuming market completeness, which essentially means that a new investment should not expand the opportunity set of the investor. Therefore, if the assumption can be used to value the underlying real asset, similarly it applies to the real option (Trigeorgis, 1996). Though, Copeland & Antikarov (2003) argue that the best approach to ROV is to use the value of the company itself (without flexibility) as the best-unbiased estimate of the underlying asset. This approach was coined the Market Asset Disclaimer (MAD) approach. This approach gives us the same answer as identifying an identical twin security though is much more practical to implement. Therefore this paper will apply the MAD approach by calculating the value of the mine without flexibility as the UAV.

Option Pricing Models

Option Valuation Technique	Specific Method
Partial Differential Equations	▪ Closed form solutions using Black-Scholes and other similar equations ▪ Analytical approximations ▪ Numerical Methods (e.g., finite difference methods)
Simulations	▪ Monte Carlo
Lattices	▪ Binomial ▪ Trinomial ▪ Quadrinomial ▪ Multinomial

Figure 7: Option pricing models
Source (Kodukula & Papudesu, 2006, p. 66)

There are a variety of ROV models; these can be chiefly divided into three main categories as shown in figure 7.A comprehensive review of these three models is provided in the appendix to the thesis.

Binomial lattice model

The binomial lattice model will be used to model the options available to Gloucester Coal the reason for this decision is due to its user friendly nature, ability to visualise the strategic options, handle fluctuating asset erosion and the ease of incorporating a changing payoff structure. The binomial model is also perhaps the most flexible and doesn't suffer from the opaque nature of the B-S model or complexity of the simulation approach. According to Kodukula & Papudesu (2006) it is the preferred model of practitioners. At its simplest form, the binomial ROV model required the modelling of two binomial trees. One models the development of UAV and the second tree values the real option. The determinants of the binomial tree are shown below:

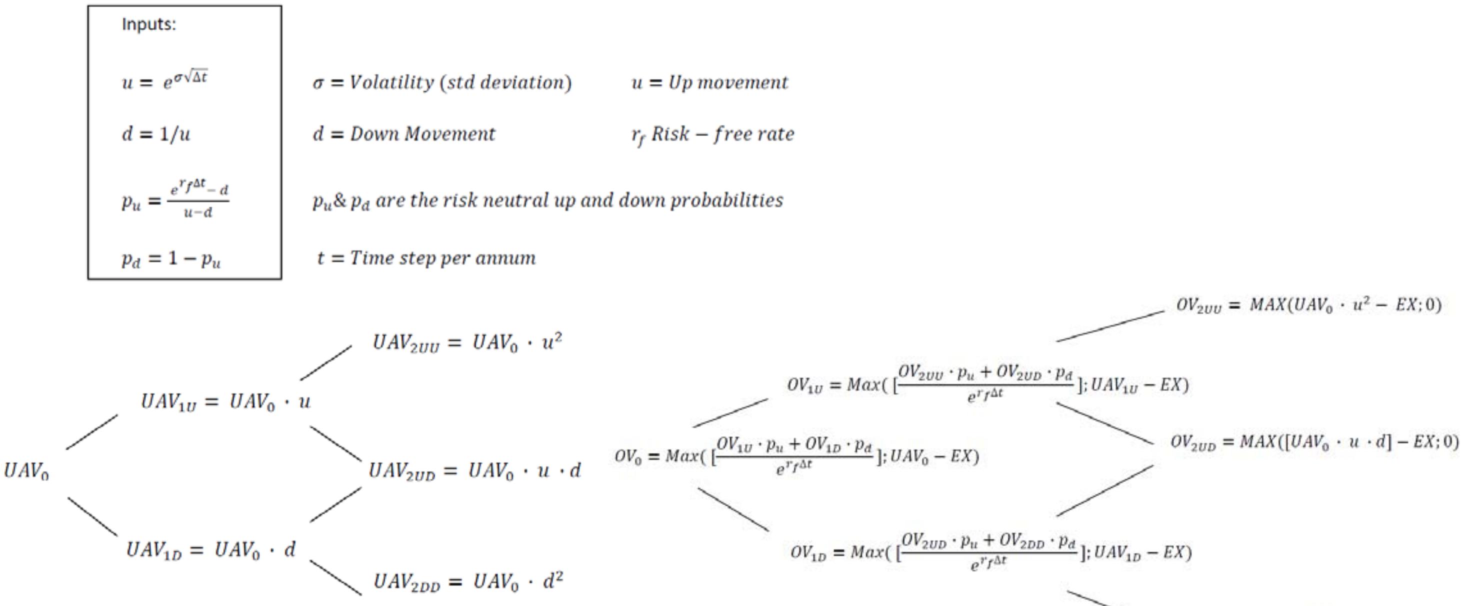


Figure 8: Binomial lattice model

Based on work from Cox, Ross & Rubinstein (1979)

Standard option valuation relies on a number of assumptions, in particular, the assumption that the underlying asset follows a Markov process, such as the Wiener process or Brownian motion (Trigeorgis, 1996). This implies that the UAV follows a random walk and has a constant volatility. Therefore it is assumed the value of the asset does not make any large jumps. A risk neutral valuation essentially converts cash flows into certainty equivalent cash flows. The risk in the cash flows is accounted for in the up and down probabilities, which is determined by the estimated volatility of the asset. Also, it's worth noting that the risk-neutral probability figures cannot be interpreted as the true probability of the asset price increasing or decreasing (Brandão, Dyer, & Hahn, 2005).

Uncertainty

Firstly, it's important to distinguish between risk and uncertainty. Risk is defined by the expected volatility of the underlying asset. Methods of calculating volatility will be explained in this section. Uncertainty drives the ROV and results from estimated volatility being projected into the future. Munn (2006) refers to this as the cone of uncertainty, which is a by-product of the underlying assumption of the asset following a random walk. Whilst volatility may be assumed to be constant the degree of uncertainty is positively related to the projected forecast period. Therefore the further out a practitioner projects the development of the UAV the greater the range is possible outcomes.

Before deciding on the appropriate measurement tool, the source of uncertainty needs to be identified. If there are multiple sources of uncertainty, there are two possible options of handling this. If the sources of uncertainty are somewhat correlated they may be combined and a single aggregate volatility factor can be used. Most option pricing models can only handle one volatility factor. However, if it is believed that the sources of volatility are independent of one another then multiple sources of volatility can be used in an option pricing model. Options with multiple sources of volatility are known as ‘rainbow options’. As most option multiples only handle single volatility inputs, this process can become quite computationally challenging.

There are multiple approaches to estimating volatility, which can be grouped into internal and external methods. Internal methods consist of management based assumptions, which are essentially educated approximations or the use of cash flow scenarios. External based methods are utilising equity based volatility figures, from a group of identified peers or by estimating the volatility figure of the underlying commodity.

It is however a delicate balance between overcomplicating and oversimplifying the estimation. For instance, utilising just the volatility of commodity prices for a mining company fails in recognising that the firm has other sources of uncertainty (Copeland & Antikarov, 2003). In order to capture multiple sources of uncertainty it is decided that Monte Carlo simulation (MCS) should be used. The MCS is presented in the case study and combines the most pertinent sources of uncertainty.

A MCS combines multiple sources of volatility into one figure. The MCS generates possible valuations based upon the DCF inputs and the key variables’ volatility estimate. Most often, initial DCF sensitivity analysis is performed to highlight the variables that have the most significant impact upon the valuation (Kodukula & Papudesu, 2006). A volatility estimate of the most pertinent variables is then generated. The number of simulations ran corresponds to the amount of volatility figures generated. The MCS provides a range of volatility figures; the expected volatility figure is then used in the ROV model. The benefit of MCS is a range of volatility estimates are provided – this provides management with a better understanding of the possible range of the volatility estimate. Based on Samuelson’s Proof, multiple sources of uncertainty can be combined even if some variables exhibit mean reversion or jumps in the return pattern. This is due to the fact that asset prices factor this in. Therefore, derivations from expectations follow a random walk, irrespective of the expected return pattern (Copeland & Antikarov, 2003). Mean reversion will be discussed in the presentation of the case study.

Flexibility

Management flexibility can be fully incorporated into ROV. Increased flexibility leads to a greater option premium on that of static NPV. However options cannot be valued on an additive basis. The incremental value of an option declines with the addition of each new option. This makes it crucial, due to limited resources, to identify the most pertinent options available when valuing the company. Furthermore, increasing the amount of options available with little valuation upside, generally just leads to modelling error and complexity.

Usability

ROV is yet to gain mainstream acceptance in the investment community. Brandão, Dyer, & Hahn (2005) attribute this to the mathematical complexity and the lack of intuitive appeal. This makes its use somewhat limited. Ryan & Ryan (2002) surveyed the CFOs of US fortune 1000 companies. In their survey of 205 CFOs they found that over 65% of respondents had never used ROV and only 1.1% of respondents utilised the method over 75% of the time. However, this conflicts with survey results obtained by Graham & Campbell (2002), who suggest of the 392 participants, 25% claim to use ROV always or mostly always and in addition to the evidence presented by Block (2007) and Truong, Partington, & Peat (2005) in the DTA section of the paper. As Triantis and Borison (2001) point out, increased investment uncertainty and the need for flexibility is likely to increase the adoption of ROV. Though mainstream acceptance of ROV will only grow as consensus on the approach is formed.

2.4 Recapitulation and valuation approach

This section provided an understanding of tools used to value projects and companies. The table below highlights the main characteristics of the valuation models being discussed. The three methods of valuation were presented according to fundamentals, ability to capture uncertainty, the inherent flexibility to adapt to uncertainty and lastly the usability of the model.

	DCF	DTA	ROV
Fundamentals	Expected cash flows are projected in a linear fashion.	Possible cash flows are driven by probabilistic outcomes.	Asset value follows a stochastic process.
Uncertainty	Systematic risk is typically captured through a measurement of beta.	Systematic risk estimated and cash flow outcomes adjusted for probability.	Captures risk and chance through evolution of asset price. Asset price is driven by volatility estimate.
Flexibility	Works with expected outcome and assumes passive management. Management assumes a passive role.	DTA is able to capture multiple outcomes and the associated management response.	All outcomes captured in the distribution of values. Management's flexibility is applied to the upper and lower values.
Usability	Easy to use and widely taught	Allows strategic options to be modelled and fairly easy to implement though scenarios driven by subjective probability	Relatively difficult to apply though offers the greatest amount of impartiality

Figure 9: Comparison of theoretical models

As explained in the ROV section, it is clear to see the ROV is driven by the static DCF value. ROV is a complementary tool that utilises static DCF as the UAV. Therefore to utilise a ROV approach a traditional DCF valuation must be performed. The valuation framework that will be applied to the case study is as follows:

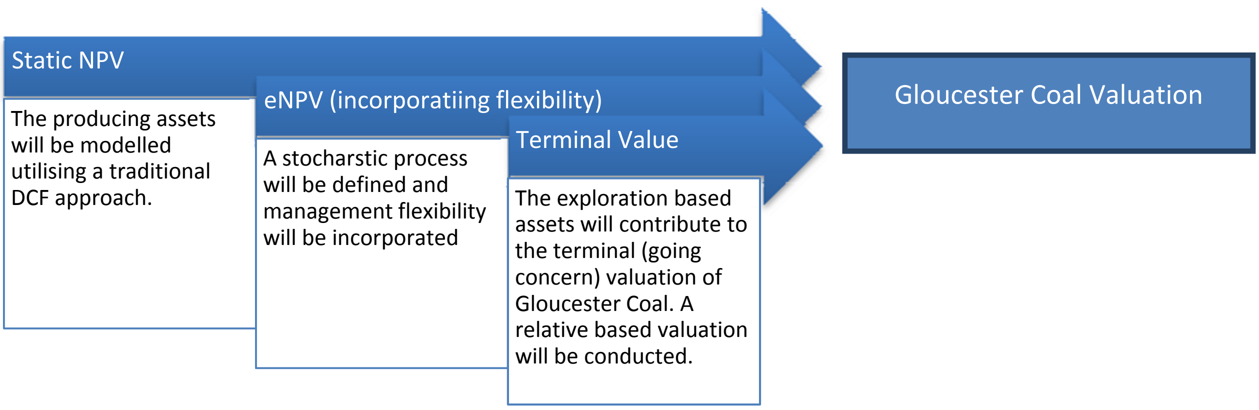


Figure 10: Valuation approach

Part II – Case Study: Gloucester Coal

Part II will be presented over several sections. Firstly an overview of the industry will be provided. This will establish an understanding of the industry dynamics. An overview of Gloucester coal will then be provided, the business activities will be presented, an analysis of the company's assets will be discussed and also the expected production of each mine will be given. A historical financial analysis will then be presented. These sections will then be synthesised into a DCF valuation of the firm. Following on from this a real options valuation will be provided, this section will model the company's ability to expand production or abandon the producing assets.

3. Industry Analysis

3.1 Overview of the coal industry

Coal is a fossil fuel that is formed by the coalification (the process of creation) of vegetation over millions of years. Coal can be broken down into two categories: black coal (hard coals) and brown coal (low rank/soft coals). Black coal consists of anthracite and bituminous. Brown coal is considered of a lower rank and consists of sub-bituminous and lignite. Coal can be classified based upon its degree of carbon energy and level of moisture. The hardest coal (anthracite) contains a high degree of carbon energy and a low level of moisture – due to its density it is referred to as a hard coal. The softest coal, lignite, contains a high degree of moisture and a relatively lower level of carbon energy. There is a direct relationship between price and degree of hardness. Carbon content is the key measure as this supplies the majority of the coal's energy. The degree of carbon content is determined by the coalification period. Anthracite coal is the oldest form of coal, dating back 360 million years; lignite dates back approximately 290 million years. This period is referred to as the carboniferous period (World Coal Institute, 2005).

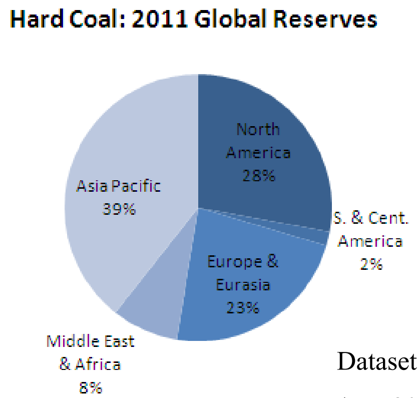
Bituminous (which consists of Thermal and Coking coal) is most occurring; accounting for 52% of total coal. Sub-bituminous is the next common, accounting for 30%. Lignite and anthracite make up 17% and 1% respectively (World Coal Institute, 2005). The focus of this paper will be on bituminous coal. Bituminous coal can be mined from both above ground (open pit mine) or recovered below ground (closed pit mine). Approximately 60% of global coal mining occurs below ground although, 80% of production in Australia occurs above surface (World Coal Institute, 2005).

3.2 Coal applications

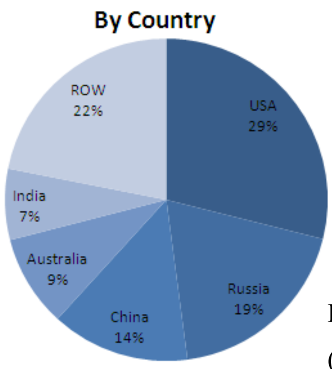
Coal is predominately used for: electricity generation, steel production, cement manufacturing and other industrial processes, and as a liquefied fuel. Thermal coal (steam coal) is for electricity generation. The coal is ground to a fine powder and injected into combustion chambers which in turn heat water to power turbines; this process is known as pulverised coal combustion (PCC). Electricity generation demands the largest share of coal production; in 2008 60% of coal consumed was used for production of electricity (U.S. Energy Information Administration, 2011). Coking coal (also referred to as metallurgical coal) is used along with, iron ore and fluxes to produce steel. Due to the characteristics of coking coal it is rarer than thermal coal and therefore attracts a higher price. Of total steel production, 64% is made from blast furnaces requiring the use of coking coal (World Coal Institute, 2005). However, the development of pulverised coal injection technology means that steel can be created utilising a blend of coals (thermal and coking coal); thereby reducing the amount of coking coal required. Cement is a critical input in the construction industry. The production of cement requires high degree of energy, which is supplied by coal. The production of 900g of cement requires approximately 450g of coal (World Coal Institute, 2005). Steel production and industry use in 2008 accounted for 36% of coal consumption (U.S. Energy Information Administration, 2011). Coal can also be converted to a liquefied fuel – this is often achieved through initial gasification. Liquefied coal however is still in its infancy.

3.3 Global production and consumption

Global coal reserves are predominately found in three main regions: Asia Pacific, North America & Eurasia. These three regions account for 90% of global hard coal. However, breaking this down further, it is clear to see that coal reserves are primarily controlled by five countries: USA, Russia, China and India, whom account for 78.1% of total resources and supply 71%.



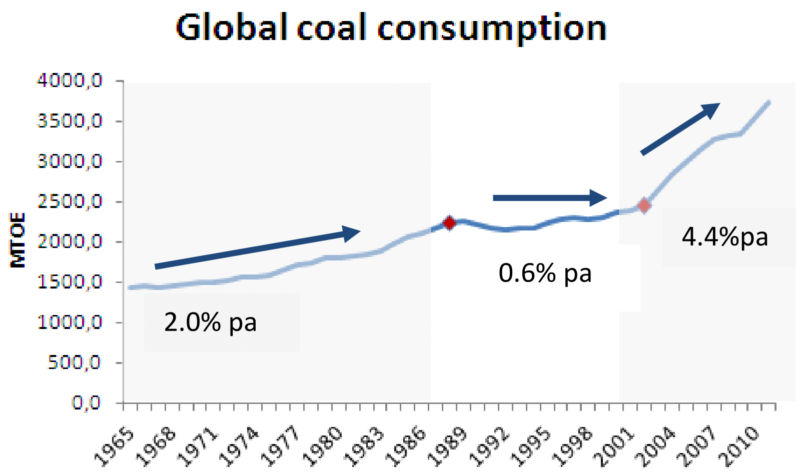
Dataset sourced from (BP, 2011)



Dataset sourced from (World Energy Council, 2009)

Figure 11: Hard coal reserves

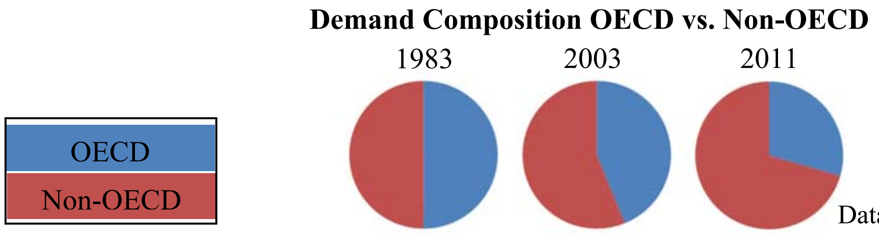
According to the WEC (2009), the proven coal resources are fairly well established. Over the years there tends to be only minor adjustments to the headline figure. Coal has the largest reserve to production lifespan of any fossil fuel, with an estimated reserve to 2010 production rates of 118 year, though this is far below the estimate recorded in 2000 of 210 years (BP, 2011). Reviewing almost 50 years of global consumption data, it is clear to see a noticeable trend. The graph below highlights three distinct growth phases in coal consumption. The first can be categorised by mild growth, loosely in line with global GDP. The second period saw rather flat growth in coal consumption. Lastly, the most recent data has been categorised by a strong upswing in coal consumption, with an average compound growth rate of 4.4%.



Dataset sourced from (BP, 2011)

Figure 12: Historical global hard coal consumption

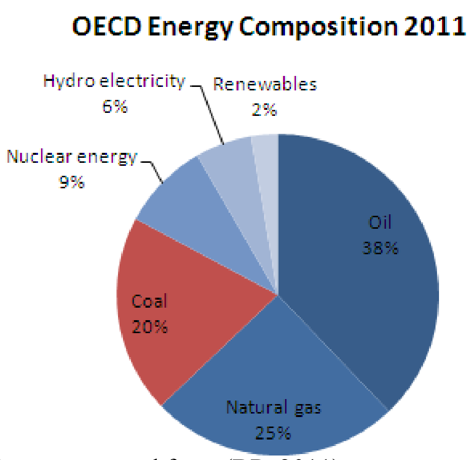
The recent upswing can be traced back to the source of demand. Reviewing consumption statistics at the end of these three periods: 1983, 2003 and 2011, it clear to see that demand is being driven primarily from the developing world.

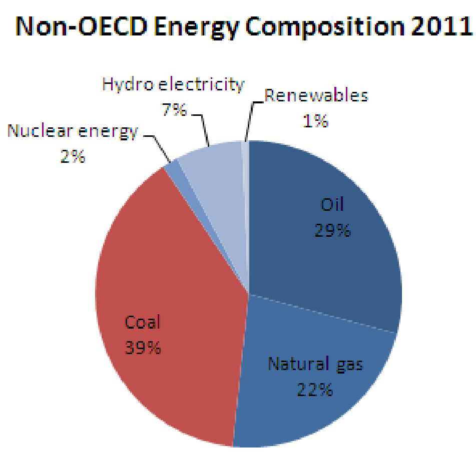


Dataset sourced from (BP, 2011)

Figure 13: Coal consumption - OECD vs. Non-OECD

In 1983, non-OECD countries accounted for 50% of global coal consumption. This has now shifted to in excess of 70%. However, knowing this, it is important to establish whether this shift has been caused purely by total growth in energy demand from the developed world or a change in the preferred energy source. Primary energy demand from OECD and Non-OECD countries was analysed. The 2011 data shows a clear difference in reliance on coal as a primary energy supply. Coal satisfies almost twice the energy demand of Non-OECD as compared to OECD countries.

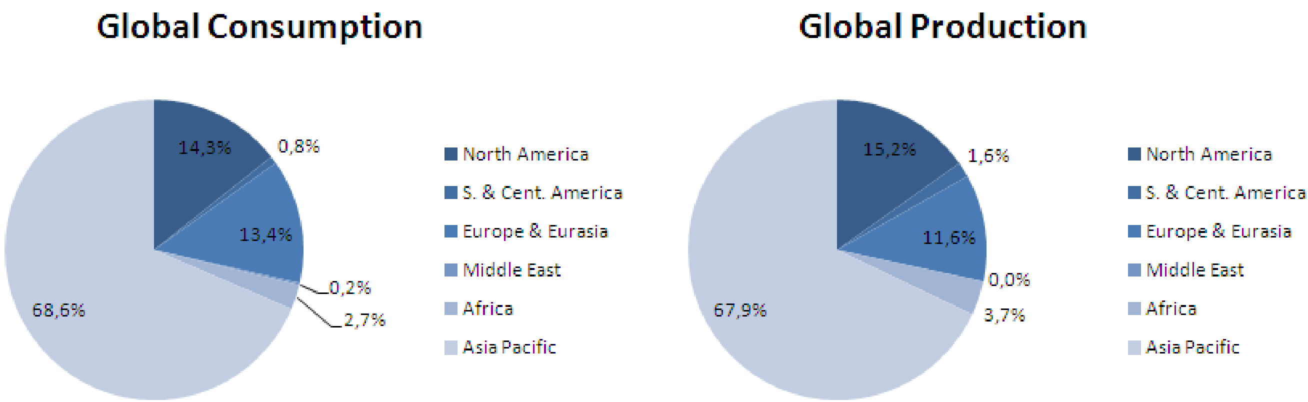




Dataset sourced from (BP, 2011)

Figure 14: Energy consumption composition OECD vs. Non-OECD

The IEA highlights that the main demand for Coal is due to electricity production, which can be closely linked to economic growth (International Energy Agency, 2011). Therefore it can be expected that the proportion of coal supply to Non-OECD countries is going to continue to grow. Focusing on regional level statistics, it's clear to see that production to consumption levels are relatively in line. This indicates that the majority of demand is met on a regional level. Asia pacific is by far the largest consumer and producer of Coal, with approximately 68% of the global market.



Datasets sourced from (BP, 2011)

Figure 15: Global coal consumption by region

Reviewing coal trade information it is quite clear to see a pattern in geographical trading zones. Australia exports predominately in the Asian region, equating to 91% of total 2009 coal exports. European demand tends to be met by US, South American and Eurasian exports, which represent respectively, 55%, 54% and 60% of each regions total export quantity. Southern Africa appears to be strategically positioned to meet both demand in Europe and Asia exporting 54% and 39% correspondingly. Transport costs play a key role in determining the sourcing location; this is perhaps the factor determining the trading zones. According to the World Coal Institute (2005), the price of shipping can account for 70% of the delivered cost. Therefore, it appears that prices can vary in each geographical market – and suppliers may be able to capture some pricing arbitrage due to geographical local advantages. Transportation costs therefore effectively create two main markets – the Atlantic and the Pacific (World Coal Institute, 2005). Therefore when analysing spot prices it is particularly important to ensure that local market prices are observed. As the case study is centred upon an Australian coal company, the focus will remain on the Asian Pacific market.

3.4 Asian Pacific Market

The Asian pacific coal market stretches from India across to the pacific island nations. Historical data, presented below, highlights the major coal consuming countries by proportionate consumption.

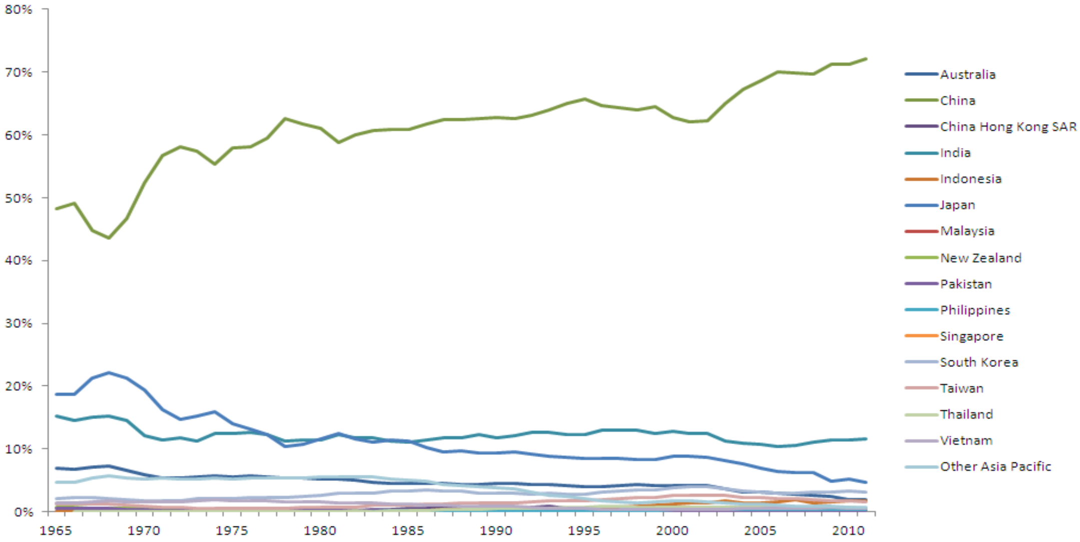
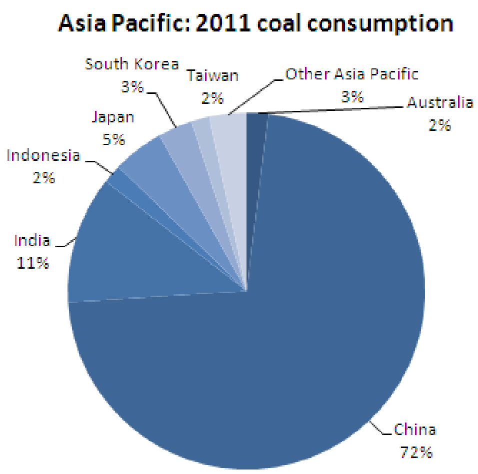


Figure 16: Asia Pacific proportional coal consumption by country

Dataset sourced from (BP, 2011)



Dataset sourced from (BP, 2011)

Figure 17: 2011 - Asia Pacific proportional coal consumption by country

China's proportionate share continues to grow, from a low of 44% in 1968 to the current 2011 level of 72%. The increased share in coal consumption has meant proportionately consumption in predominately Japan and Australia has declined. A stagnate Japanese economy, and proportionately lower economic growth in Australia is most likely the cause for the change in composition. 2011 proportionate composition is presented alongside.

China's sheer demand is primarily a factor of it being one of the world's most populous nations and its speedy economic development. Coal continues to be China's largest source of energy, accounting for 70% of China's primary energy and approximately 50% of total global coal demand (World Energy Council, 2011). Contrasting this with India, it's quite astonishing to see the sheer gap. The two nations are quite comparable on a population basis (China 1.3bn vs. India 1.2bn) however China's primary energy demand in 2011 was 4.7 times greater (BP, 2011). China's energy consumption is forecast to continue growing strongly, with India following suit. According to the IEA, Chinese and Indian coal demand is expected to grow strongly. Chinese coal consumption is forecast to grow at 3.7% per annum to 2016, whilst India continues to grow strongly at 5.6% (International Energy Agency, 2011). However, the two most populous nations, in terms of energy consumption per capita, trail the developed world. Utilising the CIA world fact book, national energy consumption was adjusted for population size. The consumption is presented per capita on a tonnes of oil equivalent basis.

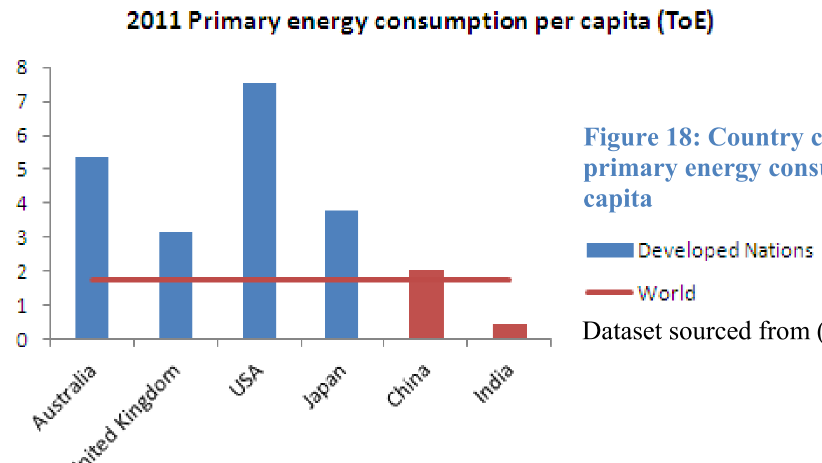


Figure 18: Country comparison - primary energy consumed per capita

Dataset sourced from (IEA, 2011)

The chart highlights that energy demand in China and India is still quite a way off the levels utilised in the developed world. Consumption in India and China would have to increase by 707% and 87% respectively to match the equivalent levels of their regional neighbour; Japan.

3.5 Asian Pacific Coal Prices

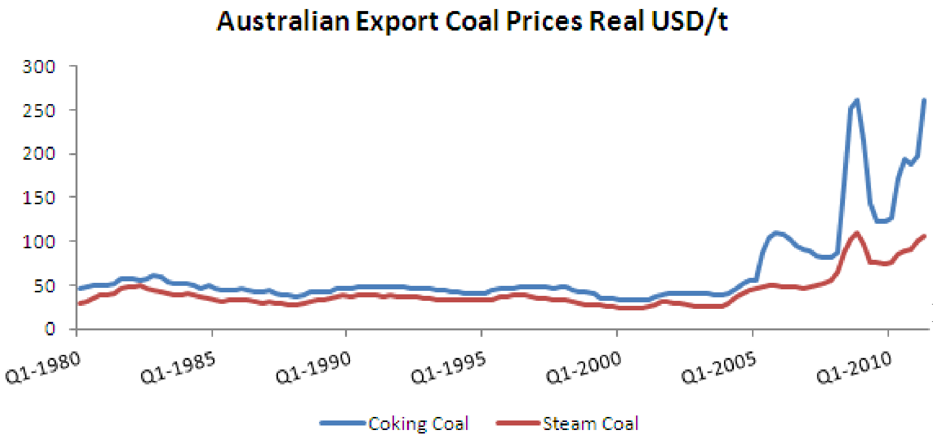


Figure 19: Australian historical coal prices

Dataset sourced from (BP, 2011)

Thirty years of historical Australian Export coal price data (reflected in real dollars) was obtained from the IEA (2011). It can be seen that prices have remained quite constant up until 2005. Post-2005 there has been a substantial jump in prices and also a widening between coking and steam coal prices.

As China accounts for such a significant proportion of global coal consumption Chinese GDP and coal consumption statistics were reviewed to get a better understanding of what was driving the large price increase over the last decade.

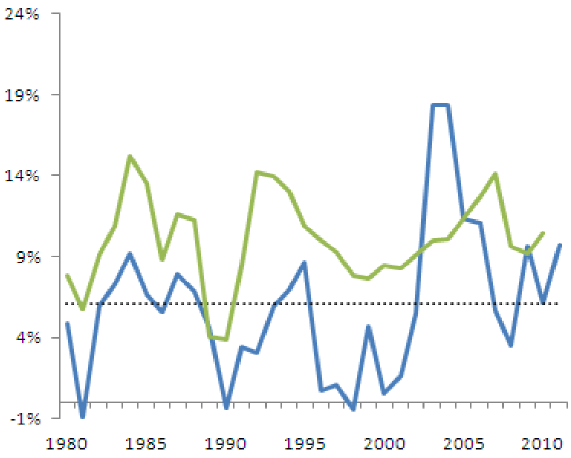
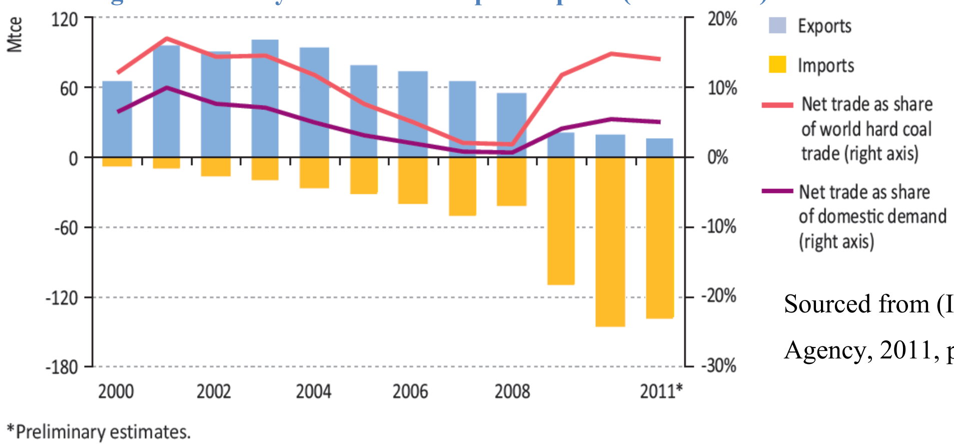


Figure 20: Chinese GDP and annual coal consumption growth

Dataset sourced from (BP, 2011) & OECD

It can be seen that Chinese coal consumption loosely follows developments in Chinese GDP. However, what's interesting to note is that the jump in Australian export prices occurred after the 2003/2004 peak. In 2003 and 2004 coal consumption grew at 18% per annum. This compares to consumption growth of 3% in 2008. The large rise in coal export prices in 2008 appears to have been caused more by structural factors than economic conditions. Looking purely at Chinese consumption and production statistics fails to show the recent developments in the local market. China has traditionally been a net exporter of coal, however this has recently changed. Data supplied by the IEA (2011) highlights that China became a net importer of Coal in 2008/09.

Figure 21: Yearly Chinese coal import/exports (2000-2011*)



Sourced from (International Energy Agency, 2011, p. 401)

According to the IEA, from 2008 to 2009 China switched from being a net exporter to the second largest coal importer. In 2010 the country's imports corresponded to 19% of the total seaborne coal market (International Energy Agency, 2011). The reason for this dramatic increase in Chinese reliance on the seaborne coal market lay predominately grounded in Chinese structural deficiencies. Tu & Johnson-Reiser (2012), of the Carnegie Foundation, explains that Chinese ports were open to competition in the 1990s, making them much more competitive than the state owned railways that have suffered from insufficient investment. The Economist (2011) provides further insight into this by highlighting that Chinese coal demand is primarily driven by the prosperous, energy hungry, cities on the eastern coast. However domestic supply is located in the north and west of the country. The cost of moving it from the North and West of China[4] to the key markets can represent 50-60% of the total cost, making foreign imports cost competitive (Morse & Gang, 2010). The cost of recovery is also quite expensive due to dated mining infrastructure and higher costs associated with recovery from deep underground. The IEA, in their 2016 market outlook report, suggests that the sheer size of the market means that any small mismatch between domestic Chinese demand and supply will likely have powerful worldwide effects on coal prices (2011).

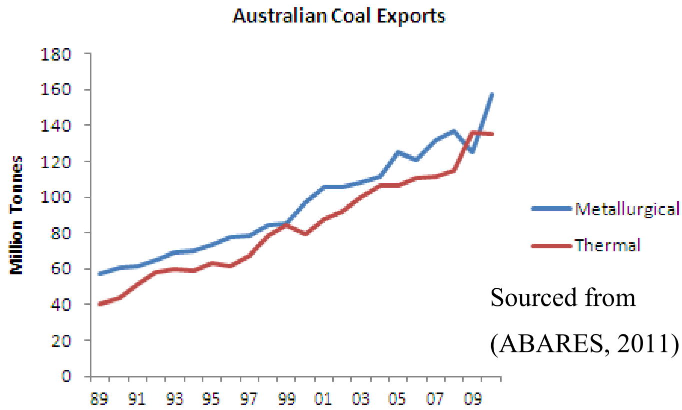
3.6 Australian Coal Market

Coal is Australia's primary source of electricity generation, accounting for 77% of 2008-09 production. However, local demand accounts for a relatively small share of Australian total coal production. In 2009, total international seaborne coal accounted for 15% of total world consumption (U.S. Energy Information Administration, 2011). Australia is the world's largest exporter of coking coal and second largest exporter of thermal coal. In 2009-10 the country exported 82% of production – approximately 64% of the world's coking coal and 19% of the world's thermal coal exports (ABARES, 2011). Total Industry Revenues in 2011-2012 are expected to reach $59.5 billion, which equates to 2.2% of Australian GDP (IBISWorld, 2012).

Coal is Australia's second most valuable export, the value of exports have grown by 15.5% per annum, as shown below. However, more recently, revenue growth has been 8.9% per annum for the five-year period of 2007 to 2012 (IBISWorld, 2012). In 2010-11 the sector was heavily affected by the flooding in Queensland (QLD); only about 15% of the states mines were in full production. This resulted in a fall in production and led to an increase in coal prices on the previous year.

The bulk of coal production occurs in New South Wales (NSW) and QLD, which account for 97% of total production. Coking coal is mainly sourced from QLD and thermal coal from NSW. According to the Reserve Bank of Australia (RBA) (Christie, Mitchell, Orsmond, & Van Zyl, 2011) the export of coal is serviced by four ports in QLD and two in NSW. In QLD: The Ports of Brisbane, Abbot Point, Gladstone and Hay Point. In New South Wales coal is exported through Newcastle and Port Kembla.

[4] Shanxi, Shaanxi and Inner Mongolia have 69% of the country's proven resource (Morse & Gang, 2010).



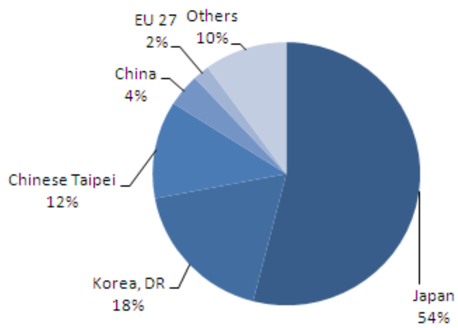
Sourced from (ABARES, 2011)

Figure 22: Australian coal exports

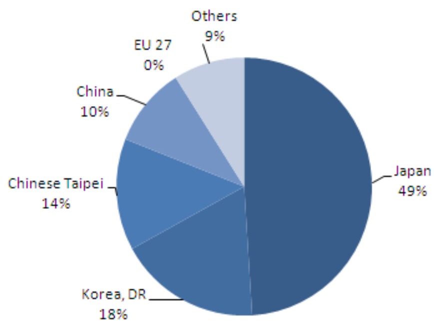
With only $7.19 billion of coal revenue in 2011-12 generated from domestic Australian sales, it is of obvious importance to review the major markets for Australian coal. Australia exports the majority of its coal to Japan, India, Korea and China. Japan is Australia's largest coal exporting destination, in 2009-10 31% of coking coal- and 49% of thermal coal exports went to the island nation (ABARES, 2011). Therefore Japanese negotiated coal contracts generally set the price level in the pacific market. However, reviewing five years of export data there is a clear growth trend in Chinese demand for Australian coal; the major uplift coincides with China becoming a net importer in 2009, which also caused seaborne coal prices to peak. The chart presented alongside highlights export volume data from 1989. Over the last 21 years metallurgical and coking coal exports have increased on average by 4.9% & 5.9% respectively.

Deconstructing this data by major trading partners a snapshot of coal export by destination is presented below for 2005-06 and 2009-10. It's clear to see that China's importance as a coal export partner has grown however Japan still remains a major export destination.

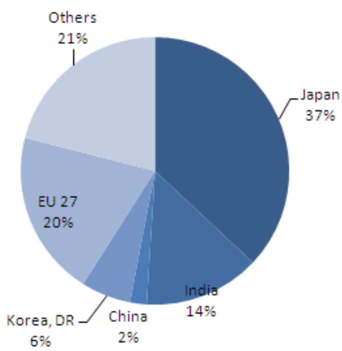
Thermal Coal Exports 2005-2006



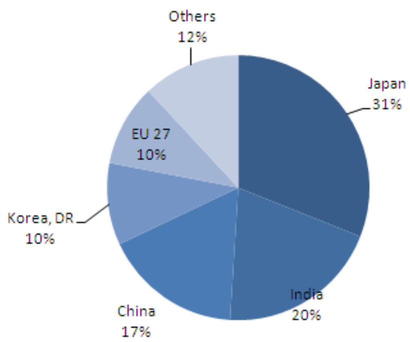
Thermal Coal Exports 2009-2010



Coking Coal Exports 2005-2006



Coking Coal Exports 2009-2010



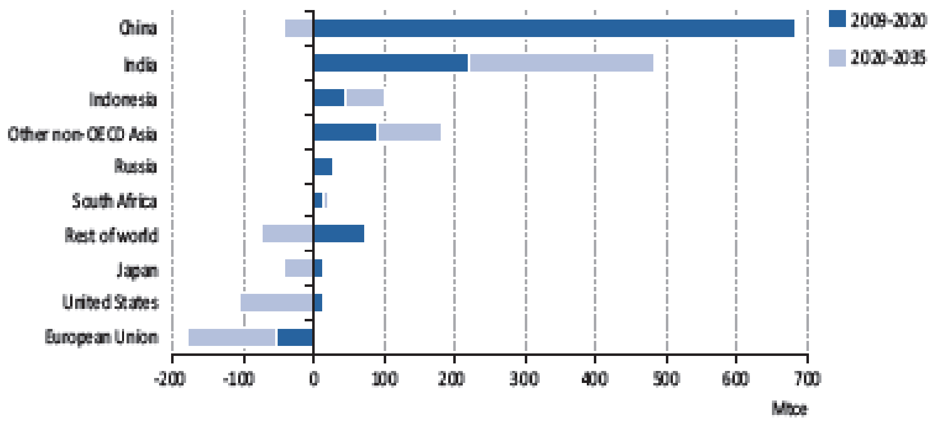
Sourced from (ABARES, 2011)

Figure 23: Australian coal exports by destination (2005/6 & 2009/10)

3.7 Future Coal Export Demand

According to BP (2012) coal demand will be spurred by Non-OECD growth, particularly in China and India. Declines in OECD countries will be offset by increased consumption in China and India. Global growth is therefore expected to continue at 4% until 2020. From 2020-2030 consumption is expected to slow to just 0.5%. China and India's inability to grow domestic production fast enough will drive the growing importance of global coal trade (BP, 2012). Chinese domestic production constraints are similarly shared by India. The IEA (2011) highlights that India's local production is hampered by several factors, namely: 90% of production is from open mines which require the resettlement of communities, the coal produced is often of low quality (up to 60% ash content), and lastly whilst coal is used in all states approximately 80% of the reserves and resources are located in only four states (Chattisgarh, Jharkand, Orissa and West Bengal) leading to an average transport distance in 2008 of 623km. This is further supported by information obtained from The Economist (2011) suggesting that much of the coal reserves are located under protected forest and land that has been set aside for ethnic minorities.

China and India's dominance in future coal demand is cogently shown in data provided by the IEA (2011). Data presented below highlights incremental demand from 2009-2020 and 2020-2035.



Sourced from (International Energy Agency, 2011, p. 381)

Figure 24: Incremental coal consumption by country 2009 to 2020 & 2020 to 2035

3.8 Cost Structure

The main costs incurred by coal miners can be split into five categories: onsite mining costs, processing, administration & support, state royalties and freight (including port charges). According to the AME group (2012c) & (2012d) onsite mining costs constitute the largest share at approximately 65%. Further analysis of AME data shows that costs have grown quite substantially over the past six years. Thermal and Coking coal costs over the last six years (2006-2012) have risen by an annualised rate of 11% and 10% per annum respectively; compared to the global average of 7% for both categories. This has led to a weakening of cost competitiveness. The cost increases are primarily due to: local based cost pressures and the strengthening of the AUD. In 2006 the Australian dollar was buying 0.76 US dollars, by 2012 the currency was buying 1.03 USD; this equates to a 36% strengthening relative to the US.

In local currency, bar royalties and freight charges, costs have risen quite evenly across the categories with an average annual cost increase of 5% for thermal and 4% for coking coal. Royalties have increased by 9% on thermal and 7% on coking coal. Whilst state governments have increased royalty rates, increased coal prices (which the royalty is calculated by) have also led to higher charges. As stated, onsite mining costs are by far the largest component of FOB cash costs however the type of mine drives the cost composition of onsite charges. In general underground mining requires a higher degree of labour and is more capital intensive, whereas open pit mines are more reliant on oil (International Energy Agency, 2011). The below chart highlights the major input costs associated with onsite mining charges by mining method.

	Underground		Open pit	
Input factors	Room/Pillar	Longwalling	Dragline	Truck/Shovel
Diesel fuel & lubricants	5-8%	5-10%	14-18%	18-26%
Expolsives	0-2%	0-2%	15-20%	17-22%
Tyres	0%	0%	5-10%	8-12%
Steel mill products	24-35%	24-35%	22-28%	19-26%
Electricity	10-18%	10-18%	5-12%	0-3%
Labour	28-39%	28-45%	18-32%	18-35%
Industrial Chemicals	8-13%	4-8%	1-4%	1-4%

Figure 25: Coal cost input factors by mine type

Data sourced from (Trueby & Paulus, 2010): input factors and relative importance in coal mining in 2006

Irrespective of the deviation between categories, it can be seen that labour constitutes a significant cost for both underground and open pit mines. Australian mining companies have experienced strong wage inflation, in 2011 Wood Mackenzie[5] estimates labour costs rose by 8% (Winning, The Wall Street Journal, 2012). Furthermore, deconstructing the input factors it can be seen that oil is a major cost driver; oil is an important factor in the production of explosives and chemicals, and is the basis of diesel fuel (Paulus & Trüby, 2011). Oil prices have recorded tremendous increases since 2001; from 2001-2010 Australian imported oil, measured in US dollars, has increased by 310% (OECD, 2011). However this is predicted to stabilise, The IEA forecasts in real terms that the oil price will trend to $109 USD in 2020 and $120 USD in 2030, representing a growth of 0.82% (International Energy Agency, 2011). Therefore, long-term oil is not forecast to be a major cost driver however short-term volatility will affect short run mining costs.

The deceleration in oil price growth appears to be in line with AME long-term forecasts – from 2012 to 2027 average FOB cash costs per annum are forecast to increase by 2% for thermal coal and coking coal. These long-term projections appear to be loosely in line with historical long-term averages. The Australian Bureau of Statistics (ABS) has maintained a producer price index for coal mining companies over the last 24 years.

[5] Wood Mackenzie is a global energy, mining metals consulting firm. See: http://www.woodmacresearch.com

This represents costs incurred for coal mining companies based on a predefined basket of goods and services and is segregated by open pit and underground mining. Over the last twenty-four years costs for open cut- and underground-mining have increased by 3.25% and 3.02% respectively. As explained, the large increase in seaborne coal trade in the last decade combined with increased commodity prices has been a driving force behind the rapid acceleration in costs: going forward this is expected to ease. The producer price index highlights that open cut mining costs have risen higher than underground mining costs. This can be partly attributed to a higher reliance on oil-based products (International Energy Agency, 2011).

3.9 Price Development

In order to establish long-term coal prices a review of relevant publications was conducted, namely: analyst reports (Macquarie, J.P. Morgan, Morgan Stanley, Nomura and Deutsche bank), AME group projections[6] & International Energy Association publications (World energy outlook 2011 & Coal Medium term outlook 2011-2016). After assessing price forecasts it was determined that AME projections provided a reliable long-term projection and were consistent with analyst consensus. Data has been sourced up until 2026. The 2026 price has been accepted as the long-term projected price, this was checked against analyst prices. The 2026 projection has therefore been carried forward at the relevant inflation rate. The inflation rate post 2026 was chosen as a good proxy for price development. This is based upon results obtained by Pindyck (1999). In his study of coal prices from 1870 to 1996 he found that the coal prices had a flat real drift i.e., real growth of approximately 0%. Therefore in nominal terms the inflation rate was deemed the most appropriate price driver. In order to adjust prices into nominal terms inflation forecasts for the next six years were attained from the Economic Intelligence Unit. Long-term inflation forecasts were based upon central bank target rates i.e., 2.5% and 2% were used for Australian and U.S. inflation. As coal prices are quoted in US dollars, the US inflation rate has been used when forecasting nominal prices. Similarly, the forecasted exchange rate is based upon the Economic Intelligence Unit six year forecast. A consensus estimate was formed for the long-term (consensus based upon economic forecasts provided by Macquarie Bank, Deutsche bank and Morgan Stanley) exchange rate. The chart below highlights the expected development in coal prices for both thermal and metallurgical coal.

[6] AME is a leading research group focusing on the analysis of global energy, steel, metals and mining industries. For further information see: http://www.ame.com.au/

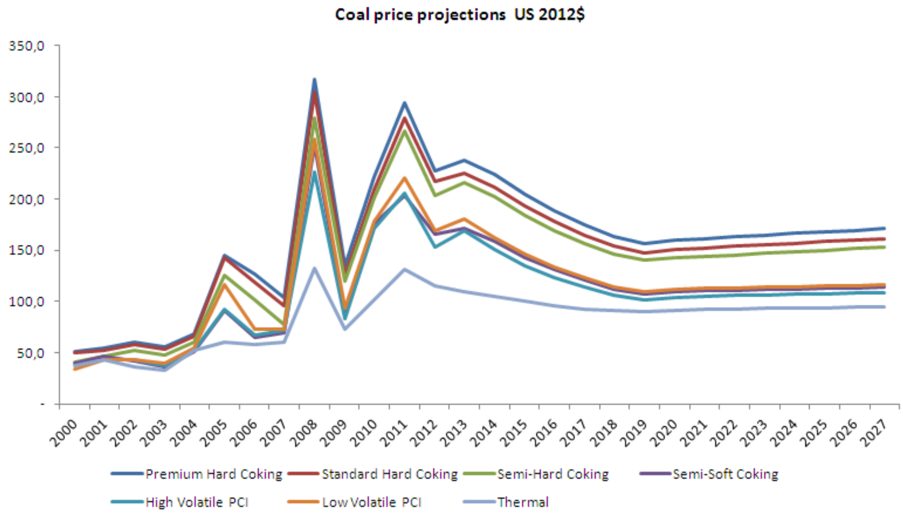


Figure 26: Historical coal prices & forward projections

Data Sourced from (AME Group Pty Limited, 2012b; AME Group Pty Limited, 2012a)

Prices are predicted to settle over the next 10 years. China's dramatic switch to a net importer (2008-09) and subsequent supply bottlenecks at Australian ports provided the impetus for the peak in coal prices. This is expected to ease as capacity adjusts to the large jump in demand. Infrastructure bottlenecks due to port capacity constraints have plagued the industry over the last few years: capacity has been growing slower than export volume. This came to the forefront in 2007 and 2008 when queues of 70 to 80 vessels occupied the Port of Newcastle. However, according to the RBA a series of committed expansion plans will take total coal export capacity to 480m tonnes by 2013, thereby alleviating some of the congestion faced by miners (Christie, Mitchell, Orsmond, & Van Zyl, 2011).

3.10 Industry Challenges

The federal government of Australia is in the process of legislating two policies that will affect the industry, the introduction of a carbon tax and the resource rent tax (mining resource rents tax or resource super profits tax). The carbon tax will come into effect on 1 July 2012 and be priced at $23 per tonne of carbon dioxide. The tax will rise by 2.5% annually for the first three years, moving to a floating-rate system in 2015. According to the Australian Coal Association this is expected to increase the cost of producing coal by $1.80 per tonne. This being said the direct impact per miner is dependent upon the degree of gassiness of each mine. According to IBISworld (2012) the average gassy mine will face a cost of about $7.40 per tonne of coal produced. The Mineral Resource Rent Tax is a tax designed to distribute revenue earned from the mining of Crown land. The tax is similar to that of a Browns tax and aims to tax economic rents. These rents occur when government issues mining companies with the right to mine Crown land. The challenging part of the tax is establishing a framework that doesn't penalise quasi-rents, which are profits earned through production that in the long term provide miners with an economic incentive to allocate resources to exploration (Garnaut, 2010). The tax will be introduced from 1 July 2012 carrying an effective rate of 22.5%

on profits above the government's long-term bond rate plus 7.0%. Existing projects are able to use current market values when calculating assessable profits and in addition the tax is exempt for small projects with resource profits less than $50 million per year (IBISWorld, 2012). The ability to use market values and a high kick in rate on returns above that of approximately 10% (7% plus government bond rate) will lead to minimal impact. This is primarily due to strong lobbying by the Australian mining sector, which was the possible cause for the overthrowing of ex-Australian Prime Minister, The Hon. Kevin Rudd[7]. Subsequent to his demise the tax plan was fundamentally adjusted to appease industry concerns.

4. Gloucester Coal

Gloucester Coal is an Australian coal mining company specialising in the production and marketing of thermal and coking coal. The company was listed on the Australian Stock Exchange (ASX) in June 1985 (Formerly CIM Resources – name change: 11 June, 2002). The company has approximately 202mn shares outstanding, at current market values, equating to a market cap of $1.39bn AUD (Closing price: 1/6/2012). This placed Gloucester Coal in the top 100 companies listed on the ASX.

4.1 Overview of Operations

Gloucester Coal's operations can be broken down into four sections: Gloucester Basin, Donaldson Coal and Monash – all of which are located in New South Wales. Lastly, Gloucester has a 50% joint interest in Middlemount located in the state of QLD. Gloucester Basin, Donaldson and Middlemount are currently in production phase; Monash is an exploration asset. Gloucester Coal's current operations are a reflection of two years of strategic transformation, with the group completing the following strategic acquisitions:

- The acquisition of a 27.52% stake in Middlemount from Noble Group. This also included the right to purchase a further 2.48% of Middlemount for $8m and an additional 20% for $100m. In December 2010 these transactions were finalised, taking Gloucester Coal's total share in the Middlemount project to 50%. Macarthur coal (now owned by Peabody Energy) owns the additional 50%. The joint venture sits as a standalone company, with a separate board and offices (Tasker, 2010)
    - As part of the acquisition, Gloucester Also receives a 4% royalty of the total free on board trimmed sales from Middlemount.
- The acquisition of Donaldson for $585m (Enterprise Value) from Noble Group (Behrmann, 2011). The acquisition also included an 11.6% shareholding in Newcastle Coal Infrastructure Group (NCIG), operator of the Port of Newcastle coal export terminal (Gloucester Coal, 2011).
- Acquisition of Monash – owner of two exploration licences in the Hunter Valley, NSW for $30million (Thomson Reuters, 2011).

[7] http://www.theaustralian.com.au/national-affairs/in-depth/how-mining-tax-sparked-fallout/story-fnccyr6m-1226281094991

These transactions have increased the degree of flexibility in Gloucester Coal's product mix: the group has a solid project pipeline across all stages of development (exploration, pre-feasibility, feasibility and production), increased geographical dispersion and increased access to coal port infrastructure. Gloucester´s project pipeline is shown in the appendix of the paper.

A detailed historical overview has been compiled and is available in the Appendix. Middlemount is currently in phase II of development, with an expected completion by 2015. The mine however has begun initial production (FY2012). The Donaldson asset is currently in production though expansionary work is currently being undertaken. An overview of the company resources are shown below:

Figure 27: Gloucester coal's resources by mine

Mining Operation	Project	Location	Mine Type	Coal Type	Resources	Reserves	Proved Reserves
Gloucester Basin	Duralie	Gloucester Geological Basin, NSW	open cut	coking (semi-hard)/ thermal	316	87	13.3
	Stratford						
Donaldson	Abel	Newcastle Coalfield, (Hunter region) NSW	underground	coking (semi-soft)/ thermal	885	160.7	115.9
	Tasman			thermal			
	Donaldson		open cut				
Monash		Hunter region, NSW	underground	Coking (semi-soft)/ thermal	577	0	0
Middlemount*		Bowen Basin, QLD	open cut	coking (Hard) /PCI	61.3	48	34.5
* Pro-rata 50% share in mine				**Total**	**1839.3**	**295.7**	**163.7**
CY: Calendar year							
figures in million tonnes							
Source: Compiled from 2011 Annual Report, September 2011 International Roadshow presentation, and 23 Feb 2012 company announcement							

In addition, Gloucester holds a total of nine exploration based leases, Monash comprises of two of these leases. The recent transactions have led to a significant increase in reserves and resources; pre transaction Gloucester coal controlled Gloucester basin, with 278mn tonnes of resources, of which, 74.8mn tonnes of estimates reserves – including 13.3mn tonnes of proven reserves (refer to measurement of coal section for description of resource categories).

4.2 Production

Over the past six years Gloucester has been producing thermal and coking coal from the Gloucester basin. Production has been quite steady, on average producing 1.8mtpa of saleable coal. Saleable coal however must first undergo several processes before being shipped to the end customer. Firstly, run-of-mine (ROM) coal is excavated from the mine site by stripping it from the overhang. A term known as the stripping ratio is used to measure this process. The stripping ratio measures the degree of earth moved per unit of ROM coal. There is a positive correlation between cost of production and an increase in the stripping ratio. The ROM coal is then transferred to the coal handling and preparation plant (CHPP). The ROM coal is processed to yield saleable coal. In the past, Gloucester has averaged a yield of 65%; therefore on average 1.54 tonnes of ROM yields 1 tonne of saleable coal.

Post acquisition of Donaldson and Middlemount, Gloucester is set to increase its production capacity and increase its product range – with a higher degree of coking coal production. By 2018 the company is set to reach a total production capacity of 12mtpa with production approximately split evenly between thermal coal and coking coal. Gloucester's production capacity is expected to peak in 2018 then subsequently decline as mining assets are depleted. Operations from all assets except for Stratford (Gloucester Basin), Abel and Tasman (Donaldson mine site) are expected to cease by 2030. Stratford, Tasman and Abel expect to be mined until 2041, 2038 and 2037 respectively (Gloucester Coal, 2012). Based upon production forecasts, below is a chart of total life of mine (LOM) production:

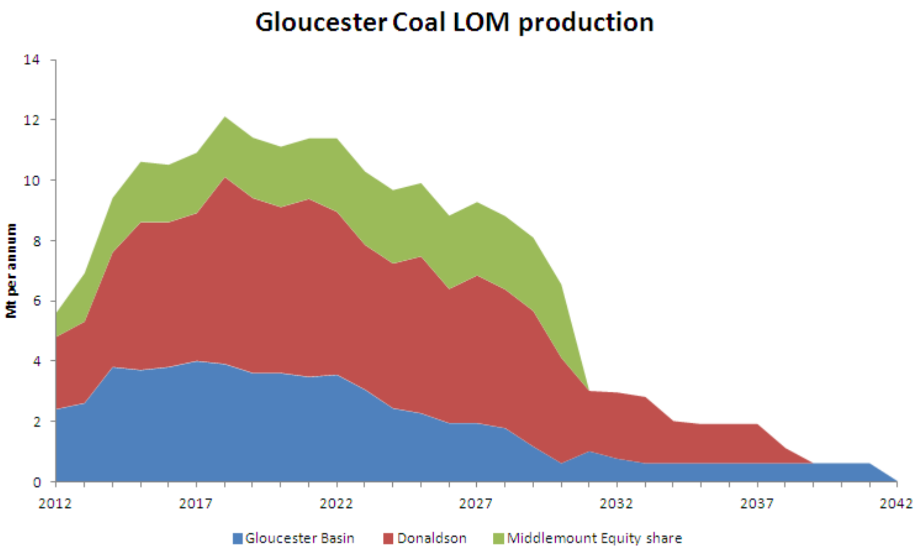


Figure 28: Gloucester coal forecasted production

Source: Compiled from data sourced in Gloucester Coal report (2012)

The production figures presume that Gloucester will mine all economically recoverable reserves. These reserves are compliant with JORC[8] mining standards. The JORC is a member of the Committee for Mineral Reserves International Reporting Standards (CRIRSCO). According to the CRIRSCO, a mineral reserve is the economically viable part of the resource body. At the time of reporting, an independent assessor has deemed that the reserve body extraction can be economically justified (CRIRSCO, 2006).

The future projections indicate that Gloucester expects to yield approximately 66% of saleable coal from each tonne of raw coal excavated from the mining assets. The expected yield per site is as follows: Gloucester Basin, 62%; Donaldson, 65%; and Middlemount, 78%. Gloucester's yields are lower than Australian coal mining averages; this is a contributing reason to higher costs of production, which will be

[8] The Joint Ore Reserves Committee is responsible for issuing the general industry reporting standards; this is widely seen as the industry benchmark and is mandatory for Australian listed mining company. Refer to http://www.jorc.org/ for further information.

presented in the upcoming financial section. National averages are presented below and have been compiled from Australian resource statistics:

Australia M. Tonnes	2010	2009	2008
Aus. coal production	449	445	425
Total saleable coal	356	345	328
Yield	79,29%	77,53%	77,18%

Figure 29: Average Australian saleable coal yield

Source: (Geoscience Australia, 2011; Geoscience Australia, 2012)

4.3 Customers

Gloucester focuses primarily on the seaborne coal market, exporting the majority of production. On average, over the last six years approximately 94% of sales were generated from exports. Of the exported production, 93% was shipped within the Asian region. Therefore it can be concluded that the company primarily relies on pricing within the Asian region when forecasting revenue. Gloucester utilises the services of Noble group to sell and market its coal. As a result of the acquisition of Donaldson, the company entered into a marketing agreement with Noble Group Limited. The marketing agreement is in relation to the sale and export of coal. Noble group assists with the sale of production volume and Gloucester pays a fee for this service. The fee is calculated at 2% of the volume-weighted price of coal sold for export sales in excess of 3.5mt but not exceeding 11.75mt (Gloucester Coal, 2011). This has been taken into account in the valuation model. According to Deloitte in a recent due diligence report (Gloucester Coal, 2012) whilst Gloucester markets some coal directly to Japanese customers, the majority of coal sold is through Noble group. Noble group, in turn on sells the product to the end customer. In 2011 and 2010 the group derived 75% and 67% of sales from the largest three customers. Though, in terms of customer concentration risk, an actively traded coal spot market partially mitigates any loss associated with losing one of these customers (Gloucester Coal, 2011).

4.4 Pricing

Gloucester negotiates quarterly contracts with customers and therefore the long-term trend is driven by future coal price projections. The acquisition of Donaldson has led to Gloucester acquiring a contract liability of $133m as at 31 December 2011. This represents out of the money sales contracts and will be released over the life of the sales contract when sales commitments are satisfied. Due to the limited size of the contracts, it is expected to have minimal impact upon total group sales. Gloucester's product range includes: thermal coal, PCI, semi-hard coking coal, and semi-soft cooking coal. Historically Gloucester Basin prices have varied from the standard benchmark thermal and coking coal price. Gloucester typically sells its thermal coal at a discount to the Newcastle benchmark price due to the higher degree of ash content (22% vs. 14%). The estimated discount on Newcastle benchmark prices is 15% (Macquarie Research Equities, 2008). In addition, Gloucester Basin semi-hard coking coal has sold at a price between that of semi-semi soft and hard coking coal (Gloucester Coal, 2006).

4.5 Rail and port capacity

The company ships coal from several locations in QLD and NSW. In NSW Gloucester is forecasted to have total port capacity in excess of 13.7mtpa by 2016. In QLD the company is expected to have a capacity of 2.0mtpa equity basis (incorporating expected allotment from the North Queensland Coal Terminal expansion) by 2016. In addition, Gloucester is currently in negotiations to secure additional capacity in QLD (Gloucester Coal, 2012). Due to the acquisition of Donaldson and Middlemount, and to cater to the forecasted expansion plan, Gloucester has taken on take or pay commitments for port and rail capacity. These are commitments to use rail and port allotments, the majority of which is recognised off-balance sheet. These commitments are discussed further in the real options assessment.

5. Financial Analysis

The last six years of financial data have been sourced from annual reports and Thompson One Banker. The purpose of this section is to provide a financial overview of Gloucester Coal, namely: profitability analysis, trend analysis and financial structure. Gloucester Coal reports its earnings like most Australian companies, at the end of the tax year – 30th June. In addition, the most recent half-year report (31st December, 2011) will also be discussed.

5.1 Accounting Policies

Gloucester Coal prepares general purpose annual reports in line with Australian Accounting Standards (also in line with International Financial Reporting Standards, which were adopted in 2006). A review of the accounting policies adopted by Gloucester highlights no major deviations from industry practice. Though in order to provide an effective analysis several methods of accounting are worth taking note: namely the treatment of exploration and expenditure and secondly the acquisition of mining assets.

Gloucester allocates a certain degree of expenditure to exploration, evaluation and development. According to the 2011 annual report, all expenditure relating to exploration of land in which the company has the legal right to explore is capitalised and presented on the balance sheet as exploration and evaluation assets. This expenditure is subject to annual impairment testing and any amount deemed to be unrecoverable is expensed in the respective year. Therefore, this line item is carried at fair value prior to commercialisation of the mining field. Once a mining field is deemed to be commercially viable the related exploration and development assets are transferred to property, plant and equipment and classified as mining property and development. This asset is depreciated on a unit of production basis over the life of the economically recoverable reserves. As of June 2011 $57 million (4.2% of assets) was classified as exploration and evaluation and $600 million (45% of assets) was classified as mining property and development (producing assets).

During the 2011 financial year Gloucester purchased a 50% stake of Middlemount and a 4% royalty stream. The underlying acquisition was treated on a proportionate consolidation method therefore all assets and liabilities acquired by Gloucester (pro rata) have been consolidated into the Gloucester's accounts. In addition, Gloucester paid $168m for the right to receive a 4% royalty payment on the total free on board sales of Middlemount. This is recognised as a financial asset, subject to impairment and amortised on a units of production basis over the estimated life of the mine.

5.2 Financial Performance

Gloucester has experienced strong revenue growth over the past six years, with a CAGR of 14.81% growing the company from $154m of revenue in 2006 to $307m in 2011. The uplift in revenue has been primarily driven by stronger underlying commodity prices. The quantity of coal sold has been quite steady over the past six years, with a modest increase of 2.11%. However the average price received per tonne has experienced strong growth of 12.43% per annum (2006: $79.84, 2011: $143.45). Gloucester has retained a fairly constant product split between production of thermal and coking coal. On the cost front, Gloucester, like many other mining companies has experienced strong cost pressure. Average cost of sales over the period has increased by 17.45%, holding net income growth somewhat back: with an increase of 6.23% per annum over the last six years. Below shows a snapshot of sales volume, revenue, cost of sales and bottom line performance.

Figure 30: Gloucester Coal financial snapshot

Average price per tonne	2006	2007	2008	2009	2010	2011	CAGR
Quantity sold (millions)	1,93	2,17	1,90	1,99	1,97	2,14	**2,11%**
Revenue (millions)	153,70	151,89	159,55	306,77	229,29	306,56	**14,81%**
Cost of sales (millions)	91,58	110,70	109,72	166,05	161,37	204,65	**17,45%**
Average Sales price	**79,84**	**70,12**	**83,84**	**154,23**	**116,39**	**143,45**	**12,43%**
Average cost of sale	**47,57**	**51,11**	**57,66**	**83,49**	**81,92**	**95,76**	**15,02%**
FOB cash cost	**46,00**	**53,00**	**60,00**	**77,00**	**85,00**	**99,00**	**16,57%**
Margin on sale	32,27	19,02	26,19	70,75	34,48	47,69	
Net Income	40,341	18,026	23,447	81,740	32,730	54,562	**6,23%**

Source: 2006-2011Annual Reports

As discussed above, costs of mining have risen quite significantly. The main drivers behind this are increased mining costs due to higher stripping ratio (the stripping ratio reflects the amount of land that is moved compared to the recovery of coal ROM), increased taxes (NSW Government royalties on open cut pits increased from 7% to 8.2% on sales price), higher port charges due to capacity constraints and lastly increased labour costs.

The results above reflect the volatile nature of commodity prices with 2009 being the strongest year to date for Gloucester. This result was driven by the structural change in the global seaborne coal market, as identified in the industry analysis, with China becoming a net importer of coal and pushing seaborne coal prices to record levels. The volatility in underlying prices is reflected in the company's ROE. The company achieved a ROE figure of 63.2% in 2006, 2011 was considerably lower than this at 5.38%. The decline in ROE however is partly due to the company retaining a larger proportion of earnings and raising a substantial amount of equity in 2011 to purchase mineral sites that are yet to reach full production phase (limited earnings uplift). In 2007 Gloucester paid out 64% of earnings in cash dividends. This has decreased over the period, with no dividend being paid in 2010 & 2011. In 2011 Gloucester issued $670m in new shares to finance the acquisition of Middlemount. The declining payout ratio and equity issuance led to a strong deleveraging of the balance sheet: Debt/Equity declined from 0.87 (2006) to 0.32 (2011). However, during the current financial year (FY2012) Gloucester has completed two additional acquisitions, which have led to an increase in financial leverage and will be discussed below in recent acquisitions.

5.3 Acquisitions

Gloucester has completed three acquisitions over the last two years; which has had an effect upon the capital structure of the business. Below summarises the recent acquisitions:

Figure 31: Gloucester Coal corporate transactions

Asset	Acquisition date	Consideration	Cash	Scrip	Ownership	Target's total debt
Middlemount	Aug 4th 2010	$533.7m	$434.2m	$100m	50%	$121.72m
Donaldson	July 14th 2011	$360m	$0.0	$360m	100%	$225m
Monash	July 14th 2011	$118.6m	$31.93m	$86.7m	100%	$0.0m

Source: 2011 & HY December 2011 Annual Report

These acquisitions have resulted in an increase in Gloucester's total debt burden. In particular, the acquisition of Donaldson led to Gloucester taking on $225m in debt (Donaldson enterprise value, $585m). This was supported by a related party loan from Noble Group. On July 14, 2011 Gloucester entered into a $400m debt facility (maturing 1 July 2015). Interest is calculated at a rate of BBSY[9] plus 3%. The company has utilised $338m of this, leading to a total burden of $411m as at 31 December 2011. This represents a $312m increase on the 30 June 2011 debt levels. The company now has a total debt to equity ratio of 0.87. The transactions were reviewed and adjusted for in the valuation model, this was to ensure an accurate FCF figure could be calculated and to ensure depletion charges were correctly allocated over the course of the valuation. The balance sheets of Middlemount, Donaldson & Monash have been presented in the appendix.

[9] BBSY: Australian Bank bill swap rate is a reference rate used. This is based upon the yield of a variety of bank bills.

5.4 Working Capital Requirements

Gloucester's historical working capital has been analysed in order to forecast appropriate capital commitments going forward. To establish a usable working capital forecast a company's working capital is often compared to sales figures in order to compute a demand-driven forecast. (Koller, Goedhart, & Wessels, 2010). Working capital reflects the net investment in operating assets of the business; this essentially refers to current assets (excluding non-operating cash) less non-interest-bearing liabilities. For simplicity, operating cash will be analysed separately.

Gloucester's cash balance has been steadily rising in preparation for the recent acquisitions. The increase in cash and cash equivalents doesn't necessarily reflect the cash balance required to sustain operations. The average cash balance over sales (2006 – HY2012) is 17.73%; though this is still significantly lower than several peers. The average percentage of cash over sales for a 5 year period for a selection of peers (2007-2011) ranged from 38% to 243%. Though the build up in cash may be due to the increased consolidation in the industry (as discussed in the industry overview) wherein miner's stockpile cash to pursue acquisitions going forward or in order to invest in continued expansion – capitalising on the recent upside in coal prices. Therefore in order to get an accurate reflection of operating cash requirements, the cash conversion cycle was calculated in order to determine the average time it takes Gloucester to receive payment on extracted coal. This is defined as the amount of days it takes on average to sell inventory (inventory period), plus the average time it takes to collect accounts from customers (receivables period), less the time taken to pay suppliers (payables period) (Ross, Westerfield, & Jordan, 2006). The results were quite volatile over the seven historical estimates generated. The cash conversion period ranged from minus 42 days to positive 45 days, with an average of negative 2 days. With such a range, further investigation was warranted.

It was decided that a figure of approximately 2% of sales would be used. This has been justified by three observations. From 2000 to 2005 Gloucester's average cash balance equated to 1.7% of sales. This appears to be more in line with normal operating cash levels. An operating cash balance of 2% equates to a cash conversion cycle of approximately 8 days, which is within the range of historic values. Furthermore, Copeland, Koller & Murrin (2010) estimate that the average corporate operating cash figure over sales equates to approximately 2%. Therefore based on historical analysis and academic literature it was deemed appropriate.

Non-cash working capital was also analysed from 2007 to 2011. Average non-cash working capital was calculated at 17.7% (Median: 9%) of sales over the period. This was compared to three other Australian coal mining companies (Macarthur Coal [now owned by Peabody], New Hope Corp and Whitehaven). The three produced averages of 45%, 11% and 31% respectively over the period (Median: 34%, 11% and 21%). In order to assess the adequacy of the historical figures this was compared to 49 mining companies (international collection with interests in coal) with financial accounts data sourced from Datastream. The data suggested the median selection produced negative non cash working capital, at approximately -3.7%. This however is somewhat inconclusive due to the large variation in the range. These computed statistics were also compared to information collected by Damodaran (2012) as at January, 2012. The information collected by Damodaran on 20 US coal miners suggested the average non-cash working capital balance was 3.61%. The inconclusive nature of the comparison made it best to rely on historical averages as an indicator to future working capital balances. In addition, whist there was a large range in values; the historical figures were closer to that of the three other Australian coal mining companies. Utilising average ratios for working capital accounts was felt to give a better representation of Gloucester specific working capital requirements and therefore the most accurate indicator.

5.5 FOB Production Costs

Going forward cash costs are expected to decline for Gloucester and Donaldson assets. According to Gloucester, cash costs are estimated to decline to $78 per tonne (excluding royalties) in the next three years (Gloucester Coal, 2012). The improved costs are due to improved efficiencies from underground assets and further economies of scale. Middlemount costs are expected to remain relatively high, based on Gloucester estimates, costs are expected to be $100 per tonne excluding royalties (Gloucester Coal, 2011), this was also cross checked with Macquarie Bank estimates. These costs were used as a base and have been reviewed by mineral industry advisor, Behre Dolbear[10], which is one of the oldest continually operating mineral advisory firms. Historical cash costs have been presented in the Appendix (Appendix I: Historical Financials) of the thesis.

However, in order to establish a projection of future cost increases, a review of the Australian mine atlas[11] was conducted in order to find similar mines to those of Gloucester, Donaldson and Middlemount. A screen shot of the mine atlas has been provided in the appendix. Mines were selected based on proximity to Gloucester mines; this is due to the geological similarities and the exposure to similar factors driving costs. Cost estimates of the mine sites and projections to 2027 were ascertained from the AME group (2012c) & (2012d). A weighted average approach was utilised in projecting cost estimates. Prices past 2027 are expected to follow the average long run coal PPI[12], as shown in the preceding cost structure section. The forward cost projections were then cross-checked against total Australian wide industry projected costs in

[10] See: http://www.dolbear.com/about-us/

[11] For a review of Australian mine sites refer to the Australian mine atlas: http://www.australianminesatlas.gov.au/

[12] Producer Price Index

order to establish reasonableness. The chart below highlights the forecasted cost driver in AUD nominal for the next 10 years.

Cost Driver	2012-2017	2017-2022	2022-2027	2027 -
Gloucester & Donaldson	2,24%	2,54%	3,18%	3,02%
Middlemount	-0,01%	3,09%	3,51%	3,25%

Source: Estimation compiled from data supplied by the Australian Bureau of Statistics and The AME group.

Figure 32: Forecasted annual price changes in cost of production (per tonne)

5.6 Capital Expenditure

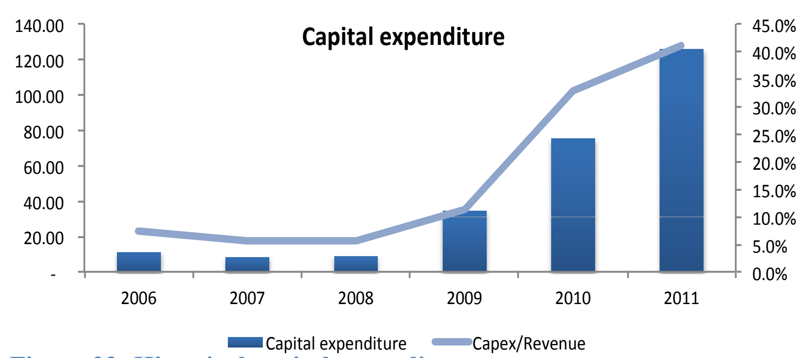


Figure 33: Historical capital expenditure

Over the last six years, Gloucester's cash flows have transformed to reflect the increased focus on production expansion. From 2009 there has been a clear ramp up in PP&E investment namely due to the expansion in coal processing in the Gloucester basin: production capacity of raw material increased from 3.2m tonnes per annum to 4.0m. In addition, Gloucester has expanded its exploration by securing additional land in the Gloucester Basin and significantly increase the amount of money spent on exploration; cash flow spent on exploration increased $13m in 2010 and $4m in 2011 (total 2010: $17m & 2011: $21m). The chart highlights the increase in capital expenditure. As it can be seen, capital expenditure is up in nominal terms and also as a proportion of revenue.

Expansionary capital expenditure is forecast to peak in 2014, as Gloucester makes its last commitments to the second phase development of Middlemount. Based on analysis of Gloucester coal's presentations, and review of the ABARE mining projects information, the company plans to make the following expansionary investments:

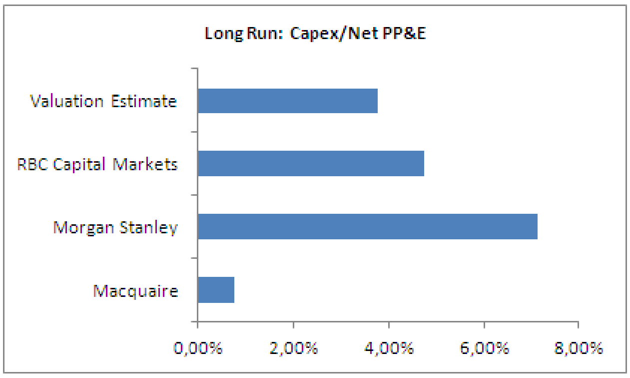
Asset	Total Expenditure	Period	Purpose
Middlemount	$120.0m	3 years	Remaining commitment for expansion of CHPP facility. Increased ROM handling by 2.625mtpa to total ROM capacity of 6.125mtpa
Abel underground	$192.0m	5 years	Increased mining capacity (increase commencing 2014)
Tasman underground	$128.0m	8 years	Increased mining capacity (increase commencing 2015)
Bloomfield (Donaldson)	$ 81.0m	3 years	Increased ROM washing capacity by 4mtpa
Monash	$ 35.0m	2 years	Planned exploration expenditure

Figure 34: Announced capital expenditure programs

Source: International Roadshow, September 2011

In addition to this, an allowance of $62 million has been provided over the next five years. This is based upon the fact that the company has indicated total 5 year capex will equate to approximately $1.1bn (including sustainable capex). The information presented above was cross checked with recently released financial data (Gloucester Coal, 2012). The majority of capital expenditure relates to the development of the Donaldson extension project and the Middlemount development. Mine development generally constitutes the majority of lifetime mine capital expenditure, at approximately 60% of total capital expenditure. Therefore, to be expected, capital expenditure tapers off post 2016. The remaining capital expenditure relates to upkeep and replacement of assets.

Sustainable (operational) capital expenditure has been estimated based on historical data. A review of the company's asset composition was conducted. The average asset life was calculated by comparing depreciation to depreciable assets. To gain an accurate forecast, depletion charges were estimated separately, therefore Mining PP&E (capitalised development expenditure from producing mines, i.e., intangible assets) was subtracted from the PP&E balance. In addition to this, non-depreciable PP&E such as freehold land was also subtracted. Depreciation (excluding depletion charges) was compared to the net PP&E balance. The average asset life of depreciable assets over the period was 14.5 years. There was however a clear decline in the trend. It was therefore deemed reasonable to set the average depreciable asset life at 12 years. This was also within the upper band of the advised asset life of PP&E in the footnotes of the financials. This translates to an estimated sustainable capital expenditure figure of 8.3% of net PP&E excluding Mining property and development and Freehold land. The figure was then compared to analyst estimates (RBC Capital markets, Morgan Stanley & Macquarie) and deemed to be reasonable.



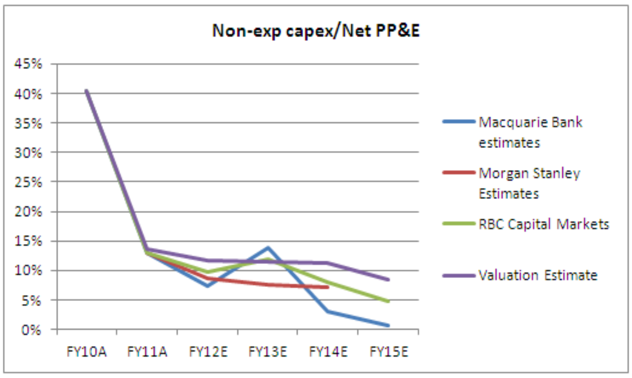


Figure 35: Capital expenditure forecasts as proportion of total net PP&E

Source: Own Estimates compared to RBC Capital Markets (May 2012), Morgan Stanley (April 2012), Macquarie (June 2012) analyst reports

5.7 Reorganisation of financial statements

In line with the method proposed by Koller, Goedhard & Wessels (2010) the financial statements were rearranged in order to reflect operating and non-operating assets. This method has also been suggested by Petersen & Plenborg (2012). The major adjustments are as follows:

- Provisions have been treated as a debt equivalent, whereby the value is subtracted from enterprise value, as opposed to accounting for the adjustment in provisions in the calculation of free cash flow. The effective discount rate has been calculated from historical information, thereby taking into account the annual unwinding (non-cash) interest charge in the income statement, this item is recognised in financial expenses which is after NOPLAT. In addition the provision has been unwound each year in the balance sheet.
- Exploration reserves purchased through the acquisition of Donaldson and Middlemount have been incorporated and factored into the depletion calculation going forward. This is based on a unit of production forecast (Refer to Appendix Q for information on depletion charges).
- Intangible port allocation of $57.4m (11.6% ownership in NCIG through acquisition of Donaldson) has been included as an operating asset. The investment gives Gloucester access rights to port capacity. Even though the ownership of this is tradable Gloucester would have to renegotiate capacity at other ports in the event this is sold. The investment has been amortised over the production profile of Donaldson.
- Historical operating cash taxes have been calculated over a six year period. This was calculated by firstly utilising the Australian corporate tax rate (30%) on operating profits and then adjusting for movements in operating deferred tax assets/liabilities. The effective tax rate was used to forecast operating taxes until 2021. This was due to the fact that the company will receive substantial deductions over the next 10 years due to the large capital expenditure. It's forecasted that in 2026 depreciation will exceed capital expenditure therefore driving the tax rate back to the headline figure.
- The deferred tax liability has grown over the last two years due to the acquisition of Donaldson, Monash and Middlemount. This has been treated as an equity equivalent primarily due to two assumptions. It is assumed over the next several years, expansionary capital expenditure will result in the avoidance of the liability (due to continued growth). After this, it is assumed that the company will most likely convert the Monash exploration lease into a producing mine. The Monash site already has high level plans. Though this is still in the concept phase and awaiting further proofing-up of the resource body. If this was not the case this may result in payment of the liability. Further clarification was sought through a review of company presentations though no guidance was provided.

- The royalty asset, which was acquired with the Middlemount acquisition, has been treated as a non-operating asset. The royalty asset is transferable and therefore can be sold whilst Gloucester retains a 50% stake in Middlemount. Including this in the calculation of NOPAT (Net operating profit after tax) would result in a distortion to the margins of the business. The royalty asset valuation was checked against the production profile used in the calculation of the company valuation. Using excel solver, the implied discount rate was calculated at 5%. If a discount rate of 9.627% (Gloucester's WACC, presented in Chapter 6) was used the valuation would drop by approximately $66m AUD. Though, as the royalty asset is subject to annual impairment testing it is assumed that the carrying value of $193m is deemed reasonable.

Incorporating the information identified in Chapters 3, 4 and 5 a forecasted Balance Sheet and Income Statement was prepared. The information is available in the financials section of the appendix (appendix A).

6. DCF Valuation

The valuation of the operating mines has been calculated on an enterprise basis, with cash flows calculated on a firm level. The formula for free cash flows to firm (FCFF) is calculated as follows:

$$FCFF = NOPLAT + \text{Noncash operating expenses} - \text{Investment in Invested Capital}$$

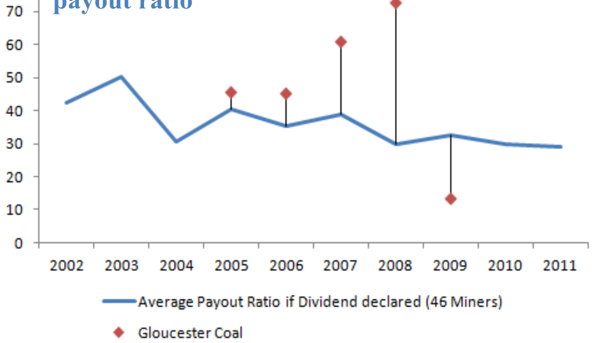
For further information on the calculation of free cash flows refer to Appendix G. The estimates discussed in the preceding chapters form the basis of the valuation. The following section discusses capital considerations, dividend policy and the cost of capital. The section will then conclude with a valuation of the production assets.

6.1 Capital Structure

An analysis was conducted to determine an appropriate payout ratio and capital structure. It should be noted that the capital structure of the company will not affect the calculation of free cash flows. The purpose of this section is to establish the estimated tax shield generated from the use of debt and an appropriate WACC.

6.2 Dividend Policy

Figure 36: Benchmarking of dividend payout ratio



Source: Datastream and company accounts

In the last two years Gloucester hasn't declared a dividend, this due to the company's recent acquisitions. However, in line with recent policy, it is presumed dividends will recommence. This is centred on the fact that the company has paid a dividend in the past and secondly, based upon adequate forecasted cash flow generation within the next few years.

To determine an appropriate dividend payout ratio, historical dividends were compared to a sample of forty-six international miners. The average dividend payout ratio is calculated by taking the average of firms that paid a dividend within that year. This method was used as it was sought to find the average dividend paid by a miner given a dividend was declared. Gloucester has paid dividends in five of the last ten financial years (as shown above). When dividends were paid, Gloucester's payout ratio tended to be higher than the sample. The average sector payout ratio has declined over the last few years however, this can be attributed to record reinvestment in the sector. Gloucester's average payout ratio of 50% will be used going forward as this is within a reasonable range to that of its global peers. Dividends will be factored into the model post peak debt, being phased in at the end of 2016.

6.3 Target debt levels

As discussed in the forthcoming cost of debt section, the median debt to firm levels for the industry sample over the past five years ranged from 0.18 to 0.23. As forecasted, Gloucester's debt burden will increase in the next two financial periods, after that returning to lower levels. Going forward it will be assumed that the firms target debt to market value (a valid proxy) is in line with the historical levels of 0.20. To maintain this target, excess cash build up will be used for buy backs and or special dividends.

6.4 Market Risk Premium[13] (MRP)

There are three generally accepted methods for estimating the MRP. The first method involves utilising survey data on analyst future expectations. The next approach is the utilisation of historical returns on equities and comparing this to returns on riskless assets. The third involves estimating a forward-looking premium based upon the current price of assets, this is referred to as implied premiums. However, whilst the number is one of the most important in corporate finance, complete consensus on the best approach is yet to be established, nor is likely to in the immediate future.

Typically economists use historical returns generated over a significant period (many decades) as an unbiased indicator of future returns. According to Koller, Goedhart & Wessel (2010) it is important to use the longest period possible when estimating the market risk premium (MRP). This is due to the fact that often shorter periods of measurement carry with it statistical noise, making the estimation less robust. In addition period specific anomalies can lead to inconsistent results. For instance, the Credit Suisse Global Investment returns Yearbook (O'Sullivan & Kersley, 2012) highlights that the Australian equity risk premium from 1987-2011 was -1.7% p.a. over that of bonds; rendering the observation unusable. A search for Australian stock market return data on Datastream was conducted though it was established that only 42

[13] The MRP represents the difference between the expected or historical return on a market portfolio and the risk-free rate.

years of historical data was available. Therefore a review of academic literature was conducted to find long-term historical return data. Brailsford, Handley & Krishnan (2012) found that the historical equity risk premium for a sample period of 128 years (1883-2010) was on an arithmetic basis 6.1% and a geometric basis of 4.7%. These results include returns in the form of dividends and capital growth. There is some debate in regards to the inclusion of the effects of franking credits in the estimation of the MRP. Australia introduced an imputation tax system in July 1987 and the effects of this on the calculation of the MRP have been documented (Gray & Hall, 2006; Officer, 1994). However, as suggested by Gray & Hall (2006), adjustments for franking credits in the corporate world are seldom made (i.e., Gamma = 0) and therefore it was deemed appropriate to follow market consensus on the issue. This approach is also used by Dimson, March and Staunton (2002).

As pointed out by Jacquier, Kane, and Marcus (2003), many academics correctly suggest that the use of the arithmetic average for forecasting future returns is the correct method if the arithmetic mean of return is known. The geometric average can be used however only when the sample period and investment horizon are of equal length (Jacquier, Kane, & Marcus, 2003). The problem lies in the fact that using arithmetic averages generally leads to an upward bias whilst using geometric averages leads to a downward bias. Blume's (1974) estimator provided a mathematical approach to adjust for this problem. This essentially provided a suggested weighting of the arithmetic and geometric estimates based upon the number of observations and forecast period. However, this approach requires a MRP to be calculated for each year of cash flows being calculated; which for obvious reasons leads to a cumbersome solution.

In addition, utilising Australian equities over a 128 year period fails to recognise the fact that many other countries have experienced much worse stock performance, such as, China, Russia, and Poland. Academics have suggested that these historical returns fail to recognise the effects associated with survivorship bias (Dimson, Marsh, & Staunton, 2003). Whilst most of the literature is focused on US equity returns, Cornell (1999) presents a cogent argument of the effects of survivorship bias. In his summary he argues that the equity premium going forward is more likely in the vicinity of 300 to 400 basis points lower. This being said, the suggested adjustment is a reflection of US returns and also affected by a different measurement period than the Australian returns presented above. However, it lays basis to the argument that the historical return may not present the best indicator for the future MRP. Furthermore, as evidenced by global stock market studies (Dimson, Marsh, & Staunton, 2002; O'Sullivan & Kersley, 2012), Australian equities have outperformed that of the United States making this issue equally prominent, if not more so.

For these reasons it was decided to review forward looking commentary in order to establish an expected MRP. Fernandez, Aguirreamalloa and Avendaño (2012) compiled a global survey of 7,192 responses from economic professors, analysts, and company managers. It provided useful results and also highlighted the convergence of expected MRP's in developed capital markets. The Australian expected MRP for 2012 was 5.9%, which was 0.4% higher than that of US survey respondents. This indicates that the investment community expect equities to perform close to trend. It was therefore decided to utilise a MRP of 5.9%, as this was within reason compared to 128 years of historical data, partly avoids problems associated with survivorship bias, and is forward looking.

6.5 Equity Beta

Five years of monthly returns were regressed against the ASX 300. The ASX 300 is a benchmark index of the largest 300 companies in Australia. Monthly returns over five years were chosen as this one the method used by Monrningstar Ibbotson, the suggested approach by Koller, Goedhart and Wessels (2010) and was also in line with early test of the CAPM (Black, Jensen, & Scholes, 1972). The 60 observations are presented alongside. A beta coefficient was estimated at 1.077. The t-stat (2.89) was above the critical level, indicating that the value of beta was significantly different from zero. However the large standard error of 0.37 meant that with 95% confidence the beta value was between 0.34-1.82. As this is a high range, with quite large implications on the valuation it was decided that further testing was required.

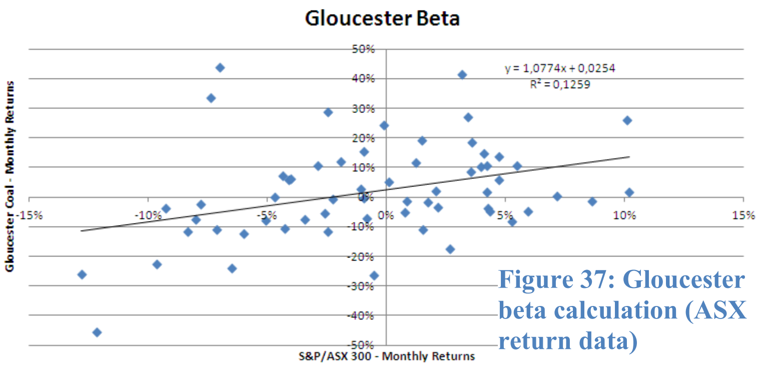


Figure 37: Gloucester beta calculation (ASX return data)

A rolling beta estimate was calculated over approximately the last three years. The length of the rolling estimate was established based upon the usability of historical data. Whilst the stock was trading around 2000 to 2004, low trading volumes make the estimates unreliable. Gloucester's beta was calculated using multiple benchmarks and converted into the respective benchmark currency. This highlighted that the ASX 300 (the largest Australian Index) is not an appropriate benchmark. Further investigation reveal that approximately 21% of the index is represented by mining stock (O'Sullivan &

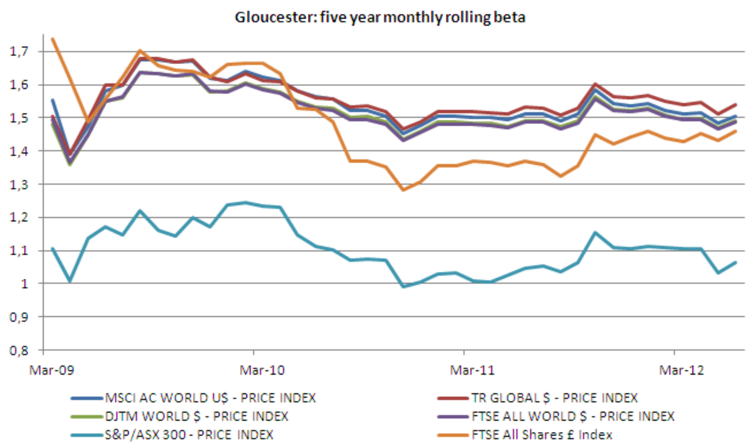


Figure 38: Gloucester beta calculation (international index data)

Kersley, 2012). Natural inference would suggest that Gloucester's stock price would have a higher correlation with the index and therefore isn't a true representation of the stock's systematic risk.

Reviewing the development in the beta it appears the beta has shifted downward since December 2010. What's surprising is the beta has remained rather steady even though the company has increased its leverage in the second half of the current financial year. However, this may be due to the relatively low level of leverage. Early studies on equity betas found that firms with lower levels of leverage tend to exhibit a lower degree of equity beta instability (DeJong & Collins, 1985). The difference between the FTSE £ and other international benchmarks has been attributed to currency effects. A FTSE $ benchmark was also used to highlight the fact.

Gloucester's beta was also compared to a group of industry peers. Due to the limited nature of pure coal companies, in addition to selecting New Hope Corp a selection of global miners were used.

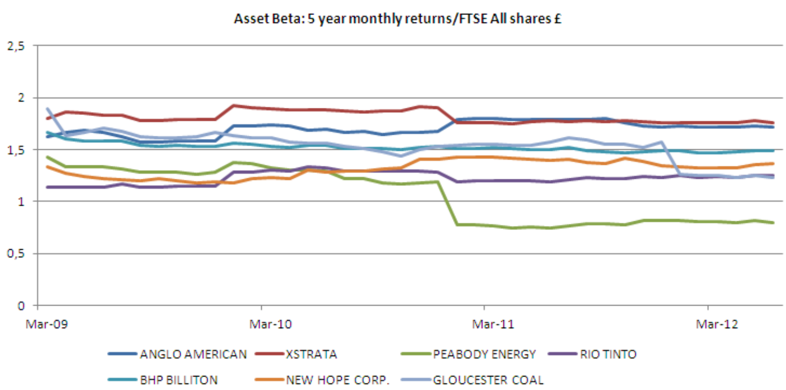


Figure 39: Asset beta comparison

The betas were calculated by adjusting for the financial leverage of each company. The book value of debt and market capitalisation of equity at year end was used (Therefore it has been implicitly assumed that these companies have issued debt at rates similar to equivalent bond yields). Whilst Modigliani and Miller use a more elaborate calculation due to information restrictions two assumptions have been made. The debt beta is assumed to be zero and the tax shield beta is equal to the unlevered company beta. These methods are in line with Koller, Goedhart & Wessels (2010). The asset betas above have widened in the last few years however this appears to be mostly due to a lowering of Peabody Energy's asset beta (note: Peabody increased its leverage late 2010). The average asset beta of the group is 1.36, which is slightly higher than Gloucester's asset beta of 1.23. It can also be seen that Gloucester's asset beta has narrowed between that of its nearest comparable, New Hope Corporation. Due to limited trading history, Whitehaven coal could not be used in the sample. Similarly as Macarthur coal is no longer listed it was unable to be used in comparison.

As Gloucester's equity beta appears to be in line with industry benchmarks and also exhibits a degree of stability, the most recent observation will be used going forward. The value of the beta is an equally weighted average across indices (excluding ASX 300). However, an adjustment will be made to take into account mean reversion in beta estimates. Initial work by Blume (1971) found that betas regressed towards the grand mean (beta = 1). Large financial firms and service providers such as Bloomberg and Merrill Lynch also adjust for temporal properties of systematic risk. The adjustment reduces the effect caused by extreme observations and is presented below:

$$\beta_{Blume} = 0.67 \cdot \beta OLS + 0.33 \cdot 1$$

$$\beta_{Gloucester\ coal} = 0.67 \cdot (1.477) + 0.33 \cdot 1 = 1{,}32$$[14]

6.6 Cost of Debt

To estimate the cost of debt for Gloucester Coal a synthetic credit rating was generated by comparing the historical and forecasted financials of the business to a set of US peers. The Standard & Poors' industrial benchmark was used. Whilst this may not be directly comparable to the mining sector, data restrictions presented a challenge to providing a credit rating. To overcome this dilemma a strategic ratings guideline for the mining sector was also incorporated. The strategic mining bond ratings guideline was developed by DBRS, a globally recognised rating firm with ratings on over 1000 corporations[15].

The method adopted is in line with that recommended by Petersen & Plenborg (2012). In order to provide a reasonableness check, the cost of debt was compared to that of Gloucester's most recent loan. Gloucester refinanced their borrowings through a loan issued by The Noble Group. The Noble Group is large shareholder of the company though it the loan was originated at arm's length and on general commercial terms. In addition it can be assumed that Gloucester has a fiduciary obligation to the remaining shareholders of the business, therefore ensuring the rate is not in excess of normal commercial terms. Furthermore, the rating was also checked against a comparable firm: Yancoal Australia. Yancoal has similar operations within Australia and therefore provided a good guide as to the accuracy of the rating.

Traditionally credit ratings assess the financial ratios of a firm on a historic basis (Petersen & Plenborg, 2012). However, in this instance, the valuation model has forecasted the income and balance statement allowing for financial ratios to be calculated. These ratios are prepared on the basis that the firm must increase its borrowings in the following years in order to finance the increased expansion and also there will be no dividend declared in the next few years. This is reasonable and in line with the most recent financial statements.

---

[14] This is the equity beta (levered beta) for Gloucester based on a debt to firm value ratio of 0.20, as discussed in the preceding section.

[15] For more information see: http://www.dbrs.com/about

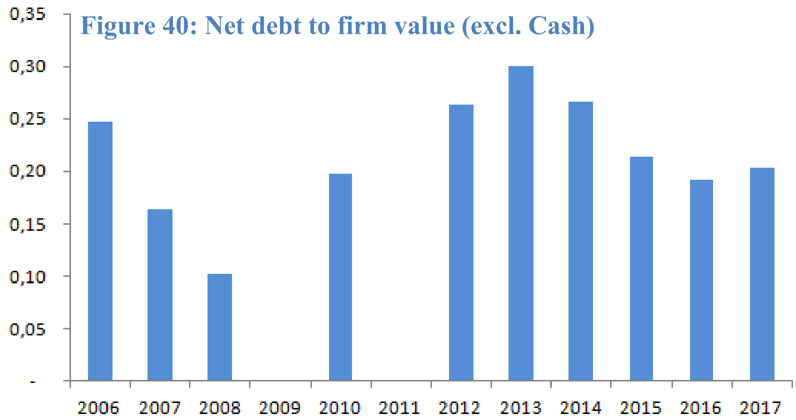


Figure 40: Net debt to firm value (excl. Cash)

Based on the projected financial performance and estimated capital expenditure, the firm's debt burden is estimated to peak in 2013. At this point the firm is estimated to have a Debt/Firm value (excluding cash and cash equivalents) of 29.97%. To contextualize this value a comparison of similar peers was conducted. Mining stocks listed in Australia, United Kingdom, Canada and America were used. All data was sourced from Datastream. Initially mining firms listed in Australia, US, UK and Canada were selected. The company business descriptions were downloaded and sorted. The companies were sorted based on the key business description that included 'coal mining'. Companies without five years of data were excluded. This yielded a sample of thirty-three Companies.

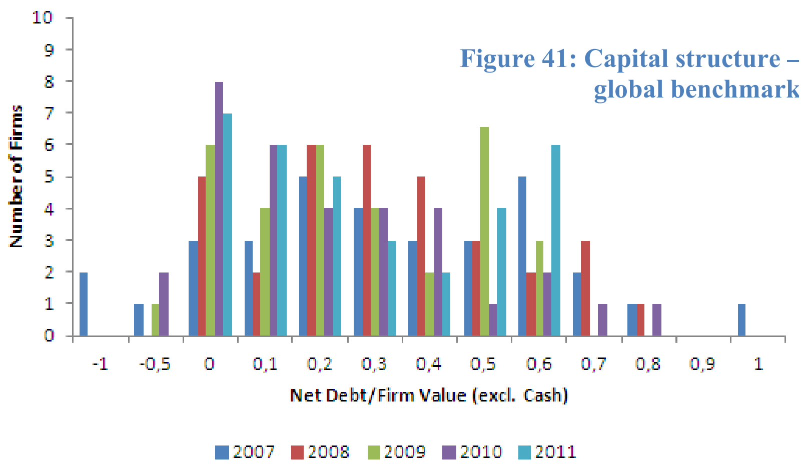


Figure 41: Capital structure – global benchmark

The data has been sorted into a histogram. Negative values indicate the firm has a surplus of cash over debt. The median value over the five year ranged from 0.18 to 0.23. However, pertinent to this paper, it is evident that the peak debt levels for Gloucester in 2013 are not unreasonable and within 'normal' operating levels. The outlier in 2007 (shown above) was checked back to the company's (Walter Energy U:WLT) financial statements to ensure data accuracy.

In line with Petersen & Plenborg (2012), the key financial ratios were computed from 2006 to 2017. Twelve years of data was used to determine an appropriate credit rating. The key ratios are presented in the appendix. The rating was calculated in line with S&P, and a rolling three year average of financial data was used.

As discussed, in addition an assessment was made in relation to strategic factors. The strategic factors are presented in the appendix and encompass five key considerations: reserves of core operations, cost competitiveness, diversification, political risk, and size and critical mass. This placed a slight negative weighting on the rating and subsequently resulted in Gloucester being assigned a synthetic rating of BBB.

Financial health assessment	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
EBIT Interest Cover (x)	22,19	13,73	17,20	336,42	77,81	24,29	0,18	6,30	8,74	8,26	7,70	5,44
EBITDA Interest cover (x)	24,68	16,65	20,07	353,62	98,30	31,63	1,99	8,28	10,73	10,80	10,91	9,33
Free operating cash flow/total debt (%)	132%	47%	-119%	499%	-164%	-61%	-38%	-2%	25%	41%	36%	33%
FFO/total debt (%)	99%	43%	102%	289%	27%	36%	14%	32%	53%	61%	57%	42%
Return on Capital (%)	NA	25%	29%	74%	20%	8%	0%	9%	15%	13%	10%	6%
Operating income/revenue (%)	40%	27%	31%	46%	30%	33%	21%	31%	36%	33%	29%	24%
Long-term debt/capital (%)	33%	7%	12%	14%	30%	5%	27%	31%	16%	22%	4%	21%
Total Debt/Capital	33%	27%	12%	14%	31%	10%	27%	31%	28%	22%	20%	21%
Assigned Rating			AA	AA	AA	AA	BBB	BBB	BBB	A	AA	A

Figure 42: Gloucester Coal - key financial ratios

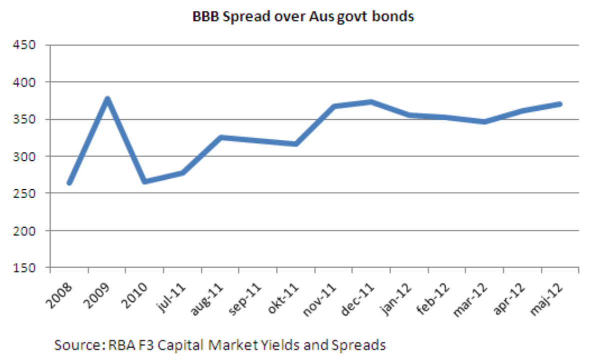


Figure 43: BBB less Aus Government yield: BBB bond spread

The BBB spread over Australian government bonds was sourced from the Reserve Bank of Australia. The average spread of 357 basis points for 2012 was used. Australian government 15 year bonds were used as a proxy for the risk free rate as the government currently holds a long-term AAA (Aaa Moody's equivalent) rating and therefore was determined to be a reasonable benchmark[16]. The cost of debt therefore was estimated at 6.65% (After tax 4.66%). As means of checking the calculation the rate was compared to Gloucester's most recent debt issuance. As per the 2012HY report, the company negotiated a $400m facility from Noble Group. The rate is calculated at a 3% premium on the BSBY (The Australian Bank Bill Bid Rate). This equates to an effective rate of 6.9%[17].

6.7 Calculation of WACC

Based on the aforementioned capital structure, market risk premium, equity beta and cost of the debt, the calculation of WACC is provided below:

$$Cost\ of\ Equity = 3.08\% + 1.32 \cdot\ 5{,}9\% = 10.87\%$$

$$Cost\ of\ Debt = 3.08\% + 3.57\% = 6.65\%$$

$$WACC = [0.20 \cdot 6.65(1 - .30)] +\ (0.80 \cdot 10.87) = 9.627$$

[16] For recent ratings review of Australia (12/06/2012) see: http://www.moodys.com/research/Moodys-says-outlook-for-Australias-Aaa-rating-remains-stable--PR_248186

[17] For information on the BSBY rate see: http://www.afma.com.au/home.html

6.8 Free Cash Flows to Firm

Free cash flows to the firm were calculated by utilising the method presented at the start of the chapter. Free cash flows have been presented in the appendix of the thesis (Appendix B: Free Cash Flow). Factoring in the discount rate calculated above a present value, for the production assets, of $1.536bn was ascertained.

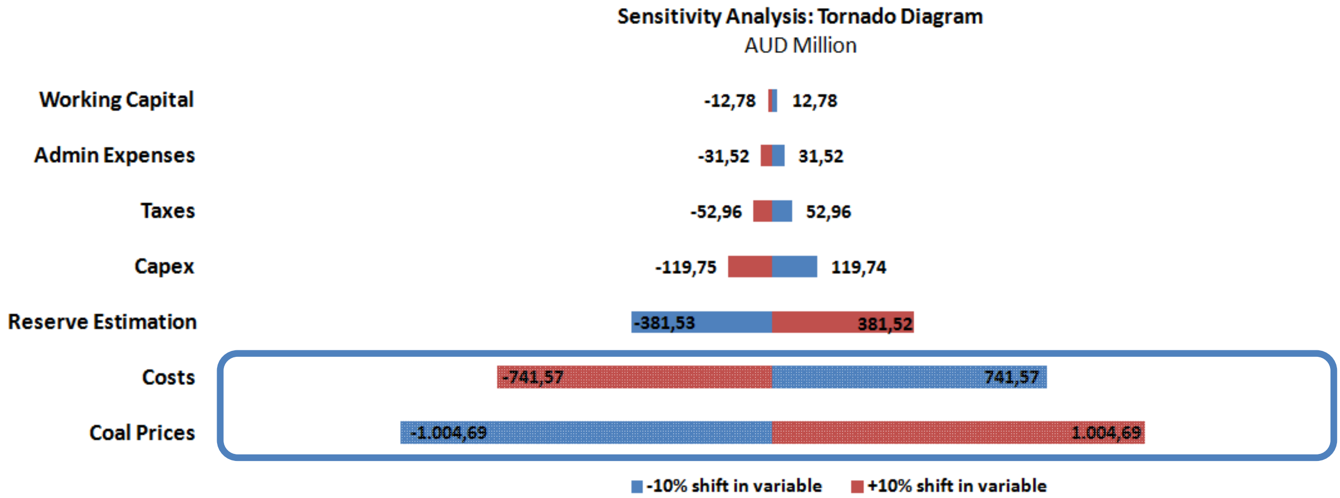
PV of production assets AUD Million	
PV 2HY 2012 - 2022	770,64
PV 2023 - 2042	765,52
PV of Middlemount, Donaldson & Gloucester	1.536,16

Figure 44: Gloucester PV of FCF from production assets

Please refer to the financial appendix for the presentation of the free cash flows.

6.9 Sensitivity analysis

In preparation for the real options model and also to demonstrate the sensitivity of the estimates used in the valuation of the production assets a sensitivity analysis was conducted. The main estimates were adjusted +/- 10% to show the effect upon valuation. The WACC was also adjusted, and a range of values is provided. In addition, the possible effect of a carbon tax is shown. However, the carbon tax policy, as per the delimitation is outside the valuation as the policy framework is still unclear of the exact impact and Gloucester has not provided any guidance as to the effect. As expected, the valuation is most sensitive to changes in coal prices, costs and estimated reserves. Coal prices are the most sensitive due to it being the largest headline figure in the valuation. i.e., changing coal prices by 10% has a greater effect than modifying the cost structure by 10% (due to the nominal values). However the likelihood of these fluctuations will be handled in the volatility section of the ROV. The results are presented below for the reader's point of reference.



Whilst all due care has been exercised in the Calculation of the WACC a range of estimates is presented below:

WACC				
7,63%	8,63%	9,63%	10,63%	11,63%
1.907,66	1.709,16	1.536,16	1.384,74	1.251,68

Figure 45: Results from sensitivity analysis

As discussed in the industry challenges, a carbon tax would have downward impact upon Gloucester's valuation. The exact extent of this impact depends on the degree of gassiness of the coal mines. IBIS world (2012) has placed a range of $1.80 to $7.40 per tonne. This results in an NPV estimate of $1,377m to $884m. As this represents such a large valuation range an additional search was conducted. Ben Willacy, Wood Mackenzie's[18] Australian coal supply lead analyst suggests that the introduction of the tax is likely to have a 4% affect on NPV (on average across the sector). Based on this estimate, it could lead to a reduction of $61.5m or similarly, an NPV of $1,475m.

7. Terminal Value

Traditionally corporations are valued on a going concern basis, that is, an estimated terminal value is provided based upon an expected growth rate of the final forecasted cash flow into infinity. For Gloucester, this would be inappropriate as the structure of the firm and operations will be heavily defined by the exploration success of the business. However, the company's longevity will be defined by its ability to create value from existing exploration licenses. The terminal value therefore, is based on an implied unit value on undeveloped exploration leases. These are assets, whereby coal has been identified. The economic viability however is less certain, whilst some high level mining plans are available for the Monash exploration lease a resource based multiple will be used to capture the entire Residual JORC resources across all exploration licenses.

7.1 Exploration Licenses

Gloucester holds several exploration licenses: three coal exploration licenses located in Gloucester basin (EA311, EA315, EL6904), four coal exploration licenses at Donaldson (EL5337, EL 5498, EL5497 & EL6964) and the Monash exploration asset (EL6123 & EL7579).

Thomas one banker was used to search for comparable exploration based companies, in order to compute an enterprise to resource valuation. Companies with an SIC industry code related to coal mining and listed in Australia were reviewed. Companies with a business description including 'exploration' were placed on a short list; this yielded ninety-seven results. As the aim was to gain an insight into the market price of undeveloped reserves, companies that were in a revenue producing state were excluded. This resulted in a reduction of twenty-nine companies (total sixty-eight). The business descriptions of the sixty-eight companies were then reviewed and separated into three categories: ones whom were not primarily resource

---

Note: Reserve estimation sensitivity is an approximation based upon changes in variable costs. Capital expenditure associated with an increase in the reserve body has not been factored in.

[18] Wood Mackenzie is one of the largest global energy consulting firms. For further information see http://www.woodmacresearch.com. To review the comments made by Ben Willacy see: http://www.bloomberg.com/news/2011-07-25/australian-coal-tax-may-cut-coal-industry-value-by-a-8-billion.html

driven, the second was companies with an interest in coal however were not pure coal play companies and lastly, companies whom focus solely on the exploration of coal leases. The latter provided nineteen commensurate firms. The websites and corporate presentations of the nineteen companies were reviewed to assess for JORC proved resources. Of the firms reviewed, seven did not have any proved resources and therefore were excluded from the comparison. The results from the twelve remaining firms are provided in appendix O. The companies provided a good cross-section of resource types and are quite similar to the coal type of Gloucester's indicated exploration leases. The average $/t of resource equated to 0.222.

Share price data for the twelve companies was sourced from datastream. The average $/t price was re-measured in the two preceding half-years. The average has declined substantially over the 12 months. In July 2011, the group had an average multiple of 0.487, then declining to 0.393 in January 2012 and is now at 0.222. However, a general decline was expected due to the recent softening in commodity prices and the broader economic slowdown. It is felt that the current stock prices most accurately reflect investor sentiment and therefore will be used as the basis for the terminal value. This equates to a total value of $313m

Mine	Residual JORC Resources Mt[19]	Coal Type	Resource Value $/t	Resource Value $M
Gloucester Basin	250	SHCC/T	0.222	55.5
Donaldson	580	SSCC/T	0.222	128.76
Monash	580	SSCC/T	0.222	128.76

Figure 46: JORC exploration reserves

Obviously, the estimate is subject to fluctuations in the multiple; this is inherent in valuation. Without the ability to work with a more detailed plan this method most appropriately fits the situation. However, individually selecting a group of closely comparable exploration companies aimed to overcome some of the pitfalls of multiples analysis.

8. Real Option Valuation

Option analysis, like valuation, is a subjective process. Some purists would argue that each option should be valued separately. However, information quality is always of key concern. Deriving a valuation from loosely constructed assumptions yields little value. This section therefore pays particular focus upon the options the company has over the entire operations, that is: to expand operating or stop mining. Due to volatility in coal prices and production costs, it is plausible to assume the company may face a situation where it wishes to either capitalise on the upside opportunities or stem its losses brought about by a downturn in coal prices or a potential cost blowout. Professor Aswath Damodaran suggests that, valuing an option on a group of mining projects may yield a lower value than the value of a portfolio of options, though the results still provide an

---

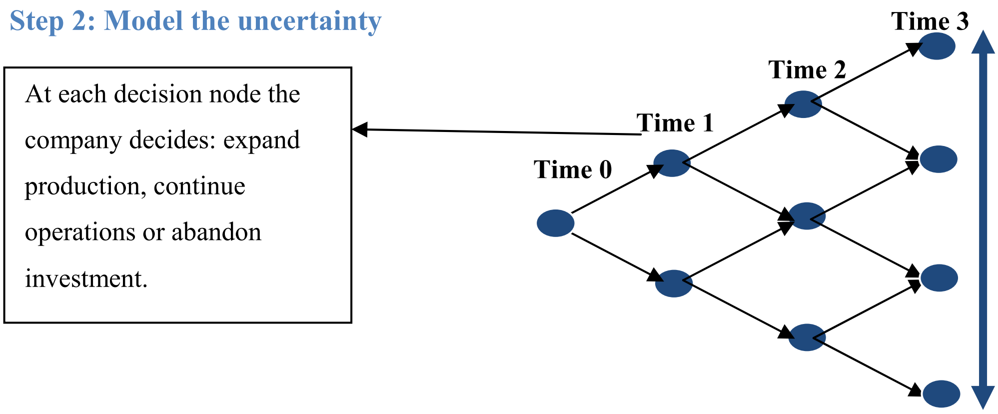
[19] Sourced from: (Gloucester Coal, 2012)

understanding of the determinants of the valuation of a natural resource firm[20]. This section utilizes the four step approach developed by Copeland & Antikarov (2003), as shown below:

8.1 Step 1: Compute base case PV without flexibility

The valuation computed for the producing mines in the preceding section will be used as the expected valuation and is in line with the method suggested by Copeland & Antikarov (2003) and Munn (Mun, 2006). The ability for management to react to uncertainty in proceeding periods will then be incorporated into the valuation. The base case valuation will be used as the UAV. The options will be modelled in yearly time steps, due to the sheer number of bifurcations. The base case valuation of the production assets (UAV) is $1,536 million.

8.2 Step 2: Model the uncertainty



As introduced in the theoretical framework, uncertainty is captured in the probability of the price paths (up state and down state). These are often referred to as risk-neutral probabilities, as the asset is priced on a risk neutral basis. The values can then be discounted over time at the risk free rate. It's assumed that the value of Gloucester Coal follows a Geometric Brownian Motion (GBM). This is essentially a random walk. This is justified by the fact that the valuation of the firm incorporates all information that was available and therefore valuation developments will be based upon unpredictable shocks (Brandão, Dyer, & Hahn, 2005). The formula used in the binomial tree is based upon work by Cox, Ross & Rubinstein (1979) whereby the probability of an up movement (increase in valuation) is defined as: $P = (r - d)/(u - d)$ and the probability of a down movement is equal to: $(1 - P)$. The value of r is equal to the risk-free rate. As we have assumed the price evolution of the firm follows a GBM the up movement (U) is defined as: $U = e^{\sigma\sqrt{(T)}}$. D

[20] These comments can be found in Professor Damoraran's real options notes. See: http://people.stern.nyu.edu/adamodar/pdfiles/eqnotes/packet3a.pdf

can be defined as: $1/d$. The up and down movement capture the fluctuation in the possible value of the firm over a time step.

From the above, it is quite clear that volatility is a prime driver of price development. The inherent weakness, as demonstrated by Willigers & Hansen (2008) is that the binomial model cannot handle mulit-dimensional uncertainty. However, the use of Monte Carlo simulation can overcome this through its ability to incorporate multi sources of uncertainty into one volatility estimate. For this reason, a Monte Carlo simulation was conducted in order to derive a volatility estimator. The steps behind this approach involve modelling the uncertain variables, calculating the degree of co-movement in the variables and then performing the simulation.

Whilst capital expenditure and mineable resources are significant points of uncertainty, it was determined that these estimates rely primarily on geological technical data, and based upon the sensitivity analysis it is clear that cost and pricing assumptions are the most sensitive estimates. Placing limitations on which volatility inputs to use is advocated by Copeland & Antikarov (2003), whom suggest not clouding the analysis with too many variables. The two main sources of uncertainty used in the calculation of volatility were coal prices and production costs. Coal prices were assessed utilising a time series statistics whereas production costs were estimated on a case orientated basis. Though, volatility estimation is fallible and therefore most papers provide a range of option values based on a sensitivity analysis of the volatility estimator (Davis, 1998).

Coal Prices

Australian export coal price data was sourced from the OECD, the maximum observations (126 quarterly data points/ 31.5 years of data) were used to analyse price volatility. The price observation were based upon Australian export prices and calculated as a mix of thermal and coking coal in line with the projected composition of Gloucester Coal's production. The average quarterly return was calculated and then the squared excess return over the period was reviewed. Five volatility estimates were calculated using historical equally weighted averages (15 years, 10 years and 5 years) and exponentially weighted averages (lambda of 0.94 and lambda of 0.909). The last observation was calculated by minimising the root mean squared error (RMSE):

$$RMSE = \sqrt{\frac{1}{T} \cdot \sum_{t=1}^{T} (r_t^2 - \hat{\sigma}_t^2)}$$

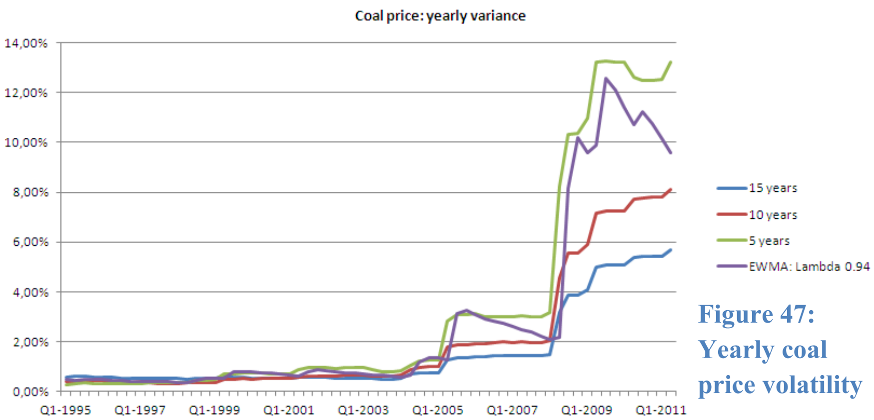


Figure 47: Yearly coal price volatility

The RMSE calculates the average distance between the predicted and realised volatility estimate. The 5 year observation generated the lowest RMSE due to an observed shift in volatility over the last seven years. It can be seen there was a clear increase in the volatility over the period, which is in line with comments made by the IEA (2011) suggesting that coal price volatility has increased since 2005. A report published by the Reserve Bank of Australia (Dwyer, Gardner, & Williams, 2011), provided commentary on recent announcements by the G-20 to address excessive commodity price volatility. The report sought to establish if recent increases in commodity derivatives had fuelled increased volatility, or whether the increase was being driven by fundamental factors. It was found that at this stage fundamental factors were the main driving force behind the increased volatility.

The five year equally weighted standard deviation equates to 35% per annum. This is quite higher than the long-term estimates calculated by Pindyck (1999) from 1870-1996 of around 9%. However, coal has had periods of significantly higher volatility. In the early 1970's the standard deviation of coal prices was 23%, and was more volatile than crude oil between 1950 – 1970 (Regnier, 2007).

Autocorrelation (Serial Correlation):

The coal price return data was analysed over a period of 5 and 10 years to assess for any autocorrelation. Autocorrelation refers the degree of correlation a variable has with itself. To test whether autocorrelation was statistically significant a Durbin Watson test was performed. The formula is as follows:

$$DW = \frac{\sum_{T=2}^{T}(\hat{\varepsilon}_t - \hat{\varepsilon}_{t-1})^2}{\sum_{T=1}^{T}(\hat{\varepsilon}_t)^2}$$

The results were calculated for 20 and 40 observations (5 and 10 years of quarterly observations) and compared to the DW critical values. Both estimations returned evidence of statistically significant positive autocorrelation (DW value of 0.87 and 0.89 respectively). According to Copeland & Antikarov (2003) the formula for autocorrelation, assuming the time series of the random variable is stationary, can be defined as:

$$Autocorrelation = \frac{Cov(X_t, X_{t+1})}{Var(X_t)}$$

The values returned: 0.54 and 0.536 (10 and 5 years respectively)

Mean Reversion

Commodity prices do exercise a degree of mean reversion; essentially this is a process whereby prices resort to a long-run average. Mean reversion therefore means the further out we look in time, the less volatility we would expect to see as volatility adjusts to a long-run average. The typical adjustment for mean reversion is:

$$\sigma_T = \sigma_t \sqrt{\sum_{t=2}^{T} [(1-a)^{T-t}]^2}$$

The process for incorporating mean reversion would involve estimating alpha and then building this into the Monte Carlo simulation. However, as pointed out by Pindyck (1999), the use of the GBM assumption may be permissible due to the long reversion period. However, as a reasonableness check, the long-run historical coal price volatility estimate will be discussed in the forthcoming Monte Carlo simulation.

Operating Costs:

A report compiled by independent mining consultant, Behre Dolbear (Gloucester Coal, 2012), indicated that production cost estimates are accurate within a +10/-10% range. This will be the vales used in the consolidated volatility estimation due to the high degree of technical knowledge behind the cost estimate. These estimates will be treated as a best and worst case scenario for each period. The results will be tested assuming a triangulated distribution with the upper and lower estimates forming the periphery. Whilst management estimations are always subjective, the use of an independent report aims to alleviate this concern.

Correlation between variables:

A search of academic literature was conducted however no tangible results were derived. Natural logic would suggest some degree of positive correlation between mining costs and coal prices. To test this relationship the Australian Bureau of Statistics coal mining materials index was compared to both thermal and coking coal export prices. Quarterly prices from September 1987 to June 2011 were used (maximum dataset). The open cut index was used over that of the underground index as a majority of Gloucester's product is derived from open cut mines. A correlation of 0.38 and 0.33 was generated between costs and that of coking and thermal coal. A median estimate will be used in the Monte Carlo simulation.

Monte Carlo Simulation

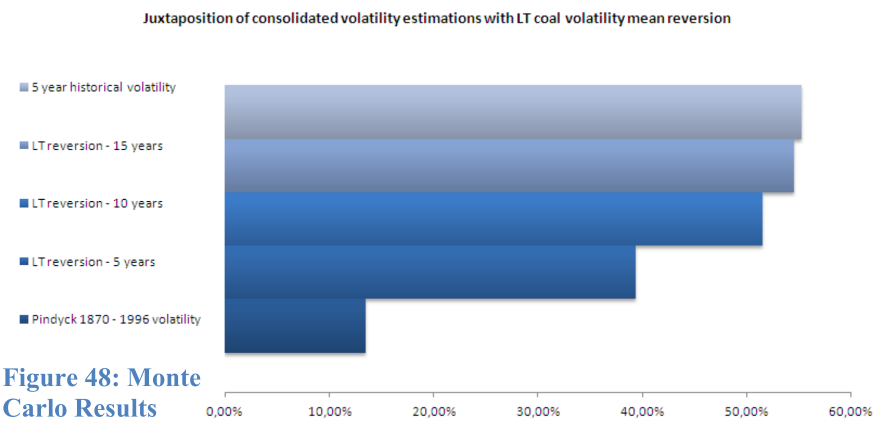


Figure 48: Monte Carlo Results

A Monte Carlo simulation was performed, utilising the above information. The standard deviation (sigma) generated was 55.29%. This was initially thought to be quite high. For this reason, and to see the effect of coal price volatility on the estimate, it was decided to factor in different scenarios. Pindyck's estimation of sigma from 1870-1996 of approximately 9% was used (Pindyck, 1999) and phased in at different periods. To test the effect this has on the volatility estimator, the cut-in time of the 1870-1996 long-term historical volatility estimator was incorporated at three different stages, a kick in: immediately, 5 years, 10 years and after 15 years. The range in volatility is shown above.

Firstly, it is quite obvious to see that the more recent, short-term volatility estimator generates a substantially higher sigma. Though what's interesting to see is that the volatility estimator only changes a small degree if volatility reverts back to longer-term averages over a 10 to 15 year period. However, the assumption of reversion to pre-1996 levels cannot be predicted. According to Credit Suisse, increased commodity volatility is indicative of a longer-term shift[21]. For that reason, the base case will be the estimated result of 55.29%.

8.3 Step 3: Identify and incorporate managerial flexibilities

In each period Gloucester is faced with a multitude of decisions, however the biggest operating decision the company can face is whether to expand the operations or deciding to close the mining operations if cost and or commodity prices decline. Whilst, process optimisation (quantity adjustments and or temporary closure) is an option available to Gloucester this is outside the scope of the paper as it requires a different modelling approach. For an understanding of this see Shafiee, Topal, & Nehring (2009). This section will elaborate upon the expansion and abandonment option that Gloucester Coal has over their operations.

1) Expansion

As explained in the Production section of the paper, coal must be processed and transported to port before being shipped to the end customer. In order to assess Gloucester's ability to expand production, given favourable conditions, an assessment of current contracted capacity was undertaken. The information has

[21] Full article available at: https://www.credit-suisse.com/us/asset_management/doc/commodities_and_volatility_white_paper_2011.pdf

been summarised from a shareholder report released on 30th April, 2012[22] and is available in appendix P. The analysis is broken down by mine site and categorised by process: coal handling and preparation plant capacity, rail entitlements and port capacity. Mining capacity was not included below as the investment decision to increase or decrease mine site production is internalised, namely, it does not rely on third party investment or supply agreements. The data will be used as a barometer to assess Gloucester's current utilisation of existing agreements or the need to enter into additional arrangements.

As highlighted in the industry overview, vessel waiting times brought about by port capacity constraints have been an inhibitor to further expansion. When assessing the ability to expand, port capacity is a key concern going forward. The data from above has been combined with the expected production profile of each mine sites.

		Gloucester Basin NSW	Donaldson NSW	Middlemount (100% basis) QLD
Production profile	Peak ROM (pre-processing	5,10	8,90	5,70
	Peak Saleable production	4,00	6,20	4,90
Known capacity	1) Processing ROM CHPP	5,30	8,00	6,13
	2) Rail agreements	3,40	5,00	6,00
	3) Port Capacity	3,5	10,2	4,00

Figure 49: Coal production capacity analysis

The group has total projected port capacity of 17.7mtpa with excess capacity in NSW (capacity in NSW and QLD is not transferable due to geographical distance). Based on the provided data, the company has 3.5mtpa of available port capacity in NSW; this will form the basis of the expansion option. To assess the cost of expansion a list of Australian wide coal projects was obtained from the Australian Mines Atlas site[23]. The list contained high level information on 28 documented mine development or expansion projects. The list was somewhat incomplete which meant that some data needed to be inputted from other sources i.e., company websites & business publications. There were seven documented expansion projects, five of these projects provided useful information in relation to expected expansionary capital expenditure. The average cost of expansion per million tonnes was $47m (with a range of 36m to 63m). This was cross checked with information obtained from the International Energy Agency (2011) that suggested capital expenditure per million tonnes for an open cut mine equated to $90m. However, it is presumed this figure includes investments in new mines. The average capital expenditure for the 7 documented new projects in Australia was $142m per million tonnes. Therefore the figure of $47m ($165m for 3.5mtpa) will be used as the cost of expansion. The variable costs will be in line with the current cost estimates. In addition, based on historical

[22] The report is available at http://www.gloucestercoal.com.au/investor_media/asx_announcements/

[23] http://www.australianminesatlas.gov.au/

information, a two year time to build period was factored in to reflect the point when the decision is made and when actual production uplift occurs.

2) Abandonment

The option to abandon operations carries significant value. Colwell, Henker and Ho (2003) studied the value of abandonment options on 27 Australian gold mining companies. They found that the value to abandon operations to be statistically significant. That being said, they found the option carries a large fluctuation between operations. They postulate that if the value of the firm becomes too low, then the company can exit its investment for the salvage value. The cost of abandonment and expected payoff is discussed below.

The company provides for the estimated closure of mine sites, the information was sourced from Gloucester's financial statements. According to note 3(Q) the estimated rehabilitation cost is estimated at face value and a series of undiscounted bonds are lodged with the Department of Resources and Energy. Therefore the cost of rehabilitation is recognised on the financials in totality. The dismantling charge is assessed by Gloucester and a discounted provision is recognised in the company accounts. The discount was assessed based on the 2011 unwinding charge (the unwinding charge is treated as interest and in effect each year the provision is marked up until realised on decommissioning of the mine site). On average, the mines are expected to be mined for just under 30 years. The discount on the estimated dismantling provision was calculated at 8%. The total estimated closure cost for the three mines is approximately \$79m. It is assumed that these costs are approximately equally shared and therefore the strike price of the abandonment option is estimated at \$26.3m per mine.

Take or pay contracts:

In order to guarantee infrastructure access both Donaldson & Middlemount entered into take or pay agreements for rail and port access. The purpose of take or pay contracts is to safeguard supply chain capacity for the upstream miner and to ensure the infrastructure provider will earn an adequate return on the initial capital investment in providing port or rail infrastructure. Essentially these agreements mean that access to infrastructure must be paid for even if it is not utilised. Donaldson's total commitment is \$470.5m and covers a contractual period of 10 years. Middlemount has entered into a 15 year take or pay contract with a committed value of \$455.7m. This commitment must be taken into account when calculating the strike price of the abandonment and temporary closure call option. The strike price will therefore decline for Donaldson & Middlemount over 10 and 15 years by \$47.05m and \$30.38m respectively.

As an example: If Gloucester was to close the Donaldson mine in five years time it would incur a charge of $26.3 million for dismantling and rehabilitation and the five years remaining take or pay commitment of $235.25m. As a result, the put option available to Gloucester coal will have a declining strike price.

The assets of the business were reviewed in order to determine an appropriate payoff from exercising the option. It was presumed that intangible assets would be unrecoverable as these investments are mine specific and are a reflection of costs incurred to develop the mine. In addition, the port allocation asset would also be given a value weighting equal to zero. The value of Property Plant & Equipment by far is the driver of the options payoff. Williamson (1988) postulates that the liquidation value of an asset is defined by its redeployability. Vishny and Shleifer (1992) augment this by putting forward a market equilibrium approach to liquidation value. Essentially they argue that in times of economic distress the most likely buyer of a firm's asset will be another firm within that industry. Though in most circumstances, the other firms is most likely also affected by the industry- or economy-wide shock that has led to the seller disposing of their assets.

Whilst Gloucester coal operates within the coal industry it is fair to suggest that the assets of the open pit mine may be redeployed into other parts of the mining sector, therefore slightly reducing the asset specificity. This being said, the mining industry as a whole is arguably tied to macro-economic variables. Therefore the resale value on mining equipment will be heavily correlated to economic conditions. Furthermore, Aldersona & Betker (1995) found that firms with higher liquidation discounts tend to have lower levels of debt. As evident by the capital structure section of the thesis, it is clear that the mining sector generally has lower gearing ratios than other sectors, such as the airline industry. Their study of 88 US companies found a median liquidation cost of 34.7% of asset value. Firms with liquidation values in the top quartile had a median recovery rate of approximately 38% (loss of 62%) and a debt to asset ratio of 0.347. Therefore assuming that intangible assets are unable to be sold, recovering working capital at full, and receiving 60% of the net book value on tangible PP&E leads to an average recovery rate of 38%. This will be the assumed abandonment cash flow used in the real options valuation.

8.4 Step 4: Conduct Real Options Analysis

The ROV has been setup in time steps (discrete time intervals) of one year. As the analysis is being conducted over a period of approximately 30 years, shorter time intervals would lead to a cumbersome binomial lattice. Utilising the volatility figure a binomial asset tree was produced. Two trees were calculated to take into account the drop in asset value caused by the cash flow generated in each respective period. As the mining assets have a finite life cash flow in effect represent the erosion of the asset value (i.e., exhaustion of the mine).

At the end of each period the asset value will be reduced by the portion of the current period's cash flow to the remaining value. This is in line with examples provided by Copeland and Antikarov (2003) and shown below:

$$PV_{ex.cash\ flow} = \left(1 - \frac{CF_{current\ period}}{\sum Remaining\ Cash\ Flows}\right) \cdot PV_{before\ end\ of\ period\ cash\ flow}$$

This inherently assumes that the reduction in the value of the mining assets is proportional to the value realised in the respective period. The resulting asset price development over the mining project is shown in Appendix C. The stochastic process is calculated as follows:

1) The PV of the asset in the next period is calculated by multiplying the current period's asset value (after cash flow) by the up and down figure.
2) To find the PV after periodic cash flow (asset erosion value) the formula as listed above is applied to the result obtained in step 1.
3) This process is repeated throughout the tree up until 2042.

Abandonment option:

The appropriate liquidation discount was applied as it was assumed that if the option was exercised, it was likely as a result of an industry wide downturn and likely firm-specific financial distress, therefore requiring the need to reflect this in the ability for the company to sell the mining assets. The contract liability arising from rail and port commitments was also calculated in each period. In addition, if the mines were abandoned early then the associated difference in the early rehabilitation and dismantlement was included. This is effectively the difference caused by the provision being smaller than the actual cost due to the liability coming to fruition earlier than forecast. However, this being said there may be small differences in the calculation due to inflation assumptions not being adjusted for (the value however is quite small). The results are presented in appendix C.

Expansion option:

Capacity was reviewed over the expansion period. Based upon Gloucester & Donaldson's expected reserves, the last year in which the option could be exercised is in 2035. The cash flow generated by expansion was calculated based on the value contribution of the Gloucester and Donaldson mine. As the NSW based mines generate a lower margin, due to cheaper varieties of coal, utilising a simple average FCF per million tonnes of total company wide production (including Middlemount) would not give an accurate measure. Therefore in each year of production, the additional uplift in production was adjusted for differences in the margin between the mines. Furthermore, temporal adjustments were made to the strike price to reflect capacity adjustments[24]. This means that not every decision node required 3.5mtpa of CHPP expansion as the company had unutilised capacity in later periods due to their current expansion plans; therefore a refurbishment allowance was provided for. The UAV with flexibility is modelled in appendix C.

Combined Option Value

In order to get an accurate option valuation, the options must be combined. This is due to the principle of non-additivity. Lenos Trigeorgis, found that the incremental value in isolation, declines as more options are added to the valuation. This has two implications. Firstly, it suggests that the options should be combined when analysing the additional value uplift and secondly, "*neglecting a particular option while including others may not necessarily cause significant valuation errors.*" (Trigeorgis, 1993, p. 2).The reason why the options need to be added to the same underlying tree is due to the fact that at each decision node, Gloucester can choose to expand, keep either option alive or abandon. The company cannot decide to exercise both options simultaneously – they're mutually exclusive.

Furthermore, to ensure that there was no double counting of cash flows, due to the interaction between the options, the expansion option assumed that any cash flow associated with planned asset sales due to the scheduled closure of the mines, occurred at the same time as the original DCF. While this might be debatable, the reason for the choice is not, if this was not done then there was a chance that the payoff would be artificially inflated. For instance there could be a situation where the model derives value from expanding the operations, receiving a cash flow associated from early asset sales, and then the option to abandon being exercised several years later. This process would double count cash flow from asset sales. A possible method to incorporate early closure of mines and the interaction of the abandonment options would be to utilise a varying payoff depending on the asset value path. Though this would become quite complex quite quickly.

The combined lattice tree is provided in appendix C. The utilisation of a ROV framework led to an increased value of $288m. This corresponds to a value uplift of 14% on that of enterprise value.

Sensitivity Analysis

The combined option portfolio was subjected to sensitivity analysis in order to determine the most important variables driving the valuation. The volatility estimate, risk free rate, recoverability rate of asset abandonment and the estimated cost of expansion were adjusted. The values were adjusted by a factor ranging from -40% of the base case estimate to +40% of the base case estimate. The results are presented below:

---

[24] Note: FCF includes capital expenditure; therefore only the initial expansionary expenditure has been recognised. Periodic cash flows inherently allow for asset replacement costs.

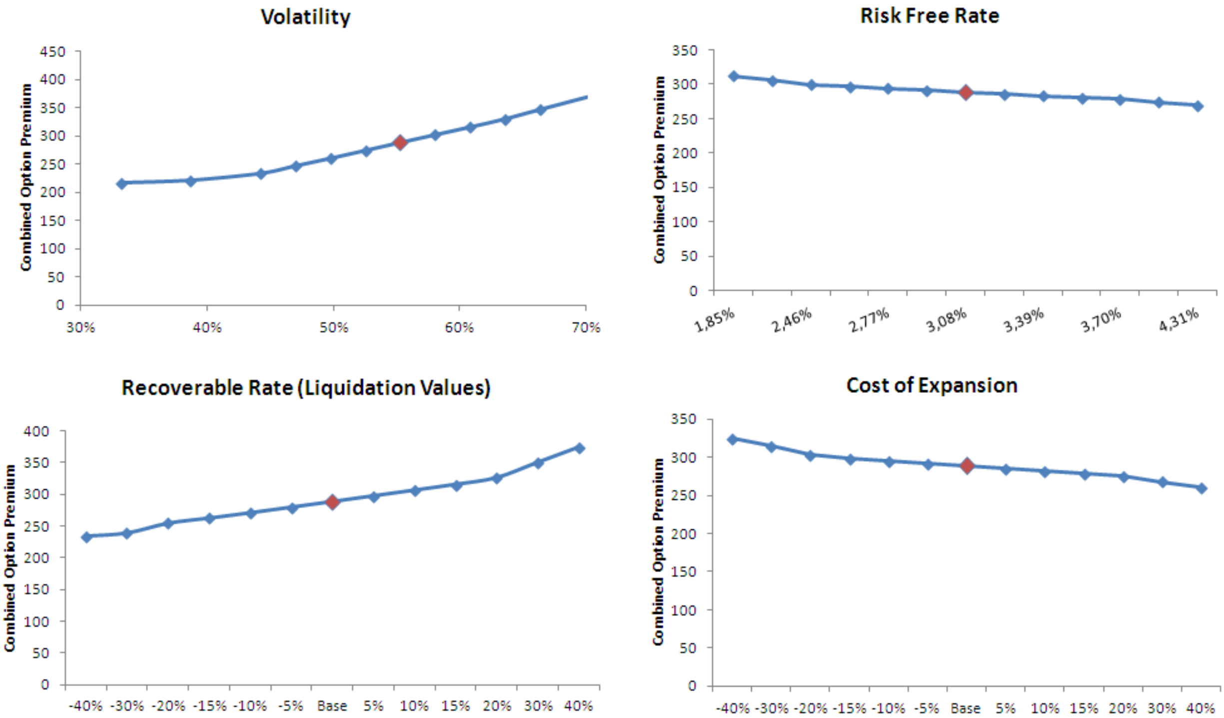


Figure 50: ROV sensitivity analysis

The red diamond highlights the base case scenario. The risk free rate appears to have the least effect, increasing in gradient at the extremities. This is most likely as a result of the conflicting movement in put and call option values in response to a change in the risk free rate. Volatility appears to have the greatest impact upon the valuation. The value begins to level out at lower points in the volatility estimate, this is due to the payoff of expansion becoming much more certain, and more likely to be executed. The cost of expansion and the recoverable rate of asset sales, move in line with expectations.

9. Recapitulation and Valuation

The valuation has been provided in three parts, a static DCF, a terminal value driven by the nine exploration leases the group holds, and the options valuation which derives its value from future uncertainty and the ability management has to actively respond to new information. To provide an indicative valuation the sum of parts combined, yield a total enterprise value of $2.2bn. As the valuation is based upon the operating assets of the business, non-operating assets must be added to the valuation. The equity value is ascertained by subtracting net debt and debt equivalents. This yielded an equity value of $1.626 billion. According to the HY2012 Annual report, Gloucester Coal had approximately 203m shares outstanding. This results in a valuation per share of $8.02. Based upon the discussion and results presented in chapters 4-8 the valuation results have been tabulated and presented below:

Valuation Summary $AUD		
	Value	Reference
Static DCF Valuation	1.536.157.827,38	Chapter 6
Exploration leases	313.000.000,00	Chapter 7
Abandonment & Expansion Option	288.304.149,14	Chapter 8
Non-Operating Assets	212.287.000,00	Chapter 5
Enterprise Valuation	**2.349.748.976,52**	
Net Debt and Debt Equivalents	-723.017.041,21	Chapter 5
Equity Valuation	**1.626.731.935,31**	
Shares Outstanding	202.905.967,00	2012 HY FS
Valuation per share	**8,02**	

Figure 51: Valuation Results

In line with the approach established in the introduction of the thesis, the value has been provided in several parts, namely: a traditional DCF model assuming no flexibility, a valuation of the exploration based activities of Gloucester Coal, and lastly, the modelling of strategic flexibility through the pricing of an expansion and abandonment option. Combining the results obtained in the aforementioned sections resulted in a valuation of $8.02 per share. The most recent trading data (1st May 2012 to 15th June 2012) shows that the stock has ranged between $6.82 and $7.78. Therefore the fair value represents a premium of approximately 9.9% on the middle of the range. The valuation is lower than the stocks historical highs, recorded in late 2010 and 2011, when Gloucester was subject to a cash share offer by the largest shareholder[25].

9.1 Analyst Valuations

The target price was compared against analyst reports provided by three banks: Macquarie, RBC Capital Markets and Morgan Stanley. Surprisingly, despite employing a different valuation approach, the results lined up with analyst reports. The paper provides strong justification for a fair value of $8.02 per share. The results have been compared to the analyst reports and are presented in the table below.

	Valuation			
Bank	Macquarie Bank	RBC Capital Markets	Morgan Stanley	Results
Date	14-06-2012	01-05-2012	18-04-2012	30-06-2012
Method	DCF	DCF with 10% premium to valuation	DCF	DCF/ROV/Multiples
Target Price	7,8	$8 ($7.27 without premium)	8,1	8,02
Note:	All mines valued on DCF basis. No mention of terminal value methodology.	$50m for Monash no mention of other exploration. Middlemount Royalty treated as non-operating	Value of $100m provided for exploration assets	Mining assets and exploration assets valued seperately
WACC	10%	8% (approx 10.5% nominal)	10.5%	9,6%

Figure 52: Comparison of results with brokerage reports

Analyst reports sourced from Macquarie Bank, RBC Capital Markets & Morgan Stanley

[25] Refer to Appendix E for historical share price and Appendix F for an historical overview.

9.2 Insights from analyst reports

Throughout the process it was quite interesting to see that the analysts covering the stock often used vastly different assumptions amongst one another though generally had target prices that were quite similar. Four main insights into the valuation reports covering the stock were gained. The reports often applied a discount or premium to the DCF value to reach a target price with very little technical information as to how the percentage was established. Secondly, it was interesting to see that the treatment of exploration based activities deviated amongst all of the analysts. Some firms assigned a valuation to exploration leases, others did not provide for it and one listed a valuation for Monash which was below the net book value of the asset, which is already measured in each period for impairment. Thirdly, calculation of terminal value or the assumption as to how many periods the model provided for was rarely alluded to. Lastly, it was interesting to see a wide range of capital expenditure assumptions. This was surprising even though the company released five years of capital expenditure information. Of course, there is a degree of subjectivity and therefore a range is warranted though it was interesting to see some of the nominal deviations from the capital budget supplied by the company. However, this being said, the reports provide a useful high level insight that can be used as a basis for further investigation.

Part III – Conclusion

10. Contributions

The paper has showcased a comprehensive valuation model, which in turn demonstrated the complementary nature of DCF and ROV (expanded NPV). This highlighted that there is value in uncertainty and flexibility that the traditional static DCF model is unable to capture. The model is computationally heavy and time consuming; requiring the need to still perform a comprehensive DCF valuation to ascertain the UAV. However, identifying and correctly assessing value is the main objective. The valuation model provided the ability to unlock strategic options available to management. This provided maximum impact when dealing with uncertainty and flexibility. The aim of the paper was to provide a pragmatic approach, transcending the realm of pure academia. The model presented, alleviates the myopic 'set and forget' presumption of DCF by uncovering and correctly valuing the strategic options an organisation face. The paper highlights the importance of understanding the link between strategy and finance and demonstrates the dilemma highlighted by Myers (1984) of two cultures addressing the same problem. The discussion between strategy and financial implication is an important one, even more so in an era shaped by tumultuously dynamic operating environments.

The ROV sensitivity analysis highlighted that estimating volatility is paramount. This can be quite a complicated process and the choices/assumptions made have a fundamental effect upon the valuation of the options. Volatility estimation is not an easy process. This paper demonstrated the application of statistical tools to recognise the best measurement period of historical data, that prior period volatility has an effect on the current period (autocorrelation), identified multiple sources of uncertainty and lastly employed a method to combine these uncertainties.

The benefit of this paper is it demonstrates how to incorporate ROV into a DCF model, providing a valuation on a companywide level. Often ROV is only used in the capital budgeting domain. However, this paper was able to demonstrate how it could be applied from a companywide approach. The benefit of this is it allows external stakeholders to review the ability management has to influence value, and perhaps assess their ability to add value. Wherefore it can be used as a critical tool to assess management's performance at harnessing the options identified. Utilising this tool provides a better understanding of the trigger points in a company valuation where active management should be employed.

10.1 Limitations

Performing the valuation utilising this framework yielded a strategic insight into the options available to the company. However, from an external investors perspective, this becomes quite complex when faced with issues such as information asymmetry. Access to content is critical; a better informed investor can always provide a more accurate valuation. This however is the case with all models and types of valuations. The natural limitation of this method involved a balance between computational complexity and the ability to discover the most pertinent options available to a company. However a natural balance between usefulness of results and computational complexity is going to, for the immediate future, continue to exist. The model was applied on a group basis in line with comments and methods suggested by Professor Aswath Damodaran[26]. The inherent limitation is that the options applied relate to group level activities, the more detailed the model becomes the greater bundle of options that can be modelled, with a focus on honing in on project specific options. However there is a fine balance between unlocking value and the time spent discovering it. Although the methods employed were specifically focused upon reviewing the most pertinent options available to Gloucester. In addition, as suggested in the scope of the case study the model utilised throughout the paper took the assumption that Gloucester Coal would realise the expected amount of economically recoverable reserves. Whilst technical uncertainty was delimited due to the need for mining specific technical knowledge, further modelling around this would yield greater investment outcomes. That being said, the degree of relatedness between technical uncertainty and other sources of uncertainty may be questionable. This therefore may lead to the adaptation of the model to a quadrinomial lattice framework. However, the fundamentals of the lattice model approach are similar.

10.2 Conclusion and future research

The paper sought to provide a pragmatic valuation through the application of an expanded net present value framework to Gloucester Coal. This commenced with an understanding of fundamental valuation models and their ability to capture uncertainty and flexibility. A comprehensive literature review and technical understanding of ROV was provided (and further supplemented in Appendix H).

The valuation of Gloucester coal was performed in three steps. Firstly, a fundamental DCF analysis was conducted, resulting in a valuation based upon no flexibility, with the mine recovering all economically recoverable coal. This involved a strategic discussion of the global industry, an understanding of the Australian market and also a strategic review of Gloucester coal. Consulting based reports, global public energy bodies, national statistical agencies and investment banking reports were used to identify expected coal prices and also mine cost drivers. A global review of coal mining capital structure, investigation into market equity premiums, an historical review and established methodology of the beta calculation was discussed, and a synthetic debt rating was performed to establish an acceptable cost of capital. Secondly, a terminal valuation calculation was performed by reviewing all Australian based mineral companies. A list of companies was sorted to identify pure coal exploration companies. Once a list was established, a review of

---

[26] See comments at http://people.stern.nyu.edu/adamodar/pdfiles/eqnotes/packet3a.pdf

company based information was performed to identify, if applicable, the amount of JORC resources the firm held. This involved reviewing company based literature and financial reports. A multiple was then applied to Gloucester Coal's exploration based reserves. Finally, a ROV framework was introduced to model the company's ability to influence the value of the producing mines. This resulted in a 14% in enterprise value. The ROV was performed utilising the four-step framework. This essentially involved highlighting the options available, modelling the uncertainty, investigating the parameters of the ROV model, and pricing the mines with flexibility incorporated.

Whilst this was outside the paper's scope, further investigation into switching options and also production optimisation would yield greater information as to the company's ability to time the extraction of resources and the value derived from storing coal for sale in a later period. Though compiling this based on external information may prove to be a challenge. Authors such as Brennan & Schwartz (1985) and Hodges (2004) provide interesting insights to this process. On the other hand, methods that better harness the interaction between DCF and options based approaches are likely to receive attention from the outside investment community. Mathews, Datar and Johnson (2007) provide interesting insights into a new approach (The DM method) that involves utilising the standard DCF method and triangulating scenario based analysis, which provides results equivalent to the Black-Scholes formula. This model shows some promise as it provides an easy transition into ROV.

Flexibility almost certainly carries value. As shown in the theoretical framework when uncertainty is high the ability to change plans; circumnavigating negative outcomes and capitalising in positive periods will always lead to greater value. However, measuring this and acting upon it are two mutually exclusive events. Whilst the valuation demonstrates options available to Gloucester coal, the value is only appropriate if management correctly address, plan and act in accordance with a changing environment. Management, like all humans are susceptible to fallibility. Ensuring that management is equipped to identify the correct period for execution of flexibility is paramount. Investigating the historical performance of management to changes in the operating environment may yield some interesting insights.

Bibliography

ABARES. (2010). *Australian commodity statistics 2010.* Canberra, ACT: ABARES.

ABARES. (2011, January 11). *Australian Mineral Statistics*. Retrieved August 19, 2012, from Department of Agriculture, Fisheries & Forestry: http://www.daff.gov.au/abares/publications_remote_content/publication_series/australian_mineral_statistics

ABARES. (2011). *Energy in Australia 2011.* Canberra, ACT: ABARE.

Adner, R., & Levinthal, D. A. (2004). What is Not a Real Option: Considering Boundaries for the Application of Real Options to Business Strategy. *The Academy of Management Review* , Vol 29.1: 75-85.

Aldersona, M. J., & Betker, B. L. (1995). Liquidation costs and capital structure. *Journal of Financial Economics* , Vol 39.1: 45-69.

Alford, A. W. (1992). The Effect of the Set of Comparable Firms on the Accuracy of the Price-Earnings Valuation Method. *Journal of Accounting Research* , Vol 30.1: 94-108.

AME Group Pty Limited. (2012a). *Export Metallurgical Coal 2012 Q1.* Sydney, NSW: AME Group Pty Ltd.

AME Group Pty Limited. (2012b). *Export Thermal Coal 2012 Q1.* Sydney, Australia: AME Group Pty Limited.

AME Group Pty Limited. (2012c). *Metallurgical Coal 2011: Mine Costs 2006-2027.* Sydney, NSW: AME Group Pty Limited.

AME Group Pty Limited. (2012d). *Thermal Coal 2012: Mine Costs 2006-2027.* Sydney, NSW: AME Group Pty Limited.

Amran, M., & Kulatilaka, N. (1999). *Real options: managing strategic investments in an uncertain world.* Boston, MA: Harvard Business School Press.

Arnold, T., & Schockley, R. L. (2010). Real Options Analysis and the Assumptions of Corporate Finance: A Non-Technical Review. *Multinational Finance Journal* , Vol 14.1/2: 29-71.

Asquith, P., Mikhail, M. B., & Au, A. S. (2005). Information content of equity analyst reports. *Journal of Financial Economics* , 245-282.

Behrmann, E. (2011, May 16). *Bloomberg News*. Retrieved March 15, 2012, from Bloomber L.P: http://www.bloomberg.com/news/2011-05-16/gloucester-coal-agrees-to-buy-donaldson-for-a-585-million-1-.html

Black, F., Jensen, M., & Scholes, M. (1972). *"The Capital Asset Pricing Model: Some Empirical Tests" Studies in Theory of Capital Markets, ed. M. Jensen.* New York: Praeger.

Block, S. (2007). Are "Real Options" actually used in the real world? *The Engineering Economist* , Vol 52.3: 255-267.

Block, S. B. (1999). A study of financial analysts: practice and theory. *Financial Analyst Journal* , Vol 55.4: 86-95.

Blume, M. E. (1975). Betas and Their Regression Tendencies. *The Journal of Finance* , Vol 5.3: 785-795.

Blume, M. E. (1971). On the Assessment of Risk. *The Journal of Finance* , Vol 26. 1: 1-10.

Blume, M. E. (1974). Unbiased estimator of Long Run Expected Rates of Return. *Journal of the American Statistical Association* , Vol 69. 634-638.

BP. (2012, January). *BP energy outlook 2030.* Retrieved March 14, 2012, from BP: www.bp.com/energyoutlook2030

BP. (2010). *BP Statistical Review of World Energy June 2010.* London, UK: BP p.l.c.

BP. (2011). *BP Statistical Review of World Energy June 2011.* London, UK: BP p.l.c.

Bradshaw, M. (2002). The use of target prices to justify analyst 'stock recommendations'. *Accounting Horizons* , 27-41.

Brailsford, T., Handley, J. C., & Maheswaran, K. (2012). The historical equity risk premium in Australia: post-GFC and 128 years of data. *Accounting and Finance* , Vol 52.1: 237-247.

Brandão, L. E., Dyer, J. S., & Hahn, W. J. (2005). Using Binomial Decision Trees to Solve Real-Option Valuation Problems. *Decision Analysis* , Vol 5.2: 69-88.

Brealey, R. A., Myers, S. C., & Allen, F. (2008). *Principlies of Corporate Finance, 9th ed.* New York, NY: McGraw-Hill.

Brennan, M. J., & Schwartz, E. S. (1985). Evaluating Natural Resource Investments. *The Journal of Business* , Vol 58.2: 135-157.

Christie, V., Mitchell, B., Orsmond, D., & Van Zyl, M. (2011 йил March). The Iron Ore, Coal and Gas Sectors. *Bulletin, March Quarter 2011* , pp. 1-8.

Colwell, D., Henker, T., & Ho, J. (2003). Real Options Valuation of Australian Gold Mines and Mining Companies. *Journal of Alternative Investments* , Vol 6.1: 23-38.

Copeland, T. E., & Keenan, P. T. (1998). Making real options real. *The McKinsey Quarterly* , #3: 128-141.

Copeland, T., & Antikarov, V. (2003). *Real options: A practitioner's guide.* New York: Texere.

Copeland, T., & Tufano, P. (2004). A Real-World Way to Manage Real Options. *Harvard Business Review* , Vol:82.3: 90-102.

Cornell, B. (1999). *The Equity Risk Premium.* New York: John Wiley & Sons.

Cox, J. C., Ross, S. A., & Rubinstein, M. (1979). Option Pricing: A simplified approach. *Journal of Financial Economics* , Vol 7.3: 229-263.

CRIRSCO. (2006, July). *CRIRSCO International Reporting Template for Exploration Results, Mineral Resources and Mineral Reserves*. Retrieved May 20, 2012, from Committee for Mineral Reserves International Reporting Standards: http://www.crirsco.com/template.asp

Damodaran, A. (1996). *Investment valution, tools and techniques for determining the value of any asset.* New York: John Wiley & Sons.

Damodaran, A. (2012). *Investment valution, tools and techniques for determining the value of any asset, 3rd ed.* Hoboken, New Jersey: Wiley & Sons Inc.

Damodaran, A. (2010). *The dark side of valuation: valuing young, distressed and complex businesses, 2nd ed.* Upper Saddle River, NJ: Pearson Education.
Damodaran, A. (2005). Valuation approaches and metrics: A survey of the theory and evidence. *Foundations and Trends in Finance* , Vol 1.8: 693-784.
Damodaran, A. (2012, January). *Working Capital Ratios by Sector*. Retrieved May 23, 2012, from Damodaran Online: http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/wcdata.html
Davis, G. A. (1998). Estimating volatility and dividend yield when valuing realoptions to invest or abandon. *The Quarterly Review of Economics and Finance* , Vol 38.3: 725-754.
Davis, G. A. (1996). Option Premiums in Mineral Asset Pricing. *Land Economics* , Vol 72.2: 167-186.
DeJong, D. V., & Collins, D. W. (1985). Explanations for the Instability of Equity Beta: Risk-Free Rate Changes and Leverage Effects. *The Journal of Financial and Quantitative Analysis* , Vol 20.1: 73-94.
Dimson, E., Marsh, P., & Staunton, M. (2003). Global Evidence on the Equity Risk Premium. *Journal of Applied Corporate Finance* , Vol 15.4: 27-38.
Dimson, E., Marsh, P., & Staunton, M. (2002). *Triumph of the Optimists: 101 years of Global Investment Returns.* Princeton, NJ: Princeton University Press.
Dwyer, A., Gardner, G., & Williams, T. (2011). *Global Commodity Markets – Price Volatility and Financialisation.* Canberra, ACT: Reserve Bank of Australia.
Economist, T. (2011). *Burning ambitions.* London: The Economist Newspaper Limited.
Elton, E. J., Gruber, M. J., Brown, S. J., & Goetzmann, W. N. (2003). *Modern Portfolio Theory and Investment Analysis, 6th Ed.* New York, NY: John Wiley & Sons.
Faff, R. W., Hillier, D., & Hillier, J. (2003). Time Varying Beta Risk: An Analysis of Alternative Modelling Techniques. *The Journal of Business Finance & Accounting* , Vol 27.5-6: 523-554.
Fama, E., & French, K. (1992). The cross-section of expected stock returns. *The Journal of Finance* , Vol 47.2: 427-465.
Fernandez, P., & Bilan, A. (2007). *110 Common Errors in Company Valuations, WP # 714.* Barcelona, Spain: IESE Business School.
Fernandez, P., Aguirreamalloa, J., & Corres, L. (2012). *Market Risk Premium used in 82 Countries in 2012: a survey of 7,192 answers.* Available at SSRN: http://ssrn.com/abstract=2084213 or http://dx.doi.org/10.2139/ssrn.2084213.
Fisher, B., & Scholes, M. (1973). The Pricing of Options and Corporate Liabilities. *Journal of Political Economy* , Vol 81.3: 637-654.
Fisher, I. (1907). *The rate of interest: its nature, determination and relation to economic phenomena.* New York: Macmillan Co.
Fisher, I. (1930). *The theory of Interest.* New York: Macmillan Co.

Fitzgerlad, B. (2012, March 10). *Business: The Australian*. Retrieved March 21, 2012, from The Australian: http://www.theaustralian.com.au/business/mining-energy/racing-to-get-a-grip-on-secure-coal-supplies/story-e6frg9df-1226295471266

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry* , Vol 12.2: 219-245.

Gamba, A. (2002). *Real Options Valuation: a Monte Carlo Approach.* University of Calgary: Unpublished.

Garnaut, R. (2010, May 21). *Business: The Australian*. Retrieved March 21, 2012, from The Australian: http://www.theaustralian.com.au/business/the-new-australian-resource-rent-tax/story-e6frg8zx-1225869337321

Geoscience Australia. (2011). *Australia's Identified Mineral Resources 2010.* Canberra, ACT: Geoscience Australia.

Geoscience Australia. (2012). *Australia's Identified Mineral Resources 2011.* Canberra, ACT: Geoscience Australia.

Gloucester Coal. (2011, May 16). *Gloucester Coal*. Retrieved May 10, 2012, from ASX Announcements: www.gloucestercoal.com.au/investor_media/asx_announcements/

Gloucester Coal. (2012, April 30). *Gloucester Coal*. Retrieved May 10, 2012, from ASX Announcemnets: www.gloucestercoal.com.au/investor_media/asx_announcements/

Gloucester Coal. (2006). *Gloucester Coal Annual Report 2006.* Sydney, NSW: Gloucester Coal.

Gloucester Coal. (2011). *Gloucester Coal Annual Report 2011.* Sydney, NSW: Gloucester Coal.

Gloucester Coal. (2011). *International Roadshow September 2011.* Sydney, NSW: Gloucester Coal.

Gordon, M. J. (1959). Earnings, and Stock Prices. *The Review of Economics and Statistics* , Vol 41.2: 99-105.

Graham, J., & Campbell, H. (2002). How do CFOs make capital budgeting and capital structure decisions? *Journal of Applied Corporate Finance* , Vol 15.1: 8-23.

Gray, S., & Hall, J. (2006). Relationship between franking credits and the market risk premium. *Accounting and Finance* , Vol 46. 3: 405-428.

Hall, J. (2005). *The impact of growth, volatility and competitive advantage of the value of equity investments and their embedded options, PhD thesis.* UQ Business School, The University of Queensland.

Hall, J., & Nicholls, S. (2007). Valuation of Mining projects using real option pricing techniques. *JASSA* , Vol 4: 22-29.

Henry, S. C. (1997). Reaal Options: Managerial Flexibility and Strategy in Resource Allocation by L. Trigeorgis. *Managerial and Decision Economics* , Vol 18.1: 66-68.

Hodges, S. D. (2004). *The Value of a Storage Facility.* West Midlands: Warwick Business School Preprint.

Hull, J. C. (2008). *Options, futures, and other derivatives - 6th Edition.* Harlow: Pearson.

IBISWorld. (2012). *IBIS World Industry Report B1101: Black Coal Mining in Australia.* Melbourne, VIC: IBISWorld.
IEA. (2011, July 28). *"Coal and natural gas import costs and export prices: Australia, Canada, US - Coal export prices by destination" IEA Energy Prices and Taxes Statistics (database)*. Retrieved July 25, 2012, from OECD iLibrary: http://www.oecd-ilibrary.org/energy/data/coal-and-natural-gas-import-costs-and-export-prices/australia-canada-us-coal-export-prices-by-destination_data-00435-en?isPartOf=/content/datacollection/eneprice-data-en
IEA. (2011). *Coal and natural gas import costs and export prices: Australia, Canada, US - Coal export prices by destination*. Retrieved June 10, 2011, from IEA Energy Prices and Taxes Statistics (database): http://www.oecd-ilibrary.org.esc-web.lib.cbs.dk/
IEA; IEF; IMF; OPEC. (2011). *Extending the G20 Work on Oil price Volatility to Coal and Gas.* Paris, France: G20.
International Energy Acgency. (2011, 12 13). *Press Releases*. Retrieved March 13, 2012, from International Energy Agency: http://www.iea.org/press/pressdetail.asp?PRESS_REL_ID=430
International Energy Agency. (2011). *Medium term coal market report.* Paris: International Energy Agency.
International Energy Agency. (2011). *World Energy Outlook 2011.* Paris: International Energy Agency.
Jacquier, E., Kane, A., & Marcus, A. J. (2003). Geometric or Arithmetic Mean: A Reconsideration. *Financial Analysts Journal* , Vol 59. 6: 46-53.
Kelly, S. (2004). *The market premium for the option to close: Evidence from Australian gold mining firms.* EFA Maastricht meeting papers.
Kester, W. C. (1993). Turning growth options into real assets . In R. Aggarwal, *Capital Budgeting under Uncertainty* (pp. 187-207). Englewood, NJ: Prentice-Hall.
Kodukula, P., & Papudesu, C. (2006). *Project valuation using real options: a practitioner's guide.* Fort Lauderdale, Florida: J. Ross Publishing.
Koller, T., Goedhart, M., & Wessels, D. (2010). *Valuation: Measuring and Managing the Value of Companies, 5th Ed.* Hoboken, NJ: John Wiley & Sons.
Kothari, S. P., Shanken, J., & Sloan, R. G. (1995). Another Look at the Cross-section of Expected Stock Returns. *The Journal of Finance* , Vol 50.1: 185-225.
Krychowski, C., & Quelin, B. V. (2010). Real Options and Strategic Investment Decisions: Can They Be of Use to Scholars. *Academy of Management Perspectives* , Vol 24.2: 65-78.
Kuhn, T. S. (1987). What are scientific revolutions? In K. L., D. J., & M. Heidelberger, *The Probabilistic revolution, Vol 1: Ideas in history* (pp. 7-22). Cambridge, MA: MIT Press.
Longstaff, F. A., & Schwartz, E. S. (2001). Valuing American options by simulation: A simple least-squares approach. *The Review of Financial Studies* , Vol 14.1: 113-147.

Luehrman, T. A. (1997). What's it worth? A general manager's guide to valuation. *Harvard Business Review* , Vol 74: 132-142.
Macquarie Research Equities. (2008). *Gloucester Coal.* Sydney, NSW: Macquarie.
Mathews, S., Datar, V., & Johnson, B. (2007). A Practical Method for Valuing Real Options: The Boeing Approach. *Journal of Applied Corporate Finance* , Vol 19. 2: 95-104.
McGrath, R. G., Ferrier, W. J., & Mendelow, A. L. (2004). Real Options as Engines of Choice and Heterogeneity. *The Academy of Management Review* , Vol 29.1: 86-101.
Merton, R. C. (1973). Theory of Rational Option Pricing. *The Bell Journal of Economics and Management Science* , Vol 4.1:141-183.
Miller, M., & Modigliani, F. (1961). Dividend policy, growth, and the valuation of shares. *Journal of Business* , Vol 34: 411-433.
Moel, A., & Tufano, P. (2002). When are real options exercised? An empirical study of mine closings. *The Review of Financial Studies* , Vol 15: 35-64.
Morse, R. K., & Gang, H. (2010). *The World's Greatest Coal Arbitrage: China's Coal Import Behavior and Implications for the Global Coal Market, Working paper #94.* Stanford, CA: Program on Energy and Sustainable Development.
Mun, J. (2006). *Real options analysis: tools and techniques for valuing strategic investments and decisions - 2nd ed.* Hoboken, NJ: John Wiley & Sons.
Munn, J. (2002). *Real options analysis: tools and techniques for valuing strategic investment decisions.* Hoboken: John Wiley & Sons.
Myers, S. C. (1977). Determinants of corporate borrowing. *Journal of Financial Ecnomics* , Vol 5.2: 147-175.
Myers, S. C. (1984). Finance Theory and Financial Strategy. *Strategic Management* , Vol 14.1: 126-137.
Myers, S. C. (1976). Using simulation for risk analysis. In S. C. Myers, *Modern Developments in Financial Management.* New York, NY: Praeger.
OECD. (2011). *OECD Factbook 2011.* Paris: OECD.
Officer, R. R. (1994). The cost of capital of a company under an imputation tax system. *Accounting and Finance* , Vol 34.1: 1-17.
O'Sullivan, M., & Kersley, R. (2012). *Credit Suisse Global Investment Returns Yearbook.* Zurich: Credit Suisse.
Paulus, M., & Trüby, J. (2011). Coal lumps vs. electrons: How do Chinese bulk energy transport decisions affect the global steam coal market. *Energy Economics* , Vol 33.6: 1127-1137.
Penman, S. (2010). *Financial Statement Analysis and Security Valuation.* New York: McGraw Hill.
Petersen, C. V., & Plenborg, T. (2012). *Financial Statement Analysis.* Harlow: Pearson Education.
Pindyck, R. S. (1999). The Long-Run Evolution of Energy Prices. *Energy Journal* , Vol 20.2: 1-27.

Plenborg, T. (2000). *Valg af Ideel Værdiansættelsesmodel.* Copenhagen: Børsens ledelseshåndbøger.
Regnier, E. (2007). Oil and energy price volatility. *Energy Economics* , Vol 29.3: 405-427.
Ross, S. A., Westerfield, R. W., & Jordan, B. D. (2006). *Fundamentals of Corporate Finance, 7th ed.* New York, NY: McGraw-Hill Irwin.
Rubinstein, M. (2003). Great Moments in Financial Economics. *Journal of Investment Management* , Vol1.1: 7-15.
Ryan, P. A., & Ryan, G. P. (2002). Capital budgeting practices of the Fortune 1000: how have things changed. *Journal of Business and Management* , Vol 8.4: 355-364.
Samis, M. R., & Poulin, R. (1998). Valuing management flexibility: A basis to compare the standard DCF and MAP valuation frameworks. *The CIM Bulletin* , Vol. 90: 69-74.
Seitz, N., & Ellison, M. (1995). *Capital budgeting and long-term financing decisions.* Dryden Press.
Shafiee, S., Topal, E., & Nehring, M. (2009). Adjusted Real Option Valuation to Maximise Mining Project Value - A Case Study Using Century Mine. *Project Evaluation Conference* (pp. 125-134). Melbourne, VIC: The Australian Institute of Mining and Metallurgy.
Shleifer, A., & Vishny, R. W. (1992). Liquidation Values and Debt Capacity: A Market Equilibrium Approach. *The Journal of Finance* , Vol 47.4: 1343-1366.
Simons, H. (2009). *Case study research in practice.* London: SAGE.
Slade, M. E. (2001). Valuing managerial flexibility: An application of real-option theory to mining investments. *Journal of Environmental Economics and Management* , Vol 41: 193-233.
Stanton, R. H., & Seasholes, M. S. (2005). *The Assumptions and Math Behind Wacc and Apv Calculations.* Working paper available at SSRN: http://ssrn.com/abstract=837384 or http://dx.doi.org/10.2139/ssrn.837384.
Stentoft, L. (2004). Assessing the Least Squares Monte-Carlo Approach to American Option Valuation. *Review of Derivatives Research* , Vol 4: 129-168.
Tasker, S. J. (2010, August 05). *Business, The Australian*. Retrieved March 15, 2012, from The Australian: http://www.theaustralian.com.au/business/middlemount-stake-falls-to-gloucester/story-e6frg8zx-1225901345853
Thomas, G. (2001). A typology for the case study in social science following a review of definition, discourse, and structure. *Qualitative Inquiry* , Vol 17.1: 511-521.
Thomson Reuters. (2011, May 15). *News: Reuters*. Retrieved March 15, 2012, from Reuters: http://www.reuters.com/finance/stocks/GCL.AX/key-developments/article/2322718
Triantis, A., & Borison, A. (2001). Real options: State of the practice. *Journal of Applied Corporate Finance* , Vol 14.2: 8-24.
Trigeorgis, L. (1996). *Real options: managerial flexibility and strategy in resource allocation.* Cambridge, MA: MIT Press.

Trigeorgis, L. (1993). The Nature of Option Interactions and the Valuation of Investments with Multiple Real Options. *The Journal of Financial and Quantitative Analysis* , Vol 28.1: 1-20.
Trueby, J., & Paulus, M. (2010). *Have Prices of Internationally Traded Steam Coal been Marginal Cost based?* Cologne: EWI.
Truong, G., Partington, G., & Peat, M. (2005). Cost of capital estimation and capital budgeting practice in Australia. *AFAANZ Conference.* Melbourne: Unpublished paper.
Tu, K. J., & Johnson-Reiser, S. (2012). *Understanding China's Rising Coal Imports.* Washington DC: The Carnegie Endowment for International Peace.
U.S. Energy Information Administration. (2011). *International Energy Outlook 2011.* Washington, DC: EIA.
Williams, J. B. (1930). *The theory of investment value.* Amsterdam: North Holland Publishing.
Williamson, O. E. (1988). Corporate Finance and Corporate Governance. *The Journal of Finance* , Vol 43.3: 567-591.
Willigers, B. J., & Hansen, T. L. (2008). Project valuation in the pharmaceutical industry: a comparison of least-squares Monte Carlo real option valuation and conventional approaches. *R&D Management Journal* , Vol 38.5: 520-537.
Winning, D. (2012, February 2). *Blogs WSJ*. Retrieved March 21, 2012, from THe Wall Street Journal: http://blogs.wsj.com/dealjournalaustralia/2012/02/02/newmont-coal-sale-talks-enter-home-stretch/
Winning, D. (2012, January 16). *The Wall Street Journal*. Retrieved May 22, 2012, from WSJ Blogs: http://blogs.wsj.com/dealjournalaustralia/2012/01/16/advantage-australia-as-china-coal-costs-more/
World Coal Institute. (2005). *The Coal Resource: A Comprehensive Overview of Coal.* London, UK: World Coal Institute.
World Energy Council. (2009). *Survey of Energy Resources, Interim Update 2009.* London, UK: World Energy Council.
World Energy Council. (2011). *World Energy Insight 2011.* London, UK: First.
Zenner, M., Hill, S., Clark, J., & Mago, N. (2008). *The most important number in Finance: The quest for the market risk premium* . New York: J.P Morgan Capital Structure Advisory & Solutions.

Appendix

Appendix A: Financials

Appendix B: Free Cash Flows

Appendix C: Real Options

Appendix D: Coal Information

Appendix E: Gloucester Coal and Australian Coal miners stock prices

Appendix F: Gloucester Coal Production profile and site locations

Appendix G: Discounted Cash Flow

Appendix H: ROV Fundamentals and Types of Option Models

Appendix I: Historical Financials

Appendix J: Acquisition of Middlemount, Donaldson and Monash

Appendix K: Gloucester cash taxes

Appendix L: Capitalisation of Operating Leases

Appendix M: Geosciences Australian Mine Atlas

Appendix N: Synthetic Debt Rating – Credit Rating agency data

Appendix O: Peers – exploration value

Appendix P: Volatility Calculation

Appendix Q: Monte Carlo inputs and distribution assumptions

Appendix R: Capacity Considerations – expansion option

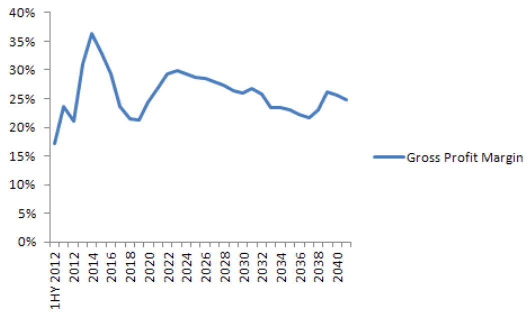
Appendix Q: Mining Depletion Calculation

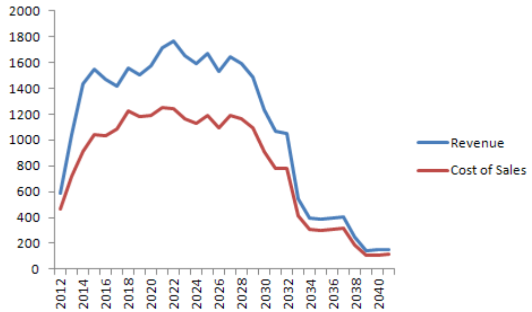
Appendix R: Share ownership structure

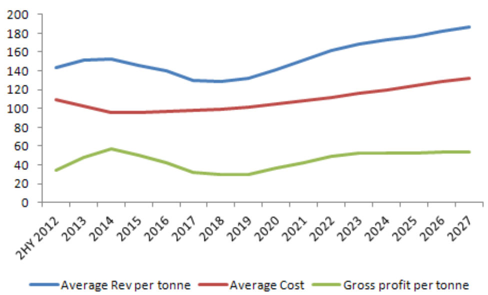
Appendix A: Financials

Analytical Income Statement AUD Million	Actual			Forecast										
	2011	1HY 2012	2HY 2012	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Revenue	306,56	226,99	365,21	592,21	1.045,76	1.437,49	1.547,02	1.465,69	1.418,81	1.555,18	1.504,76	1.573,65	1.717,35	1.765,18
Cost of sales	-204,65	-188,02	-278,86	-466,88	-721,59	-914,20	-1.038,44	-1.035,12	-1.082,45	-1.222,14	-1.183,69	-1.189,76	-1.255,44	-1.246,86
Gross Profit	101,91	38,97	86,35	125,32	324,17	523,29	508,58	430,57	336,36	333,04	321,07	383,89	461,91	518,32
Other operating income / (expense)	3,70	1,76		1,76	-	-	-	-	-		-	-	-	-
Administration expenses	-26,35	-58,00	-16,70	-74,71	-34,37	-35,34	-36,26	-37,20	-38,13	-39,08	-40,06	-41,06	-42,09	-43,14
EBITDA	79,26	-17,27	69,65	52,38	289,79	487,95	472,32	393,37	298,23	293,96	281,01	342,83	419,82	475,19
depreciation & depletion	-18,70	-26,29	-30,67	-56,95	-88,80	-115,30	-139,80	-146,71	-157,53	-165,45	-161,77	-159,16	-159,73	-154,60
EBITA	60,56	-43,57	38,98	-4,57	200,99	372,65	332,53	246,66	140,71	128,51	119,24	183,67	260,09	320,58
Add: Operating lease interest	1,51	0,80	0,80	1,60	3,00	3,81	4,32	4,31	4,51	5,09	4,93	4,95	5,23	5,19
Adjusted EBIT	62,06	-42,77	39,78	-2,98	203,99	376,46	336,85	250,97	145,21	133,60	124,17	188,62	265,31	325,77
Operating Taxes	-4,94	15,04	-8,88	6,16	-45,52	-84,00	-75,16	-56,00	-32,40	-29,81	-27,71	-42,09	-59,20	-97,73
NOPAT	**57,12**	**-27,73**	**30,90**	**3,18**	**158,47**	**292,46**	**261,68**	**194,97**	**112,81**	**103,79**	**96,46**	**146,53**	**206,11**	**228,04**

Analytical Income Statement AUD Million	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Revenue	1.657,07	1.592,60	1.669,02	1.530,55	1.646,12	1.596,13	1.489,78	1.231,01	1.067,23	1.047,45	541,02	398,71	387,17	394,91	402,81	245,12	144,36	147,25	150,19	-
Cost of sales	-1.163,44	-1.127,04	-1.190,82	-1.094,24	-1.186,58	-1.160,03	-1.096,49	-911,30	-781,70	-778,36	-414,30	-304,91	-298,17	-306,85	-315,78	-188,74	-106,60	-109,70	-112,89	-
Gross Profit	493,63	465,56	478,20	436,31	459,54	436,10	393,29	319,71	285,53	269,08	126,72	93,80	89,00	88,06	87,02	56,38	37,76	37,55	37,30	-
Other operating income / (expense)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Administration expenses	-44,22	-45,32	-46,46	-47,62	-48,81	-50,03	-51,28	-52,56	-53,87	-55,22	-48,11	-49,31	-50,55	-51,81	-53,11	-54,43	-47,43	-48,61	-49,83	-43,41
Admin exp & Other operating exp/inc.																				
EBITDA	449,41	420,24	431,75	388,70	410,73	386,07	342,01	267,15	231,65	213,86	78,60	44,49	38,45	36,25	33,92	1,94	-9,67	-11,06	-12,52	-43,41
depreciation & depletion	-148,10	-145,49	-146,18	-139,01	-140,32	-134,49	-129,58	-118,90	-106,26	-102,97	-74,98	-55,14	-52,41	-50,44	-48,57	-41,43	-36,38	-12,51	-11,97	-
EBITA	301,31	274,75	285,57	249,68	270,41	251,58	212,43	148,25	125,39	110,90	3,62	-10,65	-13,96	-14,19	-14,65	-39,49	-46,05	-23,58	-24,50	-43,41
Add: Operating lease interest	4,84	4,69	4,96	4,55	4,94	4,83	4,56	3,79	3,25	3,24	1,72	1,27	1,24	1,28	1,31	0,79	0,44	0,46	0,47	-
Adjusted EBIT	306,15	279,44	290,52	254,24	275,35	256,40	216,99	152,05	128,65	114,14	5,35	-9,39	-12,72	-12,92	-13,34	-38,70	-45,61	-23,12	-24,03	-43,41
Operating Taxes	-91,84	-83,83	-87,16	-76,27	-82,60	-76,92	-65,10	-45,61	-38,59	-34,24	-1,60	2,82	3,82	3,87	4,00	11,61	13,68	6,94	7,21	13,02
NOPAT	**214,30**	**195,61**	**203,37**	**177,97**	**192,74**	**179,48**	**151,89**	**106,43**	**90,05**	**79,90**	**3,74**	**-6,57**	**-8,90**	**-9,04**	**-9,33**	**-27,09**	**-31,93**	**-16,18**	**-16,82**	**-30,39**







Analytical Balance Sheet AUD Million	2011	HY 2012	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Total Funds Invested: Uses													
Current Operating Assets													
Operating Cash	6,74	9,99	13,03	23,01	31,62	34,03	32,25	31,21	34,21	33,10	34,62	37,78	38,83
Trade and other receivables	29,45	58,25	51,35	90,67	124,64	134,13	127,08	123,02	134,84	130,47	136,44	148,90	153,05
Other financial assets (derivatives)	4,61	2,22	-	-	-	-	-	-	-	-	-	-	-
Inventories	9,34	52,29	33,11	51,17	64,82	73,63	73,40	76,75	86,66	83,93	84,36	89,02	88,41
Waste in advance	57,74	83,11	100,52	155,37	196,84	223,59	222,87	233,06	263,14	254,86	256,17	270,31	268,46
Operating Current Assets	**107,89**	**205,87**	**198,01**	**320,21**	**417,92**	**465,39**	**455,60**	**464,05**	**518,85**	**502,37**	**511,59**	**546,01**	**548,76**
Trade and other payables	49,66	88,84	75,98	117,44	148,78	169,00	168,46	176,16	198,90	192,64	193,63	204,32	202,92
Income tax liability	2,65	0,17	-	-	-	-	-	-	-	-	-	-	-
Employee benefits	0,78	9,13	1,77	3,12	4,29	4,61	4,37	4,23	4,64	4,49	4,69	5,12	5,26
Operating Current Liabilities	**53,09**	**98,14**	**77,75**	**120,55**	**153,07**	**173,61**	**172,83**	**180,39**	**203,53**	**197,12**	**198,32**	**209,44**	**208,18**
Operating Working Capital	54,80	107,72	120,26	199,66	264,86	291,78	282,77	283,65	315,32	305,24	313,28	336,58	340,57
Property, plant and equipment	807,44	1.692,75	1.807,35	1.944,61	2.066,57	2.107,98	2.149,02	2.077,26	1.997,11	1.920,17	1.829,39	1.736,60	1.647,52
Exploration and evaluation	56,59	217,87	219,84	237,34	241,63	246,24	250,61	254,84	259,47	263,96	268,65	273,77	279,03
Capitalised Operating Leases	33,86	63,56	63,56	80,53	91,47	91,18	95,35	107,66	104,27	104,80	110,59	109,83	102,48
Other Operating Liabilities	-0,28	-0,76	-	-	-	-	-	-	-	-	-	-	-
Intangible - Port allocation		57,39	56,82	55,28	53,12	50,33	47,59	44,80	41,27	37,96	34,83	31,47	28,39
Invested Capital	**952,41**	**2.138,53**	**2.267,83**	**2.517,43**	**2.717,64**	**2.787,50**	**2.825,34**	**2.768,21**	**2.717,44**	**2.632,14**	**2.556,74**	**2.488,25**	**2.398,01**
Excess Cash	177,59	21,61											
Investments	1,00	19,29	19,29	19,29	19,29	19,29	19,29	19,29	19,29	19,29	19,29	19,29	19,29
Financial Asset - Royalties	182,00	193,00	195,17	192,17	187,23	181,30	176,62	172,21	167,85	163,13	157,19	150,01	141,47
Tax loss carry forward	16,53	-		-	-	-	-	-	-	-	-	-	-
Total Funds Invested	**1.329,52**	**2.372,42**	**2.482,29**	**2.728,88**	**2.924,16**	**2.988,08**	**3.021,24**	**2.959,71**	**2.904,57**	**2.814,56**	**2.733,21**	**2.657,54**	**2.558,77**
Total Funds Invested: Sources													
Interest Bearing Debt	99,12	410,68	524,62	678,17	645,33	520,22	466,04	483,35	472,75	466,17	438,94	424,24	416,02
Capitalised Operating Leases	33,86	63,56	63,56	80,53	91,47	91,18	95,35	107,66	104,27	104,80	110,59	109,83	102,48
Provisions (rehabilitation and dismantle)	11,97	17,45	17,72	18,28	18,89	19,54	20,25	21,01	21,84	22,73	23,69	24,73	25,85
Provision - rehabilitation			10,68	10,68	10,68	10,68	10,68	10,68	10,68	10,68	10,68	10,68	10,68
Provision - dismantling			7,04	7,60	8,21	8,86	9,57	10,33	11,16	12,05	13,01	14,05	15,17
Provisions (Take or pay)	12,01	119,81	109,20	87,98	66,76	45,54	24,32	3,09					
Donaldson - customer contract liability		133,12	105,32	77,52	62,02	46,51	31,01	15,50					
Debt and Debt equivalents	**156,96**	**744,62**	**838,14**	**960,76**	**903,35**	**742,53**	**657,21**	**651,63**	**620,69**	**616,42**	**596,91**	**583,53**	**570,20**
Deferred Income tax	157,90	243,50	243,50	243,50	243,50	243,50	243,50	243,50	243,50	243,50	243,50	243,50	243,50
Issued Capital	912,09	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62
Retained profits	102,57	65,67	82,02	206,00	458,68	683,43	801,91	807,19	842,68	876,83	964,07	1.086,42	1.201,17
Acc share transaction			-	-	-	-	-	-61,234	-120,919	-240,815	-389,891	-574,520	-774,720
Total Shareholder Capital	1.014,66	1.384,29	1.400,64	1.524,62	1.777,30	2.002,05	2.120,53	2.064,57	2.040,38	1.954,63	1.892,80	1.830,52	1.745,07
Equity and Equity Equivalents	**1.172,56**	**1.627,80**	**1.644,14**	**1.768,12**	**2.020,80**	**2.245,55**	**2.364,03**	**2.308,07**	**2.283,88**	**2.198,13**	**2.136,30**	**2.074,02**	**1.988,57**
Total Funds Invested	**1.329,52**	**2.372,42**	**2.482,29**	**2.728,88**	**2.924,16**	**2.988,08**	**3.021,24**	**2.959,71**	**2.904,57**	**2.814,56**	**2.733,21**	**2.657,54**	**2.558,77**

Analytical Balance Sheet AUD Million	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
Total Funds Invested: Uses																			
Current Operating Assets																			
Operating Cash	36,46	35,04	36,72	33,67	36,21	35,11	32,78	27,08	23,48	23,04	11,90	8,77	8,52	8,69	8,86	5,39	3,18	3,24	3,30
Trade and other receivables	143,67	138,09	144,71	132,71	142,73	138,39	129,17	106,73	92,53	90,82	46,91	34,57	33,57	34,24	34,93	21,25	12,52	12,77	13,02
Other financial assets (derivatives)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Inventories	82,50	79,92	84,44	77,59	84,14	82,25	77,75	64,62	55,43	55,19	29,38	21,62	21,14	21,76	22,39	13,38	7,56	7,78	-
Waste in advance	250,50	242,66	256,40	235,60	255,48	249,77	236,09	196,21	168,31	167,59	89,20	65,65	64,20	66,07	67,99	40,64	22,95	-	-
Operating Current Assets	**513,13**	**495,70**	**522,26**	**479,57**	**518,56**	**505,53**	**475,78**	**394,65**	**339,75**	**336,64**	**177,39**	**130,61**	**127,43**	**130,75**	**134,17**	**80,67**	**46,20**	**23,79**	**16,33**
Trade and other payables	189,34	183,42	193,80	178,08	193,11	188,79	178,45	148,31	127,22	126,67	67,43	49,62	48,53	49,94	51,39	30,72	17,35	17,85	18,37
Income tax liability	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Employee benefits	4,94	4,75	4,98	4,56	4,91	4,76	4,44	3,67	3,18	3,12	1,61	1,19	1,15	1,18	1,20	0,73	0,43	0,44	0,45
Operating Current Liabilities	**194,28**	**188,17**	**198,77**	**182,64**	**198,02**	**193,55**	**182,89**	**151,98**	**130,40**	**129,80**	**69,04**	**50,81**	**49,68**	**51,12**	**52,59**	**31,45**	**17,78**	**18,29**	**18,82**
Operating Working Capital	318,84	307,53	323,49	296,92	320,54	311,98	292,89	242,67	209,35	206,85	108,35	79,80	77,75	79,64	81,58	49,22	28,42	5,49	-2,49
Property, plant and equipment	1.563,57	1.480,87	1.396,17	1.317,34	1.212,51	1.111,88	1.014,61	926,55	849,71	774,82	585,31	550,43	517,36	485,36	454,40	429,77	142,40	135,17	123,20
Exploration and evaluation	283,98	288,74	293,72	298,30	303,22	307,99	312,45	316,13	319,32	322,46	324,08	325,27	326,42	327,60	328,80	329,53	329,95	330,39	330,83
Capitalised Operating Leases	99,28	104,90	96,39	104,52	102,18	96,59	80,27	68,86	68,56	36,49	26,86	26,26	27,03	27,82	16,63	9,39	9,66	9,94	-
Other Operating Liabilities	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Intangible - Port allocation	25,66	22,92	19,96	17,43	14,63	12,01	9,45	7,46	6,32	5,06	3,81	3,01	2,27	1,53	0,79	0,51	-	-	-
Invested Capital	**2.291,32**	**2.204,96**	**2.129,73**	**2.034,51**	**1.953,09**	**1.840,45**	**1.709,68**	**1.561,67**	**1.453,27**	**1.345,69**	**1.048,41**	**984,78**	**950,83**	**921,95**	**882,20**	**818,41**	**510,44**	**481,00**	**451,53**
Excess Cash																			
Investments	19,29	19,29	19,29	19,29	19,29	19,29	19,29	19,29	19,29	19,29	19,29	19,29	19,29	19,29	19,29	19,29	19,29	19,29	19,29
Financial Asset - Royalties	132,03	121,64	110,23	97,75	84,13	69,46	53,67	36,70	18,50	-	-	-	-	-	-	-	-	-	-
Tax loss carry forward	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Funds Invested	**2.442,64**	**2.345,88**	**2.259,25**	**2.151,55**	**2.056,51**	**1.929,19**	**1.782,63**	**1.617,66**	**1.491,06**	**1.364,98**	**1.067,70**	**1.004,07**	**970,12**	**941,24**	**901,48**	**837,70**	**529,73**	**500,28**	**470,82**
Total Funds Invested: Sources																			
Interest Bearing Debt	397,86	367,95	357,69	331,88	310,95	297,79	286,07	266,90	232,56	240,52	223,45	162,76	160,47	150,57	155,72	153,35	120,00	78,98	91,00
Capitalised Operating Leases	99,28	104,90	96,39	104,52	102,18	96,59	80,27	68,86	68,56	36,49	26,86	26,26	27,03	27,82	16,63	9,39	9,66	9,94	-
Provisions (rehabilitation and dismantle)	27,06	28,36	29,77	31,29	32,94	34,71	36,63	38,70	40,94	43,35	30,64	32,51	34,54	36,73	39,09	20,82	22,19	23,68	-
Provision - rehabilitation	10,68	10,68	10,68	10,68	10,68	10,68	10,68	10,68	10,68	10,68	7,12	7,12	7,12	7,12	7,12	3,56	3,56	3,56	-
Provision - dismantling	16,38	17,68	19,09	20,61	22,26	24,03	25,95	28,02	30,26	32,67	23,52	25,39	27,42	29,61	31,97	17,26	18,63	20,12	21,73
Provisions (Take or pay)																			
Donaldson - customer contract liability																			
Debt and Debt equivalents	**551,25**	**529,57**	**513,62**	**498,99**	**479,02**	**463,80**	**439,61**	**413,16**	**383,00**	**363,72**	**311,59**	**254,05**	**256,58**	**251,83**	**250,52**	**204,38**	**174,05**	**136,28**	**112,73**
Deferred Income tax	243,50	243,50	243,50	243,50	243,50	243,50	243,50	243,50	243,50	243,50	243,50	243,50	243,50	243,50	243,50	243,50	243,50	243,50	243,50
Issued Capital	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62	1.318,62
Contingent consideration (monash)																			
Retained profits	1.291,43	1.370,16	1.466,33	1.533,50	1.628,08	1.702,50	1.755,89	1.778,32	1.807,85	1.835,59	1.800,02	1.780,29	1.761,01	1.741,55	1.722,12	1.697,32	1.656,63	1.633,50	1.611,55
Adj acc share transactions	-962,164	-1.115,967	-1.282,829	-1.443,068	-1.612,712	-1.799,232	-1.974,989	-2.135,937	-2.261,890	-2.396,457	-2.606,031	-2.592,395	-2.609,589	-2.614,269	-2.633,277	-2.626,118	-2.863,068	-2.831,614	-2.815,572
Total Shareholder Capital	1.647,89	1.572,81	1.502,12	1.409,05	1.333,99	1.221,89	1.099,52	961,00	864,58	757,76	512,61	506,51	470,04	445,90	407,46	389,82	112,18	120,50	114,59
Equity and Equity Equivalents	**1.891,39**	**1.816,31**	**1.745,62**	**1.652,55**	**1.577,49**	**1.465,39**	**1.343,02**	**1.204,50**	**1.108,08**	**1.001,26**	**756,11**	**750,01**	**713,54**	**689,40**	**650,96**	**633,32**	**355,68**	**364,00**	**358,09**
Total Funds Invested	**2.442,64**	**2.345,88**	**2.259,24**	**2.151,55**	**2.056,51**	**1.929,19**	**1.782,63**	**1.617,66**	**1.491,08**	**1.364,98**	**1.067,70**	**1.004,07**	**970,12**	**941,24**	**901,48**	**837,70**	**529,73**	**500,28**	**470,82**

Appendix B: Free Cash Flows

Free Cash Flow AUD Million	2011	1HY 2012	2HY 2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
NOPAT	57,12	-27,73	30,90	158,47	292,46	261,68	194,97	112,81	103,79	96,46	146,53	206,11	228,04
Depreciation and Depletion	18,70	26,29	30,67	88,80	115,30	139,80	146,71	157,53	165,45	161,77	159,16	159,73	154,60
Unrealised gains/(losses) & Tax adj.	2,55	-	-	-	-	-	-	-	-	-	-	-	-
Equity settled cash flow hedge gains	8,28	-	-	-	-	-	-	-	-	-	-	-	-
Equity Settled Share based payments	0,16	-	-	-	-	-	-	-	-	-	-	-	-
Gross cash flow	**86,82**	**-1,44**	**61,57**	**247,28**	**407,76**	**401,48**	**341,68**	**270,34**	**269,23**	**258,23**	**305,69**	**365,85**	**382,64**
Change in Operating Working Capital	-19,60	-52,93	-12,53	-79,40	-65,20	-26,92	9,01	-0,89	-31,66	10,08	-8,03	-23,30	-4,00
Net Capital Expenditure & Exploration	-126,80	-75,37	-154,01	-243,57	-241,54	-185,82	-192,12	-89,99	-89,93	-89,32	-73,07	-72,06	-70,79
Waste in advance expenditure Non-Current (pre-stripping)	-	-	-	-	-	-	-	-	-	-	-	-	-
Increase (decrease) in net long-term operating liabilities	0,12	0,48	-0,76	-	-	-	-	-	-	-	-	-	-
Decrease (increase) in capitalised operating leases	0,61	-29,71	-	-16,97	-10,94	0,29	-4,17	-12,30	3,39	-0,54	-5,79	0,76	7,35
Cash paid on acquisition	-227,78	-31,62	-	-	-	-	-	-	-	-	-	-	-
Acquisitions	-328,32												
Reverse for equity component (shares issued) & Cash acquired	100,54												
Free Cash Flow	**-286,64**	**-190,57**	**-105,73**	**-92,66**	**90,08**	**189,03**	**154,40**	**167,15**	**151,03**	**178,46**	**218,80**	**271,24**	**315,20**
Period			-	1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00
Discount Factor			1,00	0,912	0,832	0,759	0,692	0,632	0,576	0,526	0,479	0,437	0,399
PV of cash flows			**-105,73**	**-84,52**	**74,95**	**143,48**	**106,90**	**105,57**	**87,01**	**93,78**	**104,88**	**118,60**	**125,72**

Free Cash Flow AUD Million	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
NOPAT	214,30	195,61	203,37	177,97	192,74	179,48	151,89	106,43	90,05	79,90	3,74	-6,57	-8,90	-9,04	-9,33	-27,09	-31,93	-16,18	-16,82	-30,39
Depreciation and Depletion	148,10	145,49	146,18	139,01	140,32	134,49	129,58	118,90	106,26	102,97	74,98	55,14	52,41	50,44	48,57	41,43	36,38	12,51	11,97	-
Gross cash flow	**362,41**	**341,10**	**349,55**	**316,98**	**333,06**	**313,98**	**281,48**	**225,33**	**196,31**	**182,86**	**78,72**	**48,57**	**43,51**	**41,40**	**39,23**	**14,34**	**4,46**	**-3,67**	**-4,85**	**-30,39**
Change in Operating Working Capital	21,73	11,31	-15,95	26,56	-23,62	8,56	19,09	50,22	33,32	2,50	98,49	28,55	2,05	-1,89	-1,94	32,36	20,79	22,93	7,99	-2,49
Net Capital Expenditure & Exploration	-69,09	-67,55	-66,46	-64,76	-40,41	-38,64	-36,77	-34,52	-32,61	-31,21	112,91	-21,45	-20,49	-19,63	-18,81	-17,53	250,56	-5,72	-0,44	123,20
Decrease (increase) in capitalised operating leases	3,21	-5,62	8,51	-8,13	2,34	5,60	16,31	11,42	0,29	32,07	9,64	0,59	-0,76	-0,79	11,19	7,24	-0,27	-0,28	9,94	-
Free Cash Flow	**318,25**	**279,24**	**275,64**	**270,65**	**271,37**	**289,50**	**280,10**	**252,45**	**197,31**	**186,22**	**299,77**	**56,26**	**24,31**	**19,10**	**29,68**	**36,41**	**275,54**	**13,26**	**12,64**	**90,31**
Period	11,00	12,00	13,00	14,00	15,00	16,00	17,00	18,00	19,00	20,00	21,00	22,00	23,00	24,00	25,00	26,00	27,00	28,00	29,00	30,00
Discount Factor	0,36	0,33	0,30	0,28	0,25	0,23	0,21	0,19	0,17	0,16	0,15	0,13	0,12	0,11	0,10	0,09	0,08	0,08	0,07	0,06
PV of Cash flows	**115,79**	**92,67**	**83,45**	**74,74**	**68,36**	**66,52**	**58,71**	**48,27**	**34,41**	**29,63**	**43,50**	**7,45**	**2,94**	**2,10**	**2,98**	**3,34**	**23,04**	**1,01**	**0,88**	**5,73**

PV of production assets AUD Million	
PV 2HY 2012 - 2022	770,64
PV 2023 - 2042	765,52
PV of Middlemount, Donaldson & Gloucester	1.536,16

Appendix C: Real Options

Asset value without flexibility

The values below represent the evolution of the UAV based upon the stochastic process established in the body of the thesis. The UAV is adjusted for value erosion, brought about by the depletion of coal reserves.

$Volatility = 55.29\%$ $\qquad$ $Risk\ Free\ Rate = 3.08\%$

$Up\ Factor = e^{0.5529} = 1.7383$ $\qquad$ $Down\ Factor = \frac{1}{e^{0.5529}} = 0.5753$

$P_{up} = \frac{e^{0.0308} - 0.5753}{1.73883 - 0.5753} = 0.392$ $\qquad$ $P_{down} = 1 - 0.392 = 0.608$

Input parameters used in calculation of binomial tree

Free cash flows from DCF model:

DCF Cash Flows	HY2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
FCF	-105,73	-92,66	90,08	189,03	154,40	167,15	151,03	178,46	218,80	271,24	315,20	318,25	279,24	275,64	270,65
Time	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Discount Factor	1	0,912184	0,8320797	0,7590098	0,6923567	0,6315567	0,576096	0,52550553	0,47935776	0,4372625	0,39886388	0,36383726	0,331886544	0,30274161	0,276156065
PV cash flow	-105,73	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	125,72	115,79	92,67	83,45	74,74

DCF Cash Flows	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
FCF	271,37	289,50	280,10	252,45	197,31	186,22	299,77	56,26	24,31	19,10	29,68	36,41	275,54	13,26	12,64	90,31
Time	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Discount Factor	0,251905156	0,229783863	0,209605173	0,191198494	0,174408215	0,159092391	0,14512154	0,132377553	0,12075269	0,110148678	0,100475867	0,091652482	0,083603932	0,076262172	0,069565137	0,063456208
PV cash flow	68,36	66,52	58,71	48,27	34,41	29,63	43,50	7,45	2,94	2,10	2,98	3,34	23,04	1,01	0,88	5,73

Formula used to calculate erosion of asset from depletion of reserves:

$$PV_{ex.cash\ flow} = \left(1 - \frac{CF_{current\ period}}{\sum Remaining\ Cash\ Flows}\right) \cdot PV_{before\ end\ of\ period\ cash\ flow}$$

Asset value without flexibility

Present Values year end after cash flow

2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
1.642	3.001	4.990	7.921	12.792	20.561	33.341	53.459	84.184	129.149	192.829	284.491	423.990	626.611	917.334	1.321.301	1.834.514	2.479.682	3.296.866	4.474.793	5.898.656	5.455.484	8.055.269	13.024.139	21.421.053	34.233.045	53.665.924	23.192.290	34.964.681	52.692.717	-
	993	1.651	2.621	4.234	6.805	11.034	17.692	27.860	42.741	63.816	94.151	140.318	207.374	303.588	437.279	607.125	820.641	1.091.085	1.480.915	1.952.137	1.805.471	2.665.859	4.310.287	7.089.212	11.329.290	17.760.524	7.675.396	11.571.422	17.438.445	-
		547	868	1.401	2.252	3.652	5.855	9.220	14.145	21.120	31.159	46.438	68.630	100.471	144.716	200.926	271.588	361.090	490.103	646.052	597.513	882.255	1.426.472	2.346.147	3.749.383	5.877.775	2.540.142	3.829.516	5.771.184	-
			287	464	745	1.209	1.938	3.051	4.681	6.989	10.312	15.368	22.713	33.251	47.893	66.496	89.881	119.501	162.198	213.808	197.745	291.979	472.085	776.448	1.240.844	1.945.226	840.650	1.267.363	1.909.950	-
				153	247	400	641	1.010	1.549	2.313	3.413	5.086	7.517	11.004	15.850	22.006	29.746	39.548	53.679	70.759	65.443	96.629	156.235	256.962	410.652	643.765	278.210	419.429	632.090	-
					82	132	212	334	513	766	1.129	1.683	2.488	3.642	5.246	7.283	9.844	13.088	17.765	23.417	21.658	31.979	51.705	85.041	135.904	213.051	92.072	138.808	209.188	-
						44	70	111	170	253	374	557	823	1.205	1.736	2.410	3.258	4.332	5.879	7.750	7.168	10.583	17.112	28.144	44.977	70.509	30.471	45.938	69.230	-
							23	37	56	84	124	184	272	399	575	798	1.078	1.434	1.946	2.565	2.372	3.503	5.663	9.314	14.885	23.335	10.084	15.203	22.911	-
								12	19	28	41	61	90	132	190	264	357	474	644	849	785	1.159	1.874	3.082	4.926	7.722	3.337	5.031	7.582	-
									6	9	14	20	30	44	63	87	118	157	213	281	260	384	620	1.020	1.630	2.556	1.104	1.665	2.509	-
										3	4	7	10	14	21	29	39	52	71	93	86	127	205	338	540	846	366	551	830	-
											1	2	3	5	7	10	13	17	23	31	28	42	68	112	179	280	121	182	275	-
												1	1	2	2	3	4	6	8	10	9	14	22	37	59	93	40	60	91	-
													0	1	1	1	1	2	3	3	3	5	7	12	20	31	13	20	30	-
														0	0	0	0	1	1	1	1	2	2	4	6	10	4	7	10	-
															0	0	0	0	0	0	0	1	1	1	2	3	1	2	3	-
																0	0	0	0	0	0	0	0	0	1	1	0	1	1	-
																	0	0	0	0	0	0	0	0	0	0	0	0	0	-
																		0	0	0	0	0	0	0	0	0	0	0	0	-
																			0	0	0	0	0	0	0	0	0	0	0	-
																				0	0	0	0	0	0	0	0	0	0	-
																					0	0	0	0	0	0	0	0	0	-
																						0	0	0	0	0	0	0	0	-
																							0	0	0	0	0	0	0	-
																								0	0	0	0	0	0	-
																									0	0	0	0	0	-
																										0	0	0	0	-
																											0	0	0	-
																												0	0	-
																													0	-
																														-

Present Value prior to cash flow being subtracted

2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
1.536	2.854	5.217	8.674	13.768	22.237	35.742	57.956	92.927	146.335	224.498	335.192	494.527	737.016	1.089.229	1.594.589	2.296.800	3.188.911	4.310.398	5.730.898	7.778.473	10.253.556	9.483.195	14.002.367	22.639.689	37.235.933	59.506.848	93.286.764	40.314.851	60.778.641	91.595.052
	945	1.726	2.871	4.557	7.359	11.829	19.180	30.754	48.429	74.297	110.930	163.662	243.912	360.476	527.723	760.117	1.055.358	1.426.509	1.896.618	2.574.255	3.393.374	3.138.426	4.634.028	7.492.515	12.323.084	19.693.554	30.872.883	13.342.039	20.114.449	30.313.018
		571	950	1.508	2.435	3.915	6.348	10.178	16.027	24.588	36.712	54.163	80.722	119.298	174.648	251.558	349.266	472.097	627.678	851.939	1.123.023	1.038.649	1.533.613	2.479.618	4.078.276	6.517.503	10.217.258	4.415.495	6.656.797	10.031.973
			314	499	806	1.296	2.101	3.368	5.304	8.137	12.150	17.925	26.715	39.481	57.799	83.252	115.588	156.239	207.728	281.946	371.660	343.737	507.543	820.620	1.349.689	2.156.942	3.381.361	1.461.290	2.203.040	3.320.041
				165	267	429	695	1.115	1.755	2.693	4.021	5.932	8.841	13.066	19.128	27.552	38.253	51.707	68.747	93.309	122.999	113.758	167.969	271.581	446.674	713.831	1.119.048	483.608	729.087	1.098.754
					88	142	230	369	581	891	1.331	1.963	2.926	4.324	6.330	9.118	12.660	17.112	22.751	30.880	40.706	37.648	55.589	89.879	147.825	236.240	370.344	160.048	241.289	363.628
						47	76	122	192	295	440	650	968	1.431	2.095	3.018	4.190	5.663	7.529	10.220	13.472	12.459	18.397	29.745	48.922	78.183	122.564	52.967	79.854	120.341
							25	40	64	98	146	215	320	474	693	999	1.387	1.874	2.492	3.382	4.458	4.123	6.088	9.844	16.191	25.874	40.562	17.529	26.427	39.827
								13	21	32	48	71	106	157	229	331	459	620	825	1.119	1.475	1.365	2.015	3.258	5.358	8.563	13.424	5.801	8.746	13.180
									7	11	16	24	35	52	76	109	152	205	273	370	488	452	667	1.078	1.773	2.834	4.443	1.920	2.894	4.362
										4	5	8	12	17	25	36	50	68	90	123	162	149	221	357	587	938	1.470	635	958	1.444
											2	3	4	6	8	12	17	22	30	41	53	49	73	118	194	310	487	210	317	478
												1	1	2	3	4	6	7	10	13	18	16	24	39	64	103	161	70	105	158
													0	1	1	1	2	2	3	4	6	5	8	13	21	34	53	23	35	52
														0	0	0	1	1	1	1	2	2	3	4	7	11	18	8	11	17
															0	0	0	0	0	0	1	1	1	1	2	4	6	3	4	6
																0	0	0	0	0	0	0	0	0	1	1	2	1	1	2
																	0	0	0	0	0	0	0	0	0	0	1	0	0	1
																		0	0	0	0	0	0	0	0	0	0	0	0	0
																			0	0	0	0	0	0	0	0	0	0	0	0
																				0	0	0	0	0	0	0	0	0	0	0
																					0	0	0	0	0	0	0	0	0	0
																						0	0	0	0	0	0	0	0	0
																							0	0	0	0	0	0	0	0
																								0	0	0	0	0	0	0
																									0	0	0	0	0	0
																										0	0	0	0	0
																											0	0	0	0
																												0	0	0
																													0	0
																														0

Underlying Enterprise Value	1.536
Time to expiry (2041)	29
Risk Free Rate	3,08%
Factor Up	1,64872127
Factor Down	0,60653066
Length of steps	1
Volatility (sigma)	55%

Asset Value with flexibility: Put Option – Abandonment

2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1.778	3.001	4.990	7.921	12.792	20.561	33.341	53.459	84.184	129.149	192.829	284.491	423.990	626.611	917.334	1.321.301	1.834.514	2.479.682	3.296.866	4.474.793	5.898.656	5.455.484	8.055.269	13.024.139	21.421.053	34.233.045	53.665.924	23.192.290	34.964.681
	1.080	1.651	2.621	4.234	6.805	11.034	17.692	27.860	42.741	63.816	94.151	140.318	207.374	303.588	437.279	607.125	820.641	1.091.085	1.480.915	1.952.137	1.805.471	2.665.859	4.310.287	7.089.212	11.329.290	17.760.524	7.675.396	11.571.422
		767	976	1.401	2.252	3.652	5.855	9.220	14.145	21.120	31.159	46.438	68.630	100.471	144.716	200.926	271.588	361.090	490.103	646.052	597.513	882.255	1.426.472	2.346.147	3.749.383	5.877.775	2.540.142	3.829.516
			672	751	907	1.234	1.938	3.051	4.681	6.989	10.312	15.368	22.713	33.251	47.893	66.496	89.881	119.501	162.198	213.808	197.745	291.979	472.085	776.448	1.240.844	1.945.226	840.650	1.267.363
				656	689	743	844	1.060	1.549	2.313	3.413	5.086	7.517	11.004	15.850	22.006	29.746	39.548	53.679	70.759	65.443	96.629	156.235	256.962	410.652	643.765	278.210	419.429
					668	690	716	748	799	895	1.134	1.683	2.488	3.642	5.246	7.283	9.844	13.088	17.765	23.417	21.658	31.979	51.705	85.041	135.904	213.051	92.072	138.808
						688	709	731	754	778	786	839	939	1.205	1.736	2.410	3.258	4.332	5.879	7.750	7.168	10.583	17.112	28.144	44.977	70.509	30.471	45.938
							709	731	754	778	775	793	818	815	841	863	1.078	1.434	1.946	2.565	2.372	3.503	5.663	9.314	14.885	23.335	10.084	15.203
								731	754	778	775	793	818	815	841	809	768	697	691	849	785	1.159	1.874	3.082	4.926	7.722	3.337	5.031
									754	778	775	793	818	815	841	809	768	697	645	624	421	455	629	1.020	1.630	2.556	1.104	1.665
										778	775	793	818	815	841	809	768	697	645	624	421	380	366	410	540	846	366	551
											775	793	818	815	841	809	768	697	645	624	421	380	365	356	347	303	134	182
												793	818	815	841	809	768	697	645	624	421	380	365	356	347	303	111	110
													818	815	841	809	768	697	645	624	421	380	365	356	347	303	111	110
														815	841	809	768	697	645	624	421	380	365	356	347	303	111	110
															841	809	768	697	645	624	421	380	365	356	347	303	111	110
																809	768	697	645	624	421	380	365	356	347	303	111	110
																	768	697	645	624	421	380	365	356	347	303	111	110
																		697	645	624	421	380	365	356	347	303	111	110
																			645	624	421	380	365	356	347	303	111	110
																				624	421	380	365	356	347	303	111	110
																					421	380	365	356	347	303	111	110
																						380	365	356	347	303	111	110
																							365	356	347	303	111	110
																								356	347	303	111	110
																									347	303	111	110
																										303	111	110
																											111	110
																												110

UAV without Flexibility	1.536
UAV with Flexibility	1.778
Premium	**241,48**

=MAX(S$105;($C$95*T425+$C$96*T426);S27)

= MAX(keeping option alive, abandonment, base value)

Asset Value with flexibility: Call Option – Expansion

2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1.770	3.116	5.251	8.445	13.755	22.385	36.515	58.701	92.384	141.301	209.807	309.096	460.604	678.563	991.029	1.416.121	2.042.656	2.963.257	4.063.197	5.656.452	6.472.096	5.456.619	8.055.269	13.256.559
	993	1.651	2.685	4.442	7.320	11.997	19.340	30.501	46.724	69.408	102.267	152.387	224.561	327.970	468.653	676.002	980.663	1.344.692	1.871.974	2.141.908	1.805.840	2.665.859	4.387.199
		547	868	1.401	2.335	3.883	6.313	10.020	15.424	22.943	33.818	50.425	74.310	108.534	155.092	223.714	324.540	445.014	619.515	708.849	597.629	882.255	1.451.919
			287	464	745	1.209	2.002	3.243	5.065	7.566	11.165	16.681	24.585	35.912	51.320	74.030	107.398	147.269	205.019	234.584	197.776	291.979	480.500
				153	247	400	641	1.010	1.637	2.477	3.668	5.513	8.129	11.878	16.978	24.493	35.536	48.731	67.844	77.628	65.447	96.629	159.013
					82	132	212	334	513	793	1.187	1.817	2.683	3.924	5.612	8.099	11.754	16.121	22.446	25.684	21.658	31.979	52.618
						44	70	111	170	253	374	594	881	1.292	1.851	2.674	3.883	5.328	7.422	8.493	7.168	10.583	17.407
							23	37	56	84	124	189	284	421	606	878	1.278	1.757	2.449	2.804	2.372	3.503	5.754
								12	19	28	41	61	90	133	194	284	416	575	804	921	785	1.159	1.898
									6	9	14	20	30	44	63	87	131	184	259	298	260	384	621
										3	4	7	10	14	21	29	39	54	79	93	86	127	205
											1	2	3	5	7	10	13	17	23	31	28	42	68
												1	1	2	2	3	4	6	8	10	9	14	22
													0	1	1	1	1	2	3	3	3	5	7
														0	0	0	0	1	1	1	1	2	2
															0	0	0	0	0	0	0	1	1
																0	0	0	0	0	0	0	0
																	0	0	0	0	0	0	0
																		0	0	0	0	0	0
																			0	0	0	0	0
																				0	0	0	0
																					0	0	0
																						0	0
																							0

UAV without Flexibility	1.536
UAV with Flexibility	1.770
Premium	**234,04**

=MAX((M450*$C$95+M451*$C$96);(SUM($M$245:$AB$245)*L271)-$AD$193;L20

=MAX(keeping option alive, expansion, base value)

Asset Value with combined Expansion and Contraction Option

2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1.824	3.116	5.251	8.445	13.755	22.385	36.515	58.701	92.384	141.301	209.807	309.096	460.482	678.563	991.029	1.416.121	2.042.656	2.963.230	4.063.197	5.656.452	6.472.096	5.456.619	8.055.269	13.256.559	21.421.053	34.233.045	53.665.924	23.192.290	34.964.681
	1.085	1.651	2.685	4.442	7.320	11.997	19.340	30.501	46.724	69.408	102.267	152.387	224.561	327.970	468.653	676.002	980.663	1.344.692	1.871.974	2.141.908	1.805.840	2.665.859	4.387.199	7.089.212	11.329.290	17.760.524	7.675.396	11.571.422
		776	992	1.433	2.335	3.883	6.313	10.020	15.424	22.943	33.818	50.425	74.310	108.534	155.092	223.714	324.540	445.014	619.515	708.849	597.629	882.255	1.451.919	2.346.147	3.749.383	5.877.775	2.540.142	3.829.516
			676	760	925	1.269	2.002	3.243	5.065	7.566	11.165	16.681	24.585	35.912	51.320	74.030	107.398	147.269	205.019	234.584	197.776	291.979	480.500	776.448	1.240.844	1.945.226	840.650	1.267.363
				657	692	750	861	1.099	1.637	2.477	3.668	5.513	8.129	11.878	16.978	24.493	35.536	48.731	67.844	77.628	65.447	96.629	159.013	256.962	410.652	643.765	278.210	419.429
					668	691	717	752	808	920	1.193	1.817	2.683	3.924	5.612	8.099	11.754	16.121	22.446	25.684	21.658	31.979	52.618	85.041	135.904	213.051	92.072	138.808
						688	709	731	754	778	791	851	972	1.292	1.851	2.674	3.883	5.328	7.422	8.493	7.168	10.583	17.407	28.144	44.977	70.509	30.471	45.938
							709	731	754	778	775	793	818	815	841	939	1.278	1.757	2.449	2.804	2.372	3.503	5.754	9.314	14.885	23.335	10.084	15.203
								731	754	778	775	793	818	815	841	809	768	697	804	921	785	1.159	1.898	3.082	4.926	7.722	3.337	5.031
									754	778	775	793	818	815	841	809	768	697	645	624	421	455	629	1.020	1.630	2.556	1.104	1.665
										778	775	793	818	815	841	809	768	697	645	624	421	380	366	410	540	846	366	551
											775	793	818	815	841	809	768	697	645	624	421	380	365	356	347	303	134	182
												793	818	815	841	809	768	697	645	624	421	380	365	356	347	303	111	110
													818	815	841	809	768	697	645	624	421	380	365	356	347	303	111	110
														815	841	809	768	697	645	624	421	380	365	356	347	303	111	110
															841	809	768	697	645	624	421	380	365	356	347	303	111	110
																809	768	697	645	624	421	380	365	356	347	303	111	110
																	768	697	645	624	421	380	365	356	347	303	111	110
																		697	645	624	421	380	365	356	347	303	111	110
																			645	624	421	380	365	356	347	303	111	110
																				624	421	380	365	356	347	303	111	110
																					421	380	365	356	347	303	111	110
																						380	365	356	347	303	111	110
																							365	356	347	303	111	110
																								356	347	303	111	110
																									347	303	111	110
																										303	111	110
																											111	110
																												110

UAV without Flexibility	1.536
UAV with Flexibility	1.824
Premium	**288,30**

=MAX(O$105;($C$95*P356+$C$96*P357);O23;(SUM($P$248:$AB$248)*O274)-$AD$196)

= MAX(abandonment, wait and see, base value, expansion)

Abandonment Option: Calculation of Payoff Structure

The payoff from abandonment was established by discounting the book values in each period by a corresponding adjustment factor. As explained in the body of the thesis, the Liquidation Discount factor were established after reviewing empirical studies. The results are shown below.

<u>Put: 2012 - 2026</u>

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Operating Working Capital	120,26	199,66	264,86	291,78	282,77	283,65	315,32	305,24	313,28	336,58	340,57	318,84	307,53	323,49	296,92
Net PP&E (tangible)	556,98	736,65	912,55	1.017,74	1.120,71	1.113,12	1.105,69	1.098,42	1.075,29	1.052,66	1.030,50	1.008,81	987,57	966,79	946,43
Net Mining PP&E (Intangible)	1.250,37	1.207,96	1.154,02	1.090,24	1.028,31	964,14	891,42	821,76	754,10	683,94	617,02	554,76	493,30	429,38	370,90
Exploration and evaluation (Intangible)	219,84	237,34	241,63	246,24	250,61	254,84	259,47	263,96	268,65	273,77	279,03	283,98	288,74	293,72	298,30
Capitalised Operating Leases	63,56	80,53	91,47	91,18	95,35	107,66	104,27	104,80	110,59	109,83	102,48	99,28	104,90	96,39	104,52
Intangible - Port allocation	56,82	55,28	53,12	50,33	47,59	44,80	41,27	37,96	34,83	31,47	28,39	25,66	22,92	19,96	17,43
Invested Capital	**2.267,83**	**2.517,43**	**2.717,64**	**2.787,50**	**2.825,34**	**2.768,21**	**2.717,44**	**2.632,14**	**2.556,74**	**2.488,25**	**2.398,01**	**2.291,32**	**2.204,96**	**2.129,73**	**2.034,51**
Discount assumptions															
-Operating Working Capital	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
-Net PP&E	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60
-Net Mining PP&E (Intangible)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-Exploration and evaluation (Intangible)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-Capitalised Operating Leases	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-Intangible - Port allocation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Liquidation Value															
-Operating Working Capital	120,26	199,66	264,86	291,78	282,77	283,65	315,32	305,24	313,28	336,58	340,57	318,84	307,53	323,49	296,92
-Net PP&E	334,19	441,99	547,53	610,64	672,43	667,87	663,41	659,05	645,18	631,60	618,30	605,29	592,54	580,07	567,86
-Net Mining PP&E (Intangible)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-Exploration and evaluation (Intangible)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-Capitalised Operating Leases	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-Intangible - Port allocation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Value of assets	**454,44**	**641,65**	**812,38**	**902,42**	**955,20**	**951,53**	**978,73**	**964,29**	**958,45**	**968,17**	**958,87**	**924,13**	**900,08**	**903,56**	**864,78**
Liquidation Discount	20%	25%	30%	32%	34%	34%	36%	37%	37%	39%	40%	40%	41%	42%	43%
Rail and Port Contractual Obligation															
-Donaldson	470,50	423,45	376,40	329,35	282,30	235,25	188,20	141,15	94,10	47,05	-	-	-	-	-
-Middlemount	455,70	425,32	394,94	364,56	334,18	303,80	273,42	243,04	212,66	182,28	151,90	121,52	91,14	60,76	30,38
Provision															
-Rehabilitation	10,68	10,68	10,68	10,68	10,68	10,68	10,68	10,68	10,68	10,68	10,68	10,68	10,68	10,68	10,68
-Dismantling	7,04	7,60	8,21	8,87	9,58	10,34	11,17	12,07	13,03	14,07	15,20	16,41	17,73	19,15	20,68
Early abandonment	37,18	36,61	36,01	35,35	34,64	33,87	33,05	32,15	31,19	30,15	29,02	27,80	26,49	25,07	23,54
Cost of Abandonment	**963,38**	**885,38**	**807,35**	**729,26**	**651,12**	**572,92**	**494,67**	**416,34**	**337,95**	**259,48**	**180,92**	**149,32**	**117,63**	**85,83**	**53,92**
Payoff from put	**-508,93**	**-243,73**	**5,04**	**173,16**	**304,08**	**378,60**	**484,07**	**547,95**	**620,50**	**708,70**	**777,96**	**774,81**	**782,45**	**817,73**	**810,86**

Abandonment Option: Calculation of Payoff Structure

Put: 2027 - 2040

	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Operating Working Capital	320,54	311,98	292,89	242,67	209,35	206,85	108,35	79,80	77,75	79,64	81,58	49,22	28,42	29,11
Net PP&E (tangible)	903,09	861,73	822,26	784,60	748,67	714,38	540,34	515,59	491,98	469,44	447,94	427,43	140,84	134,39
Net Mining PP&E (Intangible)	309,42	250,15	192,35	141,95	101,05	60,45	44,98	34,85	25,38	15,92	6,46	2,34	1,56	0,78
Exploration and evaluation (Intangible)	303,22	307,99	312,45	316,13	319,32	322,46	324,08	325,27	326,42	327,60	328,80	329,53	329,95	330,39
Capitalised Operating Leases	102,18	96,59	80,27	68,86	68,56	36,49	26,86	26,26	27,03	27,82	16,63	9,39	9,66	9,94
Intangible - Port allocation	14,63	12,01	9,45	7,46	6,32	5,06	3,81	3,01	2,27	1,53	0,79	0,51	-	-
Invested Capital	**1.953,09**	**1.840,45**	**1.709,68**	**1.561,67**	**1.453,27**	**1.345,69**	**1.048,41**	**984,78**	**950,83**	**921,95**	**882,20**	**818,41**	**510,44**	**504,62**
Discount assumptions														
-Operating Working Capital	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
-Net PP&E	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60
-Net Mining PP&E (Intangible)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-Exploration and evaluation (Intangible)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-Capitalised Operating Leases	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-Intangible - Port allocation	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Liquidation Value														
-Operating Working Capital	320,54	311,98	292,89	242,67	209,35	206,85	108,35	79,80	77,75	79,64	81,58	49,22	28,42	29,11
-Net PP&E	541,85	517,04	493,36	470,76	449,20	428,63	324,20	309,35	295,19	281,67	268,77	256,46	84,50	80,63
-Net Mining PP&E (Intangible)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-Exploration and evaluation (Intangible)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-Capitalised Operating Leases	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-Intangible - Port allocation	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Value of assets	**862,40**	**829,02**	**786,25**	**713,43**	**658,55**	**635,47**	**432,55**	**389,16**	**372,93**	**361,30**	**350,34**	**305,68**	**112,93**	**109,75**
Liquidation Discount	44%	45%	46%	46%	45%	47%	41%	40%	39%	39%	40%	37%	22%	22%
Rail and Port Contractual Obligation														
-Donaldson	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-Middlemount	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Provision														
-Rehabilitation	10,68	10,68	10,68	10,68	10,68	10,68	7,12	7,12	7,12	7,12	7,12	3,56	3,56	3,56
-Dismantling	22,33	24,12	26,05	28,13	30,38	32,81	23,63	25,52	27,56	29,76	32,14	17,36	18,75	20,24
Early abandonment	21,89	20,10	18,17	16,09	13,84	11,40	11,40	9,51	7,47	5,27	2,89	2,89	1,50	-
Cost of Abandonment	**21,89**	**20,10**	**18,17**	**16,09**	**13,84**	**11,40**	**11,40**	**9,51**	**7,47**	**5,27**	**2,89**	**2,89**	**1,50**	-
Payoff from put	**840,51**	**808,92**	**768,08**	**697,34**	**644,71**	**624,07**	**421,15**	**379,64**	**365,46**	**356,04**	**347,45**	**302,79**	**111,43**	**109,75**

Expansion Option: Calculation of Payoff Structure

1) In order to determine the FCF effect of an increase in production from Gloucester/Donaldson the weighted average contribution of the mines were compared. For each period a gross margin per tonne of coal was calculated for Middlemount and for Gloucester/Donaldson. This was calculated by factoring in production mix (type of coal), cost data and also coal price assumption.

Gloucester & Donaldson	Note	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Gross Margin per tonne	1	34,4	45,0	47,5	38,1	30,8	25,3	19,1	16,1	17,3	17,8	18,2	17,8	17,1	16,5	16,3	15,8	14,9	13,0	11,2	13,0	10,8
Middlemount		**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Gross Margin per tonne	2	62,6	87,2	76,8	64,1	53,8	44,8	34,5	28,3	30,4	31,2	31,8	32,0	32,2	32,4	32,5	32,6	31,5	30,3	29,1	27,8	26,4
Adjustment Factor	**2/1**	**1,82**	**1,94**	**1,62**	**1,68**	**1,75**	**1,77**	**1,80**	**1,76**	**1,76**	**1,75**	**1,75**	**1,80**	**1,88**	**1,96**	**1,99**	**2,06**	**2,11**	**2,33**	**2,59**	**2,13**	**2,44**

2) The adjustment factor provides for the fact that Middlemount is a higher margin mine than that of Gloucester and Donaldson. The free cash flows calculated in each period were then divided by total production. This was after scaling Middlemount production by the adjustment factor (which leads to a lower FCF figure per tonne generated from Gloucester and Donaldson).

DCF Cash Flows	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
FCF	-92,66	90,08	189,03	154,40	167,15	151,03	178,46	218,80	271,24	315,20	318,25	279,24	275,64	270,65	271,37
Time	1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00	11,00	12,00	13,00	14,00	15,00
Discount Factor	0,91	0,83	0,76	0,69	0,63	0,58	0,53	0,48	0,44	0,40	0,36	0,33	0,30	0,28	0,25
PV cash flow	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	125,72	115,79	92,67	83,45	74,74	68,36
Average/tonne	-12,25	7,97	13,54	10,18	9,68	7,19	8,23	9,45	10,43	11,49	11,76	10,04	8,82	8,92	7,74
Adj value/mine contribu	**-10,06**	**7,13**	**11,99**	**8,97**	**8,48**	**6,35**	**7,26**	**8,31**	**9,22**	**10,10**	**10,12**	**8,43**	**7,34**	**7,22**	**6,24**

DCF Cash Flows	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
FCF	289,50	280,10	252,45	197,31	186,22	299,77	56,26	24,31	19,10	29,68	36,41	275,54	13,26	12,64	90,31
Time	16,00	17,00	18,00	19,00	20,00	21,00	22,00	23,00	24,00	25,00	26,00	27,00	28,00	29,00	30
Discount Factor	0,23	0,21	0,19	0,17	0,16	0,15	0,13	0,12	0,11	0,10	0,09	0,08	0,08	0,07	0,06
PV cash flow	66,52	58,71	48,27	34,41	29,63	43,50	7,45	2,94	2,10	2,98	3,34	23,04	1,01	0,88	5,73
Average/tonne	7,95	7,67	7,91	6,88	6,11	8,21	3,72	1,54	1,11	1,57	3,03	38,39	1,69	1,47	-
Adj value/mine contribu	**6,28**	**5,69**	**5,20**	**4,73**	**3,91**	**8,21**	**3,72**	**1,54**	**1,11**	**1,57**	**3,03**	**38,39**	**1,69**	**1,47**	-

3) The production uplift was then calculated for each decision node. The total production figures were cross checked to ensure that only the amount of resources available where factored into the model, i.e., to ensure there was no over counting of production.

4) The free cash flow at each time period was calculated based upon the production profile and the cash flow contribution calculated in steps 1 & 2. The free cash flow are shown below:

Decision Node	Free Cash Flow	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	PV wrap up
2012	2014	-84,52	99,91	185,44	138,28	135,25	109,23	119,19	133,98	150,86	161,08	151,22	122,17	109,12	76,95	25,71	26,50	26,52	26,93	20,21	18,11	20,51	-	-	-	-	30,14
2013	2015	-84,52	74,95	185,44	138,28	135,25	109,23	119,19	133,98	150,86	161,08	151,22	122,17	109,12	100,00	27,61	26,50	26,52	26,93	20,21	18,11	20,51	-	-	-	-	30,14
2014	2016	-84,52	74,95	143,48	138,28	135,25	109,23	119,19	133,98	150,86	161,08	151,22	122,17	109,12	100,00	49,46	26,50	26,52	26,93	20,21	18,11	20,51	-	-	-	-	30,14
2015	2017	-84,52	74,95	143,48	106,90	135,25	109,23	119,19	133,98	150,86	161,08	151,22	122,17	109,12	100,00	71,31	26,50	26,52	26,93	20,21	18,11	20,51	-	-	-	-	30,14
2016	2018	-84,52	74,95	143,48	106,90	105,57	109,23	119,19	133,98	150,86	161,08	151,22	122,17	109,12	100,00	90,21	29,47	26,52	26,93	20,21	18,11	20,51	-	-	-	-	30,14
2017	2019	-84,52	74,95	143,48	106,90	105,57	87,01	119,19	133,98	150,86	161,08	151,22	122,17	109,12	100,00	90,21	51,47	26,52	26,93	20,21	18,11	20,51	-	-	-	-	30,14
2018	2020	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	133,98	150,86	161,08	151,22	122,17	109,12	100,00	90,21	73,47	26,52	26,93	20,21	18,11	20,51	-	-	-	-	30,14
2019	2021	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	150,86	161,08	151,22	122,17	109,12	100,00	90,21	88,52	32,81	26,93	20,21	18,11	20,51	-	-	-	-	30,14
2020	2022	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	161,08	151,22	122,17	109,12	100,00	90,21	88,52	52,73	26,93	20,21	18,11	20,51	-	-	-	-	30,14
2021	2023	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	125,72	151,22	122,17	109,12	100,00	90,21	88,52	72,66	26,93	20,21	18,11	20,51	-	-	-	-	30,14
2022	2024	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	125,72	115,79	122,17	109,12	100,00	90,21	88,52	78,64	39,68	20,21	18,11	20,51	-	-	-	-	30,14
2023	2025	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	125,72	115,79	92,67	109,12	100,00	90,21	88,52	78,64	57,90	20,21	18,11	20,51	-	-	-	-	30,14
2024	2026	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	125,72	115,79	92,67	83,45	100,00	90,21	88,52	78,64	66,48	28,97	18,11	20,51	-	-	-	-	30,14
2025	2027	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	125,72	115,79	92,67	83,45	74,74	90,21	88,52	78,64	66,48	45,54	18,11	20,51	-	-	-	-	30,14
2026	2028	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	125,72	115,79	92,67	83,45	74,74	68,36	88,52	78,64	66,48	50,98	27,28	20,51	-	-	-	-	30,14
2027	2029	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	125,72	115,79	92,67	83,45	74,74	68,36	66,52	78,64	66,48	50,98	40,95	20,51	-	-	-	-	30,14
2028	2030	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	125,72	115,79	92,67	83,45	74,74	68,36	66,52	58,71	66,48	50,98	43,30	44,32	-	-	-	-	30,14
2029	2031	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	125,72	115,79	92,67	83,45	74,74	68,36	66,52	58,71	48,27	50,98	43,30	72,25	0,37	-	-	-	30,14
2030	2032	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	125,72	115,79	92,67	83,45	74,74	68,36	66,52	58,71	48,27	34,41	43,30	72,25	13,41	-	-	-	30,14
2031	2033	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	125,72	115,79	92,67	83,45	74,74	68,36	66,52	58,71	48,27	34,41	29,63	72,25	20,48	2,47	-	-	30,14
2032	2034	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	125,72	115,79	92,67	83,45	74,74	68,36	66,52	58,71	48,27	34,41	29,63	43,50	20,48	7,88	-	-	30,14
2033	2035	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	125,72	115,79	92,67	83,45	74,74	68,36	66,52	58,71	48,27	34,41	29,63	43,50	7,45	8,34	3,54	-	30,14
2034	2036	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	125,72	115,79	92,67	83,45	74,74	68,36	66,52	58,71	48,27	34,41	29,63	43,50	7,45	2,94	5,98	2,04	30,14
2035	2037	-84,52	74,95	143,48	106,90	105,57	87,01	93,78	104,88	118,60	125,72	115,79	92,67	83,45	74,74	68,36	66,52	58,71	48,27	34,41	29,63	43,50	7,45	2,94	2,10	7,53	30,14

5) To apply this to a ROV model, the free cash flows where scaled by multiplying the summation of the Free Cash Flows by the stochastic binomial lattice model as shown below. As an example. The decision node in 2014 was summed and then multiplied by one of the three factors shown below. This produced three possible payoffs in 2014.

Binomial Grid - stochastic process

2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
1,00	1,649	2,72	4,48	7,39	12,18	20,09	33,12	54,60	90,02	148,41	244,69	403,43	665,14	1.096,63	1.808,04	2.980,96	4.914,77	8.103,08	13.359,73	22.026,47	36.315,50	59.874,14	98.715,77	162.754,79	268.337,29
	0,61	1,00	1,65	2,72	4,48	7,39	12,18	20,09	33,12	54,60	90,02	148,41	244,69	403,43	665,14	1.096,63	1.808,04	2.980,96	4.914,77	8.103,08	13.359,73	22.026,47	36.315,50	59.874,14	98.715,77
		0,37	0,61	1,00	1,65	2,72	4,48	7,39	12,18	20,09	33,12	54,60	90,02	148,41	244,69	403,43	665,14	1.096,63	1.808,04	2.980,96	4.914,77	8.103,08	13.359,73	22.026,47	36.315,50
			0,22	0,37	0,61	1,00	1,65	2,72	4,48	7,39	12,18	20,09	33,12	54,60	90,02	148,41	244,69	403,43	665,14	1.096,63	1.808,04	2.980,96	4.914,77	8.103,08	13.359,73
				0,14	0,22	0,37	0,61	1,00	1,65	2,72	4,48	7,39	12,18	20,09	33,12	54,60	90,02	148,41	244,69	403,43	665,14	1.096,63	1.808,04	2.980,96	4.914,77
					0,08	0,14	0,22	0,37	0,61	1,00	1,65	2,72	4,48	7,39	12,18	20,09	33,12	54,60	90,02	148,41	244,69	403,43	665,14	1.096,63	1.808,04
						0,05	0,08	0,14	0,22	0,37	0,61	1,00	1,65	2,72	4,48	7,39	12,18	20,09	33,12	54,60	90,02	148,41	244,69	403,43	665,14
							0,03	0,05	0,08	0,14	0,22	0,37	0,61	1,00	1,65	2,72	4,48	7,39	12,18	20,09	33,12	54,60	90,02	148,41	244,69
								0,02	0,03	0,05	0,08	0,14	0,22	0,37	0,61	1,00	1,65	2,72	4,48	7,39	12,18	20,09	33,12	54,60	90,02
									0,01	0,02	0,03	0,05	0,08	0,14	0,22	0,37	0,61	1,00	1,65	2,72	4,48	7,39	12,18	20,09	33,12
										0,01	0,01	0,02	0,03	0,05	0,08	0,14	0,22	0,37	0,61	1,00	1,65	2,72	4,48	7,39	12,18
											0,00	0,01	0,01	0,02	0,03	0,05	0,08	0,14	0,22	0,37	0,61	1,00	1,65	2,72	4,48
												0,00	0,00	0,01	0,01	0,02	0,03	0,05	0,08	0,14	0,22	0,37	0,61	1,00	1,65
													0,00	0,00	0,00	0,01	0,01	0,02	0,03	0,05	0,08	0,14	0,22	0,37	0,61
														0,00	0,00	0,00	0,00	0,01	0,01	0,02	0,03	0,05	0,08	0,14	0,22
															0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,02	0,03	0,05	0,08
																0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,02	0,03
																	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,01
																		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
																			0,00	0,00	0,00	0,00	0,00	0,00	0,00
																				0,00	0,00	0,00	0,00	0,00	0,00
																					0,00	0,00	0,00	0,00	0,00
																						0,00	0,00	0,00	0,00
																							0,00	0,00	0,00
																								0,00	0,00
																									0,00

6) The strike price in each period was then subtracted from the results in step 5. This obtained the value from expansion and drives the values in the expansion option tree. The strike value was adjusted depending on the capacity needed to reach the 3.5mt uplift in production.

Appendix D: Coal Information

Types of coal

Coal can be separated into two main groups: hard coals and low rank (soft) coals. The focus of this thesis is on hard coals, which constitute 53% of the known reserves and the majority of industry production. The global statistics are shown below:

Hard Coals	Anthracite	1%
	Bituminous: Thermal Steam Coal and Coking Coal	52%
Low Rank (soft) Coals	Sub-Bituminous	30%
	Lignite	17%

Source: compiled from data provided by The World Coal Institute (2005).

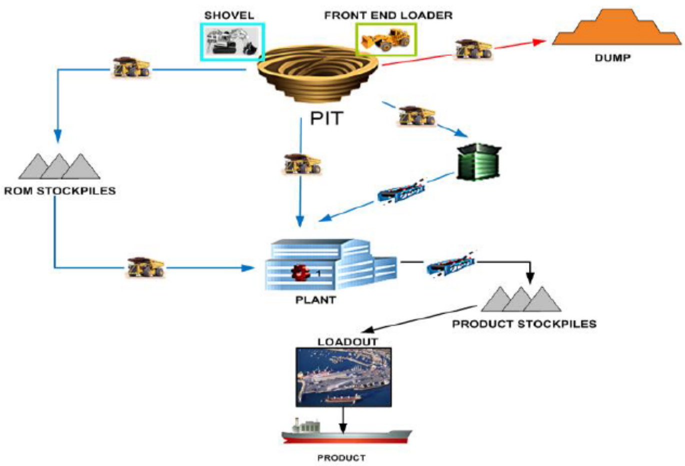
The table below shows the five countries with the largest coal reserves. The top 5 coal countries account for 78% of the known reserves and 71% of total global production. China by far produces at the highest production to reserve ratio, as shown below:

Mn tonnes	Proven Resources		Production	
United States	238.308	29%	1.039,30	15%
Russia	157.010	19%	315,00	5%
China	114.500	14%	2.536,00	38%
Australia	76.200	9%	391,10	6%
India	58.600	7%	478,40	7%
Top 5	644.618	78%	4.759,80	71%
Total	826.001	100%	6.732,00	100%

Source: compiled from data provided by The World Energy Council (2009).

Typical Production Process

The typical coal production process is shown below. The Plant is referred to as the CHPP (Coal handling and processing plant). The coal can be either railed from the mine to the processing plant or transported by truck.



Australian Coal Companies

The industry has gone through a strong period of consolidation primarily driven by two factors: strong support from resource seeking nations such as China and diversified mining giants strengthening production capacity. An article published in The Australian (Fitzgerlad, 2012) highlighted that there were $30 billion of completed M&A deals in the Australian Coal sector. This has reduced the number of pure coal miners to less than six companies. Comparable Australian coal mining companies are: Whitehaven Coal, Macarthur Coal (for historical comparisons as it has now been acquired by Peabody Energy) & New Hope Corp. Furthermore, according to The Wall Street Journal (Winning, Blogs WSJ, 2012), these companies control less than 5% of Australia's total output in 2011. This is further supported by data from IBISworld (2012), the largest 4 diversified miners with interests in coal control 45.4% of the market.

Competitive Substitutes

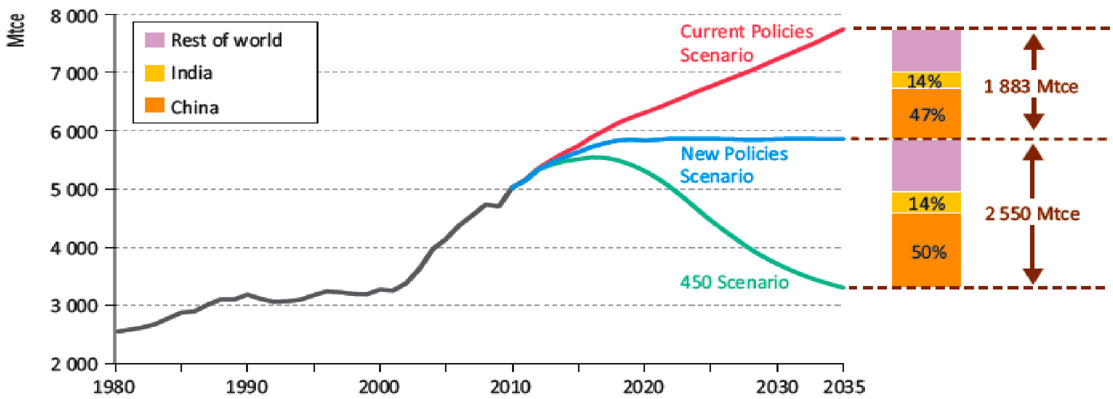
As discussed, coal is a major input used in the production of electricity. Various substitutes exist and are used to produce electricity, namely: natural gas, nuclear, wind energy and hydropower. Due to current infrastructure it's expected that natural gas will alleviate some of the burden in energy consumption, the majority being in developed nations, as countries push to meet $C0^2$ reduction targets. Though, according to OPEC data, fossil fuels are expected to represent 80% of the global energy demand over the next twenty-years (World Energy Council, 2011). Whilst coal has its substitutes, the U.S. Energy Information Administration forecasts coal will continue to fuel a large share of the world's demand for energy – in 2035 coal is expected to supply 27% of total energy; similar to current levels (U.S. Energy Information Administration, 2011).

Competition

The main driver of competition is price: customers are concerned with the total delivered price of coal and therefore miners located closer to the end customer are able to benefit over competitors. For miners, quality considerations affect the price received. Miners producing soft coking coals have the advantage of switching between markets. These lower ranking coking coals do not necessarily receive a premium over steam coals with similar energy content and are sometimes used for electricity generation. Therefore in times of high demand from still mills, further pressure is placed on thermal coal prices due to a tightening of supply (International Energy Agency, 2011). Coal miners may either wash the coal, reducing the amount of impurities (reduces the volume as well) and sell it in the coking market or opt to cut out the washing process, saving the associated costs and sell the higher volume in the thermal market. Lastly, customers are also concerned with security of supply and therefore companies with solid reputations, and mines located in geopolitical safe environments carry an added advantage. This being said, mining companies cannot effectively differentiate their product. The resource is a commoditised product and will sell in the market at market prices with adjustments made for the product specific characteristics i.e., energy content

Coal Production & Consumption

The IEA world energy outlook report (2011) highlights three main policy scenarios. These scenarios are based primarily on governmental policy. The first scenario makes forecasts based on the current policy environment. The second is termed the new policy scenario, this being the central scenario in the report, which combines the commitments announced by countries around the world. The last scenario is the 450 scenario, this is the predicted forecasts required (with a 50% chance) of meeting the goal of limiting the increase in average global temperatures by two degrees Celsius. The graph below highlights the expected developments in demand.



*Includes hard coal (coking and steam coal), brown coal (sub-bituminous coal and lignite) and peat.

Source: World Energy Outlook 2011 (International Energy Agency, 2011, p. 356)

Based on the IEA forecasts; the current policy scenario forecasts coal to grow at 1.8% per annum, if politicians stick to announced commitments then growth will be substantially lower at 0.7% per year on average (well below the 30 year average of 2.3%), if policy makers agree on suggested climate restriction levels (450 Scenario though is unlikely) then coal demand is forecasted to decline by 1.5% per annum. This establishes the fact that uncertainty in forecasted demand exists. However, as shown by the chart above, the majority of these commitments required are from China (most importantly) and India. Therefore these two nations will play a crucial role in deciding the energy mix going forward. A focus on understanding Chinese Energy policies and also China's domestic coal production issues is of primary importance when assessing the global seaborne coal market. This has been established and presented in the body of the thesis.

Australian Coal Export Data

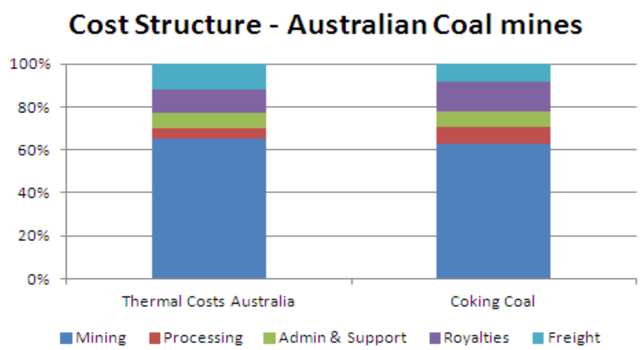
The table below presents historical export production volumes and value.

Australian Coal Export Production			2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Coking Coal	Volume	Mt	107,79	111,73	124,92	120,48	131,97	136,92	125,24	157,26	140,46
	Value	$m	7.448	6.510	10.758	17.003	15.039	16.038	36.813	24.526	29.793
	Unit Value	$/t	69,09	58,26	86,12	141,13	113,96	117,14	293,94	155,95	212,11
Thermal Coal	Volume	Mt	99,95	106,69	106,4	110,82	111,62	115,07	136,36	134,97	143,32
	Value	$m	4.448	4.372	6.336	7.206	6.758	8.365	17.885	11.884	13.956
	Unit Value	$/t	44,50	40,98	59,55	65,02	60,54	72,70	131,16	88,05	97,38
	Total Export Value	$m	11.896	10.882	17.094	24.209	21.797	24.404	54.698	36.410	43.749
	Total Export Volume	Mt	207,74	218,42	231,32	231,30	243,59	251,99	261,60	292,23	283,78
	Total Production	Mt	274,85	283,96	303,44	306,92	325,43	326,62	333,77	356,62	345,00
	Export % of Prod.		76%	77%	76%	75%	75%	77%	78%	82%	82%

Source: ABS, International Trade, Australia, cat no. 5465.0, Canberra; Department of Foreign Affairs and Trade & BREE, Ressource and Energy Statistics, December Quarter 2011, BREE, Canberra

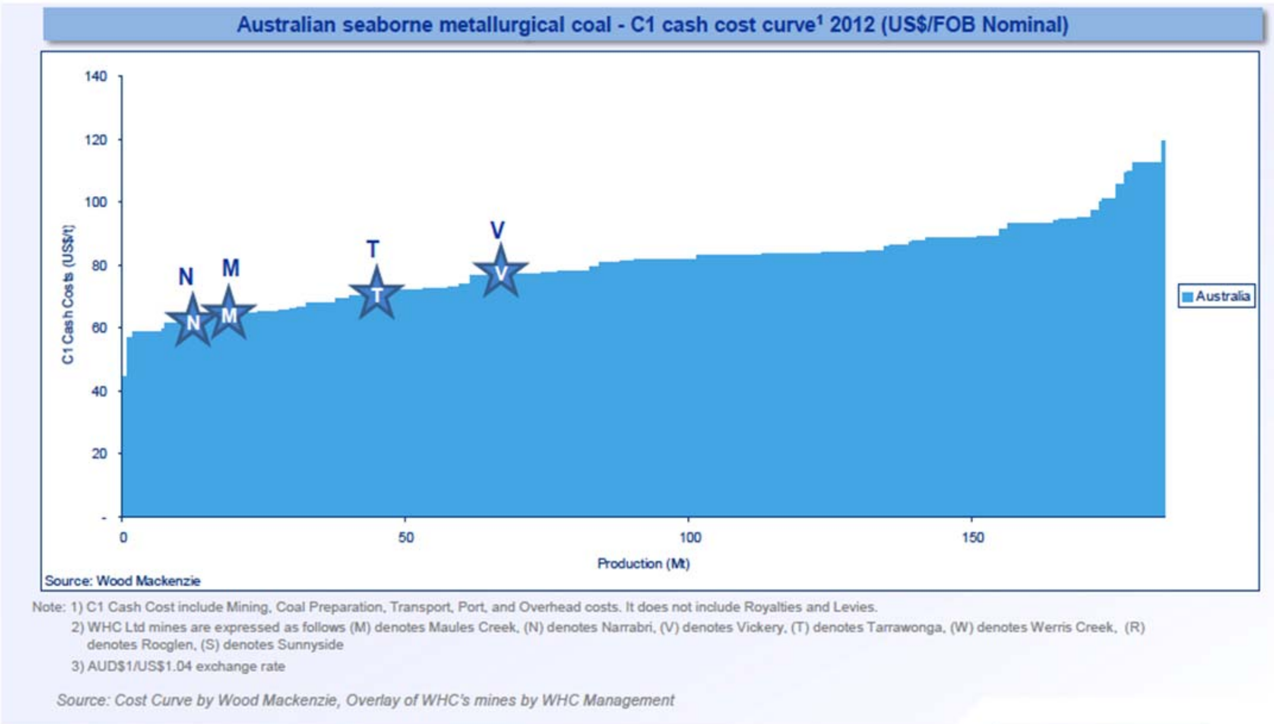
Coal Production Cost Breakdown

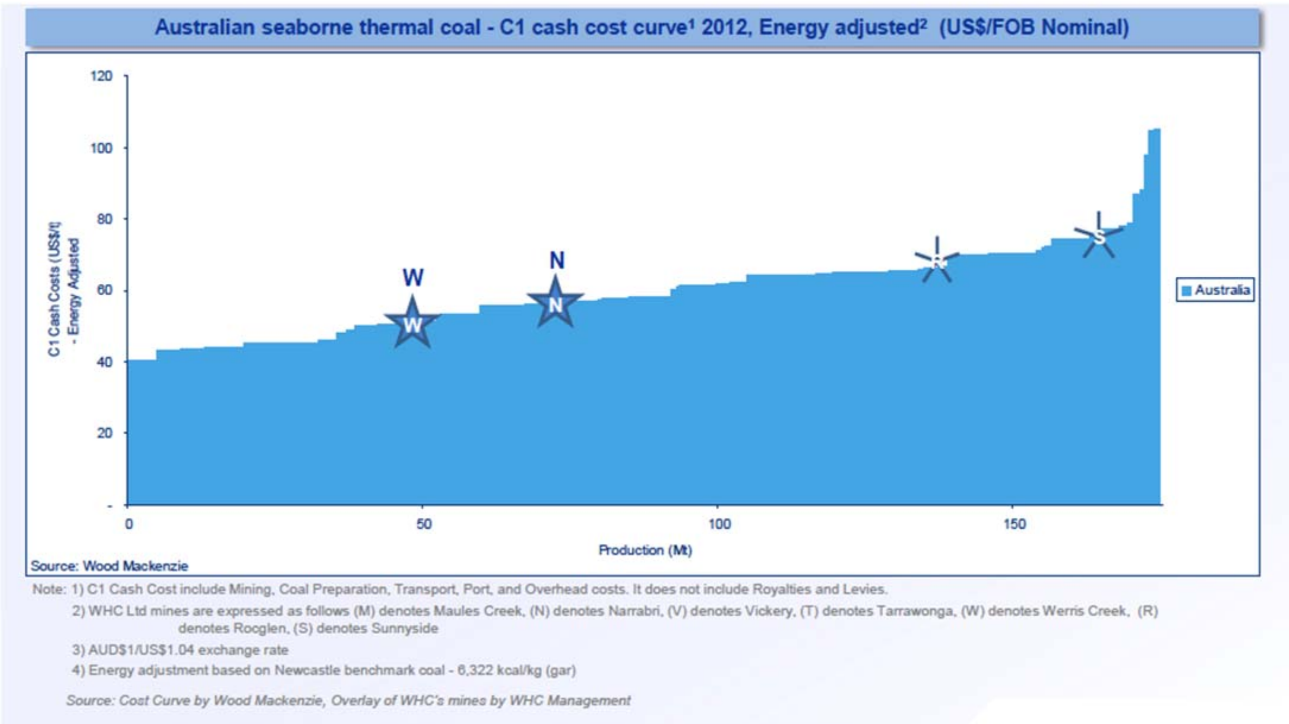
An Australian wide thermal and coking coal cost structure breakdown was charted based upon data provided by AME Group Pty Limited. The chart highlights that onsite mining costs are by far the largest cost faced by coal miners.



Source (AME Group Pty Limited, 2012c)
(AME Group Pty Limited, 2012d)

The industry cost curve for Thermal and Metallurgical (coking) coal are presented below:



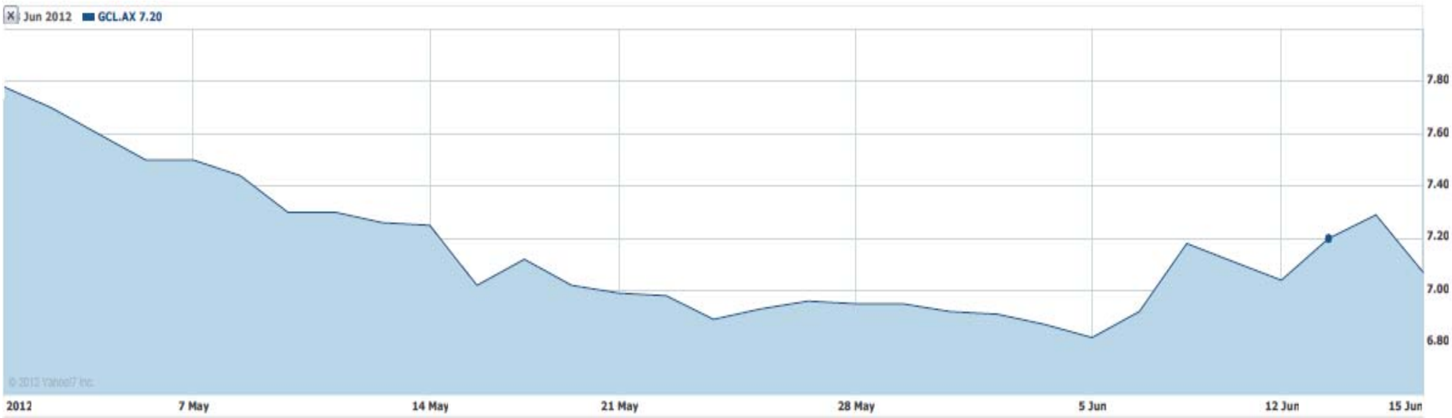


Appendix E: Gloucester Coal and Australian Coal miners stock prices

The below chart shows Gloucester Coal's stock price over a five year period

Source: Yahoo Finance

The strong stock price performance in 2010 & 2011 was namely attributable to a cash offer by the Noble Group to acquire additional shares. Refer to the appendix F for an historical snapshot of Gloucester's major events. The most recent six week trading data (1st May 2012 to 15th June 2012) is also presented.



Source: Yahoo Finance

Gloucester's stock was reviewed over a five-year period. The company's stock has underperformed that of two of its peers (Whitehaven Coal and New Hope Corporation). Due to the limited number of pure play coal companies it was decided that these two companies would provide the best comparison. The performance is somewhat skewed due to the strong performance at the start of the comparison period (2008). The jump in the share price in the first 6 months in 2008 was primarily driven by takeover speculation, with Gloucester coal being touted as good value amongst its peers during a strong period of consolidation in the sector[27].

Source: Yahoo Finance

---

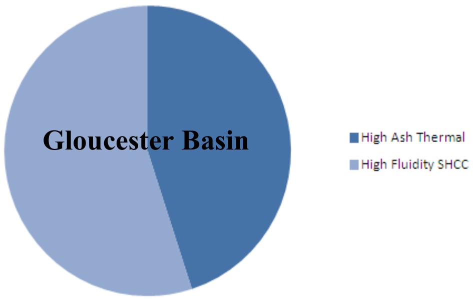
[27] See Bloomberg article for further information:
http://www.bloomberg.com/apps/news?pid=newsarchive&sid=aUYWHWrxkTow&refer=australia

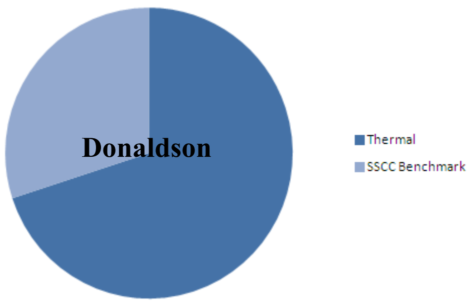
Appendix F: Gloucester Asset Overview

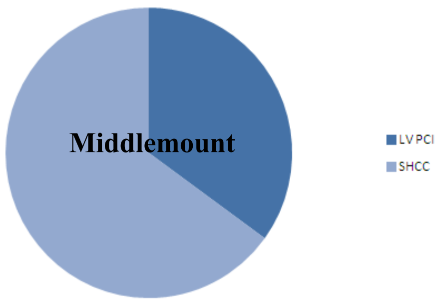
The table below highlights the major assets of Gloucester coal: Gloucester Basin, Donaldson, Middlemount and Monash.

	Mine	Gloucester Basin	Donaldson	Middlemount	Monash
Project Overview	**Project**	Duralie & Stratford	Abel & Tasman (undergound mines) Donaldson (open cut mine)	Middlemount	Monash
	Mine type	open cut	combination	open cut	underground
	Ownership	100%	100%	50%	100%
	Status	Production	Production	Production	Exploration
	Project location	Gloucester Basin, NSW	Newcastle Coalfield, NSW	Bowen Basin QLD	Hunter Valley, NSW
	Description	Stratford: located 95kms North of Newcastle. ROM coal is processed onsite at Stratford CHPP then transported via rail to NCIG (Newcastle Port). Duralie: 20kms south of Stratford operations in the southern part of Gloucester Basin. The coal is transported via shuttle train to Stratford and processed at CHPP. Final product is then exported via NCIG. Both projects utilise a truck and shovel method of excavation	Donaldson & Abel: Located 25kms from Port of Newcastle. Abel underground mine portal located at high wall of Donaldson mine. ROM is processed at Bloomfield CHPP - requiring coal to be trucked 1.6kms. Final product is then transported via rail to port. Tasman: Located south of Maitland, 20kms from port of Newcastle. Mined coal is transported 16 kms by truck to Bloomfield CHPP for processing. Open cut projects use a truck and shovel method of excavation whilst underground mine uses a board and pillar process	Located 6kms south of Middlemount. ROM coal is processed at CHPP onsite. Queensland National Rail is contracted (take or pay basis) to transport 3mtpa. Middlemount uses an open cut truck and shovel method of mining. Resources below are quoted on a pro rata basis.	Located 12kms from rail line and 95kms from the Port of Newcastle. Mine located in a region that is serviced by the Hunter Valley rail network. Drilling commenced August 2011
Resources	**CCHP Capacity**	600 tonnes/hour 5.3 ROM Mtpa	455 tonnes/hour expanding to 913t/h 4 ROM Mtpa - 8mpta (2015)	400 tonnes/hour expanding to 700 t/h 3.5 ROM Mtpa - 6.125 Rom Mtpa	
	Products	SHCC & Thermal	SSCC & Thermal	HCC & Low Volatile PCI	SSCC & Thermal
	Proved resources	13,3	115,9	34,5	0
	Reserves	87	160,7	48	0
	Resources	316	885	61,3	577

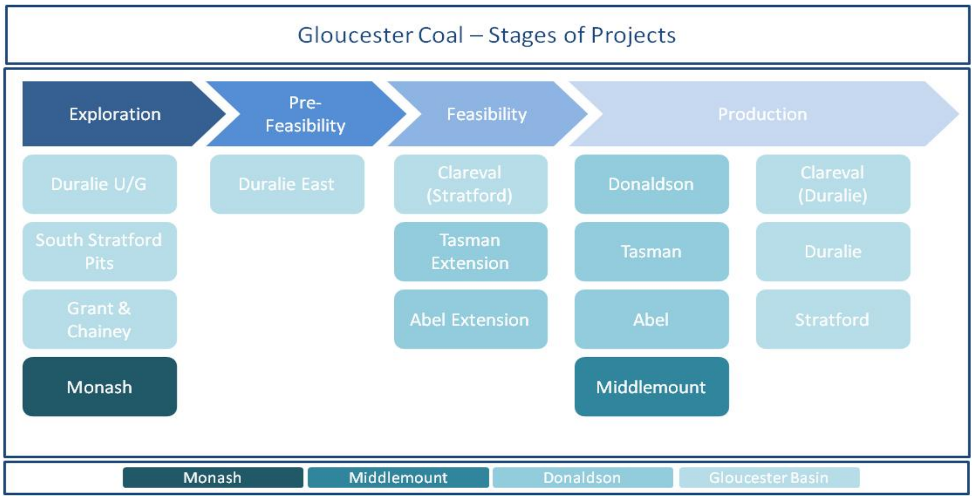
Forecasted Production profile:



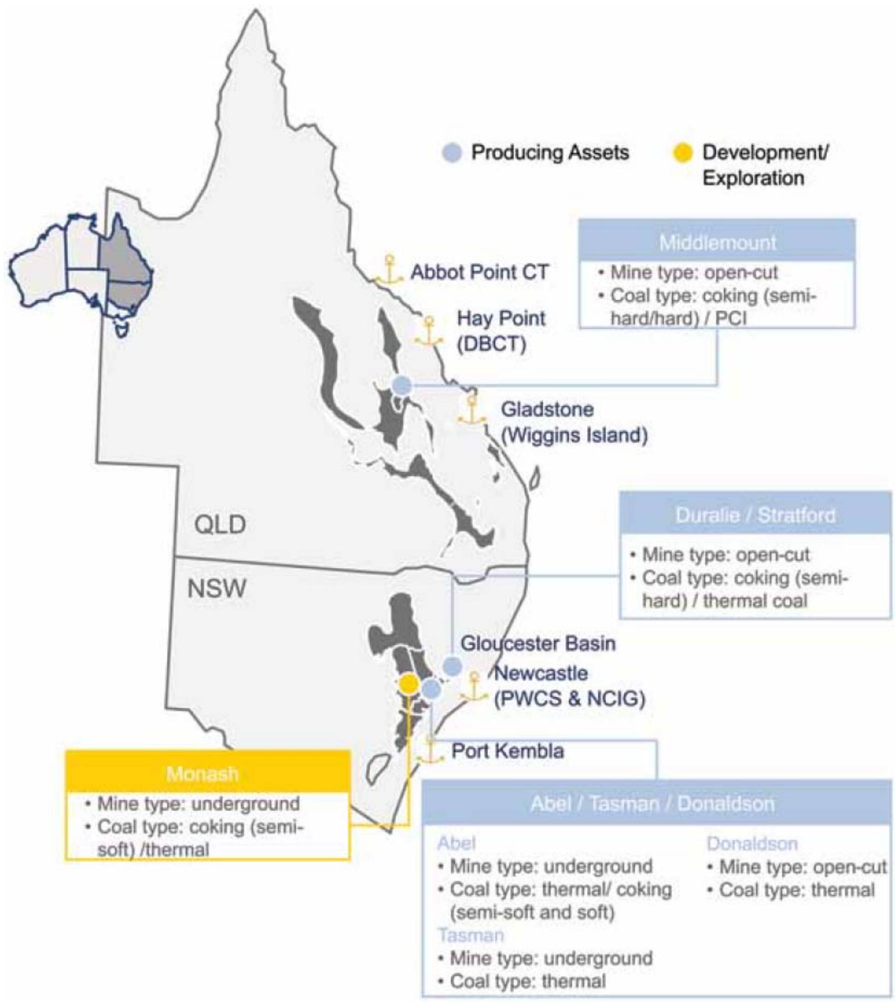




A review of the projects the currently under operation highlights the pipeline the company has going forward. The projects were classified by Exploration, Pre-feasibility, Feasibility and Production. In addition, the location of these projects is presented.



Source: Data from Gloucester Coal (2011)



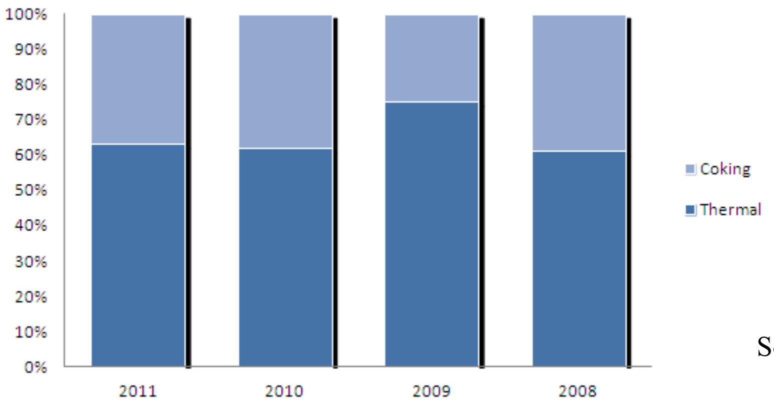
Sourced from Gloucester Coal (2012)

A review of Gloucester major announcements was conducted in order to provide a brief historical snapshot of the company.

History		
2012	February 6th	Gloucester Basin upgrade: Wenham Cox Road Resources and Reserves added 37mt resources and 12.2 mt reserves
2011	November 15th	Monash Resources upgraded by 290Mt to 577Mt
	July 14th	Acquisition of Donaldson and Monash completed (Announced May 2011). Includes 11.6% shareholding in NCIG Holdings - owner of new NCIG export terminal at Port of Newcastle
	March 17	A 68% increase in Middlemount reserves announced
2010	December 24th	Gloucester Exercises middlemount coal option early: paying $97.6m to acquire the additional shares. Discount on the 100m due to early exercise
	August 4th	Middlemount asset acquisition and royalty announced 4/08/2010: $437m which values the middlemount asset at $269.5m and royalty at $168.0 ($337.5m cash and $100m worth of shares issued to noble) for 27.52% interest and the right to receive 4% of FOBT sales from the middlemount JV also includes - option to acquire 2.48% for $8m and another 20% for $100m. Acquisition completed 29/09/2010.
	July	Gloucester Basin reserves upgraded by 17.8Mt
	June 1st	Noble makes to acquire the 12.3% of shares it doesn't own for $12.60
	May 19th	Macarthur Coal limited withdraws bid
2009	December 22nd	Gloucester receives a take over offer from Macarthur Coal, 0.84 Macarthur share for every 1 Gloucester share or a cash alternative of $8.00 per share
	June 17th	Whitehaven takeover cancelled and five new directors replace four of the previous Board members who retire with the closure of the Noble group offer
	June 17th	Noble became an 87.7% shareholder
	May 15th	Noble increases cash offer to $7.0 per share
	May 5th	Noble increases cash offer to $6.0 per share
	February	Completed the secondary flotation plant at the Stratford CHPP
	February 27	Noble made a cash bid for Gloucester at a price of $4.85 per share - conditional on Whitehaven merger not proceeding and no minimum acceptance level.
	February 20	Gloucester announce scrip takeover for Whitehaven
2008	May	Reserves and Resources increased significantly as a result of extensive exploration works
2007		Xstrata plc launched an unsuccessful takeover offer for Gloucester
		Commenced operations on the Roseville pit
2006		The Clareval seam was discovered at East Duralie
		Commenced processing at the Stratford CHPP
		Expansion at the Duralie mine led to a significant increase in reserves and resources
2005		Gloucester acquired the remaining 10% interest in the Stratford JV from ITOCHU Corporation
2004		UK Coal plc sold its 97% shareholding to a broad range of institutional investors
2003	February	Commenced operations at Bowens Road North and Duralie mines
2002	June	Renamed Gloucester Coal
1999		UK Coal plc acquired 97% of the outstanding capital of CIM following a takeover offer
		First coal production from the Stratford mine and commencement of processing at the Stratford CHPP
1995		Commenced development of the Stratford coal mine
1985		Listed on the ASX as Centenary International Mining (CIM) Resources Limited

Source: Review of: Company announcements 2012, 2011, 2010, 2009 & 2008; RBC Capital Markets analyst report: November 11, 2010; and Australian Securities Exchange: Gloucester Coal Announcements

Gloucester's historical production profile is presented below:



Source: Gloucester Coal Annual Reports

Sales Mix	2011	2010	2009	2008
Thermal	63,17%	61,88%	75,11%	60,96%
Coking	36,83%	38,12%	24,89%	39,04%

Gloucester has historically sold a higher proportion of Thermal coal, averaging approximately a 60/40 split. This is forecast to shift with the addition of Middlemount, a pure coking coal mine.

Appendix G: Discounted Cash Flow

The method used for calculating FCF was adopted from Koller, Goedhart, & Wessels (2010) and presented below:

	Free Cash Flow
1	Earnings before interest, taxes, and amortization (EBITA)
2	Cash taxes on EBITA
3 = 1 – 2	Net operating profits less adjusted taxes (NOPLAT)
(4)	Depreciation
5 = 3 + 4	Gross cash flow
6	(Increase)/Decrease in working capital
7	Capital expenditures
8	(Increase)/Decrease in net other assets
9 = 6 – 7 + 8	Gross investment
10 = 5 + 9	**Operating free cash flow**

The value of the firm's operating assets is calculated by discounting the free cash flows generated by the required return on capital. The terminal value (based on a going concern assumption) is calculated by marking up the last projected cash flow by the terminal growth figure then discounting by the spread between the terminal growth figure and WACC. This value is then discounted back by the number of periods in the forecast. The terminal value can also be established through multiples analysis or liquidation value. As a steady state terminal value is inappropriate for a company with finite resources a multiples approach was utilised.

$$Value\ of\ Firm = \sum_{t=1}^{t=\infty} \frac{FCFF_t}{(1+WACC)^t}$$

$$Value\ of\ Firm = forecast + projected\ steady\ state = \sum_{t=1}^{t=\infty} \frac{FCFF_t}{(1+WACC)^t} + \frac{FCFF_{n+1}/WACC - g_n}{(1+WACC)^n}$$

Free Cash Flow to Firm $(\mathrm{FCFF})_t = expected\ cashflow\ to\ firm\ in\ period\ t$

$$= EBIT(1-t) + depreciation - capital\ expenditures - \Delta\ working\ capital$$

$WACC = Weighted\ Average\ Cost\ of\ Capital$

Source: (Damodaran, 1996, s. 242)

Most valuations utilise the weighted average cost of capital (WACC) to capture the systematic risk of the cash flows. Though often users do not correctly understand the assumptions implied by using this method. As outlined by Stanton and Seasholes (2005) assumptions must be made with respect to capital structure: whether a firm has a constant amount of debt in dollar terms or maintains a proportional amount and the frequency of capital rebalancing. In addition the WACC is calculated on the basis that the firm is able to access the entire tax shield. The calculation of the tax shield is based on the marginal tax rate. It is assumed the firm harnesses the tax shield at the entire corporate tax rate.

The usual assumption behind WACC is the firm will target a constant proportion of debt. The proportions used to calculate WACC are not based on market values or book values. According to Fernandez (2011) the weightings are based upon vales calculated using valuation formulae. It is assumed that the firm targets the valuation in line with the WACC calculated.

The WACC formula used is shown below:

$$WACC = k_e\left(\frac{E}{E+D}\right) + k_d(1-t)\left(\frac{D}{E+D}\right)$$

$k_e = CAPM = r_f + \beta_i\left(E[R_m] - R_f\right)$

$k_d = Cost\ of\ debt$

$t = the\ effective\ corporate\ tax\ rate$

$E = Market\ value\ of\ Equity$

$D = Market\ value\ of\ Debt$

$r_f = Risk\ free\ rate$

$E[R_M] = Market\ risk\ premium$

$\beta_i = Company\ beta$

Source: (Damodaran, 1996, s. 37 & 62)

Appendix H: ROV Fundamentals and Types of Option Models

Review of Real Options Literature

Option theory has been debated and augmented in the academic community for over one hundred years. French mathematician Louis Bachelier introduced option pricing theory in 1900. According to Merton (1973), Bachelier was able to deduce an options pricing model based on the assumption that stock prices follow a Brownian motion with zero drift. Option pricing transcended the academic realm with the creation of the Fisher Black and Myron Scholes (1973) option pricing model. The Black-Scholes (B-S) model gave practitioners an easy solution to calculate the price of European-style options. Their contribution to the academic community created a stir in the finance industry and was the driving influence behind the boom in options trading. Coincidently, the creation of the model coincided with the establishment of the first options exchange: The Chicago Board Options Exchange. Prior to their work a majority of studies focused on the pricing of warrants. Warrants are somewhat like options however they are issued by the company, unlike options, the issuance of a warrant dilutes the number of shares outstanding. The introduction of warrant pricing tools helped to shape the industry, however, these models were often incomplete, since they all involved arbitrary parameters (Fisher & Scholes, 1973). Black and Scholes, with help from Merton were able to eliminate the need for establishing a stock's expected return, or any other assets' expected return, therefore removing the discount dilemma that had plagued previous academic work (Amran & Kulatilaka, 1999). The B-S model therefore only required the risk-free rate of return, as the payoff of an option is directly related to the underlying security. As the US treasury rate is often the assumed benchmark, the only free parameter is the assumed volatility figure (Hull, 2008).

The B-S formula provided a continuous-time and -state model to price European options on non-dividend paying financial assets. This means that the underlying financial asset can do anything between zero and infinity and time goes continuously (Hull, 2008). Merton (1973) commented that the B-S model was a significant "break-through" in option pricing; however, Merton was able to take the model a step further by relaxing several of the assumptions postulated around capital changes and dividend paying stock, resulting in a formula that was able to take into account a continuously compounded dividend or erosion of the underlying asset. The model is often now referred to as the Black-Scholes-Merton (BSM) model.

Work from Cox, Ross & Rubinstein (1979) aimed to simplify this approach by introducing a discrete-time option pricing formula. This helped to reduce the black-box nature of the BSM model. Cox, Ross & Rubinstein (1979) posits that the utilisations of their formula results in a numerical procedure that is both easier to use and computationally more efficient. Cos, Ross & Rubinstein (1979) assumed that the development of the stock price follows a multiplicative binomial process over a discrete period. This assumption can then be modelled as a bifurcation, resulting in either: a return of u-1 with probability of q or d-1 with the reciprocal probability (1-q).

The strength of the binomial process is that the discrete time nodes allow practitioners to visualise the evolution of the stock price, allowing for the analysis of premature exercising of the option – achieved through the backwardation process. However, if we shorten the time-steps between periods and the number of steps approach infinity the formula produces results obtained from a Brownian motion; solving this in the discrete form produces the binomial equation, in a continuous sense, the results yield closed-form equations like the B-S model (Munn, 2002). According to Cox, Ross & Rubinstein (1979), the economic arguments used in the creation of the binomial process, are exactly the same; the divergence results from Black and Scholes beginning with the assumption of continuous trading. This assertion was proved by Cos, Ros & Rubinstein and establishes the B-S model as a limiting case. The practical benefit of this is both methods can be used as a means of cross checking the computational accuracy of the result.

Up until this point, options were purely seen as a derivative instrument with a payoff determined by an underlying financial asset. Prior to the discovery of financial options, Miller and Modigliani (1961) hypothesised that the value of a firm comprised of the present value of its cash flows and the present value of growth opportunities. This was also supported by Stewart Myers (1977), suggesting that the value of a firm consisted of two parts: existing units of productive capacity and the option to purchase additional units of productive capacity in the future. The latter consists of investments the firm is yet to pursue. These discretionary growth opportunities can then be considered as options to make future investments. Myers (1977) coined the term 'real option' through demonstrating how these growth opportunities could be viewed as call options. Though initially these options were undefined; the valuation of a firm was derived from a set of growth opportunities stemming from a bundle of firm resources. This made the systematic identification of these options somewhat impalpable (McGrath, Ferrier, & Mendelow, 2004).

Lenos Trigeorgis (1996) is credited with moving the field further into the corporate realm. His work pioneered the field of real options. In 1996 Trigeorgis published, *Real Options: managerial flexibility and strategy in resource allocation*. Stephen Henry's (1997) review credited Trigeorgis for reminding managers that management flexibility carries value. Furthermore, work by Munn (2002), Copeland & Antikarov (2003) and Kodukula & Papudesu (2006) serve as technical aids. This being said, there are still criticisms in its application; the field has received considerable academic attention yet it is still to develop to the point where consensus on its main properties has emerged (McGrath, Ferrier, & Mendelow, 2004).

Types of ROV models

The three types of ROV models are Partial Differential Equations, Simulation and Lattice Models. An overview of the three is provided below:

- **Partial Differential Equations**

PDE involve solving a mathematical solution with defined boundaries, these boundaries are based upon the characteristics determining the change in option value with respect to changes in certain variables in the market. Both analytical and numerical methods are quite computationally complex and therefore not often used by practitioners, the most common PDE used is the closed form solution B-S method (Kodukula & Papudesu, 2006). The B-S formula provides a simple way to calculate the price of a European style option. The model requires the input of five variables (6 if including a dividend payment); the most difficult of the variables to forecast is the assumed underlying volatility. Methods of calculating volatility will be discussed in the following section. This being said, the model is computationally simple to use and the results are accurate. This makes the B-S formula in reality easy to use. However, the model makes seven assumptions, some in which present difficulties to using the formula to price real options. Due to the closed form nature of the B-S model it is unable to handle multiple sources of uncertainty and more than one underlying asset. Though, the most common problem associated with using the model result from optimal timing issues and multiple options. The B-S model calculates the price of European options and therefore cannot take into account the ability to exercise early. This makes it hard to price optimal timing in the case where the underlying asset is subject to value decay. In addition, it is quite common that management face multiple options, the B-S model is unable to take into account the interaction between multiple options. For instance an option to expand cannot be exercised if an option to abandon has been exercised. In this case, the value of the two options is non-additive and must be calculated together, making the B-S model unusable. Therefore the B-S model is best used when the exercise date is fixed and management only have one option to make. However a major pitfall results from users not being able to see the inner workings of the model, this makes it quite hard to convince users to rely on the model when making investment decisions and is termed the 'black box' impression (Copeland & Antikarov, 2003). For these reasons Mun (2006) suggests that the model is not a good approach in its entirety, but best at providing an approximation or a benchmark.

- **Simulation**

This generally involves running a Monte Carlo simulation, which provides the user with a series of projected asset values. A maximisation formula is applied to the end point and the results are discounted back. Traditionally the Monte Carlo method was used to calculate individual European options, as it is fairly difficult to use this method to calculate American options (Mun, 2006); this being a major flaw of the Monte Carlo method as it can't handle the interaction of multiple options, therefore not taking into account the true amount of management flexibility (Gamba, 2002). To overcome this Longstaff and Schwartz (2001) introduced the Least Squares Monte Carlo (LSMC) approach to further bridge the gap between financial options and real options. The approach overcomes some of the short comings of other option models, namely the curse of dimensionality; which refers to the inability for other models to deal with more than a few stochastic (uncertainty) factors (Stentoft, 2004). The binomial model (introduced below) becomes computationally infeasible as the number of nodes grow exponentially with the number of input factors (i.e, number of independent uncertainties). In addition, the model was created to calculate optimal exercise of American options. Whilst simulation has come a long way, the LSMC approach is still quite a statistically complex method and therefore limits is practical applicability.

Quite often Monte Carlo simulation can be used in isolation as a method to consolidate a variety of uncertain variables into one headline volatility figure, therefore overcoming the issue of a lattice model becoming too large to work with. Therefore, instead of using Monte Carlo simulations to calculate the real options, it is quite a helpful tool in determining a volatility estimate that can then be incorporated into a real options based model, such as a lattice based solution.

- **Lattice Models**

The simplified approach to valuing real options was introduced by Cox, Ross and Rubinstein in 1979. The approach simulates the evolution of the UAV in discrete time over a set period. The binomial lattice model assumes at each discrete point in time the stock can either move up (u) or down (d); this is essentially a probability tree with binary chance branches. As this is the case, the tree is recombining – various paths can lead to the same outcome. The model is also an accurate approximation to the B-S model, as the number of steps increase, or the discrete periods of time between nodes decrease the model converges upon the limiting case – the B-S continuous time model (Brandão, Dyer, & Hahn, 2005). Though the inherent advantage of the lattice model is it allows for a solution of early termination of an American option and the ability to handle compound options. The optimal solution is obtained through a process of backwardation, this essentially means that the value of the lattice is forward projected and then solved backwards, maximising the value at each node.

The lattice approach is applied under the assumption of no-arbitrage and the model can be solved by applying one of two approaches: the replicating portfolio or the risk-neutral probability approach – both yield the same results. The replicating portfolio approach is computationally more difficult to deal with as an identical set of traded assets must be identified that mimic the payoff structure of the existing asset. The traded portfolio must then be rebalanced at each time step. On the other hand, the risk-neutral probability approach adjusts the probability factors therefore allowing cash flows to be adjusted at the risk free rate, this approach is simpler to instigate and therefore is the recommended approach (Mun, 2006).

Problems with applying the Black-Scholes model

Whilst the Black Scholes (Partial differential equation) model provides a useful tool, its assumptions usually mean it is unable to be used in a real world environment due to the restrictive assumptions. Often the model is best used as a limiting case, or a proxy for the ROV. Copeland and Antikarov provide a summary of the B-S model's assumptions.

Black Scholes

The B-S Model assumes:

1. The option may only be exercised at maturity – it is a European option
2. There is only once source of uncertainty – the B-S model cannot handle rainbow options
3. The option is contingent only on a single underlying asset – therefore it cannot handle compound options
4. The underlying asset pays no dividends (however can rule this out if taking into account Merton's work on dividend paying assets)
5. The current market price and the stochastic process followed by the underlying asset are known (observable)
6. The variance of return on the underlying is constant through time
7. The exercise price is known and constant

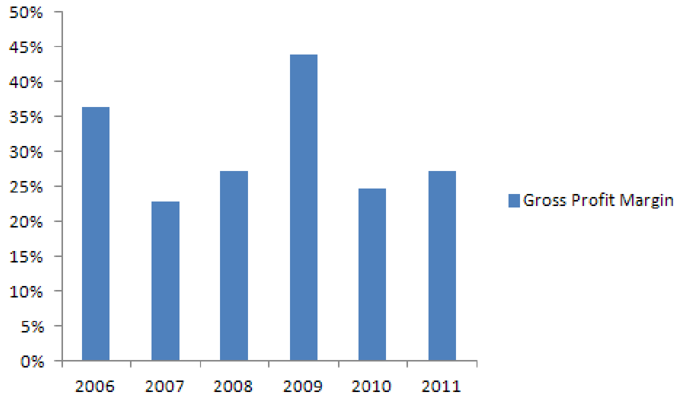
Source: (Copeland & Antikarov, 2003, p. 106)

Appendix I: Historical Financials

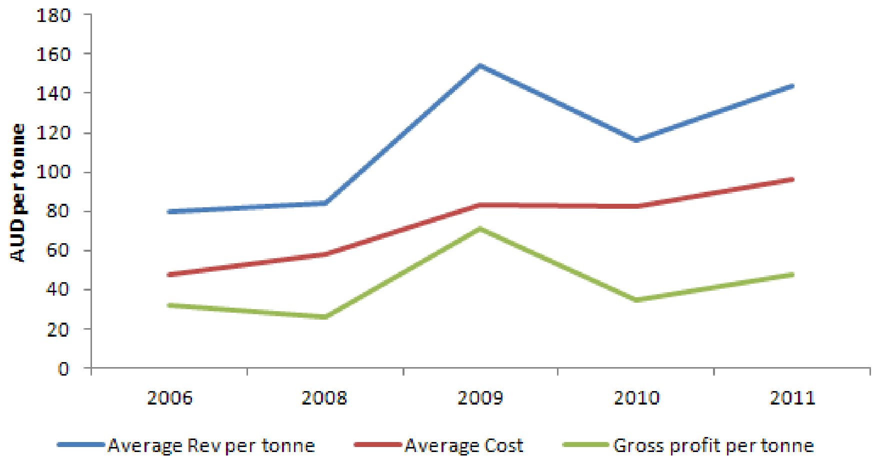
Income Statement AUD Million	2006	2007	2008	2009	2010	2011
Revenue	**153,695**	**151,888**	**159,552**	**306,771**	**229,294**	**306,555**
Cost of sales	-91,577	-110,7	-109,72	-166,05	-161,37	-204,65
depreciation, depletion & amortization	-6,271	-6,477	-6,376	-6,004	-11,306	-18,701
Total cost of sales	-97,848	-117,18	-116,1	-172,06	-172,68	-223,35
Gross profit	55,847	34,71	43,455	134,714	56,615	83,209
Other operating income / (expense)	0,42	0,343	-1,455	2,253	-0,839	5,537
Administration expenses	-4,314	-7,278	-6,490	-23,098	-14,551	-25,693
Share of loss of an associate	-	-	-	-	-	-0,656
EBIT	51,953	27,775	35,51	113,869	41,225	62,397
Financial Income	0,421	0,584	0,766	1,064	1,043	17,992
Finance costs	-2,782	-2,498	-2,444	-0,51	-0,728	-3,918
Profit Before Tax	49,592	25,861	33,832	114,423	41,540	76,471
Income Tax Expense	-9,253	-7,835	-10,385	-32,683	-8,810	-21,909
Net Income	40,339	18,026	23,447	81,740	32,730	54,562
Other comprehensive items, net of tax	0,224	1,925	0,546	7,299	-18,614	17,965
Total comprehensive income for the period	40,563	19,951	23,993	89,039	14,116	72,527

Source: Gloucester Coal Annual Reports

Historical Gross Profit Margin



The gross profit margin over the last six years, whilst volatile, has generally average around 25 to 35%. Going forward, the gross margin is expected to peak in 2014 at 36% and settle close to 25% in the long run. The chart below highlights the average rev, cost and gross profit per tonne.



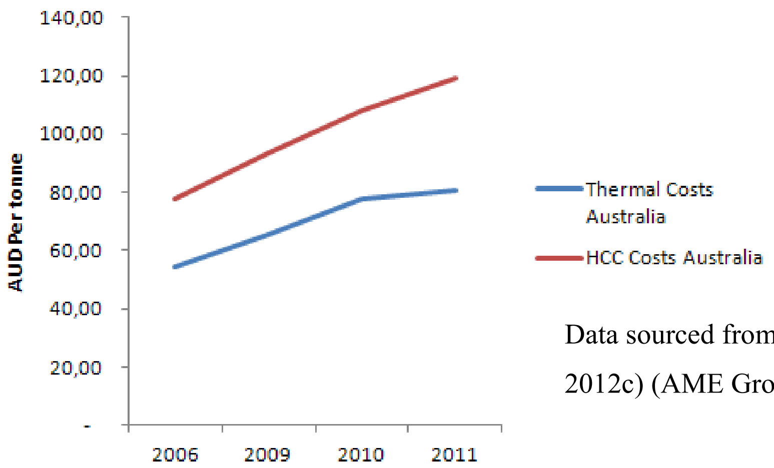
Cash Costs are presented below:

Total Cash cost per average production tonne	2011	2010	2009	2008	2007	2006
Production Costs, Interest, Administration, Royalty, Rail, Port & demurrage	99	85	77	60	53	46

Average cash costs per tonne have risen quite dramatically over the period, averaging 16.6% per annum. This is somewhat above Australian wide industry levels. Gloucester has indicated that costs should normalise going forward. Production delays and higher stripping ratios have led to an increase in the cost burden. The tables present average industry wide costs for thermal coal and coking coal:

AUD	Nominal			
Thermal Costs Australia	2006	2009	2010	2011
Mining	34,58	41,06	50,42	53,32
Processing	2,78	3,35	3,89	4,09
Admin & Support	4,15	4,93	6,04	6,35
Royalties	5,23	8,12	8,95	10,27
Freight	7,49	8,08	8,29	6,67
Total	54,22	65,54	77,59	80,71

AUD	Nominal			
HCC Costs Australia	2006	2009	2010	2011
Mining	46,39	56,56	68,04	75,37
Processing	6,42	7,64	9,14	10,31
Admin & Support	5,87	7,13	8,58	9,52
Royalties	10,61	13,32	12,62	16,66
Freight	8,50	8,95	9,74	7,51
Total	77,79	93,60	108,13	119,37



Data sourced from (AME Group Pty Limited, 2012c) (AME Group Pty Limited, 2012d)

From 2006 to 2011 Thermal Coal and Hard Coking Coal costs have increased by 8.3% and 8.9% respectively per annum.

Balance Sheet AUD Million	2006	2007	2008	2009	2010	2011
Current Assets						
Cash and cash equivalents	13,593	16,511	5,602	65,774	27,811	182,330
Trade and other receivables	6,733	12,853	24,461	21,497	16,588	29,450
Other financial assets (derivatives)	0	0	4,334	16,591	-	4,614
Inventories	7,348	6,572	9,892	5,179	19,179	9,341
Waste in advance	-	-	-	-	29,459	57,736
Total Current Assets	27,674	35,936	44,289	109,041	93,037	283,471
Non-Current Assets						
Restricted cash	-	-	-	-	-	2,004
Property, plant and equipment	72,459	72,971	73,317	98,290	146,126	807,438
Exploration and evaluation	1,166	2,75	5,000	8,700	25,619	56,593
Waste in advance	18,284	21,625	28,743	28,265	-	-
Financial asset - royalty receivable	-	-	-	-	-	182,000
Investments	0,177	0,176	0,176	0,060	0,083	0,999
Deferred tax asset	-	-	-	-	-	10,727
Total Non-Current Assets	92,086	97,522	107,236	135,315	171,828	1.059,761
Total Assets	119,760	133,458	151,525	244,356	264,865	1.343,232
Current Liabilities						
Trade and other payables	16,504	16,982	13,359	25,273	20,372	56,777
Other financial liabilities (derivatives)	-	-	-	-	9,670	-
Interest bearing loans and borrowings	-	24,761	-	-	4,538	74,555
Income tax liability	-	-	3,960	28,716	2,886	2,647
Provisions	-	-	-	0,200	0,200	1,125
Employee benefits	0,371	0,729	0,467	0,564	0,770	0,782
Total Current Liabilities	16,875	42,472	17,786	54,753	38,436	135,886
Non-Current Liabilities						
Interest bearing loans and borrowings	29,401	-	9,670	-	30,190	24,567
Deferred tax liabilities	5,291	13,190	15,813	15,898	7,175	152,099
Provisions	4,068	4,464	6,517	7,063	7,712	10,842
Other non-current Liabilities	-	-	-	-	-	4,893
Employee benefits	0,115	0,088	0,081	0,095	0,156	0,281
Total Non-Current Liabilities	38,875	17,742	32,081	23,056	45,233	192,682
Total Liabilities	55,750	60,214	49,867	77,809	83,669	328,568
Equity						
Issued Capital	122,143	126,257	138,905	137,247	137,247	898,030
Retained profits	-59,180	-56,776	-42,269	15,28	48,010	102,572
Reserves	1,047	3,763	5,022	14,02	-4,061	14,062
Total Equity	64,010	73,244	101,658	166,547	181,196	1.014,664

Source: Gloucester Coal Annual Reports

Appendix J: Acquisition of Middlemount, Donaldson and Monash

Middlemount Fair Value at acquisition	
Property, plant and equipment	122,703
Reserves and resources	446,718
Exploration and evaluation	14,767
Deferred tax asset	17,390
Cash and cash equivalents	6,110
Trade and other receivables	6,687
Inventories	2,064
Waste in advance	2,098
Financial Asset - royalty receivable	168,000
Term deposit at call	0,828
Total assets	**787,365**
Trade and other payables	-12,234
Take or pay liability (current)	-7,113
Take or pay liability (non current)	-4,900
Loans and borrowings	-121,717
Provisions	-1,569
Deferred tax liabilities	-147,533
Total liabilities	**-295,066**
Fair value of identifiable net assets	**492,299**
Share loss since acquisition	0,656
Total	**492,955**
Acquisition date fair value of consideration transferred:	
Shares issued, at fair value	100,540
Cash Paid	395,776
Consideration transferred	496,316
Cash outflow on acquisition is as follows:	
Net cash acquired from Donaldson	6,11
Cash paid	-395,776
Net Consolidated Cash Flow	**-389,67**

These figures have been adjusted in order to reflect the true movements in the accounts of Gloucester (i.e., excluding effect of acquisition).

Analytical Balance Sheet AUD Million	2010	2011	Less Adj	2011	Movement
Total Funds Invested: Uses					
Current Operating Assets					
Operating Cash	5,04	6,74		6,74	
Trade and other receivables	16,59	29,45	6,69	22,76	
Other financial assets (derivatives)	-	4,61		4,61	
Inventories	19,18	9,34	2,06	7,28	
Waste in advance	29,46	57,74	2,10	55,64	
Operating Current Assets	**70,27**	**107,89**	**10,85**	**97,04**	26,77
Trade and other payables	20,37	56,78	19,35	37,43	
Other financial liabilities (derivatives)	9,67	-		-	
Income tax liability	2,89	2,65		2,65	
Employee benefits	0,77	0,78		0,78	
Operating Current Liabilities	**33,70**	**60,21**	**19,35**	**40,86**	7,16
Operating Working Capital	36,57	47,68	-8,50	56,18	19,60
Property, plant and equipment	146,13	807,44	569,42	238,02	91,89
Exploration and evaluation	25,62	56,59	14,77	41,83	16,21
Waste in advance					
Other Operating Liabilities	-0,16	-5,17	-4,90	-0,27	-0,12
Invested Capital	**208,16**	**906,54**	**570,79**	**335,75**	
Excess Cash	22,77	177,59	6,11	171,48	148,71
Investments	0,08	1,00	0,83	0,17	0,09
Financial Asset - Royalties		182,00	168,00	14,00	14,00
Tax loss carry forward	-	16,53	-	16,53	16,53
Total Funds Invested	**231,01**	**1.283,65**	**745,73**	537,93	
Total Funds Invested: Sources					
Short term borrowings	4,54	74,56	121,72	-47,16	-51,70
Long term borrowings	30,19	24,57		24,57	-5,62
Capitalised Operating Leases				-	-
Provisions (rehabilitation and dismantle)	7,91	11,97	1,57	10,40	2,49
Debt and Debt equivalents	**42,64**	**111,09**	**123,29**	-12,20	
Deferred income taxes: operating	7,18	153,70	130,14	23,56	16,38
Deferred income taxes: nonoperating	0	4,2		4,20	4,20
Issued Capital	137,25	898,03	492,30	405,73	268,48
Retained profits	48,01	102,57		102,57	54,56
Reserves	-4,06	14,06		14,06	18,12
Equity and Equity Equivalents	**188,37**	**1.172,56**	**622,44**	550,12	
Invested Capital	**231,01**	**1.283,65**		537,93	

$AUD million

Donaldson	Fair Value at acquisition (2012 HY)
Property, plant and equipment	226,01
Reserves and resources	587,46
Exploration and evaluation	27,17
Deferred mining asset	31,52
Intangible – port allocation	57,65
Cash and cash equivalents	0,06
Trade and other receivables	13,31
Investments	15,90
Inventories	11,21
Intangibles	
Total assets	**970,29**
Trade and other payables	-53,38
Customer contracts	-138,121
Take or pay liability	-108,482
Financial liability – marketing services fee payable	-12,413
Interest bearing loans and borrowings	-225
Provisions	-12,15
Deferred tax liabilities	-127,046
Total liabilities	**-676,59**
Fair value of identifiable net assets	**293,70**
Acquisition date fair value of consideration transferred:	
Equity issued	321,23
Reduction in related party loan	-27,532
Consideration transferred	293,70
Cash outflow on acquisition is as follows:	
Net cash acquired from Donaldson	0,06
Cash paid	

Had the acquisition of Donaldson occurred at the beginning of the period, the impact to the income statement for the half year ended 31 December 2011 would have been an additional profit after tax of $4.2 million. Acquisition costs of $37.9 million are included in the income statement during the half year ended 31 December 2011 in relation to the acquisition of Donaldson.

Date of acquisition: 14th July 2011

Monash	Fair Value at acquisition (2012 HY)
Cash and cash equivalents	0,25
Exploration and evaluation	118,576
Other	0,002
Total assets	**118,828**
Trade and other payables	-0,077
Income tax liability	-0,173
Total liabilities	**-0,25**
Fair value of identifiable net assets	**118,58**
Acquisition date fair value of consideration transferred:	
Cash paid	-31,93
Contingent consideration	-86,65
Consideration transferred	-118,58
Cash outflow on acquisition is as follows:	
Net cash acquired with the Monash assets	0,25
Cash consideration paid	-30,054
Transaction costs	-1,874
Net consolidated cash outflow	-31,678

Date of acquisition: 14th July 2011

Net cash outflow from acquisition of Donaldson and Monash is $31.62 million

Will be included as part of balancing capital structure

Source: Reconstruction from Gloucester Coal Annual Reports

Appendix K: Gloucester cash taxes

	2006	2007	2008	2009	2010	2011
Marginal Taxes	30%	30%	30%	30%	30%	30%
EBITA	51,95	27,78	35,51	113,87	41,23	60,56
Marginal Taxes on EBITA	15,59	8,33	10,65	34,16	12,37	18,17
Other Operating Taxes						
Operating Taxes	-5,63	0,08	0,24	-1,64	-3,65	-1,03
Decrease (Increase) in operating deferred taxes	-1,45	-2,64	0,59	3,04	0,75	-12,65
Operating Cash Taxes	8,52	5,77	11,48	35,56	9,46	4,49
Tax shield on operating lease interest expense		0,16	0,11	0,10	0,44	0,45
Adjusted Operating Cash Taxes	8,52	5,93	11,59	35,66	9,91	4,94
Total Income Tax Expense	9,25	7,84	10,39	32,68	8,81	21,91
Taxes paid per cash flow statement	-	-2,71	-5,50	-13,50	-35,39	-17,56
Average effective rate	16,39%	21,35%	32,63%	31,32%	24,03%	8,16%
Average effective tax rate	22,31%					

Appendix L: Capitalisation of Operating Leases

Operating Leases	2006	2007	2008	2009	2010	2011
Within One year	0,184	1,323	1,338	1,426	1,426	8,307
One year or later and no later than five years	0,719	3,254	1,956	1,982	1,982	30,055
Greater than five years						2,474
	0,903	4,577	3,294	3,408	3,408	40,836

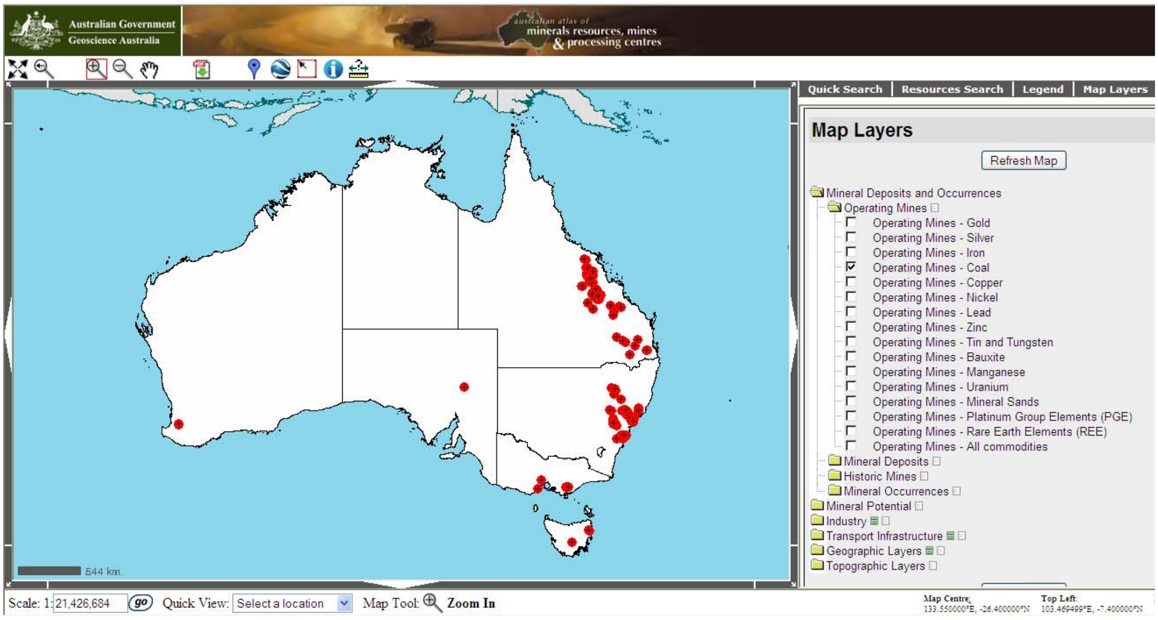
Asset Value(t-1) = Rental Expense (t) /[kd + (1/Asset Life)]

Freehold buildings	7–12 years
Plant and equipment	4–12 years
Office equipment, furniture and fittings	4–5 years
Motor vehicles	4–5 years
Mining property and development	7–12 years

Capitalised operating leases are driven from the cost of sales estimation. Based on the cost section of the thesis, it was established that mining expenses are 65% of the cost of sales. Of mining expenses, the lease expense equated to 3.35% of total mining expense. This was held constant over the projection period. An average asset life (leased asset) was estimated at 5 years. This is based upon the average life of the current commitments and also based on the fact that mining machinery (vehicles) is the main leased asset. These items are typically depreciated over a five year period – this was used as an approximate rental period.

Appendix M: Geosciences Australian Mine Atlas

Below is a screenshot of the Geoscience mine database. The website provides information on all mine sites within Australia. This was used to isolate mines close to Gloucester's producing mines and in order to establish a peer group of mines used to calculate the expected growth in yearly cost of production.



Source: http://www.australianminesatlas.gov.au/?site=atlas

Appendix N: Synthetic Debt Rating – Credit Rating agency data

The S&P key ratios were used as a base to calculate a synthetic credit rating. The ratios were sourced from (Petersen & Plenborg, 2012)

Financial health assessment: Key Ratios	AAA	AA	A	BBB	BB	B	CCC
EBIT Interest Cover (x)	21,40	10,10	6,10	3,70	2,10	0,80	0,10
EBITDA Interest cover (x)	26,50	12,90	9,10	5,80	3,40	1,80	1,30
Free operating cash flow/total debt (%)	84,2%	25,2%	15,0%	8,5%	2,6%	-3,2%	-12,9%
FFO/total debt (%)	128,8%	55,4%	43,2%	30,8%	18,8%	7,8%	1,6%
Return on Capital (%)	34,90	21,7%	19,4%	13,6%	11,6%	6,6%	1,0%
Operating income/revenue (%)	27,0%	22,1%	18,6%	15,4%	15,9%	11,9%	11,9%
Long-term debt/capital (%)	13,3%	28,2%	33,9%	42,5%	57,2%	69,7%	68,8%
Total Debt/Capital	22,9%	37,7%	42,5%	48,2%	62,6%	74,8%	87,7%

The ratios have been calculated for the historical financials and also based upon the projected financials.

The formulas employed for the calculation of the ratios are shown below:

STANDARD & POOR'S

FORMULAS FOR KEY RATIOS

1. EBIT interest coverage = $\dfrac{\text{Earnings from continuing operations* before interest and taxes}}{\text{Gross interest incurred before subtracting (1) capitalized interest and (2) interest income}}$

2. EBITDA interest coverage = $\dfrac{\text{Earnings from continuing operations* before interest, taxes, depreciation, and amortization}}{\text{Gross interest incurred before subtracting (1) capitalized interest and (2) interest income}}$

3. Funds from operations/total debt = $\dfrac{\text{Net income from continuing operations plus depreciation, amortization, deferred income taxes, and other noncash items}}{\text{Long-term debt** plus current maturities, commercial paper, and other short-term borrowings}}$

4. Free operating cash flow/total debt = $\dfrac{\text{Funds from operations minus capital expenditures, minus (plus) the increase (decrease) in working capital (excluding changes in cash, marketable securities, and short-term debt)}}{\text{Long-term debt** plus current maturities, commercial paper, and other short-term borrowings}}$

5. Return on capital = $\dfrac{\text{EBIT}}{\text{Average of beginning of year and end of year capital, including short-term debt, current maturities, long-term debt**, non-current deferred taxes, and equity.}}$

6. Operating income/sales = $\dfrac{\text{Sales minus cost of goods manufactured (before depreciation and amortization), selling, general and administrative, and research and development costs}}{\text{Sales}}$

7. Long-term debt/capital = $\dfrac{\text{Long-term debt**}}{\text{Long-term debt + shareholders' equity (including preferred stock) plus minority interest}}$

8. Total debt/capital = $\dfrac{\text{Long-term debt** plus current maturities, commercial paper, and other short-term borrowings}}{\text{Long-term debt plus current maturities, commercial paper, and other short-term borrowings + shareholders' equity (including preferred stock) plus minority interest}}$

*Including interest income and equity earnings; excluding nonrecurring items.
**Including amount for operating lease debt equivalent.

In addition, the ratings were also assessed and adjusted for mining specific strategic factors. The strategic framework is presented below.

Company-Specific Business Risks – Critical Factors

Rating Business Strength	AA Exceptional	A Superior	BBB Adequate	BB Weak	B Poor
Reserves of Core Operations	• Very long reserve life at existing production rates for key products.	• Well above average reserve life at existing production rates for key products.	• Reserve life at existing production rates for key products would range from average to above average.	• Relatively short reserve life at existing production rates for key products.	• Short reserve life at existing production rates for key products.
Cost Competitiveness	• Most operations are very low-cost (first-quartile cost on industry cost curve).	• Operations are a combination of first- or second-quartile cost.	• Average operation is second-quartile cost.	• Most operations are third- or fourth- quartile cost.	• Most operations are very high cost (fourth-quartile on industry cost curve).
Diversification	• Very well diversified by product, production location, political jurisdiction and pricing format.	• Good diversification by product, production location, political jurisdiction and pricing format.	• Several products and/or several production locations, plus multiple political jurisdictions.	• Few products and/or few production locations.	• Reliance on single commodity or single production location.
Political Risk	• Almost all production from countries considered stable/friendly to mining.	• Most of production from countries considered stable/friendly to mining.	• Majority of production from countries considered stable/friendly to mining.	• Most of production from countries not considered stable/friendly to mining.	• Heavily reliant on production from countries not considered stable/friendly to mining.
Size and Critical Mass	• Very large size able to withstand multiple project development risks and able to access people, resources and technologies.	• Large size able to withstand large project development risks and able to access people, resources and technologies.	• Mid size able to withstand moderate scale project development risks and able to access most people, resources and technologies.	• Moderate size able to withstand smaller project development risks and with potential challenges in accessing people, resources or technologies.	• Small size with concerns over ability to withstand development project risks and with potential challenges in accessing people, resources or technologies.

Source: DBRS

Decisions driving the strategic framework:

1) Based on current forecasted production rates the company has a significant amount of reserve years (in excess of 20 years). This was compared to the fourth largest coal miner in the USA (Foundation coal), which has an average reserve life of 15 years.
2) Based on historical cost structure Gloucester is classified at the higher end of producers. Though this is expected to decline in the next two to three years (Gloucester and Donaldson Basin). This will place positive pressure on rating.
3) Limited mining locations and reliance on single commodity.
4) Australia is an AAA rated country, there has been some risk around taxation issues.
5) Mid cap miner with the ability to handle small project over runs. Australia has experienced skill shortages in the recent years which has led to an escalation in mining costs.

Appendix O: Peers – exploration value

These are the peer companies used to calculate the value of the JORC compliant resource body that is not part of the main mine's reserves

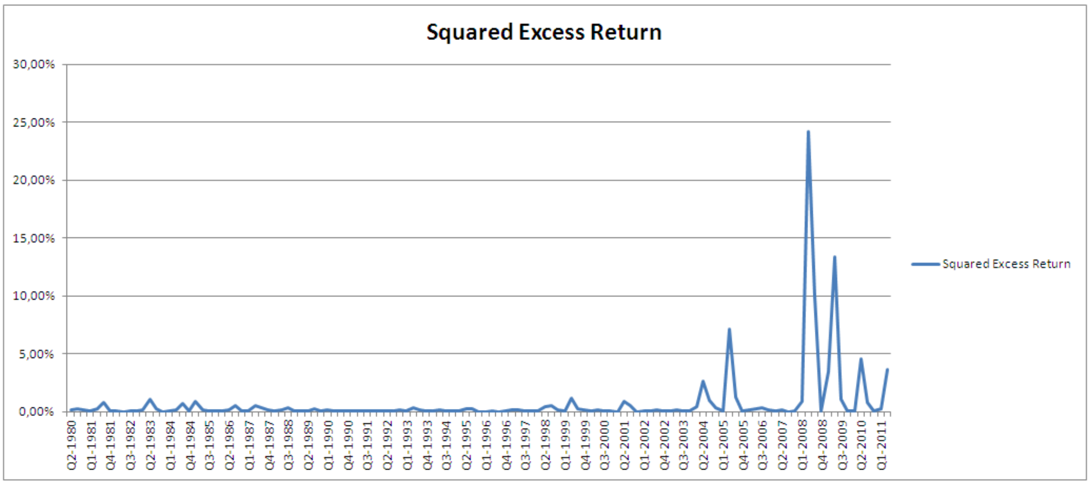
Name	Current Price Close	Current Market Cap	Shares Outstanding (million)	JORC compliant resources	Value $/T	Resource
Apac Coal Limited	0,01	1,5	148,8		0,29	T
Aspire Mining Limited	0,13	76,9	591,6	204	0,38	HCC
Bandanna Energy Limited	0,34	186,0	547,0	1600	0,12	T
Coalspur Mines Limited	0,62	338,5	545,9	985	0,34	T
Coalworks Limited	0,99	146,3	147,8	1623,5	0,09	T
East Energy Resources Limited	0,15	26,4	176,0	458	0,06	T
Endocoal Limited	0,28	45,1	161,1	388,7	0,12	T/PCI
Guildford Coal Limited	0,42	185,7	442,1	2172	0,09	T/PCI/HCC
Metrocoal Limited	0,28	57,0	203,4	3782	0,02	T
Nucoal Resources Limited	0,24	145,2	604,9	511	0,28	SSCC
Stanmore Coal Limited	0,41	59,5	145,1	498	0,12	T/PCI
Tiaro Coal Limited	0,31	30,6	98,7	40	0,76	PCI
					0,222	

			Historical Development	
Name	Source	Website	$/t 20/07/2011	$/t 25/01/2012
Apac Coal Limited	website - company overview	http://www.apaccoal.com/	0,263	0,525
Aspire Mining Limited	website - company overview	http://www.aspiremininglimited.com/	1,740	1,175
Bandanna Energy Limited	website - company overview	http://www.bandannaenergy.com.au/	0,707	0,236
Coalspur Mines Limited	website - company overview	http://www.coalspur.com/	0,981	1,025
Coalworks Limited	website - company overview	http://www.coalworks.com.au/	0,051	0,066
East Energy Resources Limited	website - company overview	http://www.eastenergy.com.au/	0,123	0,077
Endocoal Limited	website - company overview	http://www.endocoal.com.au/	0,184	0,184
Guildford Coal Limited	Ressource Table: company announcements	http://www.guildfordcoal.com.au/	0,265	0,163
Metrocoal Limited	ASX Announcement - 14/12/2011	http://www.metrocoal.com.au/	0,043	0,026
Nucoal Resources Limited	June 2012 - Investor presentation	http://www.nucoal.com.au/	0,426	0,331
Stanmore Coal Limited	website - company overview	http://www.stanmorecoal.com.au/	0,338	0,226
Tiaro Coal Limited	website - company overview	http://www.tiarocoal.com.au/	0,728	0,679
			0,487	0,393

Appendix P: Volatility Calculation

This was based on historical prices available from the OECD (1980 – 2011). The prices were calculated on a basket weighted price in accordance with Gloucester's expected production.

	Production Split				
	%		Volume		
	Thermal	Coking	LOM	Thermal	Coking
Gloucester	60%	40%	60	36	24
Middlemount	0%	100%	40	0	40
Donaldson	68%	32%	101,2	68,816	32,384
Total Resources			**201,2**	**104,816**	**96,384**
Company	**52%**	**48%**			



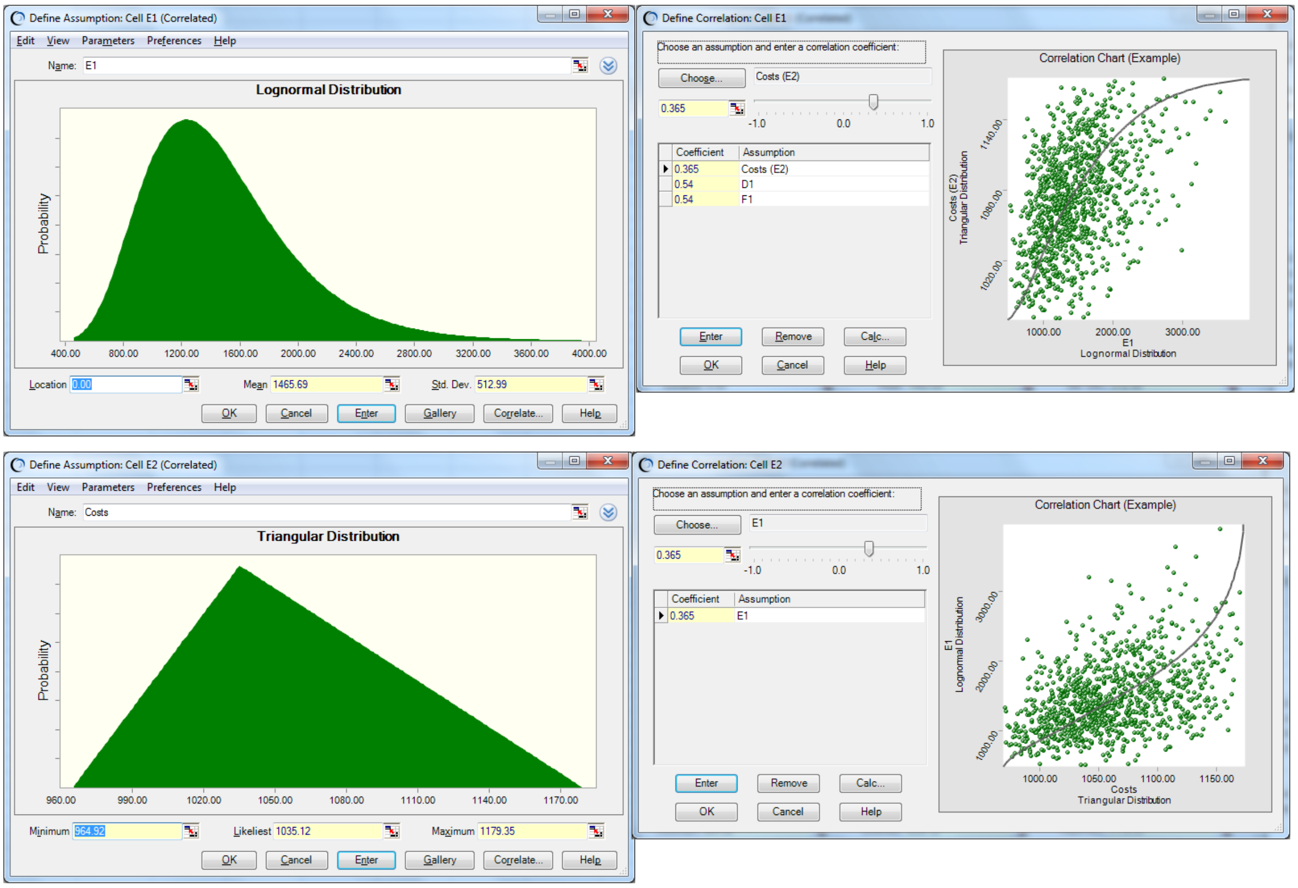
The EWMA lamda of 0.909 was calculated by minimising the RMSE.

RMSE Ranking				
Equally weighted			EWMA	
15 years	10 years	5 years	Lambda ,94	Lambda 0,909
0,036168853	0,035416428	0,033962362	0,035877146	0,035771605
3	2	1	5	4

The five year Volatility figure was selected as this had the lowest Root Mean Squared Error.

Appendix Q: Monte Carlo distribution assumptions

A log normal distribution with autocorrelation (1 year) was used for coal prices. Production costs were triangulated based upon management reports. Correlation, as discussed in the thesis is based upon industry cost and coal price trends.



Screenshots from Oracle Crystal Ball

Appendix P: Capacity Considerations – expansion option

The ability to expand operations was assessed by reviewing the capacity Gloucester has in the current rail and port agreements. Due to bottleneck as mentioned in the industry analysis, this was considered the best approach to establishing the flexibility the company has to expand production.

	Gloucester Basin	Donaldson	Middlemount (100% basis)
CHPP (Processing)	Stratford CHPP: facility has a capacity of 5.3mtpa ROM.	Bloomfield CHPP: facility has a capacity of 4.0mtpa increasing to 8mtpa over the next two years (by 2014).	Middlemount CHPP: capacity of 3.5mtpa ROM increasing by 2.65mtpa (as discussed in Capex section) to total of 6.125mtpa
Rail agreements	The Stratford facility is located at the old Gloucester mining site though production from Duralie (the main producing mine of Gloucester Basin going forward) is railed 20kms from mine site to Stratford CHPP Facility: current contract volume of ROM 3.0mtpa increasing to 3.4mtpa by 2014. CHPP to port (saleable coal): 3.1mtpa increasing to 3.4mtpa by 2014.	Contract with QR National for capacity of 3.0mtpa, 4.0mtpa and 5.0mtpa in FY- 2012, -2013 & -2014.	Two rail operators: QR national and Pacific National. 1) QR: 3.0mtpa 15 year agreement (from April 2010). 2) Pacific National: 3.0mtpa for 15 years (from 2012).
Port Capacity	Coal shipped through PWCS: 3.1mtpa capacity increasing to 3.5mtpa by 2016	Coal shipped through PWCS: port allocation of 2.2mtpa plus 3.9mtpa from 11.6% holding in NCIG Pty Ltd. NCIG capacity will increase to 6.3mtpa from 2016. Total capacity post 2016 of 10.2mtpa	Coal shipped through APCT: total capacity of 3mtpa increasing to 4mtpa through shareholding in North Queensland Coal Terminal Pty Ltd.

Appendix Q: Mining Depletion Calculation

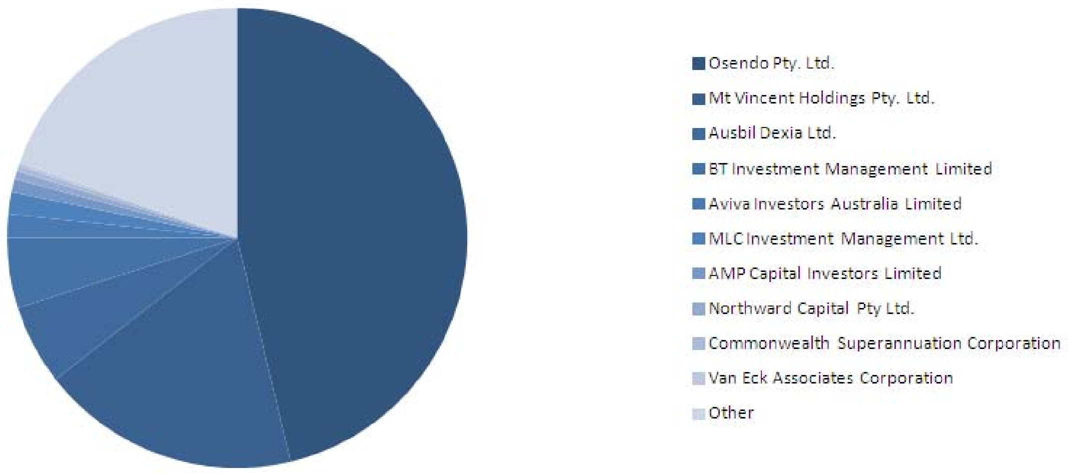
The calculation below represents the depletion expense recognised in the income statement going forward. Historical depletion charges (2006 to 2011) have also been presented. Depletion charges represent capitalised costs that were incurred prior to the mine reaching production stage. The capitalised costs are expensed on a unit of production basis over the production life of the mine. Depletion includes the premium paid on acquisition of Donaldson and Middlemount Resources.

	2006	2007	2008	2009	2010	2011
Depreciation and Amortisation	6.271.000,00	6.477.000,00	6.375.000,00	6.004.000,00	11.306.000,00	18.701.000,00
Depletion	4.451.000,00	3.519.000,00	3.437.000,00	1.744.000,00	2.205.000,00	1.767.000,00
Depreciation	1.820.000,00	2.958.000,00	2.938.000,00	4.260.000,00	9.101.000,00	16.934.000,00
Production ROM	2961538	3332308	2931000	2689000	3101000	2943000
Mining depletion per tonne ROM	1,50	1,06	1,17	0,65	0,71	0,60

Depletion Calculation	
2011 Mining Property and Development (net)	600.572.000,00
of which: middlemount	521.943.000,00
Non middlemount	78.629.000,00
Saleable coal	60.489.860,00
Gloucester Basin Charge per tonne	1,30
Reserves (paid on acquisition of Middlemount)	446.718.000,00
Mining PP&E	75.225.000,00
Middlemount total mining PPE	521.943.000,00
Saleable coal	39.773.000,00
Reserve premium charge	11,23
Exploration charge	1,89
Middlemount Charge per tonne	13,12
Reserves (paid on acquisition of Donaldson)	587.455.000,00
Mining PP&E	84.984.570,00
Donaldson total mining PP&E	672.439.570,00
Saleable coal	100.686.000,00
Reserve premium charge	5,83
Exploration charge	0,84
Donaldson Charge per tonne	6,68

Appendix R: Share Ownership Structure

The share ownership structure as at 15th March 2012 is presented below:



Investor Name	% O/S
Osendo Pty. Ltd.	46,26%
Mt Vincent Holdings Pty. Ltd.	18,20%
Ausbil Dexia Ltd.	5,62%
BT Investment Management Li	4,93%
Aviva Investors Australia Limite	1,65%
MLC Investment Management	1,54%
AMP Capital Investors Limited	0,93%
Northward Capital Pty Ltd.	0,58%
Commonwealth Superannuatio	0,39%
Van Eck Associates Corporati	0,22%
Other	19,68%
Top 10 Shareholders	80,32%

Source: Thomson Financial

The top two shareholders are holding companies owned by The Noble Group, giving the company a consolidated holding of approximately 64.6% of the shares outstanding.