Evaluating the effect of life cycle cost forecasting accuracy on mining project valuations

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ABSTRACT

The study was conducted to establish what effect life cycle cost forecasting accuracy has on project valuations with special reference to a global mining organisation's coal business unit in South Africa. The research stemmed from the fact that the organisation identified through its own research in 2009 that its capital projects rarely met the originally budgeted life cycle cost forecasts estimated during the project development stages. These forecasts were generally found to be underestimated. Overrunning of cost budgets in project management terms results in project failure.

The study employed two main empirical research sections. The first section took a case study approach where past implemented project results were collated and analysed. The main aim was to determine how close to reality the original life cycle cost estimates were, and secondly how any variances to the originally budgeted costs impacted on the anticipated project value post implementation. Secondly, the study employed in-depth interviews with seven project specialists within the organisation that were also involved in the development stages of the investigated projects.

The study concluded that life cycle cost forecasts are very important project business case inputs and that the necessary time and effort should go into developing them so as to ensure that they are as comprehensive and accurate as possible. The sensitivity analysis that was conducted revealed that a coal mining project business case is the second most sensitive to variations in life cycle costs after variations in commodity price. The results indicated that a 20% increase in life cycle costs can destroy an equivalent project value of up to 100%. Accurate life cycle cost forecasting is therefore essential in order to estimate to a certain degree of accuracy the value of a project which in turn will be used to inform capital investment decision making.

Key Words: Life Cycle Costs, Forecasting Accuracy, Capital Project Development, Project Valuation, Life Cycle Costing (LCC).

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GLOSSARY OF TERMS

Activity-based Costing (ABC) – is a costing method based on activities that is designed to provide managers with cost information for strategic and other decisions (Seal *et al.,* 2009:827).

Activity Based Life Cycle Costing (AB-LCC) – is a cost forecasting approach combining various aspects from Activity-Based Costing (ABC), LCC, and Monte Carlo methods (Rodriquez & Emblemsvag, 2007:371).

Benchmarking - refers to the comparison of a developed cost estimate, with an estimate of a historical project of similar scope, to corroborate the data (Organisation A, 2011:6).

Business Case – is a documented economic feasibility study used to establish validity of the benefits of a selected component lacking sufficient definition and that is used as a basis for the authorisation of further project management activities (PMBOK, 2013).

Capital Expenditure (CAPEX) – refers to the monetary requirement for the start/continuation/completion of a capital project (Organisation A, 2011:5).

Capital Investment Decision Making / Capital Budgeting – is the process of planning significant outlays on projects that have long term implications (Seal *et al.*, 2009:828).

Cost Estimate – is an approximation of the probable cost of a product, program, or project, computed on the basis of available information (Organisation A, 2011:5).

Discounted Cash Flow (DCF) – refers to financial evaluation techniques that recognise the time value of money (Seal *et al.*, 2009:373).

Greenfield Project - is the development of a project into an area in which no previous development exists (Lee, 2011:3).

Internal Rate of Return (IRR) – represents the interest yield promised by a project over its useful life (Seal *et al.*, 2009:832).

Life Cycle Costs – of an item is the sum of all funds expended in support of that item (this includes CAPEX, OPEX and SIB CAPEX) from its conception and fabrication through its operation to the end of its useful life (Korpi & Ala-Risku, 2008:240).

Life Cycle Costing (LCC) – is defined as the concept of including acquisition, operational, sustaining and disposal costs when evaluating various design alternatives (Korpi & Ala-Risku, 2008:240).

Mineral Resource – is a concentration or occurrence of material of intrinsic economic interest in or on the Earth's crust in such form, quality and quantity that there are reasonable prospects for eventual economic extraction. The location, quantity, grade, geological characteristics and continuity of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge (SAMREC, 2009).

Monte Carlo Methods – is a probabilistic approach based on a broad class of computational algorithms that rely on repeated random sampling to obtain numerical results (PMBOK, 2013: 11.4.2.2).

Net Present Value (NPV) – is the difference between the present value of the cash inflows and the present value of the cash outflows associated with an investment project (Seal *et al.*, 2009:834).

Operational Expenditure (OPEX) – refers to the normal operational running costs of an operation such as labour, fuel, electricity, direct material and other general consumables. (Defined by the author of this study.)

Operational Readiness Planning (ORP) – refers to the planning of operational systems and/or tasks identified in the Operational Readiness Plan that is required to ensure that the project gets successfully handed over to operations (Organisation A, 2011:6).

Post-audit Review – is the follow-up after a project has been approved and implemented to determine whether the expected results are actually realised (Seal *et al.*, 2009:835).

Project – is a temporary endeavour undertaken to create a unique product, service or result (PMBOK, 2013).

Project Life Cycle – is a collection of generally sequential project phases whose name and number are determined by the control needs of the organisation involved in the project (PMBOK, 2013).

Project Management – is the application of knowledge, skills, tools and techniques to project activities to meet project requirements. Projects usually need to be managed within the competing demands for scope, time, cost, risk and quality (PMI, 2013).

Project Valuation – describes in monetary terms how much a project is worth. NPV is the most common evaluation criteria that represent this project value (Maroyi, 2011:2).

Sensitivity Analysis – involves calculating the effect of other possibilities, such as the rise in the market price of a product (Seal *et al.*, 2009:838).

Stay In Business Capital (SIB CAPEX) - is defined as CAPEX undertaken in order to maintain the life of existing assets without materially increasing capacity (Organisation A, 2010:110).

Target Costing (TC) - is a cost management system that aims to justify the production of a product only through its profitability which is controlled by the product design (Kee, 2010:204).

Value Engineering (VE) – is the creative approach to optimize life cycle costs, save time, increase profits and increase quality more effectively (Save, 2013:1).

LIST OF ABREVIATIONS

ABC – Activity-Based Costing

AB-LCC – Activity Based Life Cycle Costing

CAPEX - Capital Expenditure

DCF – Discounted Cash Flow

EPCM – Engineering, Procurement and Construction Management

IRR – Internal Rate of Return

JIT – Just In Time

KPI – Key Performance Indicator

KSF – Key Success Factor

LCC – Life Cycle Costing

NPV – Net Present Value

OPEX – Operational Expenditure

PB – Payback Period

PMI – Project Management Institute

PMBOK – Project Management Body Of Knowledge

ORP – Operational Readiness Planning

RBCT – Richards Bay Coal Terminal

SACRM – The South African Coal Road Map

S&SD – Safety and Sustainable Development

SCM – Strategic Cost Management

SIB CAPEX – Stay In Business Capital

TC – Target Costing

VE – Value Engineering

CHAPTER 1: NATURE AND SCOPE OF THE STUDY

1.1. INTRODUCTION

An investigation was conducted in 2009 within a specific multinational mining organisation on capital project execution and the results of the study revealed that most mining, minerals and metals capital projects including those implemented within the organisation exceeded cost and schedule targets. The identity of the mining organisation will not be disclosed for purposes of this study due to the sensitivity and nature of the research topic, and will be referred to as “Organisation A” from here on.

The investigation further revealed that in most cases it was the project life cycle costs that were over budget with the main reason being that they were initially underestimated during the project development and planning stages. Project life cycle cost forecasts are a direct input into a project’s valuation model, and inaccurate estimates could therefore adversely impact on project valuation results and in turn capital investment decision making.

The findings of the 2009 investigation led to the initiation of this research study being conducted to investigate and establish the effect that life cycle cost forecasting accuracy has on mining project valuation.

1.2. BACKGROUND

Capital project execution has been on Ernst & Young’s top 10 business risk register for the mining and metals industry since 2011 and is impacting on organisations’ market value more than ever due to its impact on shareholder confidence (Elliot, 2013:8).

In 2010, only 2.5% of major mining capital projects globally were successful in meeting the critical project criteria of scope, cost, schedule, and business benefits (Da Silva *et al*., 2012:3). Of the companies that reported project overruns publicly (between October 2010 and March 2011), the average cost overrun was about 71% of the original project cost estimate (Mitchell, 2011:3).

To make the situation even worse, capital project development within the mining industry has been put on the back burner as capital scarcity and the inability to raise funds has hit the industry across the globe (Elliot, 2013:4). The Financial Times reported during February 2013 that the mining and metals industry is suffering from a “capital strike” in the face of rising cost and lower commodity prices (Blas, 2013:1). Mining organisations have been coming under pressure from shareholders to show smarter and more disciplined spending especially when it comes to capital projects (Blas, 2013:1).

Addressing the risks surrounding the delivery of mining capital projects is crucial with many organisations having incurred cost escalations that have forced them to defer, cancel or revise their capital project business cases (Hudson, 2011:18). Mining organisations are managing these risks by focusing on the integrity of stage-gated project delivery, early intervention, the deployment of robust project controls and the maturity of project delivery practices (Steffen *et al.*, 2008:3).

1.3. PROBLEM STATEMENT

Despite the project governance policies and the project management approaches which are available to organisations, projects continue to fail (Weyer, 2011:8). Project failure occurs when the original planned benefit is not realised or when the project is not completed on time, within budget, within scope and to the required quality.

Forecasts of cost, demand, and other impacts of planned capital projects have been a common problem across various industries around the globe (Weyer, 2011:8). Inaccurate forecasts causes project business cases to be off target which organisations use to decide in which projects to invest and where to allocate its scarce capital resources. This research done by Weyer on project failure suggests that project failure is directly related to and a result of wrong decisions being made because of poor project planning and inaccurate forecasting.

Referring back to the investigation that was conducted in 2009 within Organisation A and a further analysis of its project base, the organisation identified the biggest drivers of value destruction and project failure in terms of cost and schedule to be (Organisation A, 2010:12):

- OPEX overspends
- Slower than forecast production build-up

- Poorer than forecast ore grade quality
- SIB CAPEX overspends

The investigation identified that life cycle cost overruns (OPEX and SIB CAPEX) was the biggest value destroyer equivalent to approximately 400% of the originally estimated project Net Present Value (NPV). Apart from being the greatest value destroyer, it was also found to be the most common value destroyer. The cost overruns were mainly attributable to the initial life cycle cost forecasts developed during the project planning stages being underestimated and unrealistic to achieve.

The area of concern for Organisation A is therefore to understand the validity of its project business cases (project valuations) based on the accuracy of its inputs, particularly the OPEX and SIB CAPEX estimates. These costs are collectively referred to in this study as the life cycle cost estimates that will be required to sustain a planned mining asset. Invalid project valuations could adversely influence capital investment decision making and in turn destroy shareholder value.

The 2009 investigation covered Organisation A as a whole including all its operations across the globe and across various commodities. No differentiation were however made between its various business units and it is therefore not known whether the South African coal business unit has performed in a similar fashion over the past few years.

Specifically understanding the magnitude of the effect that life cycle cost forecasting accuracy has on project valuations within Organisation A's coal business unit in South Africa, will be able to guide future efforts during the development of project life cycle cost forecasts.

1.4. OBJECTIVES OF THE STUDY

Primary objective

The primary objective of the research is to investigate the effect that life cycle cost forecasting accuracy has had on mining project valuations within Organisation A's South African coal business unit over the past 10 years. The objective is to quantify the impact of inaccuracies and to compare it with that reported for the bigger organisation in 2009. This way the past performance of the business unit in terms of capital project execution can be evaluated and specifically the impact of life cycle cost forecast accuracy on project valuations can be determined.

Understanding the impact will be able to guide future efforts of the business unit during life cycle cost estimation and project valuations which ultimately inform capital investment decision making.

Secondary objectives

- Confirm that for the South African coal business unit cost overruns are also mainly attributable to poor cost estimating and forecasting as opposed to poor cost management.
- Identify possible reasons for the inconsistencies experienced in life cycle cost estimate accuracy in the past within Organisation A. Determine cost estimating and forecasting principals to be adopted in future within Organisation A to achieve more accurate project valuations.
- Conduct a sensitivity analysis on project valuation results based on variations in life cycle cost inputs, price and establishment capital for a range of mining projects currently being developed. The results from this sensitivity analysis will be compared to the historic results so as to establish whether any correlation exists.

1.5. RESEARCH METHODOLOGY

The methods of investigation that were used in this research study are as follows:

Literature study

A comprehensive literature study was conducted to investigate project life cycle costs and the forecasting thereof. The research covered various aspects of life cycle costs' including what it is and how it fits into capital project development, how it influences project valuations and ultimately capital investment decision making. The research also looked at how life cycle costs can be accurately forecasted and how to account for risk during forecasts. The concept of Life Cycle Costing (LCC) was investigated and how it can contribute to achieving more accurate cost forecasts and at the same time optimise project value. The sources of research included text books, relevant articles from journals, magazines and the internet.

Empirical study

A qualitative case study approach was adopted for the main part of the empirical research. It focused on analysing post-audit results of past implemented mining projects within Organisation A's coal business unit in South Africa. Post-audit results were collated and analysed so as to determine how life cycle cost estimate accuracy has influenced project valuations in the past. The analysis was further supplemented with primary data gathered through unstructured in-depth interviews with selected project practitioners and specialists within the organisation.

In support of the primary objective of the study a sensitivity analysis on project valuation results was also conducted. The analysis covered variations in life cycle cost inputs, commodity prices and establishment capital for a range of mining projects which were still in their development stages at the time. The results from the sensitivity analysis were compared to those results obtained from the case study research so as to establish whether any correlation existed.

The research methodology is explained in detail in Chapter 3 and can be summarised as follows:

Design

The main research study took a descriptive case study approach focussing on secondary data, but was supplemented with primary data gathered through explorative research methods such as unstructured in-depth interviews. The research methods used in this research design were explorative and qualitative.

Population

The case was limited to 3 capital projects that have been implemented within Organisation A's coal business unit in South Africa over the last 10 years. The individuals consulted as part of the research were a small group of seven people, but were highly specialised project practitioners and were involved in some or all of the 3 cases investigated.

Measuring instruments

Following a case study research approach, most of the data was secondary in nature that were collated and analysed. Primary data were however also gathered through explorative means in the form of unstructured in-depth interviews.

Data analysis

The secondary data was processed into systematic visual representations that could be used to draw conclusions from. For the primary data, a manual process of content analysis and theme identification was used to compile a descriptive explanatory framework of the investigation. The data was also then further processed and displayed in a matrix format for easy interpretation based on the frequencies of the encountered themes.

The last part of the empirical study involved conducting a sensitivity analysis on various projects within the organisation that were still in the pipeline of being developed. The various financial models of these projects were used to determine what effect variations in the commodity price, the establishment capital and the life cycle cost estimates had on the project valuation.

1.6. SCOPE OF THE STUDY

The literature research on the topic will be comprehensive and will cut across various industries and applications of the concept. The empirical research will however be limited to mining projects within Organisation A’s coal business unit in South Africa. In order to facilitate the time allowed for the research, the scope was further narrowed down to only focus on three greenfield mining projects that were implemented over the last 10 years.

A greenfield mining project is the development of mining into an area in which no mining infrastructure exists. Conversely, a brownfield mining project is the development of mining infrastructure in an area which the expansion of current mining and its related infrastructure will take place (Lee, 2011:3).

1.7. LIMITATIONS OF THE STUDY

Due to the nature and sensitivity of the information, the identity of the mining organisation and its specific mining projects will not be disclosed.

As described in the scope of the study (section 1.6), the empirical research has been narrowed down to only consider coal mining projects in South Africa within a specific mining organisation. Future research on the topic can therefore be expanded to include a wider industry range of mining projects.

1.8. CONTRIBUTION OF THE STUDY

Odendaal (2009:9) established in research on a similar research topic that although a wealth of knowledge and literature exist on project management, only a small section in most of these works refer to cost estimation and cost management. This is a concern especially looking at the potential project value that can be destroyed by poor cost forecasting as was illustrated by Organisation A's investigation in 2009.

Wetekamp (2011:900) points out the fact that a knowledge area on project finance for example is totally missing in project management literature and that core concepts such as NPV need to be strengthened. Organisation A and the mining industry need to be made aware of the importance of developing accurate project valuations so as to inform good capital investment decision making. In order to obtain accurate project valuations, the valuation model inputs of which the life cycle cost forecasts are apart need be complete and accurate.

Odendaal's (2009:11) research which covered metallurgical research projects, found that many of the project leaders are engineers which are not always trained to estimate and manage costs effectively. They further don't always understand and appreciate the effect that cost forecast accuracy has on project valuations, and in turn how inaccurate project valuations can adversely impact on capital investment decision making. Life cycle cost forecasting and how it influences project valuations and the concept of LCC have therefore been examined in detail as part of the literature chapter of this research study.

The empirical research chapter aimed to evaluate the effect of life cost forecasting accuracy on project valuation results. By quantifying this effect and demonstrating the impact that cost forecast accuracy has on project valuations, it may be used to inform project leaders within the organisation and the industry and possibly influence future efforts during life cycle cost forecasting.

1.9. LAYOUT OF THE STUDY

Chapter 1 introduce the research and includes a discussion of the nature and scope of the study, the problem statement, the research objectives, the research methodology, limitations of the study and the importance of the study and its potential benefits.

Chapter 2 investigates life cycle cost forecasting and its impact on project valuations. The literature research covers various aspects of life cycle costs including what life cycle costs are and why it must be estimated, how it fits into capital project development and how it can impact on project valuations and capital investment decision making. The concept of LCC is also investigated and how it can contribute in achieving more accurate life cycle cost forecasts and subsequently optimises project value.

Chapter 3 outlines and analyses the results of the empirical research study that was conducted. The aim and results of the evaluated cases and the sensitivity analysis are discussed. The key findings from the empirical study are then summarised in line with what is required to answer the research problem.

Chapter 4 summarises the key findings from the overall research study. Referring to information from both the literature and empirical study, conclusions are drawn and recommendations given that can be reviewed and then possibly implemented by Organisation A.

CHAPTER 2: LIFE CYCLE COST FORECASTING AND ITS IMPACT ON PROJECT VALUATIONS

2.1. INTRODUCTION

Mineral resources such as coal are finite and the mining thereof leads to depletion. For coal mining organisations to stay relevant into the future, a continuous pipeline of capital projects therefore need to be maintained. Prospective projects must be developed and designed according to good project management principals through the various project development stages in order to enhance investment confidence. From the available project pipeline a decision then need to made in which projects to invest based on their technical soundness, business case risk and financial attractiveness.

It is thus very important that accurate project evaluations are done so as to inform good capital investment decision making. Looking at past implemented projects within Organisation A and the mining industry in general however, it is evident that planned project results are very seldom achieved. Da Silva *et al*. (2012:3) refers to a study conducted by PricewaterhouseCoopers' in 2010 on major mining capital projects globally which found that only 2.5% were successful in meeting the critical criteria of scope, cost, schedule, and business benefits.

Cost overruns especially in terms of forecasted life cycle costs required to sustain a planned mining operation have been identified by Organisation A as the biggest destroyer of value when looking back at its past implemented projects. The organisation found that the main reason for the life cycle cost overruns were because they were initially underestimated during the project development and planning stages. Project life cycle cost estimates are a direct input into a project's valuation model, and inaccurate estimates could therefore adversely impact on project valuation results and in turn capital investment decision making.

LCC was investigated as a cost management approach that can possibly be adopted in a project environment so as to achieve more accurate project life cycle cost forecasts to be used during project valuations. LCC is concerned with considering and accurately estimating all future costs related to a product and then using that information to make decisions and to optimise the design of that specific product.

In summary, this chapter firstly describes the coal mining industry in a global context as well as in a South African context. It then focuses on capital project development and project valuations and how it influences capital investment decision making. The chapter also investigates past project failures within Organisation A as well as in the mining industry, for possible causes leading to such failures. The chapter concludes with a detailed investigation into project life cycle costs and how a concept such as LCC can assist in developing more realistic cost forecasts and prevent project failure.

2.2. THE SOUTH AFRICAN COAL MINING INDUSTRY

Mining has played an integral part in the development of the South African economy and has contributed significantly in making its economy the strongest on the African continent (GCIS, 2012:130). The mining industry in South Africa is the country's largest employer, with approximately 460,000 employees and a further 400,000 employed by the suppliers of goods and services to the mining industry (Universal Coal, 2013).

South Africa is rich in mineral resources at an estimated market value of US$2,5 trillion (GCIS, 2012:130). The South African mining sector contributes approximately 8% to the gross domestic product, and increases to 18% when taking into account the indirect effect of mining on the economy (GCIS, 2012:130). South Africa ranks among the top ten countries in the world when it comes to the production of minerals such as manganese, iron ore, gold, chrome, ferrochrome, platinum and coal.

South Africa is the country with the sixth largest deposit of coal in the world equivalent to approximately 11 % of the world's total coal reserves (Universal Coal, 2013). South Africa produces on average 224 million tonnes of saleable coal annually, making it the fifth largest coal producer in the world (Eskom, 2013). Coal is South Africa's second largest earner in value of total sales after gold, making out 6.1% of the country's total export goods (Universal Coal, 2013).

Coal is internationally still the most common energy source, accounting for approximately 36% of the world's electricity production and it is likely to remain so until at least 2020 (Eskom, 2013). A quarter of South Africa's coal production is exported to international markets, predominantly India and China, making South Africa the third largest coal exporting country in the world (Universal Coal, 2013). The Richards Bay Coal Terminal

(RBCT) was upgraded in 2010 with a subsequent increase in export capacity from 70 million tonnes per annum to 91 million tonnes per annum (Universal Coal, 2013). SACRM (2013:18) forecasts that this export capacity will be reached by 2023.

The remaining three quarters of coal production feeds the various local industries, with the bulk (53%) being used for electricity generation by South Africa's power utility, Eskom (Eskom, 2013). Eskom generates approximately 95% of South Africa's electricity and approximately 45% of the electricity used in Africa (Eskom, 2013). Approximately 90% of the electricity produced by Eskom is from coal fired power stations (Eskom, 2013). The key role South Africa's coal reserves play in the economy is evident from the fact that Eskom is the 7th largest electricity producer in the world, and Sasol the largest coal-to-chemicals producer in the world (Eskom, 2013).

With a growing demand for electricity in South Africa and the African continent, and the fact that Eskom's older power stations are closing down in the medium term, results in significant new power generation capacity being required over the next 30 years (SACRM, 2013:13). Eskom's capacity expansion budget was R385 billion up to 2013 and is expected to grow to more than a R 1 trillion by 2026 in order to double its capacity to 80 000MW (Eskom, 2013). South Africa is likely to continue to include coal as part of its energy mix, where it has the potential for continuing to provide secure and affordable energy supply, extending employment and increasing export revenues (SACRM, 2013:1).

Eskom projects that new coal supplies of around 60 million tonnes per annum will be required by 2020 in order to provide sufficient coal for their power stations (SACRM, 2013:5). This is to replace coal from declining coal mines, to extend the lives of certain power plants and for new committed coal fired power stations. This translates into a total capital amount of between R 60 and R 90 billion, and a further R 20 to R 30 billion to fund potential export expansions as indicated by the RBCT expansion (SACRM, 2013:5).

The expected growth in the South African coal mining industry will require approximately R 100 billion worth of investments into capital projects that will need to be implemented by 2020. Investments in mining projects can be very risky because of the amount of uncertainty involved such as geological characteristics, mining conditions, commodity prices, mining and processing cost and cost escalations. A step-by-step approach is therefore adopted by most mining organisations in evaluating capital projects whereby the risks and opportunity are methodologically assessed and quantified (Steffen *et al.,* 2008:4).

2.3. CAPITAL PROJECT DEVELOPMENT

Projects are an essential part of doing business and are often implemented with the aim of achieving an organisation's strategic goals. In contrast with operations, projects differ in that they are temporary and unique while operations are on-going and repetitive. According to the internationally recognised Project Management Institute (PMI, 2013), a project can be defined as a "temporary endeavour undertaken to create a unique product or service". The product or project deliverable in the context of this research study is a new coal mine, either opencast or underground in nature.

Many organisations in all sectors of industry accomplish a great deal of value-added work through projects (Weyer, 2011:6). Projects are implemented and delivered through applying various techniques collectively known as project management. The PMI (2013) defines project management as "the application of knowledge, skills, tools and techniques to project activities to meet project requirements". Projects usually need to be managed within the competing demands for scope, time, cost, risk and quality (PMI, 2013).

Projects are normally divided into various project stages which collectively are referred to as the project life cycle. The project life cycle defines the beginning and the end of a project. Deliverables from preceding stages are generally the input into the next and need to be approved before work can commence on the next project stage. These approval periods between phases are commonly referred to as stage gates and the reviewers responsible for the approval are normally independent technical or project specialists (Steffen *et al.,* 2008:4). The probability of successful project completion and accuracy gets progressively higher as the project progresses through its life cycle and as its deliverable gets defined in more detail (PMBOK, 2013: Sect. 2.4.1).

The typical stages as identified by Organisation A that are associated with the development of a mining asset or in other words a new coal mine can be summarised as follows:

- Opportunity identification

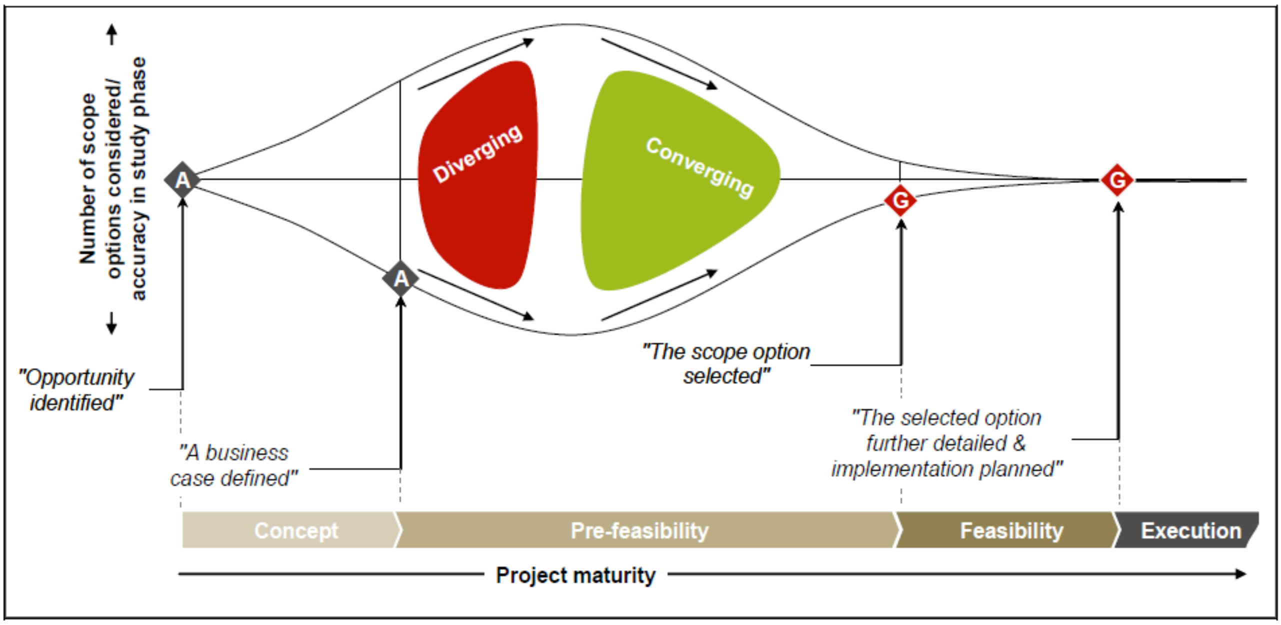
    - Exploration through geological drilling campaigns
    - Resource development (quantifying the coal resource that was identified)
- Conceptual study
- Pre-feasibility study
- Feasibility study (including permitting, agreements and funding)
- Project implementation (including detailed engineering, procurement, construction and commissioning)
- Ramp-up
- Operations
- Closure

Organisation A considers stage 2 through to stage 6 being project specific phases forming part of the project life cycle while the other three stages (stages1, 7 and 8) are considered part of the overall asset development life cycle. The asset development life cycle can therefore be summarised in four developmental stages namely Opportunity Identification, Project Development, Operations and Closure. Project management activities are therefore theoretically speaking only required during stages 2 to 6 of the asset development life cycle to design, construct and hand over an operational mine (the deliverable) to the operator.

During the project development stages of an asset a viable business case need to be developed before it can be presented as a prospective investment proposal to the organisation's investment committee. This is normally an iterative process and can take up to several years before a viable or attractive business case is developed to exploit a specific mineral resource. Various options are investigated and trade-offs are done as part of this process to ensure the technical soundness of the project as well as to maximise the project value and yield.

Each of the project development stages has their own specific objectives and purpose in contributing towards defining the final project deliverable. Once an opportunity has been identified, various options are investigated in an attempt to prove a viable business case at the end of the Concept Stage. Continuing in a "divergent" manner more options and trade-off studies are done during the Pre-feasibility stage up to the point when the most optimal scope option has been identified. The selected scope option then gets defined in detail during the Feasibility stage which takes a "convergent" development approach in terms of scope options and accuracy in preparation for the Execution stage that follows. As the project advances through the development stages the scope options reduce up to the point where the final scope option is selected and at the same time the project accuracy progressively improves as graphically illustrated in Figure 2.1.

Figure 2.1: The objectives and purpose of the various project development stages



(Source: Organisation A, 2010:22)

Each scope option being investigated during the project development stages involve a set of future cash flows which are forecasted based on a specific set of design criteria which are then discounted to compute a project yield and present value. A discounted cash flow (DCF) model is normally the basis from where a project net present value (NPV) and internal rate of return (IRR) are determined. The NPV, IRR and PB (payback period) approaches are the primary investment criteria used by South African mining companies for the evaluation and acceptance of a project (Maroyi, 2011:2).

The forecasted cash flows has a direct impact on the project or scope option valuation result, and should therefore be as accurate and comprehensive as possible to represent the actual cash flows that will be realised should the option be selected for implementation. Estimating future cash flows form part of the project activities classified as cost management. Project cost management include processes to ensure that a project will be completed within the approved budget and include these activities (PMBOK, 2013: Ch. 7, Introduction):

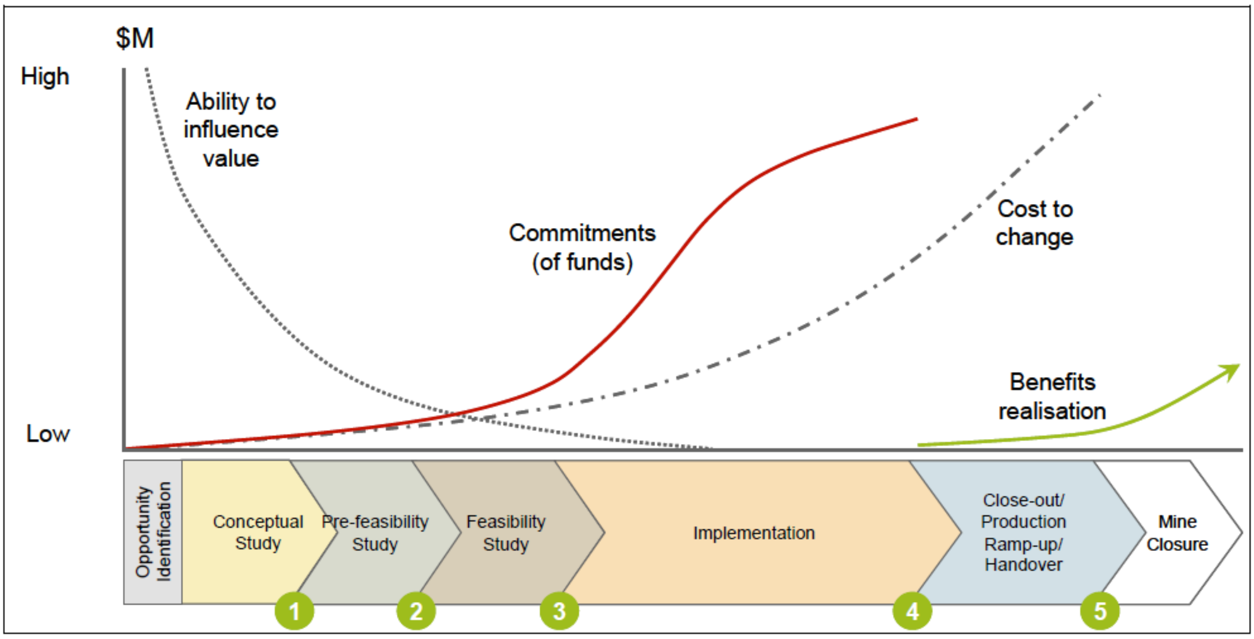
- Resource Planning – determine what resources and quantities will be required
- Cost Estimating – estimate what those identified resources will cost
- Cost Budgeting – allocate the cost estimate to work activities
- Cost Control – control changes to the project budget

Project cost management and the processes listed above are primarily concerned with the cost of the resources required to establish and implement the project for the client. Within Organisation A the project establishment cost is also commonly referred to as establishment CAPEX. Project cost management however also involves establishing the cost of using and sustaining the project's product (PMBOK, 2013). Organisation A refers to the operating cost that the client will incur by using the product as OPEX and the sustaining cost required for the product as SIB CAPEX. This broader view of project cost management involving the forecasting and analysing of prospective financials of the project's product is often referred to as LCC (PMBOK, 2000:83).

LCC is defined as the concept of including acquisition, operational, sustaining and disposal costs when evaluating various design alternatives (Korpi & Ala-Risku, 2008:240). In a project environment choosing between alternatives and optimization is often referred to as VE which is defined as the creative approach to optimize life cycle costs, save time, increase profits and increase quality more effectively (Save, 2013:1). Capital project effectiveness is a key driver of business success as well-conceived projects maximises return on investment and subsequently shareholder value (Hudson, 2011:18).

The ability to influence project success and project value is the greatest during the early project development stages and declines thereafter as the project proceeds towards implementation (Hudson, 2011:19). The cost to the developer also increases with each stage of development. The greatest value add can therefore be achieved by making good decisions early on in the overall asset development life cycle as graphically illustrated by Figure 2.2.

Figure 2.2: The relationship between influence and time in the project life cycle



(Source: Organisation A, 2010:20)

Because the ability to influence value declines with time, organisations are pursuing structured project development methodologies supported with rigorous project evaluation standards to ensure that the most value add is realised during the early project development stages (Da Silva *et al.,* 2012:4). Project valuations to an appropriate degree of accuracy is therefore required early on during the concept and pre-feasibility stages in order to facilitate the correct evaluation and early selection of project business case options.

Minimum accuracy levels of forecasted cash flows to be used in business case valuation models are normally set within the project development standards of organisations, after which a contingency is applied to account for risk and the uncertainty inherent to the estimates (PMBOK, 2013: 7.1.3.1). As the project progresses and the scope get better defined, the more accurate the cash flow forecasts and subsequently the project valuation becomes. The accuracy levels or class estimates prescribed by Organisation A for their CAPEX, OPEX and SIB CAPEX estimates are illustrated in Table 2.1.

Table 2.1: Estimate accuracy levels for the different project development stages

Phase of the Project	Class	Classification of Accuracy
Concept Stage	0	Accuracy range of +40% to -25% before contingency is considered. Cost estimates need to support the business case and a decision to proceed to a pre-feasibility stage.
Pre-Feasibility Stage	1	Accuracy range of +25% to -15% before contingency is considered. Cost estimates need to support the selection of a single option and a decision to proceed to feasibility stage.
Feasibility Stage	2	Accuracy range of +15% to -5% before contingency is considered. Cost estimates sufficiently detailed ready for implementation.

(Source: Organisation A, 2011:10)

It is important that project valuations especially at the end of the feasibility stage are as accurate and realistic as possible, because ultimately it will be used to inform capital investment decision making (Hudson, 2011:19).

2.4. CAPITAL INVESTMENT DECISION MAKING

The survival organisations in today's highly competitive business environment are predominantly determined by its ability to revive itself through the allocation of capital to productive use (Tziralis *et al*., 2009:1). The term "capital investment decision making" or alternatively "capital budgeting" is used to describe how organisations plan and select in which projects to invest.

Projects have long term implications for the profitability of an organisation and its shareholders and therefore projects with the most attractive future returns at the least risk are normally selected for investment (Seal *et al.*, 2009:372). Good capital budgeting is an important determining factor of a firm's success for several reasons (Maroyi, 2011:1):

- Capital investments typically account for a large amount of the funds of an organisation.
- Capital investments normally have a fundamental effect on the future cash flows of an organisation once an investment decision has been made.
- It is often not possible to reverse a decision, or it is very costly to do so, once the funds have been committed and funds are normally tied up for a long time.
  Investments affect the profitability and long-term strategy of an organisation.

Good capital budgeting is especially important in the mining industry due to the complex nature of its projects, the risks involved and their capital intensity. Ethically and legally as stipulated through the King Code of Corporate Governance (IOD, 2009:12) it is expected of JSE (Johannesburg Stock Exchange) listed organisations to be transparent and to always act in the best interests of their providers of capital, its shareholders. This is especially relevant when it comes to capital investment decision making due to the long term implications associated with it. Capital budgeting needs to be done in a responsible manner where transparency, integrity and accountability take precedence.

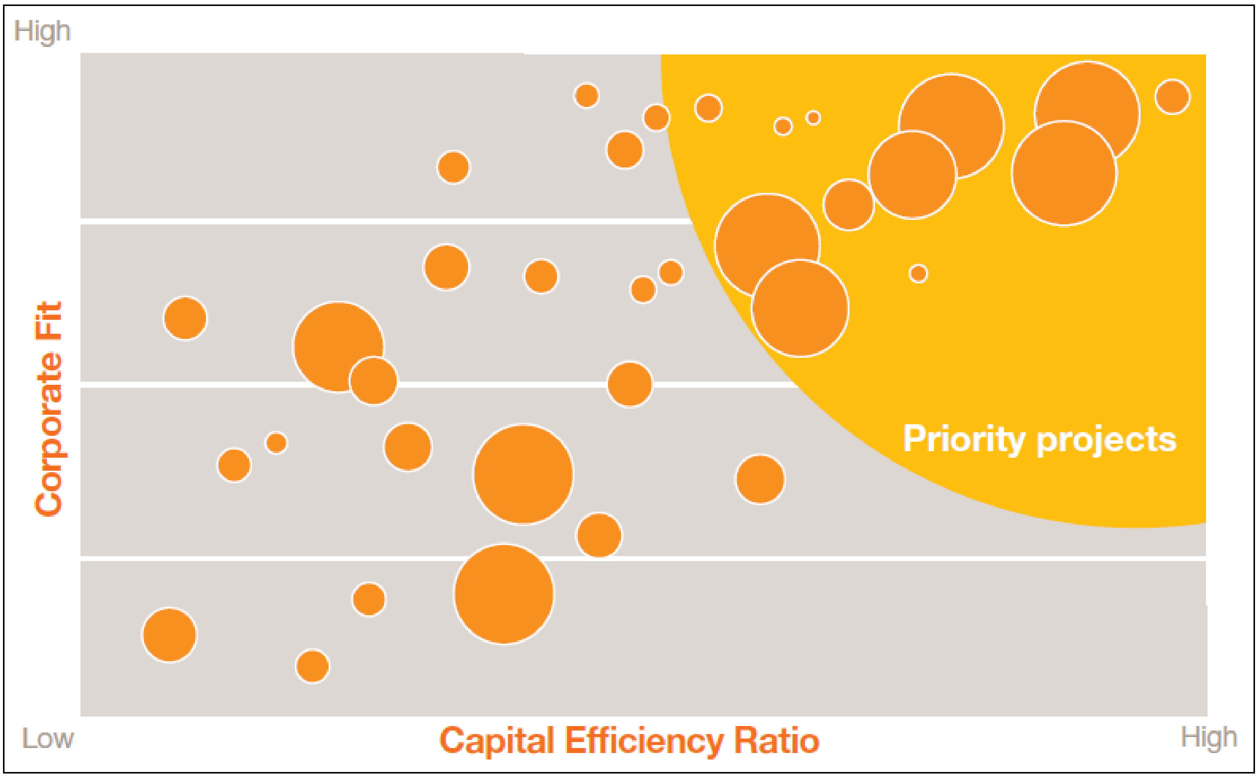
Mining organisations raise capital for prospective projects from a variety of sources including common equity, preferred equity, straight debt, convertible debt and exchangeable debt (SACRM, 2013:5). Capital project development within the mining industry has however been put on the back burner as capital scarcity and the inability to raise funds has hit the industry across the globe (Elliot, 2013:4). The Financial Times reported during February 2013 that the mining and metals industry is suffering from a “capital strike” in the face of rising cost and softer prices (Blas, 2013:1). Mining organisations have been coming under pressure from shareholders to show smarter and more disciplined spending especially when it comes to capital projects (Blas, 2013:1).

Capital project execution has been on Ernst & Young’s top 10 business risk register for the mining and metals industry since 2011 and is impacting on organisations’ market value more than ever (Elliot, 2013:8). Capital allocation and access to capital however tops the business risk register in 2013 for mining and metals organisations globally, up from number eight in 2012 (Elliot, 2013:4). These are strategic risks that threaten the long-term growth prospects of mining organisations within the industry.

A fundamental principal of economics is that resources are scarce and the goal of economic choice is therefore to obtain the greatest value from existing and available resources (Carbaugh, 2011:3). This principle is very relevant under the current economic conditions where mining organisations need to carefully select their capital projects for investment which will deliver the greatest return based on a certain amount of risk taken and capital spent. For this strategy to be properly executed however, it is important that accurate capital project evaluations are done so as to inform good investment decisions.

The importance of capital budgeting call for management to use proper procedures to evaluate their projects since failure to make the correct decision can result in the company suffering financially in the long run (Seal *et al.,* 2009:372). Such a procedure usually entails some form of ranking where pre-established key performance indicators (KPIs) that are aligned with corporate strategy such as NPV, IRR, Capital Efficiency Ratio, operational drivers and strategic fit are considered (Da Silva *et al.,* 2012:8). Ranking and prioritising projects within an organisation's project pipeline will assist in allocating the necessary resources and effort. Figure 2.3 is a graphical example of how some of the big multinational mining organisations are prioritising their projects based on strategy or corporate fit, value (size of bubble) and capital efficiency.

Figure 2.3: Ranking and prioritising future growth options

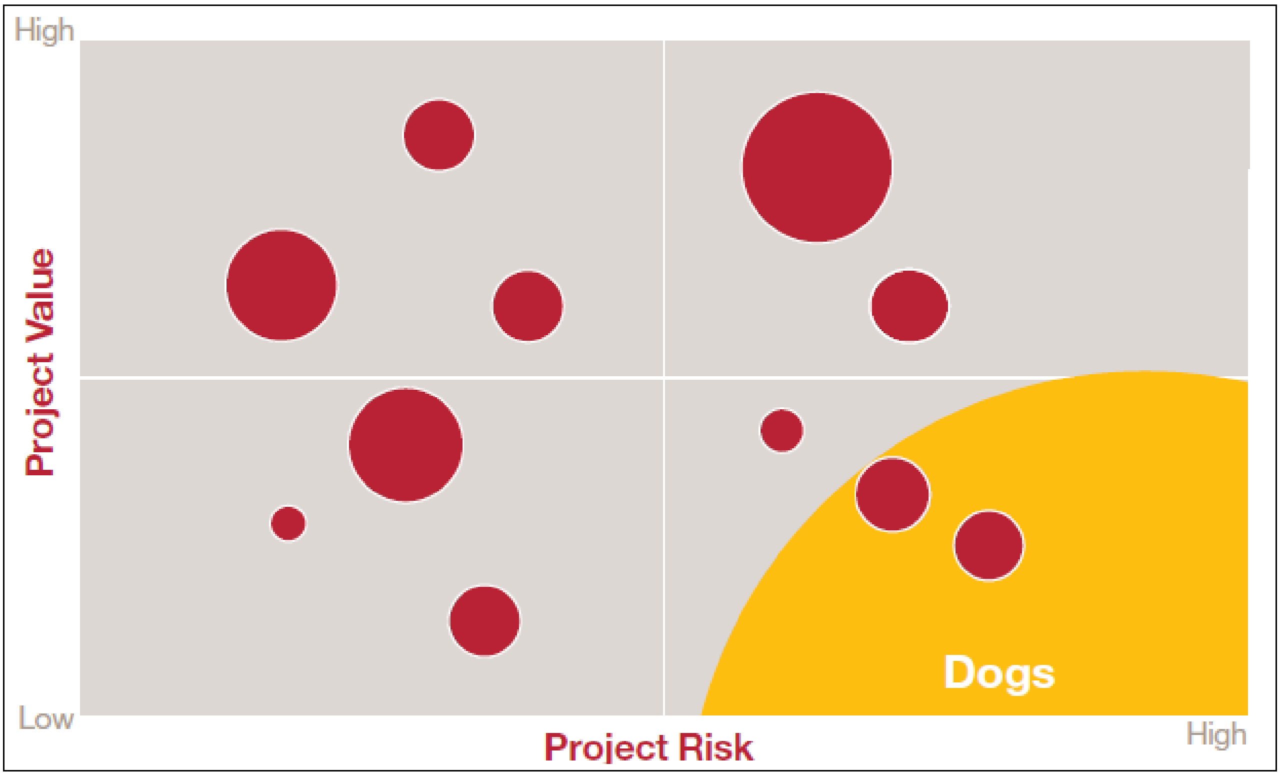


(Source: Da Silva *et al*., 2012:5)

These big multinational mining organisations are also taking it a step further by incorporating risk and uncertainty into the ranking process. If investment is considered in a high risk project, then the prospective return need to be such that it justifies the risk being taken. Projects with high risk rankings and low returns are therefore not good investment opportunities and are labelled as "dogs" as illustrated in Figure 2.4. Key risks and uncertainties identified by these organisations include that impact on project valuations include (Da Silva *et al*., 2012:9):

- Change in project scope;
- Poor cost estimation;
- Undisciplined project management approaches;
- Unrealistic availability estimates for labour, equipment and materials;
- Poor understanding of projects and interdependencies; and
- Lack of independent review, assessment and reporting.

Figure 2.4: Comparing project value to project risk



(Source: Da Silva *et al.,* 2012:9)

Using ranking tools as these described will assist organisations in identifying the most attractive projects to investment its scarce and valuable capital in. In South Africa the NPV and IRR approaches are the primary investment criteria used for the evaluation and acceptance of projects (Maroyi, 2011:2). Accurately forecasted future cash flows are a critical component of these evaluation techniques to determine whether a proposed project is clearly feasible, doubtfully feasible or clearly uneconomic. These techniques recognise the time value of money i.e. a rand today is worth more than a rand one year from now and are commonly referred to as the discounted cash flow (DCF) methods (Seal *et al.*, 2009:373).

In DCF analysis the focus is on cash flows and not accounting profits. The reason is that accounting profit is based on accrual concepts that ignore the actual cash flows in and out of an organisation. Typical cash outflows in DCF analysis include the initial capital investment of the project, working capital and the continuous and periodic outlays of operating costs such as repair and maintenance costs, labour, explosives and electricity. Typical cash inflows include sales revenues, cost savings, salvage value and the release of working capital.

Under the net present value method, the present value of all cash inflows are compared to the present value of all cash outflows that are associated with a specific project (Maroyi, 2011:38). An appropriate discount rate must be chosen to discount the cash flows to their present value. A firm's cost of capital is usually the most appropriate choice for a discount rate (Seal *et al.*, 2009:377). The difference between these cash flows is called the net present value, and indicates whether a specific project is feasible when the NPV is greater than zero or not feasible when the NPV is less than zero (Maroyi, 2011:38). The NPV evaluation technique is very popular with project managers around the world using this methodology to compare the value of projects against investment targets (Wetekamp, 2011:898).

The internal rate of return method can be described as the computation of the interest yield promised by an investment project over its useful life (Seal *et al.*, 2009:378). The IRR of a project is basically the discount rate at which the NPV is equal to zero. Once calculated, the project IRR can be compared to the company's required rate of return (usually the cost of capital) to establish whether a project is acceptable or not.

The DCF methods can be used to perform two main capital budgeting tasks namely screening decisions and preference decisions (Seal *et al.*, 2009:372):

- Screening decisions are those relating to whether proposed projects meet some pre-set standards of acceptance such as a minimum IRR of 12%.

- Preference decisions relate to selecting among several competing options eg Machine A chosen above Machine B because of a higher NPV and IRR.

Because capital investment decision making is such a critical task within organisations to determine in what projects to invest their capital, it is essential that quality DCF evaluations are done. The cash flow estimates used within the DCF analysis must therefore be as accurate and comprehensive as possible to provide a true reflection of the project yield and value as well as not to jeopardise decision making because of inaccurate information. Delivery of accurate forecasts of a numerous variables (cash flows and macroeconomic data) is inherent in all capital budgeting and investment appraisal methods (Wetekamp, 2011:899). The decision maker needs to consider all the factors that will have an impact on the project, because if the evaluation of a project is wrong, the project will be in trouble from the outset (Wetekamp, 2011:899).

One way of determining how effective one's capital investment decision making is done, is by conducting a post-audit investigation of each investment project (Maroyi, 2011:2). It involves a follow-up investigation after approval and commissioning to determine whether the expected results and cash flows were actually realised. This is a key part of the capital budgeting process to determine whether realistic data is being submitted to support capital budgeting proposals. If it is found that actual results are far out of line from original estimates then corrective action should be taken by management.

An investigation into project execution success was undertaken by Organisation A in 2009 and the results of the study showed that most mining, minerals and metals projects exceeded cost and schedule targets, including those implemented by Organisation A (2010:12). Capital project execution is considered a major business risk facing the mining and metals industry (Da Silva *et al.*, 2012:3; Elliot, 2013:8; Hudson, 2011:18; Wittig, 2013:392).

Addressing the risks surrounding the delivery of mining capital projects is crucial with many organisations having incurred cost escalations that have forced them to defer, cancel or revise their capital project business cases (Hudson, 2011:18). Mining organisations are managing these risks by focusing on the integrity of stage-gated project delivery, early intervention, the deployment of robust project controls and the maturity of project delivery practices (Steffen *et al.*, 2008:3).

2.5. THE CAUSES OF PROJECT FAILURES

Despite the project governance policies and the project management approaches which are available to the project manager, projects continue to fail (Weyer, 2011:8). Project failure occurs when the original planned benefit is not realised or when the project is not completed on time, within budget, within scope and to the required quality.

In a report by Richard Wittig (2013:392) which was presented at the 2013 Coal Operators Conference in Australia, the cost and schedule overruns of mining projects are also exclaimed. Wittig (2013:392) refers to 2009 research which indicated that only 12.5% of mega projects in the minerals industry actually delivered the benefits that were originally anticipated. Da Silva *et al*. (2012:3) refers to a study conducted by PricewaterhouseCoopers' in 2010 on major mining capital projects globally which found that only 2.5% were successful in meeting the critical criteria of scope, cost, schedule, and business benefits. Of the companies that reported project overruns publicly (between October 2010 and March 2011), the average overrun was about 71% of the original project cost estimate (Mitchell, 2011:3).

Flyvbjerg *et al.* (2009:1) report that it is common for large infrastructure projects across the globe to be completed late, over-budget and not to perform to expectations. They further report that cost overruns and benefit shortfalls of up to 50% is common and in some instances can even exceed 100%. The low success rate of projects across various industries is alarming and therefore constitutes a significant management problem. Weyer (2011:8) reports that when projects run over in cost or fall short of the benefits expected, it leads to inefficient allocation of resources, further delays and higher cost.

Forecasts of cost, demand, and other impacts of planned capital projects have been a common problem across various industries around the globe (Weyer, 2011:8). This causes the project business cases to be inaccurate which managers use to decide whether to invest in new projects or not making these projects very risky (Flyvbjerg, 2006:4). The research done by Weyer in 2011 on project failure suggest that project failure is directly related to and a result of wrong decisions being made because of poor project planning and inaccurate forecasting. McCurley *et al*. (2013:454) also acknowledges poor cost estimating as the main contributor to cost overruns in the department of defence.

Weyer (2011:9) summarises that the reasons for inaccurate forecasting and poor project planning are due to the following three categories (as summarised in academic literature):

- Technical explanations;
- Political-economic explanations; and
- Psychological explanations.

Technical explanations relate to the planning tools, methodology and available data with which estimates and forecasts are being done (Weyer, 2011:9). If these tools are inadequate or the data is invalid it will lead to inaccurate forecasts being developed. In addition, technical explanations can also allude to a lack of experience and technical knowledge on the side of the project design team, which could cause project planning to be off target.

Realising the importance of projects however in the recent years, organisations and researchers have put a lot more attention into improving project management as well as the tools used to conduct project management with (Steffen *et al*., 2008:4). Staffing of projects with skilled personnel and the provision of training has also been given priority by organisations making the technical explanations somewhat “unacceptable” within this day and age (Weyer, 2011:9).

The second reason relates to the intentional “cooking” of project forecasts, which make up the political-economic explanations for project failure. It is also referred to as the strategic misrepresentation of the benefits and cost associated with a project. It occurs when an individual or an entire organisation wants to either protect their particular interest or hide potential failure (Weyer, 2011:10). This explanation is a form of deception which in a project environment can be driven by the intention to secure resources or get project approval.

The third reason is drawn from psychological findings in explaining these inaccurate forecasts as part of the “planning fallacy”. In particular, a psychological phenomenon labelled as “optimism bias” is held accountable (Weyer, 2011:11). When an individual fall prey to planning fallacy, he or she is unable to make rational decisions based on the balancing potential of profit or loss while considering probability (Weyer, 2011:11).

This explanation stems from the work done by Kahneman and Tversky (1979) who found that human judgment is naturally optimistic due to overconfidence and insufficient regard for distributional information (Flyvbjerg, 2006:6). Explanations in terms of optimism bias have their relative merit in situations where political and organisational pressures are absent or low, and conversely strategic misrepresentation have their relative merit where political and organisational pressures are high (Flyvbjerg, 2006:5). In conventional project management theory it is suggested to eradicate optimism because it possibly can lead to optimism bias and subsequently faulty project planning (Weyer, 2011:6).

Reference class forecasting was originally developed to compensate for the type of cognitive bias during decision making under uncertainty, which won Daniel Kahneman the Nobel prize in economics during 2002 (Weyer, 2011:11). Reference class forecasting improves the accuracy of forecasts by taking a so-called "outside view" on prospects being forecasted, while conventional forecasting takes an inside view (Flyvbjerg, 2006:2).

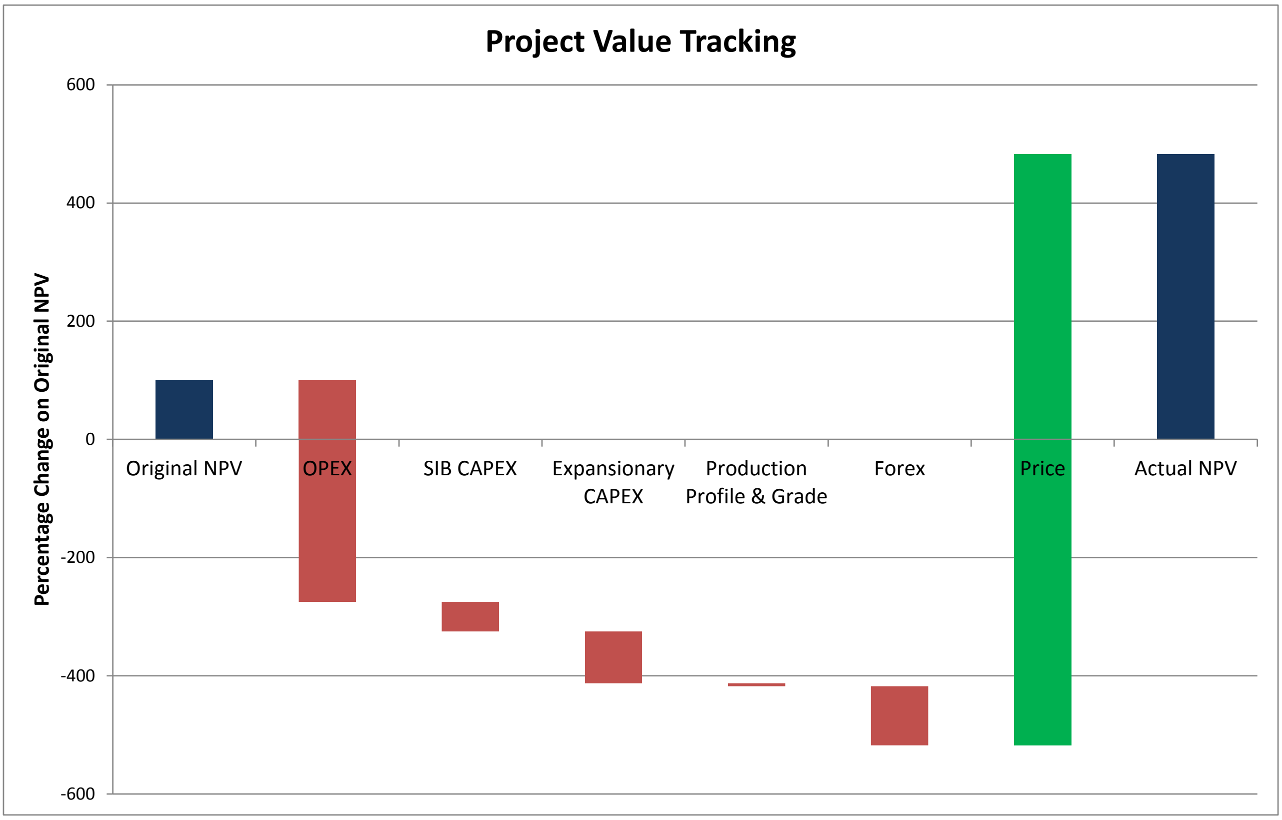
The outside view on a given project is based on knowledge about actual performance in a reference class of comparable projects to establish a likely outcome or result. This concept is very similar to benchmarking where actual results of past implemented projects or actual operations can be used to verify and calibrate cost estimates or forecasts in general.

Referring back to the investigation that was conducted in 2009 within Organisation A and a further analysis of its project base, the organisation identified the biggest drivers of value destruction and project failure in terms of cost and schedule to be (Organisation A, 2010:12):

- OPEX overspends;
- Slower than forecast production build-up;
- Poorer than forecast ore grade quality; and
- SIB CAPEX overspends.

In Figure 2.5 the impact of these various drivers on the original estimated NPV are illustrated in a waterfall graph. The original NPV is given as 100% and then the various project factors either add or deduct a certain value % until the actual project value is reached which was realised post-investment. The graph is based on a range of selected projects across the various business units within Organisation A implemented over the past few years.

Figure 2.5: Organisation Project Value Tracking



(Source: Organisation A, 2010)

The graph illustrates both the impact of controllable factors such as OPEX, SIB CAPEX, Expansionary CAPEX, Production & Grade as well as uncontrollable factors such as FOREX and Price. Noticeably OPEX and SIB CAPEX overruns accounted for approximately 400% of the destroyed value. Luckily for the organisation, better than expected commodity prices countered the cost overruns and its projects still yielded positive results.

Based on the investigation conducted in 2009 within Organisation A, its business units jointly identified a list of key drivers of the symptoms. The list of six key success factors was:

- Project team competence and skills level.
- Selection of key Engineering, Procurement & Construction Management (EPCM) partners.
- Ensure detailed definition of project objectives, scope and engineering definition.
- Project execution plan: Ensure implementation of comprehensive plan for management of each phase including people, processes, governance and technologies for adequate control.
- Operational readiness planning: Focus on especially hand-over planning as well as production ramp-up.
- Business case: Ensure consistent approach to reflecting detailed estimation of costs in business case with focus on OPEX, ramp-up, grade and SIB CAPEX.

Point number 6 which relates to project overruns on life cycle costs (OPEX and SIB CAPEX) were identified as the most significant value destroyer which accounted for approximately 400% of destroyed project value in the past. Apart from being the greatest value destroyer, it was also found to be one of the most common value destroyer. Underestimated life cycle costs were experienced on almost all the projects that were investigated.

Most of the reasons given by the investigation for the underestimated life cycle cost forecasts were related to the technical explanations such as planning tools, methodology, skills of project personnel and the availability and quality of input data. Political-economic and psychological explanations were not mentioned in the investigation and therefore the focus of the literature study was directed towards life cycle costs and the accurate forecasting thereof in a project environment. The other two reasons were however not disregarded as possible contributing factors to the past overruns that were experienced.

By focussing on improving the key success factors as identified by Organisation A it aspires to achieve three long-term goals:

- Optimising capital allocation to projects: supporting portfolio decisions by providing in-depth attractiveness assessments from a technical and project management perspective.
- Improving project cost and time performance:
    - Avoid cost and time overruns, whilst not sacrificing quality (first target).
    - Achieve best-in-class position compared to peers (second target).
- Improving operational performance of new operations: Ensuring that OPEX, SIB ramp-up and production targets are planned right and delivered accordingly.

In the current economic environment where capital scarcity is at the order of the day, companies that can demonstrate their proficiency in allocating capital as well as their ability to deliver predictable project results will be able to instil trust in potential investors and attract more capital investment than their competitors. A key focus point for Organisation A as identified through its research is to improve on its ability to forecast more accurate life cycle costs which are used during project evaluations and in turn inform capital investment decision making.

2.6. FORECASTING AND ESTIMATING LIFE CYCLE COSTS

Korpi and Ala-Risku (2008:240) conducted an in-depth review of life cycle cost literature, and selected the definition to describe life cycle cost as: "The life cycle cost of an item is the sum of all funds expended in support of the item from its conception and fabrication through its operation to the end of its useful life".

The item referred to in the definition will in this case be a new coal mine and its life cycle will consist of the asset development stages as described in section 2.3:

- Opportunity Identification (Exploration);
- Business Case Development & Commissioning (Project Life Cycle);
- Operations; and
- Closure.

Life cycle costs can be divided into two main categories namely acquisition and sustaining costs (Emblemsvag, 2003:30). The acquisition fraction of life cycle cost is relevant to stage 2 of the asset life cycle while the sustaining fraction is relevant for stages 3 and 4.

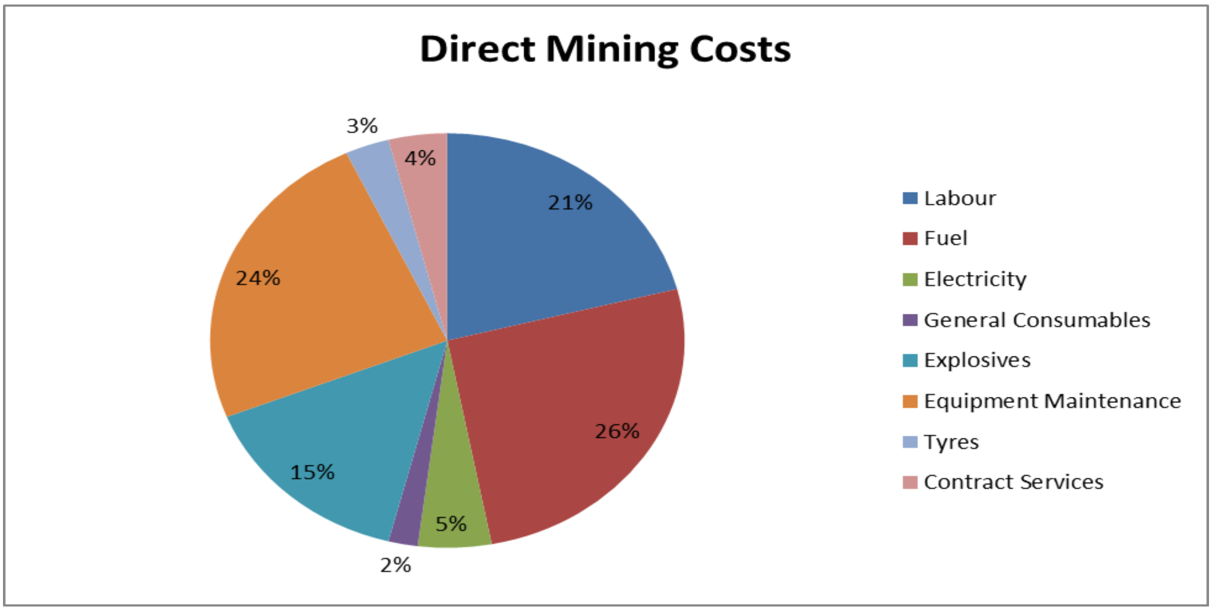
The focus of Organisation A is however on improving forecast accuracies of sustaining life cycle costs relevant to the operations and closure asset development stages.

Mining operations comprises of processes, activities and sub-activities which consume resources (such as material, labour, equipment) thereby incurring cost. The cost of each process, activity and sub-activity ultimately detract from the net value of the resource when the final product is delivered to the market. A life cycle cost estimate reflects this on-going expenditure that will be required to run an operation effectively from day to day but will also include equipment or resource replacement costs as well as decommission costs for when the operation is finally closed down at the end of its useful life.

Organisation A uses a cost classification system to distinguish between the various types of cost relevant to its projects and operations. The acquisition life cycle cost of a product is commonly referred to as establishment CAPEX. The general sustaining life cycle costs required for the day to day operations of an asset is referred to as OPEX and the irregular sustaining costs required to keep the asset operational such as in the case of equipment replacements and infrastructure upgrades are classified as SIB CAPEX (Organisation A, 2010:110).

For purposes of predicting cost behaviour, management accountants commonly classify costs into two cost categories namely variable and fixed costs. Variable costs are strictly proportional to activity while fixed costs remain at the same level for changes in activity within a relevant range (Seal *et al.,* 2009:38). Cost can also be classified as direct or indirect for purposes of assigning it to cost objects (Seal *et al.,* 2009:38). As an example Figure 2.6 illustrates a cost breakdown of direct mining costs required for an opencast mining operation to function. Organisation A classifies these direct mining costs under its OPEX category.

Figure 2.6: Direct Mining OPEX by Type and Fraction



(Source: Organisation A Opencast Project, 2012)

The costs indicated in Figure 2.6 are direct costs that can be easily traced to the level of activity under consideration which in this case is mining. There are however also indirect cost which cannot easily be traced to the level of activity for example marketing and sales, administration, technical services and research and development. These costs are however incurred and need to be included as part of the life cycle cost estimate.

Table 2.2 as an example illustrates the replacement intervals of opencast mining equipment which will constitute a SIB CAPEX expenditure. In compiling this specific estimate the project team first need to establish how many hours per annum throughout the mine's life each piece of equipment will operate, and thereafter an equipment replacement schedule can be compiled and costed to form part of the SIB CAPEX life cycle cost estimate. As an example, a Komatsu 730E haul truck will operate approximately 5,000 hours per annum. Its life span is 80,000 hours and will therefore need to be replaced every 16 years which will constitute SIB CAPEX expenditure.

Table 2.2: Equipment replacement intervals

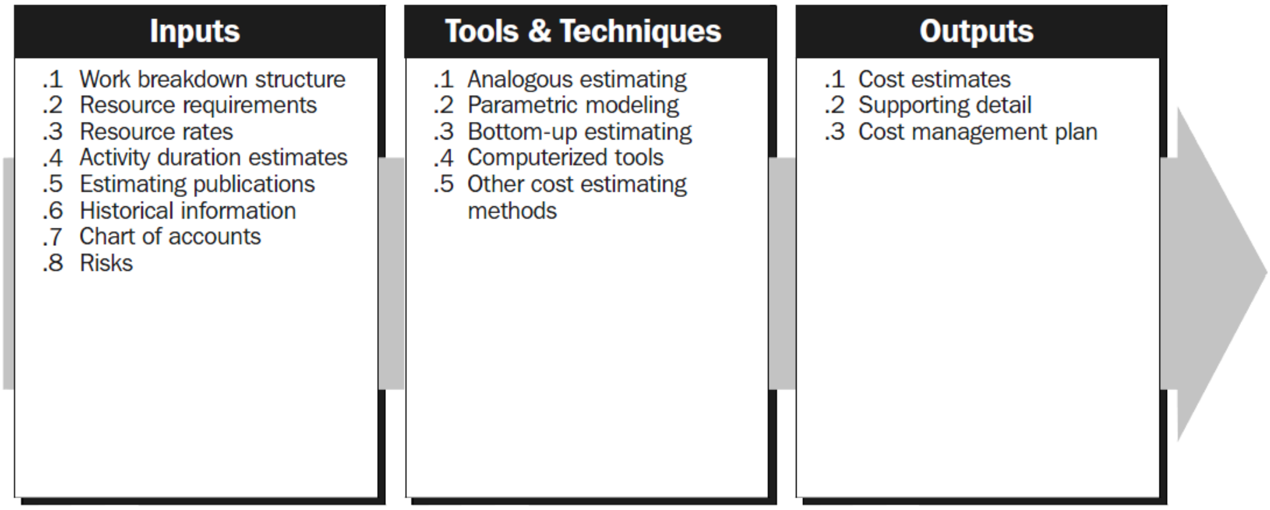
Equipment	Replacement Hours
P&H 9020 Dragline	Life
Komatsu D475 Super Dozer	50,000
Komatsu PC4000 Hydraulic Face Shovel	80,000
Komatsu WA1200 Front End Loader	50,000
Komatsu 190t 730E Haul Truck	80,000
Komatsu PC1250 Excavator	50,000
Komatsu 90t HD785 Haul Truck	50,000
Komatsu HM400 Articulated Dump Truck	40,000
CAT D6640 Overburden Drill	80,000
Sandvik D25KS Coal Drill	35,000
Sandvik Pantera DP1500 Parting Drill	35,000

(Source: Organisation A Project, 2012)

As can be seen from the illustrative examples a lot of detailed planning is required during the project development stages to accurately estimate and predict what the life cycle costs will be for an asset over its useful life. It is common for mining projects to have planned operational life spans in excess of 25 years, which make compiling these estimates extremely complex and time consuming. The time and effort is however essential as life cycle cost estimates are direct inputs into a project's discounted cash flow valuation model and it is therefore important to be as accurate and close to reality as possible.

Various planning tools and forecasting methodology is available to assist project teams in developing life cycle cost estimates. The Project Management Institute's PMBOK (2013:7.2) guideline on cost estimating describes the estimating process from where it starts with collating inputs from various project data sources such as the Work Breakdown Structure (WBS) and planned resources up to the point where the data is processed by using accounting techniques such as Bottom-up estimating into cost estimates. The cost estimating process as described by PMBOK is graphically illustrated in Figure 2.7.

Figure 2.7: Cost Estimating Process



(Source: PMBOK, 2000: 87)

The first three cost estimating tools and techniques as indicated by PMBOK are very similar to the techniques identified by Korpi and Ala-Risku's (2008:243) in their research:

- Estimating by analogy - The cost estimator draws analogies between different products or their features, and uses that to factor costs. This method requires a high degree of judgment and its accuracy is highly dependent on the experience and expertise of the estimator.
- Parametric estimating methods - Parametric estimation uses different statistical techniques and look for the factors on which the life cycle costs depend. The parametric method requires in-depth and comprehensive data.
- Estimating by engineering procedures (Bottom-up) - Costs are assigned to elements at their lowest level of design detail and then combined into a total for the product or system. This type of estimating is very accurate provided that the data is available but can be very time consuming and costly.

Computerised tools and techniques consist of spread sheets, simulations and statistical tools that can assist to simplify cost estimating and thereby facilitate rapid consideration of cost estimate alternatives (PMBOK, 2013: 7.2.2.8). Various other cost estimating tools exist that can assist in improving a cost estimate's accuracy (PMBOK, 2013:7.2.2):

- Three-Point Estimating – The accuracy of a single point activity cost estimate may be improved by considering estimation uncertainty and risk by using three estimates under three scenarios namely most likely, optimistic and pessimistic.

Depending on the distribution of the values within the range the "expected cost" can be determined.

- Reserve Analysis – Cost estimates may include contingency reserves to account for cost uncertainty. Contingency reserves are the budget that is allocated for identified risks, which are accepted and for which contingent responses are developed. These risks are also referred to as the "known unknowns. Estimates may also include management reserves, which are there to cater for the "unknown unknowns".
- Group Decision Making – Team-based approaches such as brainstorming is useful for engaging team members to improve the estimate accuracy and committing themselves to the emerging estimate.

PMBOK (2013:7.2.2.1) exclaims that "Expert Judgment" guided by historical information is very important during the whole cost estimation process. It provides valuable insight about the environment and information based on experiences from past similar projects. Expert judgement can also be used to determine whether to combine estimating methods in a specific scenario and how to reconcile differences between them. Benchmarking of final cost estimates against similar projects or operations is just as critical to determine whether they are realistic and in line with what was experienced in the past.

In a project environment trade-off studies and cost benefit analysis type studies are common and required from the early development stages of a project. Cost estimates are therefore also required early on as inputs into these studies to inform decision making. Korpi and Ala-Risku (2008:240) reports that the sustaining life cycle cost of a product can be many times that of the initial purchase or investment cost, and that 70% to 90% of the total life cycle costs become defined already in the design phase. This comment just reiterates how important it is to firstly understand and then also to optimise life cycle costs from the early designs stages.

A concept exists that marries these two requirements of understanding and quantifying all expected life cycle costs and then using that information to make decisions. This approach is known as LCC. As described by PMBOK (2013: 12.1.3.4) LCC is the concept of including acquisition, operational and disposal costs when evaluating various alternatives.

Emblemsvag (2003:30) considers LCC to be just as much an approach to capture all future costs as it is a technique to compute to a certain degree of accuracy the life-cycle costs for a specific product.

2.7. LIFE CYCLE COSTING

LCC was originally designed for procurement purposes in the US Department of Defence and is still today most commonly used in the military sector as well as the construction industry (Korpi & Ala-Risku, 2008:241). The most common uses of LCC were found by Korpi and Ala-Risku (2008:256) to be for source selection studies for different products and design trade-offs, both in terms of comparison and optimization. Emblemsvag (2003:24) summarised the three main purposes for LCC as:

- LCC can be an effective engineering tool for providing decision support in the design and procurement as this was the original intent for which it was developed in the case of the US Department of Defence.
- LCC overcomes the shortcomings of traditional cost accounting and can give useful cost insights in cost accounting and management.
- LCC is a useful design and engineering tool for environmental purposes, a topic that in recent years have received a lot of attention.

Traditional cost management systems are only concerned with the costs incurred within the four walls of the organisation and also only try to manage costs after they have been incurred, instead of eliminating them before they are committed (Odendaal, 2009:51). LCC grows in significance as organisations become increasingly aware of the importance to consider all future costs inside and outside the organisation including environmental costs, safety related costs, customer service costs and costs associated with being socially responsible (Bettini *et al.,* 2012:58).

Although LCC was predominantly used for procurement and design decision making purposes in the past, Rodriquez and Emblemsvag (2007:371) contends that LCC can also be effectively used for long-range scenario planning. This type of planning can provide management with insightful data to understand what actions need to be taken given a certain challenge. Adopting LCC in a project environment therefore makes sense especially during the early development stages when various scope options are investigated and trade-off are being conducted (Odendaal, 2009:52). The fact that LCC attempts to capture all costs throughout a product’s life cycle will contribute to comprehensive well executed trade-off studies.

The LCC approach leads to proactive cost management, as opposed to reducing costs after they are incurred, which is reactive cost management (Emblemsvag, 2003:2). The Japanese took this approach after World War II when they embraced the concept of Target Costing (TC) by eliminating cost before it is incurred. Kee (2010:204) defines TC as a cost management system that aim to justify the production of product only through its profitability which is controlled by the product design. This assisted them in rebuilding their industry while competing with the strong U.S. industry at the time. This is a much more effective approach than today’s cost cutting as it produces results much more efficiently and forms the basis of systematic work toward gaining sustainable profitability in the long run (Emblemsvag, 2003:ix).

Many, if not most, open systems incur more costs during their life span than compared to their initial purchasing costs (Emblemsvag, 2003:25). According to Barringer (1998:4) the cost of sustaining or maintaining equipment for instance are frequently 2 to 20 times the acquisition costs. These statements again highlight the importance of knowing upfront what the product will eventually cost to operate so that the downstream costs can be eliminated or managed upfront by design which may also include managing their associated risks.

Bettini *et al*. (2012:57) acknowledges LCC analysis also as a good tool to use before implementing new technology as is commonly the case with greenfield projects. This method allows for providing an estimate of the economic sustainability of a planned item, such as a technology in its phase of development before implementing it. It is during these development stages that initiatives such as VE are critical so as to optimize the project value. VE is defined as the creative approach to optimize life cycle costs, save time, increase profits and increase quality more effectively (PMBOK, 2013).

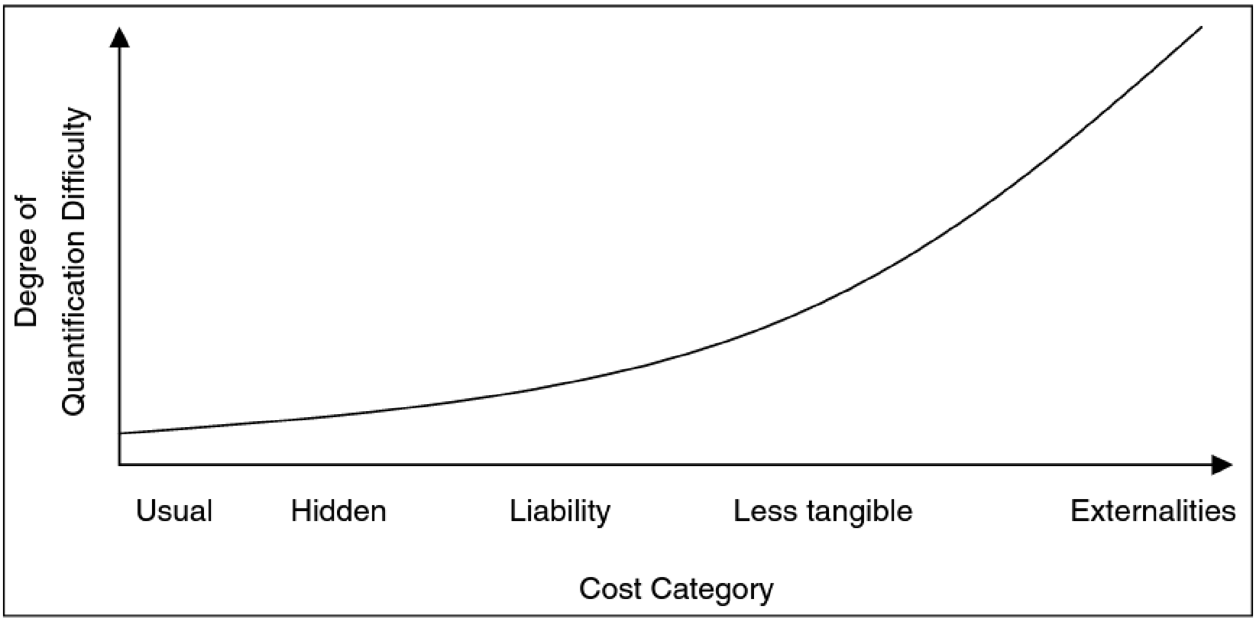
Based on the research of Bettini *et al.* (2012:58) on LCC they have found that a particular characteristic of LCC is to grasp costs coming from demand that have not yet a price. As a result it is useful in designing more environmental friendly products by considering the possible impacts along the life cycle. Demands for the reduction of environmental impacts, and more ethical behaviours, are examples of expenses not economically appraised by the market. Legislation is becoming stricter year by year especially in the coal mining sector and mining organisations must strive to reduce their impact on the environment so as to become more sustainable enterprises.

Emblemsvag (2003:34) indicates that in general four types of costs must be considered namely usual, hidden, liability, less tangible and externalities:

- Usual costs are those costs that traditional cost accounting methods normally account such as labour, raw materials, utilities and supplies.
- Hidden costs are typically associated with regulation of some sort such as reporting, training, monitoring and notification. Hidden costs are normally lumped together with overhead costs and then assigned based on direct labour or machine hours.
- Liability costs arise due to noncompliance and potential future liabilities such as penalties, legal staff, future liabilities from hazardous waste or customer injury.
- Less tangible costs are very difficult to estimate and include examples such as brand image, customer acceptance and loyalty, corporate image and worker morale.

Emblemsvag (2003:33) further acknowledges another cost category external to the economic system referred to as externalities. This is normally a societal cost, and simply incomprehensible in an economic sense due to its unknown nature and the uncertainty involved. Cost categorization is therefore two-dimensional consisting of those that are obvious and those that are less obvious. The less obvious the cost is the greater the difficulty to quantify it. This is illustrated graphically in Figure 2.8 below.

Figure 2.8: Degree of Quantification Difficulty



(Source: Emblemsvag, 2003:34)

By adopting a LCC approach from the very early project development stages such as during the concept study phase, and all future costs are investigated and considered in detail, will assist in progressively developing a comprehensive and more accurate cost estimate by the time the feasibility project phase is reached. It is also by this time that the final project valuation and business case will be determined and presented to the organisation's investment committee.

Odendaal (2009:42) summarises the key advantageous and disadvantageous of the LCC approach:

Advantageous:

- LCC is a total cost approach undertaken in the acquisition or development of any capital project. It assists decision making in many aspects including those associated with equipment replacement, planning and budgeting.
- Effective choices can be made between competing alternatives of a stated objective.
- It serves as a management tool that allows the operating cost of projects to be evaluated at frequent intervals.
- It is useful for controlling programmes and reduces total costs.

- The total cost commitment undertaken in the acquisition of any asset, instead of only the initial capital cost, is considered.
- Areas are identified in which operating costs may be reduced.
- The decision maker is compelled to consider the relationship between the important variables, the organisation's objectives and its environment.

Disadvantageous:

- It is time-consuming to collect all the relevant data throughout the life cycle of a project.
- The accuracy of data is sometimes doubtful. Long term projects is often characterised by uncertainty and hence the difficulty of making economic forecasts if the values of variable factors are unknown.
- It may be difficult to obtain data.
- Costs will be incurred at different times and cannot therefore be treated in the same way.

Linking back to section 2.5 on project failures, McCurley *et al.* (2013:454) identified that a major contributor to poor cost estimates is the enormous amount of unknowns and uncertainty that exist when these estimates are made. Estimates are normally prepared early on in the project life cycle, well before concrete technical information is available and they are therefore subject to great uncertainty. Early life cycle cost estimates are therefore often based on a desired capability rather than a concrete solution and often results in the estimates being inaccurate (McCurley *et al.*, 2013:454).

Due to the inherent uncertainty in LCC and the fact that such long term views are taken about future costs, it is important to know how to account for risk and uncertainty (Korpi & Ala-Risku, 2008:243). The role of LCC is to provide insight into future matters regarding all costs. Since the future is always associated with uncertainty and risks, a truly proactive cost management system must be able to handle all sorts of risks that can negatively impact on the organisation (Emblemsvag, 2003:4).

As the King Code of Governance dictates, cost management need to be expanded to take on a risk-based approach that focuses on total costs (IOD, 2009:14). LCC must therefore take risks and uncertainties into account in order to be really useful for decision makers (Korpi & Ala-Risku, 2008:243). By adopting this approach, LCC will help companies eliminate costs before they are incurred and manage business risks related to costs, cash flows and profitability.

According to Wetekamp (2011:899) there are two general types of risk management actions that can be applied in project management. The first one is oriented towards the reduction of the risk's degree and if this cannot be achieved a second type of strategy must be adopted namely hedging of risks. The hedging of risks typically refer to the reserve analysis techniques as discussed in section 2.6 where contingencies are allowed for in cost estimates to reduce the impact of unknown events or risks.

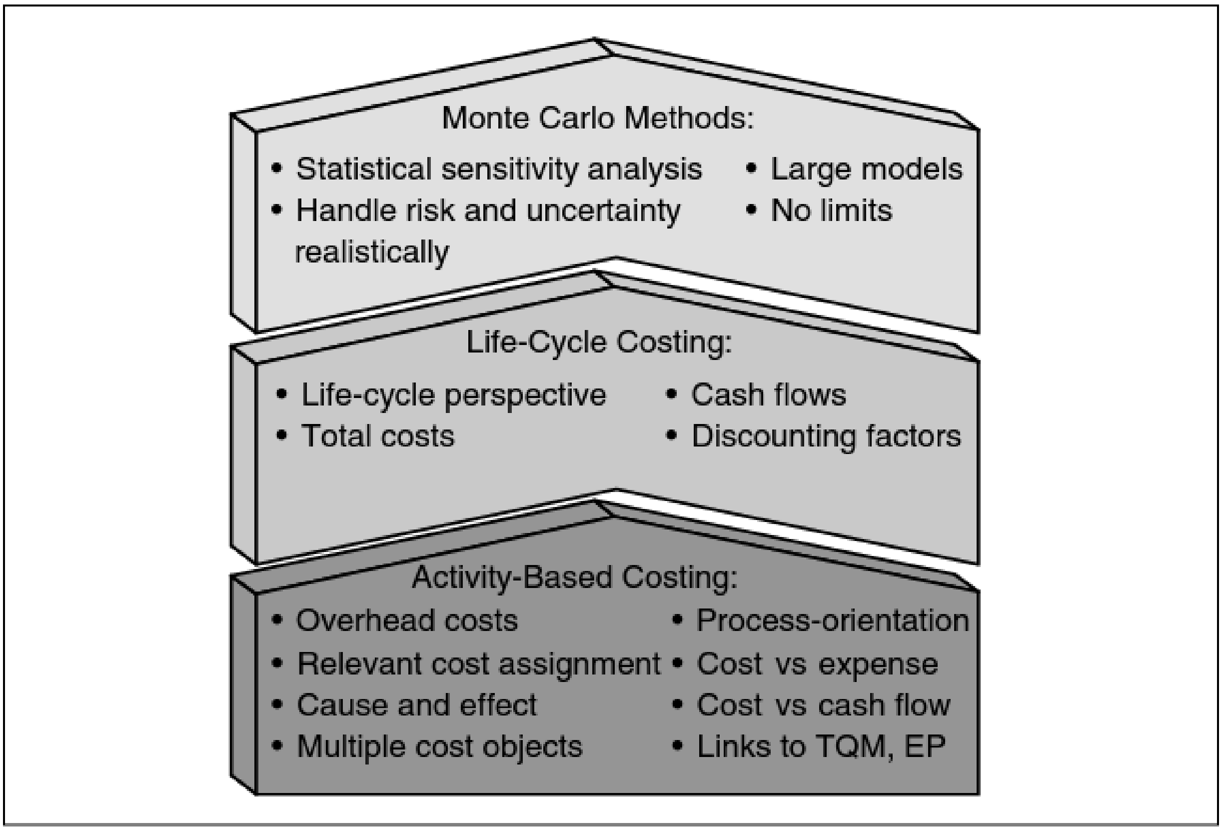
Mining projects have various sources of uncertainty that need to be managed to ensure project success. These business risks include among other commodity prices, cost escalation and inflation factors, mining conditions, geology and mineral resource estimates (Lee, 2011: 35). It is thus important to adopt a risk-based approach when forecasting costs to be used in project valuations for decision making purposes.

An example of an advanced risk-based LCC approach that also incorporates enhanced economic forecasting methodology is that developed by Emblemsvag (2003) known as Activity-Based LCC (Korpi & Ala-Risku, 2008:243). Rodriquez and Emblemsvag (2007:371) describe Activity-Based LCC as a synthesis between Activity-Based Costing (ABC), LCC, and Monte Carlo methods. The LCC approach adopted an ABC costing methodology due its popularity and success in the industry and Monte Carlo methods to account for risk and uncertainty.

ABC is a costing method based on activities that is designed to provide managers with cost information for strategic and other decisions (Seal *et al.,* 2009:827). ABC has the ability to accurately measure resources consumed by cost objects using different cost drivers that result in activity consumption, and allocating activity costs to cost objects on a cost driver consumption basis (Odendaal, 2009:109). Monte Carlo methods on the other hand are probabilistic approaches based on a broad class of computational algorithms that rely on repeated random sampling to obtain numerical results (PMBOK, 2013:11.4.2.2).

The Activity-Based LCC concept is described as a three layer approach incorporating aspects from ABC, LCC and Monte Carlo methods as illustrated in Figure 2.9. From ABC concepts were derived such as including overhead costs and the consideration of multiple cost objects. From LCC the life-cycle perspective and the focus on total costs were derived. The Monte Carlo simulation methods made it possible to handle risk and uncertainty in an appropriate way (Rodriquez & Emblemsvag, 2007:373).

Figure 2.9: Three layers of Activity-Based LCC



(Source: Rodriquez & Emblemsvag, 2007:373)

The described Activity-Based LCC approach is a good example that encompasses all the aspects required to produce accurate life cycle cost estimates. If the LCC concepts as described in this research study are adopted during cost estimate development in the early project stages it should improve the chances of forecasting more accurate future cost outcomes.

2.8. SUMMARY

This chapter set out to achieve the following objectives:

- To describe the coal mining industry in a global as well as in a South African context and specifically look at the industry growth prospects and the need for capital projects in future.
- To develop a theoretical framework around capital project development in the mining industry, how project valuations are conducted and how it is used to inform capital investment decision making.
- To investigate past project failures within Organisation A as well as in the mining industry, and to identify possible causes leading to such failures.
- To investigate the concept of LCC and how it can be adopted in a project environment to improve cost forecasting and ultimately business case accuracy.

In line with the first objective of this chapter, the research revealed that the expected growth in the South African coal mining industry will require approximately R 100 billion worth of investments into capital projects by 2020. It was established that South Africa which is the 5th largest coal producer in the world plays an important role in the global coal supply chain. With the rapid economic growth experienced in the developing countries of Asia and Africa, the demand for electricity continues to grow and subsequently also the demand for coal.

A substantial amount of capital projects within the coal mining industry in South Africa are therefore imminent. Investments in mining projects are however very risky because of the amount of uncertainty involved such as geological characteristics, mining conditions, commodity prices, mining and processing cost and cost escalations. As was seen from the literature review a phased approach is therefore adopted by most mining organisations in developing and evaluating capital projects whereby the risks and opportunities are methodologically assessed and quantified.

Capital project development and execution has been on Ernst & Young's top 10 business risk register for the mining and metals industry since 2011 with very few projects that have been successful in meeting the critical project criteria of scope, cost, schedule, and business benefits (Elliot, 2013:8). Capital allocation and access to capital however tops the business risk register in 2013 for mining and metals organisations globally, up from number eight in 2012 (Elliot, 2013:4). These are strategic risks that threaten the long-term growth prospects of mining organisations within the industry.

Inaccurate forecasts of cost, demand, and other impacts of planned capital projects were found to be common problem across various industries around the globe. This causes the project business cases to be inaccurate which managers use to inform capital investment decision making. The research done by Weyer (2011:8) on project failure suggest that project failure is directly related to and a result of wrong decisions being made because of initial poor project planning and inaccurate forecasting.

Organisation A's investigation in 2009 identified that the biggest drivers of value destruction and project failure to be in the areas of:

- Life cycle cost overspends (OPEX and SIB CAPEX)
- Slower than forecasted production build-up
- Poorer than forecasted ore grade quality

In all instances Organisation A identified poor project planning and the initial underestimation of project forecasts during the project development stages to be the main reason for the project failures experienced. Reasons for inaccurate forecasting and poor project planning found in the literature are categorised under:

- Technical explanations related to the planning tools and data being used to compile forecasts.
- Political-economic explanations related to organisational pressures and the intentional misrepresentation of data to get projects approved.
- Psychological explanations related to the natural optimism bias of human beings that can lead to overoptimistic project forecasts.

Organisation A's investigation only listed technical explanations such as the planning tools and techniques as reasons for the underestimated forecasts and therefore that was the focus of the literature study. Various formal planning tools and forecasting methodology exist and were investigated that can assist project teams in developing life cycle cost estimates namely:

- Cost Estimating tools and techniques
    - Estimating by analogy
    - Parametric estimating methods
    - Estimating by engineering procedures (Bottom-up estimating)
- Reserve Analysis relates to the inclusion of contingency reserves to account for uncertainty and risk.
- Three-Point Estimating which is a form of sensitivity analysis.

The literature study identified LCC as a concept that provides for all the requirements in a project environment of firstly considering and capturing all expected life cycle costs, and then using that information to make decisions and to optimise the product design. As described by the literature LCC is the concept of including acquisition, operational and disposal costs when evaluating various alternatives. Emblemsvag (2003:30) considers LCC to be just as much an approach to capture all future costs as it is a technique to compute to a certain degree of accuracy the life-cycle costs for a specific product.

The literature study revealed that because LCC is much more than just a technique but also an approach, it can be further expanded to incorporate other cost management and cost accounting aspects such as the Activity-Based LCC. This is an example of an advanced risk-based LCC approach that also incorporates enhanced economic forecasting methodology. Adopting LCC in a project environment therefore makes sense as it considers all future costs, it can account for risk, it produces comprehensive forecasts and can therefore inform good decision making.

A good understanding of life cycle costs and the forecasting thereof was formed through the literature study that was conducted. The knowledge gained was used to inform and guide the empirical research which followed in order to answer the study objectives.

CHAPTER 3: EMPIRICAL INVESTIGATION

3.1. INTRODUCTION

This chapter's main aim is to fulfil the primary objective of the research study which is to quantify the effect that life cycle cost estimate accuracy has had on mining project valuations in the past. Understanding this effect and whether this impact was significant or not will be able to guide future efforts during life cycle cost forecasting.

A descriptive case study approach was adopted for the main part of empirical research. It focused on analysing post-audit results of past implemented mining projects within Organisation A's coal business unit in South Africa and was supplemented with data gathered through an inquiry document and unstructured in-depth interviews with selected project practitioners and specialists in the organisation.

In line with a secondary objective of the study a sensitivity analysis on project valuation results was conducted. The analysis covered variations in life cycle cost inputs, commodity prices and establishment capital for a range of mining projects which were still in their development stages at the time. The results from the sensitivity analysis were compared to those results obtained from the case study research so as to establish whether any correlation existed.

The empirical investigation is therefore divided into two separate studies, one which took a case study approach by looking at historical data from past implemented projects and the other consisting of a sensitivity analysis on projects still in their development stages. As part of the secondary objectives this chapter also investigated possible reasons for inconsistencies experienced in life cycle cost estimate accuracy in the past within Organisation A.

Now following in this chapter is the research methodology covering all aspects of the research design, approach and methods used for data collection, followed by the two main empirical studies and a summary of the key findings from this chapter.

3.2. RESEARCH METHODOLOGY

Rajasekar *et al.* (2013:2) define research as the process that involves obtaining scientific knowledge by means of various objective methods and procedures. Research is a systematic process of collecting, analysing and interpreting information in order to explore unexplained phenomena as well as those which were previously explained but misunderstood (Welman *et al.,* 2011:9). The research problem is the axis around which the whole research project revolves and the research design should address the research problem.

There are two main approaches to research namely a quantitative and qualitative approach. Quantitative research uses structured methods to evaluate objective data, whereas qualitative research uses more flexible methods to investigate subjective data. Quantitative research further aims for larger numbers of cases and the analysis of the results is usually based on statistical significance whereas qualitative research involves small samples of people, studied by means of in-depth methods (MacDonald & Headlam, 2011:9).

Qualitative research is not so much concerned with the methods and techniques to obtain appropriate data for investigating the research hypothesis, as in the case of quantitative research (Rajasekar *et al.*, 2013:2). Qualitative data are based on meanings expressed through words or metaphors and can successfully be used to describe phenomena in small groups or organisations. The scope of this research study is more exploratory in nature as the researcher did not know what to expect and therefore matches the definition of a qualitative research approach.

Qualitative research asks broad questions and collects word data from respondents. The researcher identifies themes and describes the information according to those themes and patterns exclusive to that set of respondents. Qualitative research is often used as a precursor to quantitative research studies to firstly explore the topic and identify possible leads which can be used to formulate an accurate and testable hypothesis (Welman *et al.,* 2011:188).

The historic project data collated from Organisation A's post-audit investigation reports were found to be insufficient to fully evaluate the effect of life cycle cost estimate accuracy on project valuations. The review documents contained very little diagnostic information as to what went wrong and what the primary reasons were behind the inaccurate cost forecasts and project valuations. Additional primary data therefore had to be obtained from project specialists that were involved in the specific projects so that more in-depth knowledge could be obtained to answer the questions of what went wrong and why, as well as what could be done by the organisation to improve the situation going forward. Seven individuals within the organisation were identified for this purpose.

Once the most appropriate research approach has been identified, the researcher has to decide on the most appropriate method of primary data collection. A qualitative research study is descriptive in nature and the primary task is to uncover and explicate the ways in which people in a particular setting come to understand, account for, take action and manage the problems and difficulties they encounter (Welman *et al.,* 2011:193). Typical methods of data collection include (MacDonald & Headlam, 2011:35):

- Case study research
- Participant observation
- Unstructured in-depth interviews
- Focus groups
- Participatory research

For this research study a combination of case study research and unstructured in-depth interviews were used to conduct the main part of the empirical study. The second part of the empirical research which consisted of a sensitivity analysis (see section 3.4) was much more quantitative in nature. Once an appropriate research design and suitable means of measuring the relevant variables had been selected, an appropriate procedure to analyse the data had to be obtained.

Theme identification is one of the fundamental tasks in qualitative research which can be described as the “umbrella” constructs identified by the researcher before, after and during data collection (Welman *et al.,* 2011:211). Preliminary themes relevant to the topic being researched were identified prior to the unstructured in-depth interviews. These preliminary themes were collated based on the researcher’s understanding developed around the topic from the literature study as well as the post-audit documents that were compiled and analysed.

The preliminary themes were used to compile an inquiry document so as to guide the interviews that followed. The questions in the document were open ended in nature and the inquiry document can be referred to in Appendix A. The preliminary themes that were covered in the inquiry document are:

- Organisation A's historic performance in developing accurate project valuations.
- The impact of cost management versus cost estimating on project valuations.
- Project valuation accuracy and its impact on capital investment decision making.
- Intentional versus unintentional poor cost estimating within the organisation.
- Cost estimating techniques used in the past and going into the future.
- Skills of project personnel in conducting LCC and estimating costs in general.
- Specific costs or cost categories normally being underestimated or omitted.
- Managing risk and uncertainty during cost estimation.
- The value of employing LCC as a technique in capital project development.
- The value of benchmarking and considering historic project performance.

The inquiry document was e-mailed to the seven individuals prior to having the unstructured interviews. They were requested to complete the inquiry document and return it electronically via e-mail. This process of completing the inquiry document beforehand assisted during the interviews as the individuals were already familiar with the background of the study and their completed questionnaires could be used as a reference point from where the topic could be further explored.

Following the interviews additional themes were identified through a process of content analysis and were added to the theme list. Content analysis is a basic technique involving counting the frequencies and sequences of words or concepts in order to identify keywords or themes (Welman *et al*., 2011:220). Through content analysis of the field notes, transcripts and inquiry documents, a descriptive explanatory framework of the investigation was compiled. The data was then further processed to be displayed in a matrix format for easy interpretation based on the frequencies of the encountered themes.

Using various data displays interpretations were made and conclusions were drawn based on the proposed study framework.

3.3. ANALYSING ORGANISATION A'S PAST PERFORMANCE

As explained in section 3.2, the research methods utilised was a combination of case study research and unstructured in-depth interviews. The case study research method was used to investigate the past performance of Organisation A in terms of developing accurate life cycle cost estimates and how the accuracy impacted on project valuations and possibly capital investment decision making. In case study research it is important to narrow the case by establishing boundaries (Welman *et al.*, 2011:194).

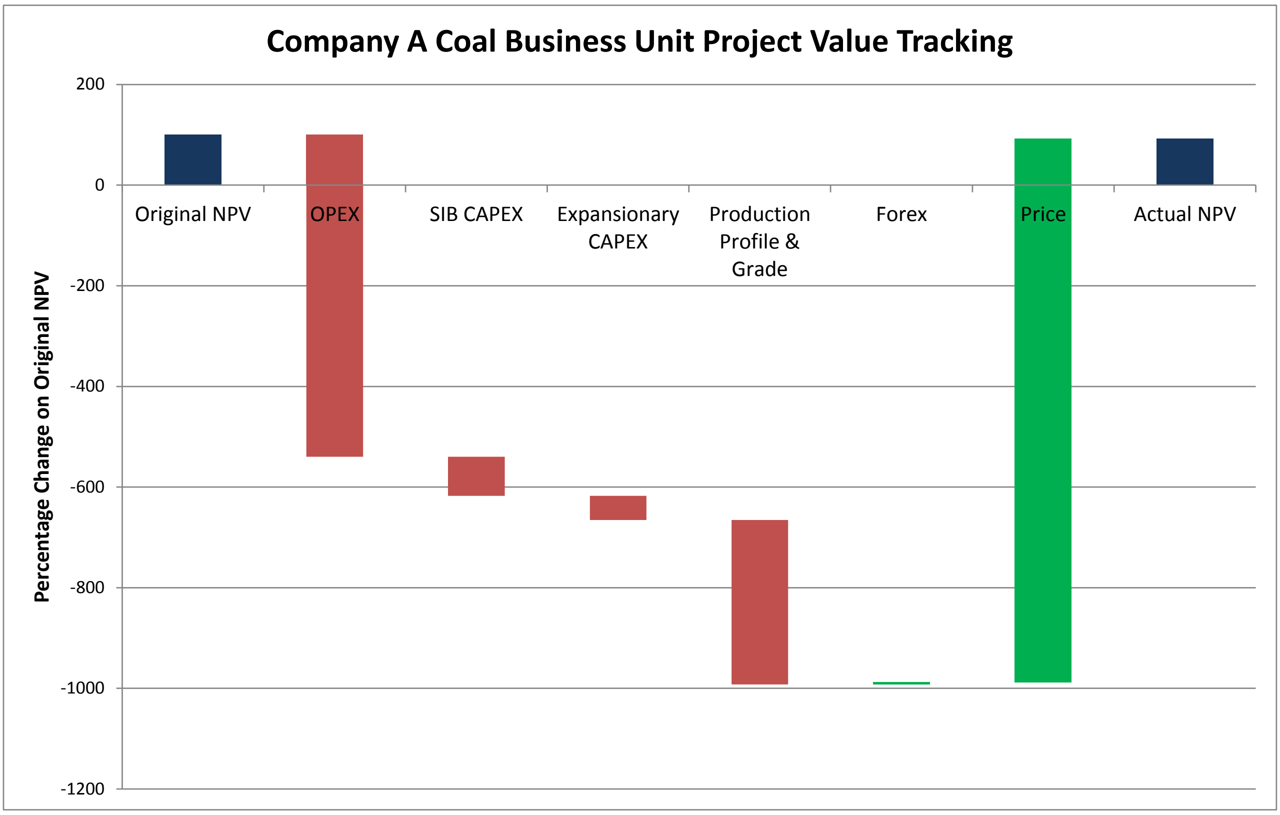
The case therefore only covered three major greenfield capital projects that were implemented within Organisation A's coal business unit over the past 10 years. These projects consisted of two opencast and one underground mining operations producing export thermal coal for the European, Indian and Chinese markets. The most recent project has completed its commissioning phase at the end of 2012.

Post-audit reviews have been conducted by the organisation on all three projects. The reviews summarised the actual achieved results once the operation had reached a steady state of production. The researcher found that limited information was available in these review documents comparing the achieved project results to those budgeted for prior to investment. It was also found that limited lessons learnt relative to business case development and project valuation were recorded in these documents.

The starting point for the research was therefore to firstly obtain the relevant post-audit documents and financial data, to analyse the reports and raw data, and to compile illustrative data displays. Due to the sensitivity of the information much of the raw data and actual values could not be disclosed within this research study. An illustrative data display was however developed that express the results in a percentage format, thereby not disclosing any values.

The results obtained were very similar for the coal business unit compared to those of the bigger Organisation A as determined from the benchmarking study in 2009. The mentioned illustration is a waterfall diagram showing how much value was detracted or added by the various business case factors such as OPEX and SIB CAPEX. The diagram is based on the average values obtained from all three investigated cases and is given in Figure 3.1.

Figure 3.1: Project Value Tracking in Organisation A's Coal Business Unit



(Source: Own Compilation)

From the graph it can be seen that OPEX is again the major destroyer of value, followed by Production Profile & Grade and then SIB CAPEX. The OPEX and SIB CAPEX destroyed value equivalent to approximately 700% of the original NPV. Higher than expected commodity prices helped the projects to still end up with a positive NPV and prevented the organisation from incurring major financial losses.

Table 3.1 provides more detail as to how much each business case factor was over-or-under budget post-implementation. The values given are again representing the average of the three investigated cases.

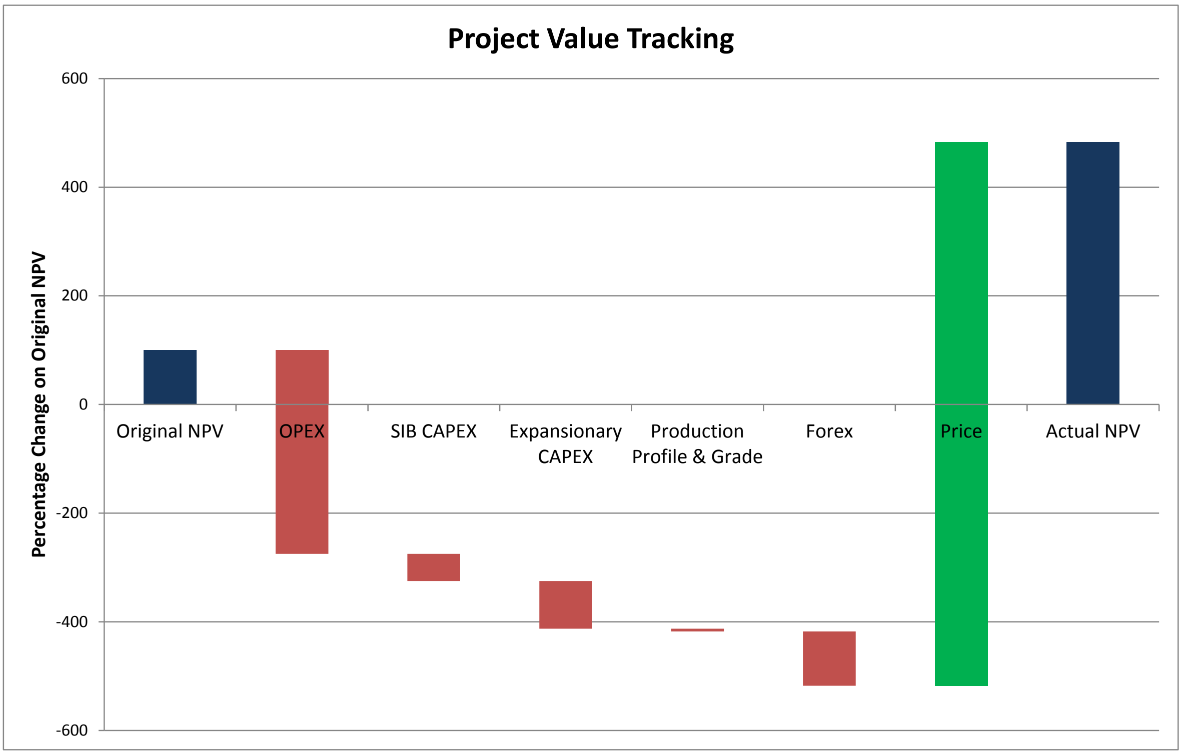
Table 3.1: Case study research results

Business Case Factor	% Over / Under Budget	% Project Value Destroyed / Added
OPEX	(44%)	(640%)
CAPEX	(4.7%)	(48%)
Price	41%	1080%
Production Profile & Grade	(37%)	(326%)

(Source: Own Compilation)

From the results in the Table 3.1 it can be seen that the business cases were the most sensitive to variations in price, followed by life cycle cost and then lastly expansionary CAPEX. The sensitivity analyses that were conducted and described in section 3.4 of the empirical study produced similar results and were used to compare with Table 3.1. For ease of reference and for comparison purposes the value tracking diagram for the bigger organisation (2009) as discussed in Chapter 2 is again illustrated here in Figure 3.2 below.

Figure 3.2: Organisation Project Value Tracking



(Source: Organisation A, 2010)

The value tracking results for both the bigger organisation and its coal business unit are summarised in Table 3.2 for comparison purposes.

Table 3.2: Case study research results on destroyed NPV %

Business Case Factor	Organisation A Average (2009)	Coal Business Unit Average (2012)
OPEX	(375%)	(640%)
SIB CAPEX	(50%)	(78%)
Expansionary CAPEX	(88%)	(48%)
Production Profile & Grade	(5%)	(326%)
Forex	(100%)	4%
Price	1000%	1080%

(Source: Own Compilation)

Based on the results summarised in Table 3.2 we can see that the coal business unit performed similar to the bigger organisation in that it exceeded budget on all four controllable business case factors. In terms of life cycle cost overruns it seems as if the coal business unit performed worse with a destroyed value equivalent to 718% of the original NPV. In terms of Production Profile & Grade planning the coal business unit also performed significantly worse. Based on the results it can be established that the past performance of Organisation A's coal business unit in terms of project business case development was relatively poor.

If the life cycle costs were better understood and more accurately estimated prior to investment, some design changes could have been made to the asset so as to bring the costs in line with what is required for a viable business case. If this was done earlier during the project development stages and the higher commodity prices were realised as what happened in the past, then the total value yielded to the organisation and its shareholders would have been significantly higher.

As mentioned previously in section 3.2, the post-audit documents contained very little diagnostic information in terms of lessons learnt and reasons why the projects did not adhere to the original budgeted costs. For this reason alternative avenues had to be pursued to get more insight into what happened. Supplementary data was therefore obtained from individuals who were involved in the 3 cases being investigated.

Seven individuals within the organisation's project support office were identified who were actively involved in one way or another with the 3 case projects either during their development or implementation stages. The selected individuals are employed in senior roles within the organisation and are well experienced in project management within the mining industry. Data was collected through an enquiry document and in-depth unstructured interviews.

Based on the preliminary themes identified by the researcher, an open ended questionnaire, or rather inquiry document was compiled and sent to the seven individuals. The purpose of the inquiry document was to orientate the individuals before the interviews were conducted and it also served as a guide for discussions during the interviews. The document consisted of fourteen questions and can be referred to in Appendix A together with the cover letter that was sent to the individuals. The various questions and themes that were explored as part of the investigation will be discussed below and the feedback received from the individuals either through completed inquiry documents or during the interviews will also be incorporated in the discussion.

Question 1 of the inquiry document explored the current job profiles of the seven respondents, their experience levels within the project development environment and also in which projects they were involved in over the past 10 years. From the feedback it was evident that the seven individuals are very experienced within the project fraternity as well as in the mining industry. Their roles varied within the project environment with one senior project director, two senior project managers, two mine design engineers, one project engineer and one financial manager.

Their cumulative work experience in project development specifically amounted to 105 years, which is an average of 15 years' experience each. Based on their extensive experience and their physical involvement with the 3 cases gave the data gathered through the empirical research some credibility.

Question 2 explored whether OPEX and SIB CAPEX overruns are a common occurrence and therefore problem within Organisation A. All seven respondents agreed that from their past experience OPEX and SIB CAPEX overruns are a common problem not only within the organisation but also in the mining industry.

Following with question 3 the enquiry document tried to establish whether the cost overruns experienced were mainly attributable to poor cost management during operations or due to the initial estimate / budget being underestimated and unrealistic. Only one of the seven respondents felt that the cost overruns were partially attributable to poor cost management during operations. The respondent argued that when the mining operations realised that the commodity prices were better than expected, that they started to spend on “nice to haves” which were not originally budgeted for. All the other respondents however felt that the main reason for the overruns was mainly due to the initial estimates being underestimated.

By referring to the post-audit results of past implemented projects within Organisation A as well as its coal business unit, the respondents were exposed to the life cycle cost overruns experienced in the past and how much project value these overruns destroyed. They were asked in question 4 whether project approval could have been negatively influenced because the initial forecasted costs could not be achieved. All the respondents agreed that the projects would not have been approved if the actual costs were used during the project evaluation because it would not have met the required hurdle rate. They further commented that if commodity prices were however assumed at a more realistic level that the project could have been approved. In summary to the question, all the respondents acknowledged the fact that capital investment decision making could adversely have been affected by the initial cost forecasts being inaccurate.

This highlights the fact that capital investment decision making is negatively influenced due to inaccurate information being used during the project development stages. This could be detrimental to the organisation as could be seen from the demonstrated waterfall diagrams in Figure 3.1 and Figure 3.2. If it was not for the better than expected commodity prices, Organisation A would have been incurring huge losses on the projects that they have implemented.

Question 5 asked the respondents whether in their opinion the life cycle cost forecasts were underestimated intentionally to get the project approved or whether it was done unintentionally. Six of the seven respondents felt that the commodity prices, exchange rates and escalation factors used in the project valuations were normally overly conservative. Within Organisation A, these assumptions get dictated to the project teams by the marketing and finance departments, which they are not allowed to query.

Because of the known conservative revenue streams the project teams then intentionally lower their operating cost estimates so as to obtain a more “realistic” project valuation. The project teams usually justify these lower operating costs by benchmarking it against best practice as opposed to common practice and then also by arguing that new technology and the latest equipment will improve operational performance and costs.

Although most of the respondents routed for intentional underestimation, some felt that there were costs being unintentionally left out of the original estimates due to oversights. These oversights can however be minimised according to the respondents by conducting what Organisation A refers to as Operational Readiness Planning (ORP). This type of planning is a forward looking process, which is applied to effectively prepare the owner operational unit for safe and optimal production output from day one. It usually entails getting the operational team involved early on in the project development stages and conducting detailed operational planning so as to prevent any oversights from the project design team.

Question 6 asked the respondents by referring to those cases where life cycle costs were underestimated unintentionally, whether it was due to poor estimating techniques, lack in skills and experience of the design team, lack of information or something else. Most of respondents felt confident in the estimating abilities of the design teams and their knowledge of costs. They felt that some oversights did however occur, especially for costs that are difficult to quantify and that are far into the future for example mine closure and environmental liability costs. Two respondents did however consider that there were some lack in skills and training of project personnel to conduct proper life cycle cost estimating and the use of probabilistic estimating approaches. The lack in skills seem to be specifically referring to the estimating process as opposed to the technical skills and know how concerning the design of a coal mine.

Question 7 tried to identify those costs or type of costs that were normally omitted or completely underestimated that had a big impact on the achieved cash flows and the actual project valuations. The respondents reported that it was those less obvious costs and costs that are difficult to quantify such as those related to Safety and Sustainable Development (S&SD), wage escalation rates, personnel training, environmental liabilities and rehabilitation costs. In some instances however the cause of the cost overrun was due to legislation changes while the project was in the implementation phase. An example of this is special pollution control measures that had to be incorporated during implementation as part of a project's revised water use license.

In question 8 the respondents were asked whether risk and uncertainty was sufficiently addressed during cost forecasts in the past. All the individuals acknowledged the importance of addressing risk and uncertainty in projects by allowing for some contingencies and that there is definitely room for improvement. Not all the past implemented projects addressed risk and uncertainty and it was identified as a definite shortcoming. The methodology usually followed was firstly to conduct a high level sensitivity analysis after which some contingencies were allowed for based on the "gut feel" of the project team. It also seems from the responses as if no advanced computer simulations such as Monte Carlo simulations were used in the past projects to calculate contingencies.

Several individuals felt that it was not really necessary to utilise complicated software packages to calculate contingencies. The respondents felt that a simple sensitivity analysis on key cost factors with a high, medium and low scenario would be sufficient. The sensitivity analysis, together with benchmarking against past implemented projects and using the project team's experience were considered to be sufficient controls to address possible risks and uncertainties. Again the issue was raised that the most sensitive area of the project valuation model was usually the commodity price and the exchange rate over which the project team had no control over.

The respondents were asked in question 9 whether more should be done to address risk and uncertainty during cost forecasting in the project development stages. All the individuals acknowledged the importance and felt that it is good practice to try and reduce risk and uncertainty upfront. It is also better to identify and mitigate risks at the planning stages of the project rather than to try and rectify problems during implementation or after the project has been completed. The costs are less if the risk mitigation is done early on during the planning stages.

The respondents acknowledged that if costs and revenues were accurately estimated from the start during the project development stages and it was found that the business case was not viable, that design changes could have been made in order to get a viable business case. This approach is in line with the principals of LCC and TC where the product design is used to influence costs. This was considered by the respondents as a better and less risky approach as opposed to "fudging" the business case with unrealistic inputs.

For this approach to work however realistic factors must be applied on both the revenue and cost side which does not seem to be the case in Organisation A. Over conservative revenue assumptions causes the project teams to compensate by using optimistic cost assumptions. All the aspects of the business case therefore get skewed and cannot be used to inform any design decisions.

One respondent also felt that much more could be done to address risks around assumed production profiles, grades and ramp-up factors. Incorrect assumptions normally lead to an escalation of cost on a per tonne basis and then result in more capital investment being required to realise original production forecasts.

The respondents were exposed to literature stating that between 70% and 90% of the total life cycle costs become defined and committed already in the project design phases. VE is therefore crucial during the project development stages to optimise the long term costs of the operation through design initiatives. The aforementioned facts led to question 10 asking the respondents whether future life cycle costs were considered thoroughly enough throughout the project design phases in the past.

The majority of respondents replied that the LCC principal has not yet found its place in the organisation's project fraternity. During the project design phases emphasis is mainly put on delivering the asset as per scope of work, on budget and in time as opposed to emphasis on the operational phase design and cost implications. Project design focus should extend to ensure that sustainable operational goals and costs will be achieved with a high level of certainty. Other reasons for this are thought to be around skills and knowledge around the LCC topic and its methodology. Some respondents felt that more could be done from the organisation's corporate office with the up skilling and recruitment of knowledgeable project personnel.

Linking to the previous topic question 11 asked the respondents whether VE and the monitoring of LCC throughout the project development stages can contribute to cost estimates being more accurate. One respondent answered this question with a very short but effective answer: "Understand the issue, and you can react to it". If life cycle costs are monitored and evaluated from the very early project development stages such as from the concept and pre-feasibility stages, these estimates will grow in certainty and accuracy together with the project as it advances through to the feasibility stage.

All the respondents acknowledged that considering detailed life cycle costs from early on in the project's life it will automatically improve the project planning, and will result in the project becoming more stable with reduced risk. Although this is considered to improve the estimate accuracy, the biggest value stems from the VE aspect and the design changes this process initiates to improve the overall project value.

Question 12 explored the type of cost estimating techniques that was normally used in the past e.g. benchmarking or factorised estimates based on other projects, zero-based or bottom-up costing and detailed engineering estimates. The respondent feedback informed that the type of estimating depended greatly on the stage of the project. The closer the project got to feasibility and implementation the more accurate the costing became and the techniques changed.

During the scoping phase of the project factorised estimates were acceptable. During the pre-feasibility stage benchmarking against other projects and operations would be supplemented with detailed engineering estimates. The type of equipment were normally finalised during the feasibility study and this is when the life cycle costs of each type of equipment were more accurately determined. The respondents exclaimed that it was normally extremely difficult to compile a complete zero based budget for a complex project. The amount of time and effort as well as the level of information required for producing this type of estimates are normally the stumbling blocks. The project teams did the best they could to achieve zero based estimates as far as practicably possible and used benchmarking with similar operations for the remainder and also to test the validity and accuracy of the estimates.

The respondents were asked in question 13 whether any cost verification / benchmarking was done in the past after the life cycle cost estimates were compiled. From the feedback it was evident that most of the projects had their life cycle cost estimates benchmarked against similar projects or operations. The respondents explained that this process gave comfort especially if estimated life cycle costs were comparable with benchmarked figures. From the responses in question 5 however, it was picked up that in most cases life cycle costs were reduced to the lower or best practice levels of the benchmarked range for various reasons:

- To compensate for conservative project revenue assumptions dictated to the project team by the marketing and finance departments.
- The views are more often than not that the new operation will be state of the art and that the machines/equipment will achieve better life spans while little attention is given to what the norm is and then using that as a baseline with a view to improve on performance once the new colliery is in operation.

All the respondents acknowledged the importance and the value obtainable from such a benchmarking exercise. By deliberately choosing to use the "lower" end of the benchmarked range does however somewhat defeat the purpose of such an exercise. There is thus room for improvement and much more value can be extracted from such a process.

The respondents were asked during the last question whether there were any other factors not covered in the previous thirteen questions that could have influenced cost overruns in the past. The respondents were also asked to make recommendations that could assist the organisation in developing more accurate life cycle cost estimates and to produce more accurate business cases to support decision making. Quite a few points were raised by the respondents other than those discussed in the preceding thirteen questions:

- There is a need to develop standardised processes to guide teams through life cycle cost estimation. Currently each project team is doing their own thing whereas a sound system is needed that can be used by all yielding the same quality results for each project. This comment can be classified under a theme of project governance and also partially under training and skills development.
- The organisation's mines do not have good operational data / KPI information populated to a level desirable for effective benchmarking. There are no structures for uniform and consistent Activity Based Costing across the various operational sites. Operations personnel and management accountants should address this issue together with asset optimisation specialists. This will assist with both Bottom-up costing and actual benchmarking during the project design /development stages with the view to establish more accurate life cycle cost estimates.
- One respondent feels that the project development stages are far too long and that work is redone far too many times. This is as a result of controllable as well as uncontrollable scope changes and the inability or delay in making project decisions. This leads to shortcuts ("why worry if you will have to do the work 10 times over?") and the original work becoming totally irrelevant. Project teams strive for an accuracy that is unattainable in the early stages and give up on accuracy when it is really required because they have redone the work so many times and nothing has materialised. According to the respondent the "project teams become battle weary and there is a total lack of sight on the end goal". This issue forms part of a theme concerned with project governance.
- Currently project teams are not adequately staffed to conduct life cycle cost estimation to the level of detail required. One possible solution is to establish a specialised team within the project support office whose sole purpose is to compile cost estimates. Currently each project team compile their own cost estimates and do not necessarily always have the required skills within their team to do the work properly.

After all the data collection was done, a manual process of content analysis on the field notes, transcripts and inquiry documents followed. Ten key themes were identified during this process which covered most of the possible causes of project life cycle cost overruns within Organisation A.

Based on the identified themes a descriptive explanatory framework of the investigation was compiled. The identified themes and their frequency of occurrence are illustrated in Table 3.3.

Table 3.3: Frequencies of themes

Theme	Frequency
Poor cost management	2
Overoptimistic cost assumptions	20
Lack of emphasis on LCC and VE	13
Poor cost estimating techniques	0
Overoptimistic production assumptions	19
Lack in skills / experience of personnel	3
Poor management of risk and uncertainty	5
Insufficient benchmarking	6
Project governance and procedure issues	4
Insufficient project staffing	3

(Source: Own Compilation)

The data in Table 3.3 was further processed to be displayed in a matrix format for easy interpretation based on the frequencies of the encountered themes and is illustrated in Table 3.4.

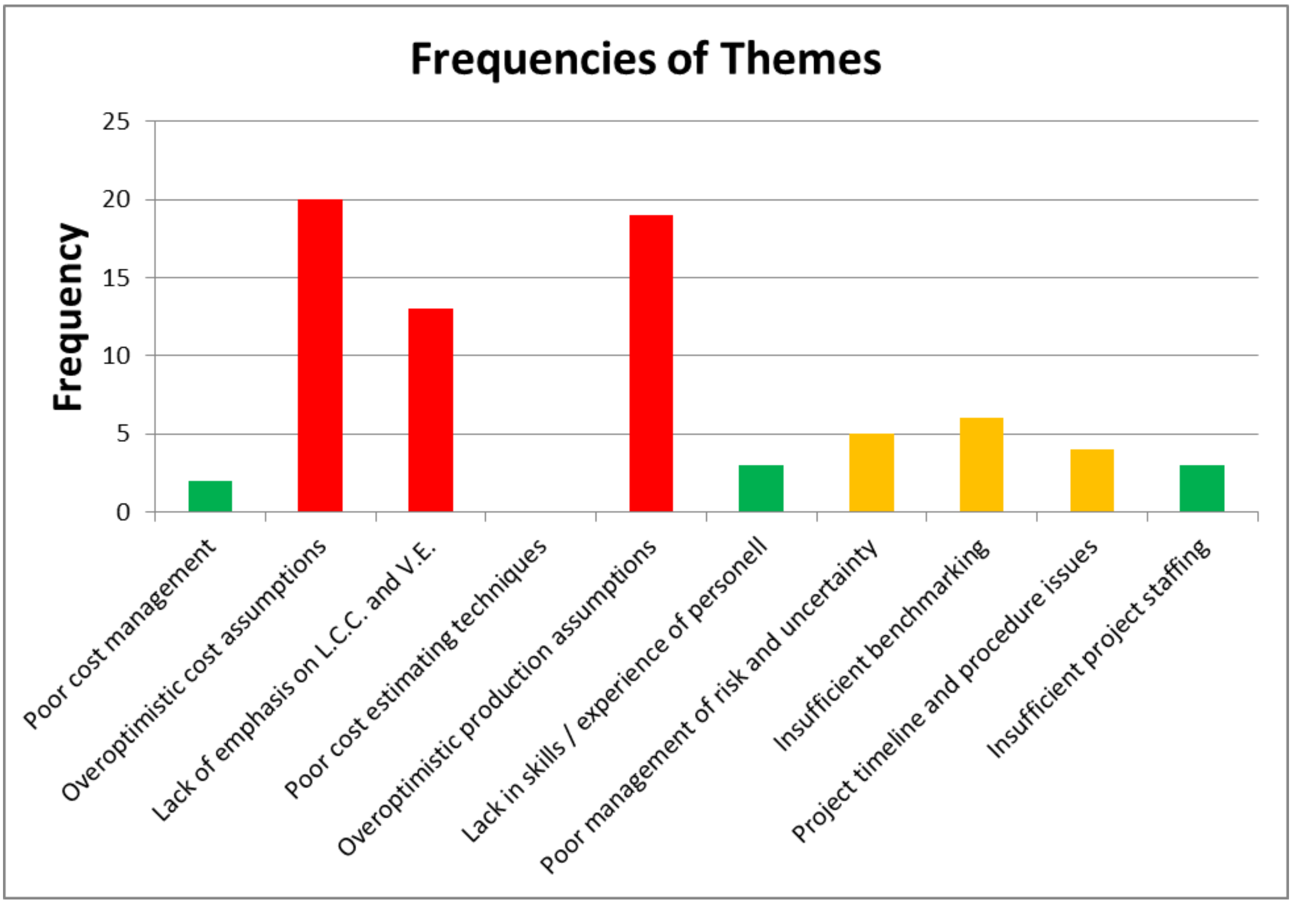
Table 3.4: Matrix of importance attributed to each theme

	Importance			
Theme	**None**	**Low**	**Average**	**High**
Poor cost management		x		
Overoptimistic cost assumptions				x
Lack of emphasis on LCC and VE				x
Poor cost estimating techniques	x			
Overoptimistic production assumptions				x
Lack in skills / experience of personnel		x		
Poor management of risk and uncertainty			x	
Insufficient benchmarking			x	
Project timelines and procedure issues			x	
Insufficient project staffing		x		

(Source: Own Compilation)

The importance rating of the themes were based on their frequency of occurrence during the data collection stages. A simple grading of high, medium and low were used to rank the various themes in importance. A graphical illustration of the results is given in Figure 3.3.

Figure 3.3: Frequencies of themes presented in a bar chart



(Source: Own Compilation)

Each of the ten identified themes or KSF's (Key Success Factors) impacting on accurate project valuations will briefly be discussed starting with the high frequency KSF's which are considered to be the most important and ending with the low frequency or less important KSF's:

Overoptimistic costs assumptions

Based on the responses from the seven participants it showed that they were of the opinion that the main reason for the cost overruns experienced in the past was because of overoptimistic cost assumptions. This over optimism in most cases did not come about unintentionally because of a lack in experience or knowledge on the side of the project team, but rather intentionally to try and compensate for overly conservative revenue assumptions in the project business case.

Based on the feedback received from the respondents, a huge amount of effort was put into developing both the establishment CAPEX estimate as well as the life cycle cost estimate for the projects. It is custom in the organisation that the selling price, exchange rate and escalation factors used in the project business case is dictated to the project team who are not allowed to query the assumptions used or the accuracy of the factors. These factors are normally very conservative as can be seen from the historic project reviews. As a result of the unrealistic factors dictated to the project teams other avenues are sought to make the project financially viable and this normally leads to the cutting of the CAPEX and life cycle cost estimates.

The project teams look to justify the lower costs by stating that new technology and equipment will be utilized and support it with benchmarks against industry best practice as opposed to normal practice. These efforts are normally just an eye blind to get the project approved, but the expected improvements are rarely achieved.

As a result of the current organisational culture and the way things are being done in the organisation, project teams continually get criticised for underestimating OPEX and SIB CAPEX while the marketing department gets praised for achieving better prices than were expected. The respondents believe that if better and more realistic revenue factors are dictated to the project team that the overruns on OPEX and SIB CAPEX will reduce as well as the huge “gains” seen on price would also reduce.

The current way of developing business cases and estimating costs are not in line with what is required for a LCC project approach as there is no firm grip on what the product being designed will actually cost in future. By compensating for certain unrealistic aspects of the business case in the form of lower life cycle cost estimates and higher production rates and grades causes one to lose control and not knowing what will actually transpire in the future. This can be considered a very risky way of conducting asset development.

The current organisational approach in conducting asset development makes it very difficult to incorporate something like VE to its full potential as the costs and the business case are never really fully understood. Using the past evaluated project results as example, realistic cost and production factors during the project development stages possibly could have shown that some design changes were necessary to maximise the project value e.g. the scale or production output of the mining operation as a function of the realistic overhead or fixed costs. It might have shown that the asset's output would need to increase by 1 million tonnes per annum in order to comfortably cover the overhead costs and at the same time achieve a healthy profit.

In order to rectify the situation and the way business cases are being developed within the organisation, corporate intervention will be required to change the current asset development system. One possible solution to the problem will be to assign the responsibility of estimating the revenue assumptions to the project team. By doing this they will have full control over the entire business case and all the assumptions, for which they can be held accountable. Over and above the aforementioned proposal, the organisation will also need to formally communicate that no compensation of any sorts will be allowed within a project business case and that all factors must be realistic and achievable.

Overoptimistic production assumptions

Overoptimistic production assumptions stems from exactly the same issue as explained above. While the technical metrics indicate that a project is attractable (e.g. good strip ratio, reasonable yields and ore grades) the business case show the opposite due to overly conservative revenue assumptions. This again leads to certain optimism in the technical assumptions such as the production rates and ore grades to compensate for the conservatism in the financial arena.

During operations when the "unrealistic" budgeted production levels are then not met, it leads to an escalation of the cost on a per tonne basis because of the amount of fixed costs, which usually ends up in additional capital investment to realise the original production forecasts. For coal mining operations, fixed costs normally account for 70% of the total operational costs (Prinsloo, 2013).

Compensation on both fronts of reduced costs and increased production assumptions really skews the business case and eliminates any chance the project team had to accurately predict what would transpire in future. This can be considered a very risky way of conducting asset development as the organisation don't have a clear understanding what the project value will end up being in the future.

Lack of emphasis on Life Cycle Costing and Value Engineering

In the view of the respondents, not a lot of attention and appreciation is given to the accurate estimation of life cycle costs. The focus is more on delivering the asset on time and within budget as opposed to ensuring that the new asset will be a sustainable mining enterprise with optimised cash flows.

Life cycle costs are more often than not deemed unimportant as it is considered not to have too a big impact on NPV because it occurs in the later years and is therefore usually not given a lot of attention. From the project reviews however it can be seen that life cycle costs has a major effect on project valuations and definitely needs to be given a lot more attention during the project development stages.

A lack in practicing LCC and understanding the costs early on together with utilising VE to optimise designs usually leads to expensive retrofits during operations. Optimised designs will not require retrofits and will address operability, maintainability, and reliability early on and hence lower the life cycle costs and increase the project value.

Insufficient benchmarking

All the respondents consider benchmarking to be a very powerful tool that cannot be utilised enough. The investigation found that most of the projects implemented in the past did undergo some form of benchmarking analysis to verify costs. The respondents described the process to add value and bring comfort especially when the estimated life cycle cost estimates were found to be close to the benchmarked figures. In most cases however the costs were reduced to the lower levels of the benchmarked ranges for reasons explained earlier.

Some respondents were also of the opinion that the organisation does not maintain a good enough database of operational data and KPI information populated to a level desirable for effective benchmarking. There are no standardised structures for uniform consistent ABC across the various operational sites and the information is not readily available from one central location. Operations personnel together with management accountants and asset optimisation specialists need to develop a standardised costing system for the organisation. This will assist with both Bottom-up costing and actual benchmarking during the project development stages with the view to estimate more accurate life cycle cost cash flows.

Poor management of risk and uncertainty

Most of the respondents were of the opinion that risk and the unknown were not sufficiently addressed and mitigated during the previously implemented projects. The respondents felt that is better to try and identify and mitigate risks at the planning stages of a project than to try and rectify problems during implementation or after the project has been completed. The cost of these design changes or risk mitigation measures is also significantly lower if they can be addresses early on in the project.

In the past it has been experienced that legislation changes that came about post-investment or during implementation has resulted in cost expenditures that were not originally budgeted for. It is good practice that for these uncontrollable situations or unknown conditions to allow for some form of contingency in the cost estimates.

None of the respondents were convinced that complicated Monte Carlo simulations or the like is required to quantify risk. Using the experience of the project team together with a simple high, medium and low sensitivity analysis is considered sufficient to inform realistic contingencies that can be provided for.

Project timelines and procedural issues

The failure of management to make quick decisions on issues guiding projects through their various development stages was identified as another problem hampering accurate cost estimation. The extended time it takes to get a decision approved through the organisational structures influences project timelines. Because of the extended timelines cost estimating work gets redone quite a number of times before any real progress is made. In the words of a respondent the project teams become “battle weary” and give up on accuracy when it really is required because they have done them over and over so many times for no real benefit to the project.

This is again a problem that will need to be addresses at a corporate level within the organisation. Through communication and awareness on the issue as well as simplified approval processes the time to make decisions can be reduced to prevent and avoid project delays.

Although an overarching project governance document exist within the organisation spelling out the deliverables and processes to be followed for the various project development stages, no detailed procedure exist explaining in detail how life cycle cost estimating should be conducted. Normally the project teams working on different projects each adopt their own way of estimating costs.

The quality of cost estimating therefore varies from team to team as no standardised approach is followed. A standard procedure detailing exactly what should be done to accurately estimate life cycle costs will eliminate these inconsistencies. Because the different business units within the organisation operate in their own unique way, a standard operating procedure on cost estimating specially adopted for the coal business unit will be of assistance.

Insufficient project staffing

The more a project progresses through the project development stages, the more detail in its definition and accuracy in estimation is required. In the past, project teams have not been adequately staffed to acknowledge the project's progress and the increase in estimation accuracy required.

A dedicated estimating team within the project support office is one option in solving the problem. This team will be highly specialised and trained in the techniques and processes of accurately estimating life cycle costs.

Lack in skills and experience of personnel

Some respondents felt that initiatives such as LCC and VE have not yet found its place in the organisation as a result of the lack in skills, exposure and knowledge on the topics. Few people know about LCC and even fewer know how to incorporate it into project development. The same applies to the skills and experience required in utilising certain techniques too accurately estimate life cycle costs. Project staffing,

staffing quality and skills development should receive much more attention within the organisation to fill project teams with competent persons.

The research found that the lack in skills and experience were predominantly related to cost management and the cost estimating techniques as opposed to the technical skills and knowledge required to design and develop the asset.

Poor cost management

Although most of the respondents were of the opinion that past experienced cost overruns were mainly attributable to poor cost estimating as opposed to poor cost management, some did acknowledge that elements of poor cost management did exist.

This was normally the case when the operational teams realised that the asset was making a profit either due to higher than expected prices or other factors, that they began to spend money on the things not originally budgeted for. The things the money was spent on were normally not crucial to the operation but rather “nice to haves”. These occurrences did contribute somewhat to the cost overruns experienced in the past.

Poor cost estimating techniques

Surprisingly, no issues were identified during the empirical investigation regarding cost estimating techniques. Estimating techniques used in the past varied between detailed engineering and Bottom-up estimating techniques to factorised cost estimates depending in what stage the projects were in.

Because in most instances costs were verified through benchmarking, the respondents were confident that the techniques they employed were accurate enough. As was seen from the empirical results the cost overruns were mainly related to intentional cost cutting as opposed to technical reasons such as poor cost estimating techniques that were employed.

A standardised approach in technique and procedure as recommended earlier will however assist the organisation to achieve consistent results across all its projects.

Formal training of project personnel on the standard operating procedure as well as the cost estimating techniques will assist it further to obtain good results.

3.4. SENSITIVITY ANALYSIS

As part of the secondary objectives of the study, a sensitivity analysis on project valuation results were conducted for a range in variations of life cycle costs, coal price and establishment CAPEX. The business case models of actual projects in their development stages were used for the analysis. Five capital projects were selected and consisted of 2 underground and 3 opencast mining projects.

A DCF model was used as the basis from where the project NPV and IRR were determined, which were used as the key project valuation indicators. The term project valuation describes in monetary terms how much a project is worth. These techniques including PB are the most common techniques used in the South Africa to evaluate projects (see section 2.4).

The sensitivity analysis was run for 10 different variations in life cycle costs, CAPEX and coal price respectively. The variations included both possibilities of either over and under estimating the cost assumptions. The sensitivity analysis investigated each of the factors separately and no combinations were analysed. The process followed for the analysis is as follows:

Step 1: Calculate the base NPV from the original assumed factors;

Step 2: Factorise one of the investigated areas like CAPEX and keep the base values of the other two areas unchanged;

Step 3: Recalculate the NPV;

Step 4: Log the change in NPV as a percentage under the specific investigated area; and

Step 5: Repeat the process for one investigated area at a time.

There were several reasons for conducting the sensitivity analysis including:

- To quantify how sensitive Organisation A’s coal mining projects are to variations in the variables of life cycle costs, CAPEX and coal price respectively;

- To illustrate the impact that inaccurate cost assumptions could have on project valuations; and
- To compare the results from the sensitivity analysis with that achieved in past implemented projects so as to establish whether any correlation exist.

Numerical Example

To illustrate how the project valuation as well as the sensitivity analysis was conducted, a numerical example is described for a typical coal mining project. For simplicity sake the following assumptions were made as outlined in Table 3.5.

Table 3.5: Project Assumptions

Evaluation Period: Construction time +25 years
Construction Time: 3 years (Capital spread equally)
Project construction starting next year
Full production from operating year 1 onwards
Numbers in real terms - Inflation removed
Cost of studies not considered
Tax expenses not included

(Source: Own Compilation)

The main economic factors used for the illustrative project evaluation is summarised in Table 3.6.

Table 3.6: Project Economic Factors

Establishment CAPEX	R 3 billion
ROM (Run of Mine) production per annum	4 million tonnes
Saleable product A per annum (Export Market)	2.3 million tonnes
Saleable product B per annum (Local Market)	0.55 million tonnes
Saleable product A price per tonne	$ 82.82 / tonne
Saleable product B price per tonne	R 190.17 / tonne
Exchange rate	R 8.75 / $
Export selling expenses per product A tonne	R 143.45 / tonne
OPEX per ROM tonne	R 187.90 / tonne
SIB CAPEX per ROM tonne	R 10.00 / tonne
Discount rate	10%

(Source: Own Compilation)

Applying the above factors to the planned production profile of the mine results in cash flows as illustrated in Table 3.7.

Table 3.7: Project Cash Flows

Cash Flows:	**Year 1**	**Year 2**	**Year 3**	**Year 4 - Year 28**
Product A Sales	R 0	R 0	R 0	R 1 337 075 486
Product B Sales	R 0	R 0	R 0	R 104 593 500
Establishment Capital	(R 1 000 000 000)	(R 1 000 000 000)	(R 1 000 000 000)	R 0
OPEX	R 0	R 0	R 0	(R 751 600 000)
SIB CAPEX	R 0	R 0	R 0	(R 40 000 000)
Net Cash Flow	**(R 1 000 000 000)**	**(R 1 000 000 000)**	**(R 1 000 000 000)**	**R 650 068 986**

(Source: Own Compilation)

By feeding the forecasted cash flows into the DCF model, the illustrative project yielded the evaluation results as depicted in Table 3.8. The formula used to compute the net present value is given as:

$$\mathrm{NPV}(i) = \sum_{t=0}^{N} \frac{R_t}{(1+i)^t}$$

Where i is the discount rate, Rt is the net cash flow, t is the time of the cash flow and N is the total number of periods. The internal rate of return follows from the net present value as a function of the rate of return. A rate of return for which this function is zero is the internal rate of return.

$$\text{NPV} = \sum_{n=0}^{N} \frac{C_n}{(1+r)^n} = 0$$

Where r is the internal rate of return, Cn is the net cash flow, n is the period of the cash flow and N is the total number of periods.

Table 3.8: Project Evaluation Results

Valuation Result	Base Case	Increase life cycle costs (OPEX & SIB CAPEX) by 10%
NPV	R 2 141 076 195	R 1 547 242 734
IRR	18%	16%
Payback Period	8 yrs	9 yrs
Change in NPV	N/A	(27.7%)

(Source: Own Compilation)

By referring to the results in Table 3.8, the sensitivity analysis process will be described according to the steps as described earlier (see section 3.4):

Step 1: Calculate the base NPV from the original assumed factors. The base case project valuation at a discount rate of 10% resulted in a project NPV of around R 2 billion.

Step 2: Factorise one of the investigated areas, like CAPEX, and keep the base values of the other two areas unchanged. In this example life cycle costs were increased by 10% or "factorised" by multiplying it with a factor of 1.1 while the coal price and establishment CAPEX were left unchanged.

Step 3: Recalculate the NPV. By increasing the life cycle costs by 10% represents a scenario where these costs were initially underestimated, and it caused the project valuation to drop to around R 1.5 billion.

Step 4: Log the change in NPV as a percentage under the specific investigated area. In this example the underestimation resulted in the project valuation to drop by 27.7%.

Step 5: Repeat the process for one investigated area at a time.

Sensitivity Analysis Results

Based on the same principals as demonstrated in the numerical example, the sensitivity analysis was conducted on five actual projects within Organisation A. The results from the sensitivity analysis is summarise in Table 3.9 below. Each of the business factors were analysed by multiplying them with ten different factors. Multiplying life cycle cost with a 1.05 factor for example will represent a scenario where life cycle costs were underestimated by 5%. A total of 150 sensitivity iterations (30 per project) were run. The results in Table 3.9 represent the average of the five evaluated projects.

Table 3.9: Sensitivity Analysis Results

	NPV % Added / Destroyed		
Factor	**Life Cycle Cost**	**CAPEX**	**Coal Price**
0.5	245	113	-450
0.8	98	45	-180
0.9	49	23	-90
0.95	24	11	-45
1	0	0	0
1.05	-24	-11	45
1.1	-49	-23	90
1.2	-98	-45	180
1.3	-147	-68	270
1.5	-245	-113	450
2	-490	-226	900

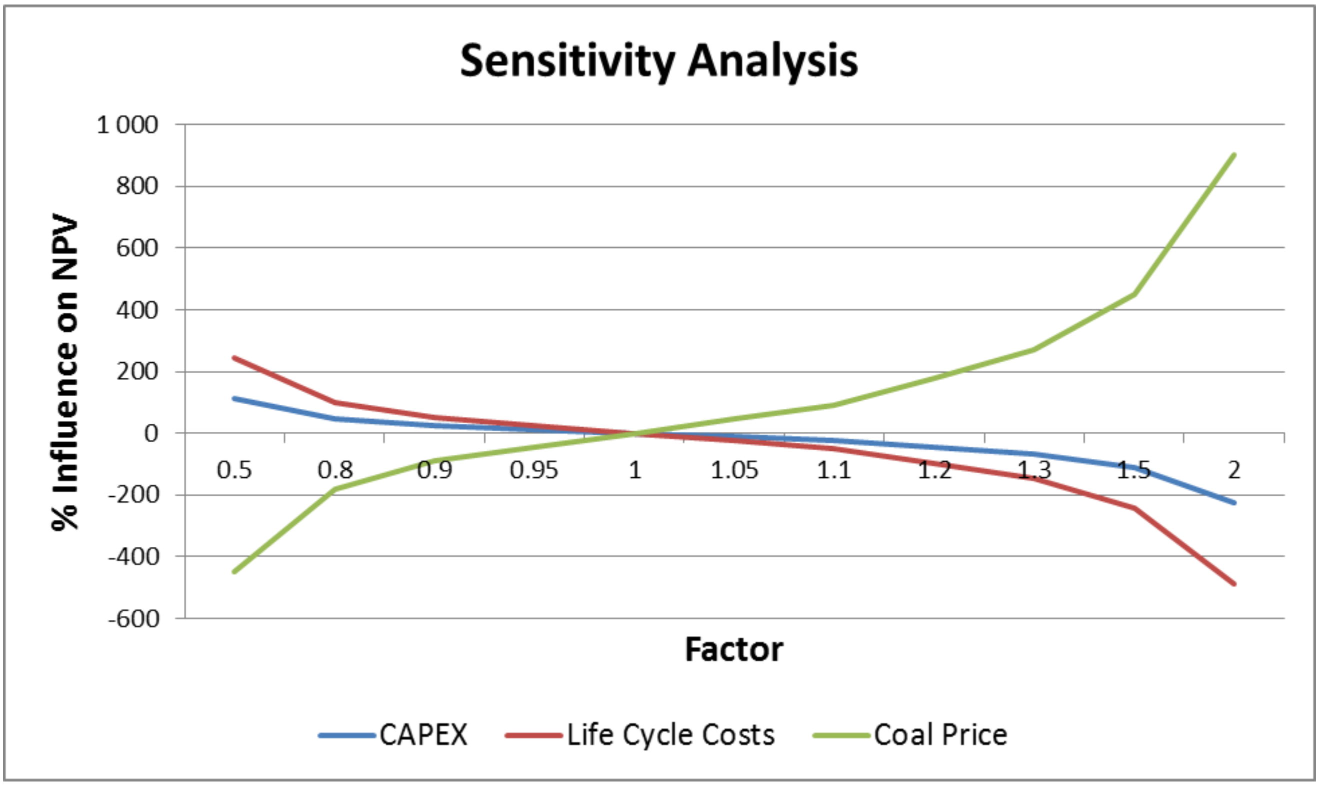
(Source: Own Compilation)

As expected from the analysis results an increase in life cycle costs or CAPEX reduces the NPV and an increase in coal price or revenue increase the NPV. The results indicate that the NPV is the most sensitive for variations in coal price, followed by life cycle costs and then lastly CAPEX. This is in line with the results illustrated in Table 3.1 of the case study research (section 3.3) of past implemented projects in the organisation. The magnitude of the impact on NPV is however not that comparable with the sensitivity analysis showing a reduced impact on NPV compared to the case study results.

From the results in Table 6 it can be seen that if life cycle costs are 20% more than what was originally anticipated, it will destroy nearly 100% of the original NPV. A 1% increase in life cycle cost therefore destroys approximately 5% of project value. In the case of CAPEX, an increase of approximately 40% over budget will destroy 100% of the original NPV.

The same analysis results have been graphically illustrated in Figure 3.4 below:

Figure 3.4: Sensitivity Analysis Results



(Source: Own Compilation)

With the results obtained from the analysis and as illustrated in Figure 3.4 it is evident that small variations in business case factors including life cycle costs can have a major impact on the project valuation. These results can be used to create awareness among project leaders not only within Organisation A but also in the mining industry that more effort should be put into optimising and accurately forecasting business case factors.

As was determined from the interviews, the focus of the project teams are normally more on delivering the asset on time and within budget. Limited attention is given to forecasting and optimising life cycle costs through initiatives such as LCC, TC and VE. These initiatives can add a lot of value to a project because the flip side is also true when looking at Figure 3.4. If life cycle costs are reduced by 20% during the development stages, it will increase the project value equivalent to100% of the original NPV. Through LCC and VE costs can be optimised through revised and improved product designs thereby reducing the life cycle costs and subsequently increasing the overall project value.

3.5. SUMMARY

This section summarises the key findings from the two main empirical research sections that formed part of this study as detailed within this chapter. The first empirical research investigation took a case study approach where past implemented project results were collated and analysed. The main aim was to determine how close to reality the original life cycle cost estimates were, and secondly how any variances to the originally budgeted costs impacted on the anticipated project value post implementation.

The results from the three investigated cases showed that the actual achieved life cycle costs were generally significantly higher than the original budgeted estimates. It was confirmed through the research that these cost overruns were mainly as a result of the original cost estimates being underestimated, and therefore impractical to achieve. The estimates were underestimated by big margins of up to 40% and destroyed project value equivalent to approximately 700% of the original anticipated NPV.

Even though the costs were significantly underestimated, all the projects ended up with a positive NPV because of higher than expected commodity prices that were realised and which prevented the organisation from incurring major financial losses. The project results from the coal business unit were found to very similar to that of the bigger organisation as was reported in 2010. The coal business unit did however show bigger variances to budget in the business case areas of anticipated life cycle costs and production profile and ore grade.

In an attempt to find the reasons behind the experienced cost overruns, the researcher conducted an explorative research study to investigate the matter. The study consisted of in-depth interviews with seven project specialists within the organisation that were also involved in the development stages of the investigated projects. Surprisingly the results indicated that the main reasons for the overruns were mainly related to project governance issues within the organisation as opposed to technical reasons.

Ten KSF's or reasons for the experienced cost overruns were identified through the research and were ranked in importance based on a descriptive explanatory framework that was developed for the investigation. The ranking was related to the frequency that theme occurred during the interviews. The top three reasons are:

- Overoptimistic Cost Assumptions.
- Overoptimistic Production Assumptions.
- Lack of emphasis on LCC and VE.

The first two reasons are related to the fact that according to the organisation's procedure of developing projects, the project team is only responsible for estimating the establishment CAPEX, the life cycle costs and the production parameters related to the asset. The assumptions influencing the business case revenue such as the coal price, exchange rate and escalation factors are dictated to the project team by the marketing and finance departments.

The assumptions received from the marketing department are usually overly conservative, and the project team does not have the authority to question the factors. The fact that these factors are usually overly conservative is demonstrated in the project valuation breakdown (waterfall diagram in Figure 3.1) that were developed from the reviewed past project results. The underestimated revenue assumptions added to the project an equivalent value of approximately 1,080% of the original estimated NPV which compensated for the underestimated life cycle costs.

What happened in the past is that the technical metrics indicated that a project is attractable (for example: good strip ratio, reasonable yields and grades, easy mining conditions) while the business case results showed the opposite due to overly conservative revenue assumptions. Knowing this, the project team then include a certain amount of optimism in the technical assumptions such as the production rates and ore grades as well as the life cycle costs in order to compensate for the ultra-conservatism in the financial arena.

Compensation on both fronts of reduced costs and increased production assumptions really skews the business case and eliminates any chance the project team had to accurately predict what would transpire in future. This can be considered a very risky way of conducting asset development as you don't have a clear understanding of what the project value will end up being in the future.

The fact that the business case is skewed makes it difficult to incorporate LCC, TC and VE to its full potential as you don't really know what the actual costs and revenue will end up being in future. Apart from being difficult to incorporate, not enough emphasis was put on LCC in the past and it was therefore identified as the third major reason for poor project planning in the past.

During project development the focus is more on delivering the asset on time and within budget as opposed to ensuring that the new asset will be a sustainable mining enterprise with optimised cash flows. Life cycle costs are more often than not deemed unimportant as it is considered not to have too a big impact on NPV because it occurs in the later years and is therefore usually not given a lot of attention.

From the project reviews however it can be seen that life cycle costs has a major effect on project valuations and definitely needs to be given a lot more attention during the project development stages. A lack in practicing LCC and understanding the costs early on together with utilising VE to optimise designs usually leads to expensive retrofits during operations.

The second part of the empirical research was to conduct a sensitivity analysis and to establish how sensitive a greenfield coal mining project business case is to variations in the factors of life cycle costs, establishment CAPEX and coal price. The results indicated that the NPV is the most sensitive for variations in coal price, followed by life cycle costs and then lastly CAPEX.

From the results it was also seen that an increase of 20% in life cycle costs can destroy nearly 100% of the original NPV. A 1% increase in life cycle cost therefore destroys approximately 5% of project value according to the analysis. The results obtained from the analysis demonstrate that a small variation in life cycle cost can have a major impact on the project valuation.

The results from the empirical research can be used to create awareness among project leaders not only within Organisation A but also in the mining industry that more effort should be put into optimising and accurately forecasting life cycle costs.

CHAPTER 4: CONCLUSIONS AND RECOMMENDATIONS

4.1. INTRODUCTION

The research study was conducted in order to establish what effect life cycle cost forecasting accuracy has on project valuations with special reference to a global mining organisation’s coal business unit in South Africa. The research stemmed from the fact that the organisation identified through its own research in 2009 that its capital projects rarely met the originally budgeted life cycle cost forecasts estimated during the project development stages. These forecasts were generally found to be underestimated.

Overrunning of cost budgets in project management terms results in project failure. This is because the anticipated business case benefits are negatively affected, which causes the project valuation and yield to decline in relation to the original expectations of the organisation and its providers of capital, the shareholders. In the current economic environment where capital is scarce, investors are especially weary of organisations that can’t deliver what they originally promised.

Project valuations determined during the project development stages get used to inform important organisational decisions such as the allocation of capital. Inaccurate cost forecasts will however result in inaccurate project valuations which in turn can result in wrong decisions being made. It is therefore important to understand the magnitude of this effect so that the necessary precautionary measures can be taken by Organisation A going forward.

4.2. RESEARCH FINDINGS

The main research findings for both the literature and empirical research sections are summarised below:

Literature study

Coal is internationally as well as locally still the most common energy source and with the growing economies of Africa and Asia the local industry is expected to grow substantially into the future. The growth expected in the South African coal mining industry will require approximately R 100 billion worth of investments into capital projects by 2020 (SACRM, 2013:5). The development of various greenfield capital projects will, therefore, be required in the industry in order to meet the expected growth.

The ability to influence capital project success and project value is the greatest during the early project development stages and declines thereafter as the project proceeds towards implementation. Organisations are therefore pursuing structured project development methodologies supported with rigorous project evaluation standards to ensure that the most value add is realised during the early project development stages.

Minimum accuracy levels of forecasted cash flows to be used in business case valuation models are set within project development standards by organisations. By the end of the feasibility project stage it is expected that the cost forecasts and the project business case to be as accurate and realistic as possible, so that it can be used to inform capital investment decision making.

The research revealed that capital allocation and access to capital is the number one risk on Ernst & Young's top 10 business risk register in 2013 for mining and metals organisations globally, up from number eight in 2012 (Elliot, 2013:4). The correct allocation of scarce capital has therefore become a key competitive measure in the mining industry, and is directly related to the quality and accuracy of the information available to inform decisions. In the South African mining industry, the NPV and IRR valuation approaches are the primary investment criteria used to inform capital investment decision making.

Capital project execution success was also found to be relatively poor in the mining industry and considered a major business risk facing the mining and metals industry (Da Silva *et al.*, 2012:3; Elliot, 2013:8; Hudson, 2011:18; Wittig, 2013:392). Project planning and the forecasts of cost, demand, and other impacts of planned capital projects were found to be a common problem in the mining industry around the globe. This causes project business cases to be inaccurate which managers use to inform capital investment decision making. The literature research suggest that project failure is directly related to wrong decisions being made because of initial poor project planning and inaccurate forecasting.

Reasons for inaccurate forecasting and poor project planning in the literature are categorised under:

- Technical explanations related to the planning tools and data being used to compile forecasts.
- Political-economic explanations related to organisational pressures and the intentional misrepresentation of data to get projects approved.
- Psychological explanations related to the natural optimism bias of human beings that can lead to overoptimistic project forecasts.

Most of the reasons given by Organisation A for the past underestimated life cycle cost forecasts are related to technical explanations such as planning tools, methodology, skills of project personnel and the availability and quality of input data. Political-economic and psychological explanations were not mentioned in their investigation and therefore the focus of the literature study was directed towards the technical considerations around life cycle costs and the accurate forecasting thereof. As part of this focus LCC was investigated as a possible solution to the poor project planning experienced in the past.

The literature study identified LCC as an approach that can provide for all the requirements in a project environment of firstly considering and capturing all expected life cycle costs, and then using that information to make decisions and to optimise the product design. LCC is an approach of including acquisition, operational and disposal costs when evaluating various alternatives. LCC is considered to be just as much an approach to capture all future costs as it is a technique to compute to a certain degree of accuracy the life cycle costs for a specific product. Adopting LCC in a project environment makes sense as it considers all future costs, it can account for risk, it produces comprehensive forecasts and can therefore inform good decision making.

Empirical research

The project results from the coal business unit were found to very similar to that of the bigger organisation as was reported in 2010, in that it significantly overshot anticipated life cycle cost forecasts. The coal business unit did however show bigger variances to budget in the business case areas of anticipated life cycle costs and anticipated production profile and ore grade. The life cycle cost estimates specifically were underestimated by big margins of up to 40% and destroyed project value equivalent to approximately 700% of the original budgeted NPV.

Ten reasons for the experienced cost overruns were identified through the research and were ranked in importance based on a descriptive explanatory framework that was developed for the investigation. The top three reasons that were found are:

- Overoptimistic cost assumptions
- Overoptimistic production assumptions
- Lack of emphasis on LCC and VE

The over-optimism related to the first two reasons did not come about unintentionally because of a lack in experience or knowledge on the side of the project team, but rather intentionally by them in trying to compensate for the overly conservative revenue assumptions in the project business case. In Organisation A it is custom that the selling price, exchange rate and escalation factors used in the project business case gets dictated to the project team by the corporate marketing and finance departments. These factors are normally very conservative as was seen from the historic project review results (see section 3.3).

As a result of the unrealistic factors dictated to the project teams other avenues are sought to get a project approved such as assuming an optimistic amount for establishment CAPEX, lower than anticipated life cycle costs and unrealistic production assumptions. This is a form of poor project planning and forecasting that fall into the category of "political-economic explanations" which are related to the intentional misrepresentation of data. Project teams are often subject to organisational pressures to develop project business cases within a limited amount of time which in some instances results in the intentional "cooking" of project business case factors.

The third reason does not necessarily refer to the actual LCC and VE techniques as researched in the literature study, but rather the approach of considering all future costs and using that to inform design and other related decisions. From the interviews it was evident that a general perception existed that life cycle costs do not have a major influence on a project's valuation due to it being spread out over time and sometimes far into the future. The focus was generally more on accurately forecasting the establishment CAPEX and to a certain extent the implementation schedule.

The sensitivity analysis results indicated that the project NPV is the most sensitive for variations in coal price, followed by life cycle costs and then lastly establishment CAPEX. An increase of 20% in life cycle costs can destroy nearly 100% of the original anticipated NPV. A 1% increase in life cycle cost therefore destroys approximately 5% worth of project value according to the analysis. The results obtained from the analysis demonstrate that a small variation in life cycle cost can have a major impact on the overall project valuation.

4.3. RECOMMENDATIONS

Based on the study findings certain recommendations are made to Organisation A to consider and possibly implement. The recommendations are summarised below:

- The fact that life cycle costs have a big impact on project valuations as illustrated through this study need to be embraced. Through awareness campaigns, corporate communication channels and training programmes this fact need to be instilled within the organisation and especially the project support office.
- Based on the finding of the study that political-economic explanations were responsible for the poor project planning experienced in the past, a quantitative research study must be initiated to investigate the case in more detail.
- In line with the likely causes picked up through the study, the organisation can consider giving the project team full responsibility of all aspects regarding the project business case. This will include the commodity price, exchange rate and escalation assumptions. This way the project team will assume full accountability for the business case success.
- Adopt a project orientated LCC approach linked with VE. This can be seen as a best practice approach in a project environment to optimise product designs, reduce cost and increase the project value. The necessary training and development of project staff on the approaches will also be required.
- In line with the remaining seven KSF's identified in the empirical research study, the following recommendations are made (refer to section 3.3 for more detail):
- Establish a standardised ABC structure and information link across the various operational sites so that KPI information can become readily available from one central location that can be used for benchmarking.

- A probabilistic approach to risk management need to be adopted on all projects to ensure that sufficient reserves are allowed for to cater for the “known-unknowns” as well as the “unknown-unknowns” of the future.
- Project support office staffing and training need to be in line with a LCC approach as it will require detailed and in-depth planning.
- Develop a standard operating procedure specific to the coal business unit projects that detail how life cycle cost estimating should be conducted. This procedure can then be adopted by all project teams within the project support office to ensure consistent and uniform results are achieved at all times.

4.4. Evaluation of the study

The study managed to achieve the primary and secondary objectives that were set out at the beginning:

- The effect that life cycle cost forecasting accuracy has had on mining project valuations in the past were quantified.
- Poor project planning as opposed to poor cost management were verified as the main reason for the experienced cost overruns in the past.
- Political-economic explanations were identified as the main reason for the poor project planning experienced in the past.
- LCC was identified as a best practice approach to forecasting future life cycle costs. It was further identified that this approach can be adopted in the project environment and that it will contribute in achieving more accurate life cycle cost forecasts.
- The sensitivity analysis demonstrated the importance of forecasting accurate life cycle costs as it has a significant impact on the project business case.

Qualitative research studies are often used as precursors to quantitative research studies especially when the researcher doesn’t know what to expect. This research study revealed various unknown aspects of the problem at hand such as the political-economic driven underestimations that can now be further explored through more in-depth quantitative research methods. The research was further limited to a specific mining organisation in the South African coal industry. Future research can expand to cover the coal industry as a whole in South Africa.

4.5. CONCLUSIONS

The primary objective of the research was to investigate and quantify the effect that life cycle cost forecasting accuracy has had on mining project valuations within Organisation A's South African coal business unit in the past. By doing this a more specific objective was looking to be attained, and that is to understand the impact that life cycle cost forecast accuracy has on coal mining project valuations.

From the investigated cases it could be seen that the coal business unit performed poorly in producing accurate business case results when compared to the bigger organisation average. The main forecasted business case inputs that were looked at include controllable factors such as forecasted life cycle costs (OPEX, SIB CAPEX), establishment CAPEX and Production & Grade factors as well as uncontrollable factors such as forecasted FOREX and coal price.

Life cycle cost forecasts were found to be often underestimated by big margins of up to 44% and that it resulted in destroyed value equivalent to 700% of the originally anticipated project valuation. The sensitivity analysis revealed that a coal mining project business case is the second most sensitive to variations in life cycle costs after variations in commodity price. Life cycle cost forecasts are therefore the controllable business case factor with the biggest influence on project valuations.

The results indicated that a 20% increase in life cycle costs can destroy an equivalent project value of up to 100%. The study therefore concludes that life cycle cost forecasts are very important project business case inputs and that the necessary time and effort should go into developing them so as to ensure that they are as comprehensive and accurate as possible. This will subsequently also improve the project valuation accuracy which in turn will be used to inform capital investment decision making.

In line with the secondary objectives of the study the reasons for the inconsistent project results experienced in the past were investigated so as to establish what the causing factors were and how it could be addressed going forward into the future. The research revealed that the inconsistencies were mainly related to poor project planning and the underestimation of forecasts as opposed to poor cost management and not sticking to the original budget.

The poor project planning were furthermore found not to be related to any technical explanations or the inadequacy of the planning tools used, but rather because of “political-economic explanations” which are related to the intentional misrepresentation of data (see section 2.5). Conservative business case assumptions dictated to the project teams prevented them from proving a viable project business case. This together with the impact of organisational pressures lead to them using intentional optimistic cost and production assumptions in order to get the project approved.

The researcher did not anticipate that political-economic reasons would be the main cause of the experienced poor project planning, and therefore the literature study focused on technical planning tools and techniques such as LCC. The literature around the concept of LCC revealed however that it is a flexible yet comprehensive approach with the ability to capture all future costs. It is suitable to be adopted in a project environment and will contribute in improving forecasting accuracy as well as optimising product designs and ultimately the project value through the concept of VE.

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Appendix A

(Cover Letter)

Good day,

I am doing a research project, which is part of my dissertation to be submitted in partial fulfilment of the requirements of a MBA degree. Attached is a research document containing 13 questions with the aim to determine how life cycle cost accuracy estimated during the project development stages could influence capital investment decision making and the project business case.

You are one of a small number of people who are being asked to give your opinion on this issue. You were selected because of your experience and your involvement in past implemented projects within the organisation. It would take about 20 minutes of your time to complete the inquiry document.

All the information you provide will be treated with the highest confidentiality. Please answer all the questions at a time when you are unlikely to be disturbed. Your answers are essential to building an accurate picture of the topic.

Please return your completed inquiry document to me electronically via e-mail on or before Friday 20 September 2013. You can type your answers in this document after each question.

I hope you find completing the document enjoyable, and thank you for taking the time to help me. If you have any queries, or would like to have more information about this research project, please call me on 083-278-9666.

Thank you for your help!

Stefan Jansen van Vuuren

Background

Capital investment decision making is a critical task where company managers need to make important decisions in what projects to invest the organisation's capital. This is especially important in the mining industry due to the nature of the projects and their capital intensity. Capital budgeting is a crucial aspect for a firm's success for several reasons:

- Capital investments typically account for a large amount of the funds of an organisation.
- Capital investments normally have a fundamental effect on the future cash flows of an organisation once an investment decision has been made.
- It is often not possible to reverse a decision, or it is very costly to do so, once the funds have been committed and funds are normally tied up for a long time.
- Investments affect the profitability and long-term strategy of an organisation.

Decision making is normally guided by evaluating the anticipated project cash flows and computing project valuations eg NPV, IRR and the Payback Period. By comparing these valuation indicators, the most attractive project is then normally selected for investment. The accurate estimation of future project cash flows is therefore key to the success of this decision making process.

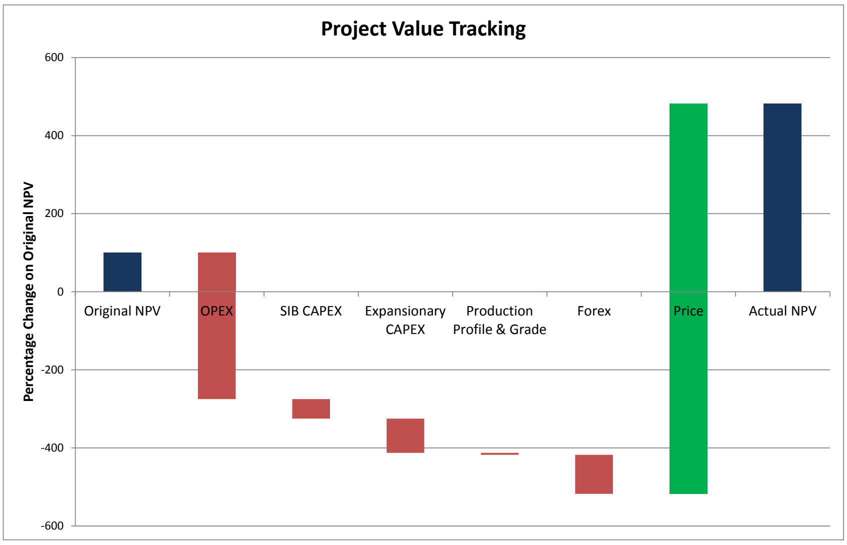
A benchmarking exercise was conducted in 2009 within our organisation to measure the performance of its projects against other independent studies. The results of the study showed that most mining, minerals and metals projects exceeded cost and schedule. This finding support a report published by Ernst & Young in 2011 stating that inconsistent project deliverables and cost overruns within the mining and metals industry is common and regarded as a major business risk going forward.

Our organisation identified the biggest drivers of value destruction in terms of cost & schedule to be:

- Operating cost (OPEX) overspends
- Slower than forecast ramp-up
- Poorer than forecast ore grade quality
- Stay In Business Capital (SIB CAPEX) overspends

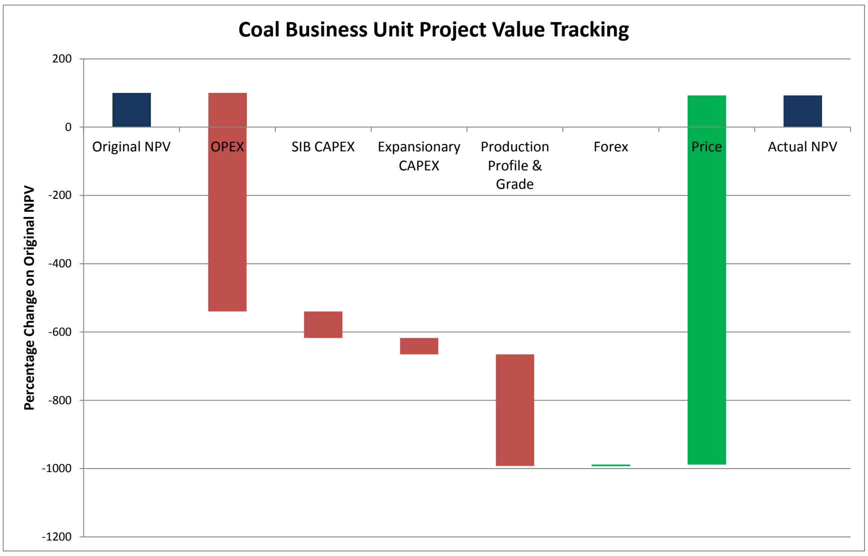
Figure 1 below summarises the effect as explained above that controllable factors (OPEX, SIB CAPEX, Expansionary CAPEX and Production & Grade) as well as uncontrollable factors (FOREX and Price) has had on project valuations within our organisation in the past.

Figure 1: Organisation Project Value Tracking



Similar to the larger organisation, the SA coal BU's projects followed the same trend with OPEX and SIB CAPEX overruns destroying approximately 700% of the original NPV. Luckily our organisation experienced better than anticipated commodity prices.

Figure 2: SA Coal BU Project Value Tracking



Note: Life cycle costs refers to all the costs associated with maintaining, operating and decommissioning the implemented asset i.e. OPEX and SIB CAPEX

Questions

How many years' experience have you got in the project development environment and in which projects implemented in the last 10 years were you involved? Briefly state your role in each project.

By looking at the illustrated waterfall diagrams in Figure 1 and Figure 2 as well as from your past project experience do you agree that OPEX and SIB CAPEX overruns is a common problem and therefore a major concern to the organisation? Please give your view on this statement.

Would you say that the cost overruns experienced were mainly attributable to poor cost management during operations or due to the initial estimate / budget being underestimated and unrealistic? Please elaborate.

Based on the same waterfall diagrams, do you think the project would have been approved and implemented if the life cycle cost estimates were done realistically? Explain why.

If in your opinion the life cycle cost estimates were initially underestimated, do you think it was done intentionally to get the project approved or unintentionally? Explain why.

If you feel that the life cycle costs were underestimated unintentionally, would you say it was due to poor estimating techniques, lack in skills and experience of the design team, lack of information or something else? Please elaborate.

What costs or type of costs in your mind, if any, were normally omitted or completely underestimated that had a big impact on the achieved cash flows and the actual project valuations? Please explain.

During project valuations cash flows are forecasted far into the future. In your opinion, was risk and uncertainty sufficiently addressed during the original cost estimates such as the contingency calculated and allowed for through a Monte Carlo Simulation? Please elaborate.

Do you feel more should be done to address risk and uncertainty during cost estimation in the project development stages? Please explain.

It is said that between 70% and 90% of the total life cycle costs become defined and committed already in the project design phase. Value engineering is therefore crucial during the project development stages to optimise the long term costs of the operation through design initiatives. Do you think that future life cycle costs are considered thoroughly enough throughout the project design phases? Please explain.

In your opinion, will value engineering and the monitoring of life cycle costs throughout the project development stages contribute to cost estimates being more accurate at the end of the day? Please explain.

What type of cost estimating techniques was normally used in the past eg benchmarking or factorised estimates based on other projects, zero-based costing or detailed engineering estimates? Please elaborate.

Were any cost verification / benchmarking done after the life cycle costs estimates were compiled? Was this process of assistance? Please explain.

Is there any other recommendations not covered above that could assist the organisation in developing more accurate life cycle cost cash flows to produce accurate business cases and to support decision making?

Appendix B:

Letter from editor

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November 5, 2013

TO WHOM IT MAY CONCERN

Re: Letter of confirmation of language editing

The dissertation **"Evaluating the effect of life cycle cost forecasting accuracy on mining project valuations"** by **S.H. Jansen Van Vuuren** (23270306) was language, technically and typographically edited. The sources and referencing technique applied was checked to comply with the specific Harvard technique as per North-West University prescriptions. Final corrections as suggested remain the responsibility of the student.

Antoinette Bisschoff

Officially approved language editor of the NWU since 1998
Member of SA Translators Institute (no. 100181)