Total cost of crude oil ownership for South African oil refiners

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ABSTRACT

The modern world is dependent upon the continuous production of liquid fuels, most of which are derived from crude oil. South Africa has very limited reserves of crude oil, which means that the five oil refineries located within its borders have to import most of their requirements. Adding this to the fact that fuel prices are regulated in South Africa and that oil refining is a low margin business, it then becomes evident that these companies have to do as much as they can to keep costs low in order to optimise profits.

One of the tools that can assist managers in oil refineries in identifying points of leverage in procuring crude oil, is a total cost of ownership (TCO) analysis. The literature review highlighted that TCO studies, a form of activity based costing (ABC), is more complex than traditional costing methods, which hinders it use and affects its trustworthiness in practice. Furthermore, it was found that there is a trade-off between complexity and accuracy.

The aim of this research was to identify the elements of crude oil TCO for a South African oil refinery and the accuracy and precision thereof. The method of data collection was via semi-structured interviews and archival data retrieval. The aim was firstly to determine how the TCO was calculated in the chosen organisation, and then to use the information from the semi-structured interviews and archives to determine the actual TCO. This was then used to determine the accuracy of the TCO analysis done by the chosen company.

It was found in this study that the accuracy of the indirect cost element of the TCO was only 78% and had a higher standard deviation than the actual costs. The conclusion is that although this level of accuracy compares to other studies done in practice, there is still room to improve the reliability of current crude oil TCO analyses that are carried out in the chosen organisation, simply due to the high value of crude oil. Given that there is a correlation between improvement in ROI and the use of ABC methods, the conclusion is that more accurate TCO studies are important for low margin businesses such as oil refining.

DECLARATION

I, Kiren Bageloo, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Kiren Bageloo

Signed at ……

On the …….. day of …… 2011

DEDICATION

To my wife, Kash, who supported me throughout this enduring period, and who has shown me that patience is truly a virtue. You were my pillar of strength when I needed it and an inspiration during the toughest of times.

AND

To my Parents for making me into what I am today, and for providing me with the ethically and morally sound foundation that I have used to enjoy life.

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To my manager at my place of work, your support and assistance has truly helped me to complete this research, and is sincerely appreciated.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

1.1 Purpose of the study

The purpose of this research is to identify the points of leverage that South African oil refiners have in reducing the total cost of procuring, handling and using crude oil in the manufacture of petroleum products, by looking at the elements, reliability and accuracy of such calculations. The analysis will start from the point that the crude oil is planned for and end at the point where processing of the oil into fuel begins. In doing so, data from a single South African oil refiner was collected and analysed.

The results will give management personnel at oil refineries an indication of the different elements of the total cost of ownership (TCO) of crude oil and their relative value to each other, along with the reliability and accuracy of these elements. Furthermore, this report will assist management in developing the right crude oil procurement strategy by giving them an indication of which areas of crude oil TCO to place the most emphasis on in order to reduce crude oil costs.

1.2 Context of the study

The modern world is dependent upon the continuous production of liquid fuels such as petrol, diesel, jet fuel and other heating fuels, most of which are derived from fossil fuels. Crude oil derived liquid fuels constitute the majority of the fuels produced around the world, and this is the most traded commodity (Smith 2009). This means that almost every country in the world is dependent on crude oil, thus putting the countries that have crude oil reserves in good stead. Additionally, the author points out that the majority of reserves of crude oil are concentrated in the Middle East and North Africa, whereas the United States, Europe, China and Japan account for nearly all of the imports. Thus, it is no surprise that most of the aforementioned countries are among the richest in the world.

South Africa has very limited oil reserves, which is why about 80% of its crude requirements are met by imports from the Middle East and Africa (Vanderschuren, Jobanputra and Lane 2008). The authors have also looked at the growth of fuel demand in South Africa up to 2033, and state that demand for fuel, specifically road transport fuel, will continue to grow during this period. To add to this complexity, South Africa is situated relatively far away from these countries, which increases the overall cost of procurement of crude oil for South African oil refiners.

Oil refining is a low margin business, with margins currently in the $1-10 per barrel range (Pan, Li and Qian 2009; Hardy 2010). Since crude oil is presently around $70 per barrel (Bruce 2010), this creates a situation whereby crude oil refiners are subject to a high variable cost component. Therefore it is likely that if these firms can find ways of achieving any savings on crude oil procurement costs, then this will have a positive impact on their refining margin, and hence profit. Some companies such as Total and BP already have this advantage. Both these companies own crude oil fields (Houser 2008), which means that they are not obliged to purchase all of the crude oil requirements from other companies or from the Middle East. However, there still are many other companies that do not own any crude oil fields and have to purchase all of the required crude oil from the open market.

As can be seen in figure 1 below, there are presently six refineries in South Africa. Davidson, Winkler, Kenny, Prasad, Nkomo and Sparks et al. (2006) estimate the combined refining capacity of these plants to be 676,000 barrels per day of equivalent fuel. Further to this, due to demand being higher than production, the country imports a significant quantity of fuel. It is estimated that around 10 billion litres per annum of fuel imports will be required by 2015 (PetroSA 2010).

Four of the refineries produce fuel from crude oil, with the fifth one being a coal based plant owned by Sasol (Davidson, Winkler, Kenny, Prasad, Nkomo, Sparks et al. 2006). This coal to liquids plant, along with Natref, is the only producer of fuel in the inland region where Johannesburg, the business hub of

South Africa, is located. The remaining refiner produces fuel from gas, and is located along South Africa's southern coast.

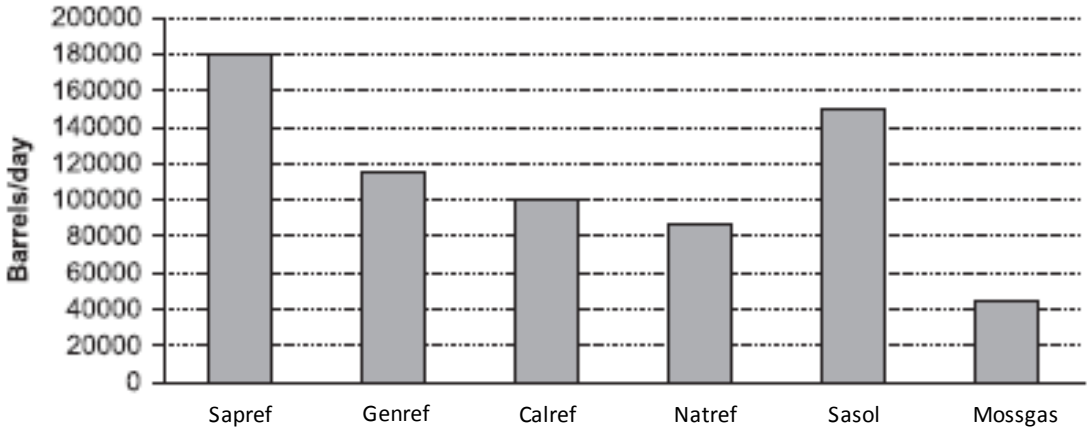

Figure 1: Sizes of South Africa's fuel production facilities

(Davidson et al. 2006: 56)

Fuel prices in South Africa are regulated by the government (DOE 2010). The prices of both petrol and diesel used at the wholesale level are regulated, while at the pump, only the retail price of petrol is regulated. Even though these regulated prices are linked to the international price of crude oil, steady profit margins are not guaranteed, due to crude oil prices fluctuating on a daily basis.

With demand for fuel continually on the increase (Smith 2009), the world is bound to see the construction of more oil refineries to meet this demand. In fact, the South African government, along with PetroSA, is currently evaluating the prospect of building another refinery in South Africa (PetroSA 2010). The government-owned fuel company further states that this refinery will process 400,000 barrels per day of crude oil and will be the largest in Africa. Even though this might be a potential solution to address the underproduction of fuel in South Africa, this new refinery will create a situation where there would be an oversupply of fuel in the country. Hence, there would be a greater need for existing refineries to find ways of cutting costs to be more competitive. One of the tools that can be used in assisting oil refiners in identifying points of leverage in reducing crude oil procurement costs is a Total Cost of Ownership (TCO) analysis.

Ellram and Siferd (1998: 56) define TCO as “a purchasing tool and philosophy aimed at understanding the relevant cost of buying a particular good or service from a particular supplier”. They further make a point of how it is an important tool that can be used to support the company’s strategic management, and that it is a complex tool that involves identifying which costs are most relevant in the acquisition, possession, use and disposition of a good or service. Young and Swan (2006) identify the elements of the landed cost, which is related to a TCO, of imported products to include price, transportation, customs duties, inventory management, administrative overheads and risk. The authors have attempted to develop a six stage model which addresses the elements mentioned above, and allows procurement departments to make informed sourcing decisions. Given this, and the fact that an average manufacturer spends around 56% of sales revenue on managing purchased goods and services (Handfield 2006), it seems that a TCO analysis could possibly be used by South African oil refiners in assisting them to identify opportunities to reduce their TCO of crude oil. An analysis of the TCO of crude oil for a South African oil refiner was, with the intention of using the results to identify points of leverage to reduce a firm’s crude oil TCO.

1.3 Problem statement

1.3.1 *Main problem*

This is to determine the elements of a total cost of ownership calculation done for imported crude oil for a South African oil refiner, and assess the accuracy and precision of it.

1.3.2 *Sub-problems*

The first sub-problem is to determine the elements of the TCO of imported crude oil for a South African oil refiner.

The second sub-problem is to assess the accuracy and precision of a TCO analysis done for imported crude oil for a South African oil refiner.

1.4 Significance of the study

The study fills a gap in that there is currently no research on the use and reliability of TCO analyses on imported crude oil or other imported commodities. Furthermore, there is no research on the aspects of crude oil TCO that South African oil refiners should focus on, in order to optimise their time and money spent on the procurement, handling and use of crude oil.

Unusually high refining margins over the recent past have resulted in oil refiners seeing increased profits (Hardy 2010). This has resulted in inefficiencies in certain parts of the business, such as crude oil procurement, being camouflaged. With the subsequent collapse of the oil price to around $36 per barrel, and a similar drop in refining margins, oil refiners were suddenly forced to find avenues to reduce costs. Hence, this study will provide guidance to managers of oil refineries in South Africa in doing so, by understanding the make-up of the TCO for crude oil that is imported; and also understanding which elements of the TCO, besides the purchase price, require the most attention.

Anyone who is looking at the prospect of building new refineries in South Africa will find this study useful when determining the feasibility of such ventures. In the analysis, all the elements of the TCO of crude oil can be identified and taken into account, thus making a more accurate financial model of the proposed business venture.

1.5 Delimitations of the study

- The data was collected from one South African company only.
- The data was collected for a period when crude oil prices were relatively high compared to the periods prior to that. If crude oil prices had to fall to levels experienced in the period prior to that used, then the recommendations to oil companies might be different.

- The TCO analysis starts at the beginning of the crude oil lifecycle, i.e. the planning phase, and ends at the point of processing. It does not include the processing of crude oil.

1.6 Definition of terms

- Total cost of ownership (TCO) - a purchasing tool and philosophy aimed at understanding the relevant cost of buying a particular good or service from a particular supplier (Ellram and Sieferd 1998).

1.7 Assumptions

- The data obtained from the oil refiner is deemed accurate.

The reason for assuming this is that the data that was collected was read off invoices containing the actual costs. These costs can only be incorrect if these invoices were tampered with, which has a very low probability. If for some reason the data is inaccurate, then the results of this research will not reflect reality and will have a degree of inherent error, in the sense that the results of the actual TCO studies done by the chosen oil company will be either more accurate or less accurate than what is concluded from this study.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

A literature review of the key themes pertaining to this study has been outlined in this section. It starts off by looking at the crude oil literature and its components, viz. price, procurement at refinery operations, transport and storage. The review then follows on to consider the concept of TCO, examining its elements, looking at barriers to implementation and at TCO studies that have already been done. It proceeds to review the concept of activity-based costing, and the accuracy and reliability thereof. It ends with a summary of the key elements learnt from this literature review.

2.2. Background discussion

Modern oil refineries are operationally complex and have four main areas of operation, viz. planning, tanker-lightering operations, sales and scheduling. Crude oil procurement is integrated across several areas of the business, and should be performed efficiently to ensure profitability of the refinery (Julka, Karimi and Srinivasan 2002; Pan et al. 2009). Scheduling at an oil refinery entails decision-making according to the times and sequences of the receiving of the crude oil, and itself is important to the running of the refinery business.

Many organisations have looked into applying the TCO concept in their procurement departments or to include it in their strategies (Ellram 1995; Ellram and Sieferd 1998; Ellram 2006; Song, Platts and Bance 2007). An average manufacturer spends 56% of its revenue on managing the purchase of goods or services (Handfield 2006). Thus, companies stand to gain a lot by placing more focus on procurement activities. Also, given the importance of crude oil procurement to oil refineries, a TCO approach might be a good way of further optimising this process.

This literature review will focus on the crude oil procurement process at oil refineries and the TCO concept, TCO analyses of products that are available in literature, along with the reliability of activity-based costing methods.

2.3. Crude Oil and Total Cost of Ownership

2.3.1 *Crude Oil*

In this section, the focus will be on the following aspects of crude oil:

- Procurement at Oil Refineries
- Price
- Transportation and Storage

There has been some documentation in literature on these aspects. In addition, the price and transportation form part of the TCO of crude oil, and it is anticipated that these two aspects will be the major contributors to the TCO, and will be reviewed in the sections that follow.

Procurement at Oil Refineries

Crude oil procurement is one of the many tasks that are involved in running a crude oil refinery. The other significant tasks include logistics, scheduling, refining and final product blending, all of which can be further broken down into many other sub-tasks (Julka et al. 2002; Guyonnet, Grant and Bagajewicz 2009; Pan et al. 2009). Furthermore, Pan et al. (2009) allude to the fact that modern refineries are operationally complex and low margin, while operating in a highly competitive industry. This makes the procurement of crude oil particularly important in ensuring that these refineries obtain good profit margins. This is further substantiated by Julka et al (2002), who state that efficient and optimal crude procurement is essential in the profitability of the refinery.

Further to this, the crude oil procurement department needs to be integrated with the other departments in the refinery supply chain to achieve a competitive

advantage in today's business environment (Julka et al. 2002). Kaufmann, Dees and Mann (2009) also talk about the oil industry supply chain. They believe that aspects of oil refining, viz. crude oil price, inventory levels and utilisation rates, are influenced by changes in the energy supply chain that are transmitted horizontally and vertically. Horizontal changes are generated by fuels at a similar stage in processing, e.g. crudes of different grades, while vertical changes are along the supply chain of a particular business, e.g. the price of crude oil being influenced by refining margins or the price of the final product.

The first aspect of procurement, and not just for crude oil, but for any commodity, is the selection of the grade to be used (Karmarkar and Rajaram 2001; Julka et al. 2002). Ultimately, the grade is selected to meet product demand. However, there are normally several choices available in doing so. Some of the decisions that are encountered include selecting the grades to be used, determining the quantity of each grade and how to blend them. According to Julka et al (2002), this is normally done periodically at fixed or variable intervals, which are typically four to five days in length. The crude is also purchased 30 to 45 days in advance, which is known as the lead time. However, this is dependent on the source of the crude oil and its relative location to the refinery. For example, it will take a longer time for crude oil to be delivered from Saudi Arabia to Germany, than to South Africa.

Price

The crude oil price has been well researched recently, especially after it spiked to over $140 per barrel in 2008 (Dees, Karadeloglou, Kaufmann and Sanchez 2007; Persson, Azar, Johansson and Lindgren 2007; Borenstein 2008). While the exchange rate and speculation might possibly be two of the causes of the oil price spike, Borenstein (2008) believes that the main reason for this is a simple one, namely that demand for oil is much greater than supply. He attributes some of the contributors to this growing demand as coming from the major developing countries, viz. China, India and others. As more people from these countries earn more money, more of them can afford automobiles, thus increasing the demand for fuel.

To add to this, supply of oil has not increased as fast as demand. It seems that certain dominant suppliers, such as Saudi Arabia, are hesitant to increase supply into the market to meet the extra demand. In fact, they have decreased supply recently. Furthermore, mismanaged oil fields, domestic conflicts and well depletions have added to the problem of too little supply (Borenstein 2008).

Dees et al (2007) does not concur with Borenstein (2008) on the main reason for the price increases. The authors allude to the fact that production of oil increased significantly between World War II and the 1970s despite a decline in the oil price, and in the 1980s when the oil price increased, production declined. They attribute these contradictions to factors such as resource depletion, technical change, economic incentives and political considerations. They do, however, agree that the OPEC countries are the dominant suppliers and can influence the oil price, and that the price is relatively volatile. These factors make it difficult to model. Even so, they did attempt to model the oil price, and found that for non-OPEC production, oil demand and oil supply is quite inelastic over the medium term, i.e. 3 to 5 years.

Persson et al (2007) have also attempted to model the oil price. They go one step further than Dees et al (2007) by including the effect of the production and supply of fuel from tar-sands, coal, hydrogen fuel cells, and also the impact of carbon taxes. As can be seen in Figure 2, oil is expected to be almost depleted by 2050, with coal, oil shale and nuclear becoming the dominant sources of energy. The assumption is that the current proven reserves of crude oil amount to 6300 EJ. The results indicate that a carbon tax will result in increased revenue for oil producers, while competing technologies such as hydrogen fuel cells will result in a drop in the oil price.

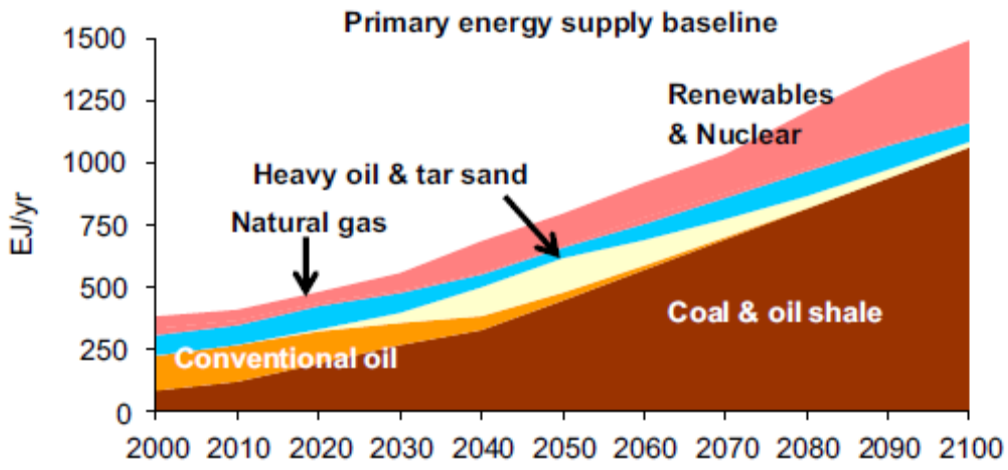

Figure 2: Assumptions of Persson et al (2007) oil price model

According to Borenstein (2008), the exchange rate is another factor that affects the price of crude oil. Thus, the strength of the US dollar affects the world supply/demand balance of crude oil. For example, a purchaser from a country that has a currency that is appreciating against the US dollar will have a relatively lower price of crude oil, which then increases the demand for oil in that country.

Borenstein (2008) also addresses the issue of the role of speculation in the oil market. There have been some commentators who blame speculators for driving up the oil price by purchasing long-term oil futures as part of a hedging strategy. These long-term futures are pulling spot prices through an intertemporal arbitrage. Borenstein (2008) disagrees with this theory, stating simply that the high oil prices were matched by real physical demand in the market. There would not have been sufficient customers in the market if the oil price were artificially high.

Transportation and Storage

Once the crude oil is purchased, it then has to be transported to the refinery, unloaded and stored before being processed. The transportation is usually done with very large crude carriers (VLCCs) which carry several parcels of different crudes, which could be for different customers (Pan et al. 2009). The decision-making process used to determine the times and sequence of the unloading

and storage of crude from several different VLCCs is referred to as crude oil scheduling. Crude oil scheduling is another important aspect of the oil refining business, and is dependent on a number of factors, such as the lead time of crude delivery, the number of storage tanks, their capacities, the number of VLCCs that can be unloaded at any time, inventory levels and the processing rates of the refinery (Julka et al. 2002; Pan et al. 2009).

According to Pan et al. (2009), the primary objective of crude oil scheduling is to maximise the total gross profit of the refinery, which is the netback from crude oil minus operating costs. One of the key operating costs is demurrage, which is incurred if the time taken by a VLCC is longer than the time stipulated in the contract between the two parties involved.

Julka et al. (2002) have developed a model that can be used for crude scheduling. This model was then used on three illustrative case studies:

Impact of Procurement Policy:

This study analysed the effect of choosing fixed crude parcel sizes over variable sizes. The result of the simulation indicated that the variable parcel size policy reduced the throughput and inventory of the refinery by 6%. However, it failed to provide enough crude oil to run the plant at maximum throughput.

Effect of Demand Fluctuation:

The results of this study indicated that volatile demand requires the purchase of larger parcel sizes. In order to accommodate these larger parcel sizes, sufficient storage capacity is required. All of these must be taken into account by the scheduler.

Benefit of Extra Storage:

The results of this study indicated that extra storage capacity can be used to accommodate the larger parcel sizes required to meet volatile demand. However, an economic analysis of the trade-off between additional capacity and increased sales must be done to validate the capital spend that is required for this extra capacity.

The nature of the transport business ensures that the heaviest goods travel via ocean, as opposed to air (Hummels 2007). Air transport is much faster than ocean and thus dictates a much higher price. Goods can be delivered as quickly as one day, while delivery by ocean takes weeks, depending on the relative locations of the source and destination. To add to this, time does not matter much for bulk commodities which have long shelf lives and are simple to manufacture (crude oil being one of them). These are the reasons why ocean shipping constitutes 99% of world trade by weight.

Hummels (2007) also points out that the value of the product relative to its weight (value/weight ratio) determines which mode of transport should be used. For example, shipping cost could be 25% of the cost of wine, while this ratio could be as low as 1% for electronic products, even though one needs to take out higher insurance policies for the electronic products. In fact, it is estimated that a 10% increase in the product price results in an 8.6% decrease in the ad-valorem transport cost (Hummels and Skiba 2004).

Another interesting point to note is that, after taking US gross domestic product (GDP) and price inflation into account, shipping cost per unit of mass of bulk commodities has been steadily declining since the 1950s (Hummels 2007). This can be attributed to changes in technology, larger and faster vessels, and the increase in loading and unloading times over the years. However, note that these findings are for commodities in general, and there is no mention of the shipping of crude oil specifically.

2.3.2 *Total Cost of Ownership*

TCO, which is a relatively new topic in the business world, has had some research done on it, and is slowly gaining momentum in terms of usage by corporate entities (Ellram 1995; Hurkens and Wynstra 2006; Song et al. 2007; Janhonen 2008). In general, when making purchasing decisions, managers weigh different alternatives based on certain criteria. In the most basic case, the only criterion is the price of the product in question (Hurkens and Wynstra 2006). In most cases, the company stands to benefit if all costs are taken into account with a tool like TCO, when making purchasing decisions.

Ellram (1995) expands on this by emphasising that the TCO concept is a complex approach, which entails the consideration of the most significant or important cost elements in the acquisition, possession, use and subsequent disposition of the goods in question.

Degraeve et al. (2005), Wouter et al. (2005) and Janhonen (2008) also give a similar view on the concept of TCO and go even further by classifying it as a concept of activity based costing (ABC).

Elements of TCO

The price of a product or service is in most cases the biggest element by value. The elements other than price may include elements such as order placement, research and qualification of suppliers, transportation, receiving, inspection, rejection, replacement, downtime caused by failure, supplier management, disposal costs, and so on (Ellram 1995; Song et al. 2007). The elements are not necessarily the same for different products or services, and have to be determined through proper investigation.

Janhonen (2008) has a similar view, and has broken up the TCO costs elements into three categories, viz. acquisition, ownership and post-ownership costs. The elements of each category have been broken down further:

- Acquisition Costs:
    - Purchase Price
    - Planning Costs
    - Quality Costs
    - Taxes
    - Financing Costs

- Ownership Costs:
    - Downtime costs
    - Risk costs
    - Cycle time costs
    - Non-value add costs
    - Supply chain or supply network costs

- Post-ownership Costs:
    - Salvage value or disposal costs
    - Environmental costs
    - Product liability costs
    - Customer dissatisfaction costs

An aspect that was not analysed in this review has to do with the elements of TCOs that cannot be quantified. One needs to determine how to deal with these elements in the TCO analysis. For example, in most cases the reputation of the supplier is an important criterion. This needs to be quantified and included in the TCO when deciding on which supplier to choose. However, it must be noted that there was mention that aspects such as flexibility and customisation are difficult to include in TCO analyses (Kumara, Anderssonb and Rehmec 2010).

Another aspect that was not identified in this review has to do with departmentalisation of organisations. One will find that the different elements of the TCO of a particular product could lie across several departments, and each department only looks at the elements that are relevant to that department. For example, in importing wheat from Europe, the TCO will include the following elements: (i) price, (ii) transport, and (iii) storage, all of which lie in different departments.

Application of TCO Analyses

TCO analyses are used for several different reasons by corporates in business today. However, there are three primary reasons for its use, as follows (Ellram 1995):

i. Supplier selection: This merely entails choosing the supplier for the right reasons.
ii. Supplier performance measurement: This relates to maintaining a relationship with a supplier over time and assistance with identification of improvement opportunities. Supplier management and supplier selection normally go hand in hand, and are the primary driving forces behind TCO adoption.

iii. Driving major process changes: When a company plans to undergo major changes, for whatever reasons, TCO can be used to determine the best way forward.

Other reasons for using TCO include the following: (i) to provide data for negotiations; (ii) to concentrate resources on the important purchases; (iii) supply base reduction/volume allocation decisions; (iv) to improve organisations' decision making; and (v) to reduce costs / cost management (Ellram 1995; Degraeve, Labro and Roodhooft 2005; Ellram 2006).

	Organization											
Reason	A	B	C	D	E	F	G	H	I	J	K	% indicating
High dollar value		X	X	X	X	X	X			X	X	73%
Ongoing, repetitive buys	X	X			X	X	X	X				55%
Important to other decisions				X						X		18%
Outsourcing potential									X	X		18%
Difficult to manage	X											9%

Categorized above based on:

Firm	Characteristics of Purchases Analyzed
A	bottleneck items, repetitive, high risk
B	$100,000 and above, ongoing
C	major purchases—all sector-level decisions, beyond that it is at the discretion of the commodity team
D	major productive capital expenditures; can also vary other input costs/yield like raw materials, supplies—see effect of differential performance over equipment life
E	all production inputs—up to teams if they actually want to use
F	commodity purchases, significant expenditures
G	repetitive, long-term buys
H	routine, repetitive purchases with a history
I	high level decision, "cost take-out opportunity" on processes
J	major purchases with a process focus, may consider many costs simultaneously
K	up to team; big dollar items, cost-benefit consideration

Table 1: General characteristics of buys considered for TCO analyses

(Ellram and Sieferd 1998)

Essentially, TCO is potentially an instrument for management of purchases, at whatever level it may be. However, in applying it in practice, one must

analyse the elements that have the largest influence on the total cost, and focus on these elements (Wouters 2008). Ellram and Siferd (1998) concur with this statement, and indicate that the best approach to TCO application is to focus on the relatively important purchases. A purchase can be important for any of the following reasons: (i) high monetary value, (ii) repetitive buy, (iii) important to other decisions, (iv) difficult to manage, or (v) possibility of outsourcing. Their study revealed that 73% of the respondents saw “high monetary value” as the most important criterion to use, as can be seen in Table 1.

Landed Costs

The Landed Cost concept is related to that of TCO. In fact, the Landed Cost is actually a part of the TCO, which consists of the following elements with regard to the importation of a particular product from another country: (i) price, (ii) transportation, (iii) customs duty, (iv) storage costs, and (v) administrative overhead costs (Young, CPM and Swan 2006; Young, Swan, Thomchick and Ruamsook 2009).

TCO Analyses

The literature does not offer many TCO analyses. There is one study that examined the TCO of cartridge and bag filters (Buehner 2009). The study found that when change-out and disposal costs were added to the cost of the filter, the cost more than quadrupled. The elements of the TCO included filter cost per annum (taking into account the number of times the filter has to be changed), labour cost, disposal cost and depreciation. The result was that the filter cost (string wound filter) was $20 160 per annum and the TCO was $35 600 per annum, which equates to 56.6% of TCO.

Ellram (1995) gives an example of a TCO of an electronic component that is imported from overseas. The free on board (FOB) price is $12 000 for 950 units. The following cost elements were then added to the FOB price: delivery, inspection, re-work of finished goods, engineering consulting and delivery delays, which took the TCO up to $14 554. Hence, the price is 82.5% of the TCO.

Another study was done on resistors, transformers and printed circuit boards (PCB) that were purchased by a European telecommunications company (Degraeve et al. 2005). Figure 3 below shows the activities in the value chain that are relevant to these products. The results of this study showed that the price element was between 92% and 98% of the TCO. The author found that the procurement policy at the time increased the TCO by ordering the same product from different suppliers, instead of making optimal use of quantity discounts.

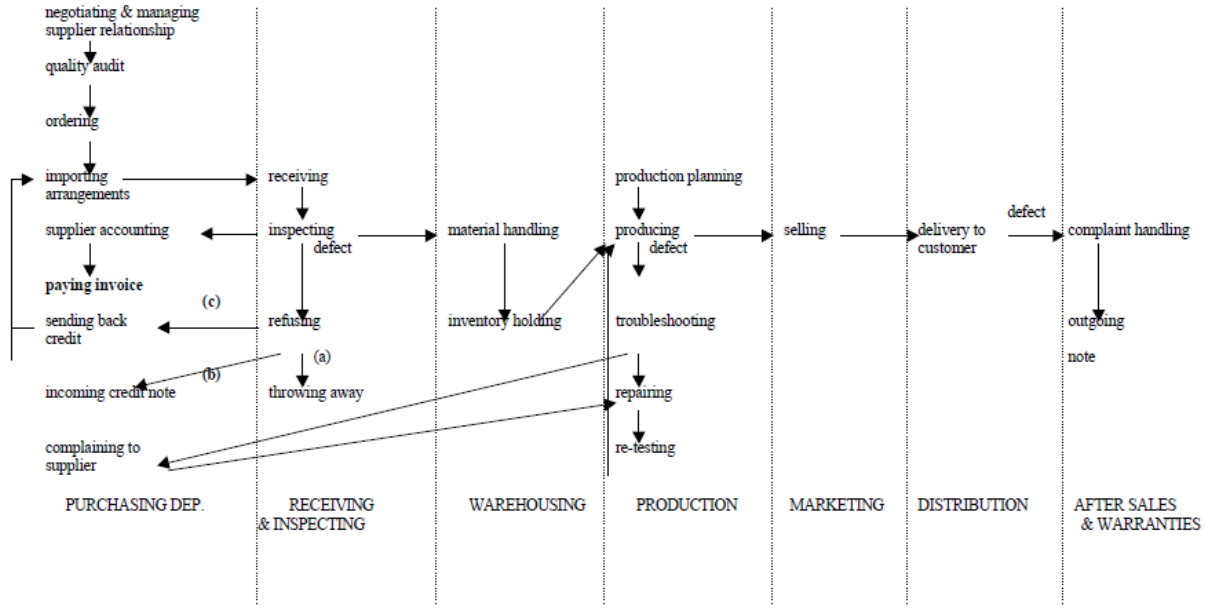

Figure 3: The value chain relevant to transistors, transformers and PCBs

(Degraeve et al. 2005)

2.3.3 *Research Proposition 1*

The elements of a TCO of crude oil purchased by a South African oil refinery will include the following: price, transportation, customs duty, storage costs, and administrative overhead costs.

2.4 Activity Based Costing

Since the TCO method is a concept of ABC (Degraeve et al. 2005), the advantages and reliability of ABC will be analysed in this section, with the assumption that this will be applicable to TCO methods.

The ABC concept, along with its advantages, have been extensively researched (Cagwin and Bouwman 2002; Stapleton, Pati, Beach and Julmanichoti 2004; Baykasoglu and Kaplanoglu 2008; Vazakidis, Karagiannis and Tsialta 2010). ABC has been defined as a costing method which takes into account all the activities and functions involved in a company, and allows accountants to assign overhead costs to a particular product or service (Vazakidis et al. 2010). These activities that are assigned, are generally referred to as the cost drivers, and understanding them can lead to a greater knowledge of the firm's business processes and underlying expenses (Stapleton et al. 2004). Another way of describing ABC is that it provides detailed cost information regarding the reasons for cost creation, which can be used for further analysis and proper decision making (Vazakidis et al. 2010).

2.4.1 *Advantages of ABC*

In comparing ABC to traditional costing systems, Stapleton et al. (2004) believe that ABC provides a good understanding of where resources are being spent, customer value is being created, and exactly where the money is being either made or lost, and is an alternative to labour-cost-based product costing. ABC can be used to identify and reduce activities that are non-value add to the business. The authors believe that ABC has assisted many companies around the world to improve the efficiency and effectiveness of their operations.

Furthermore, there is a positive association between improvement in ROI and ABC which is implemented in complex and diverse firms, where costs are relatively important (Cagwin and Bouwman 2002). Further to this, the authors found through their studies that positive synergies are realised from concurrent use of ABC and other methods.

2.4.2 *Accuracy and Precision of ABC*

Although ABC has many advantages, there are some aspects of it, or the application of it, that could possibly affect reliability. Stapleton et al. (2004) believe one of these obstacles to be that the output of ABC is more difficult to define. Furthermore, it is not always easy to define the cost drivers and activities. Also, data collection is more complicated and rigorous than traditional costing methods, which adds to the overall cost of implementing ABC. Overall, ABC can be a labour intensive exercise for a firm, with benefits of these efforts not always being realised.

ABC models tend to be too complex in general, which can affect the accuracy and trustworthiness of the results by managers, which is a major issue in implementing these systems (Homburg 2001; Barrett 2004). Even though there are some companies that offer software that can make the task of performing ABC easier by manipulating large amounts of data with ease, there is still a trade-off between complexity and accuracy. Barrett (2004) believes that ABC can never be completely accurate, and has reported results of a study which shows the relationship between complexity and accuracy in ABC, which can be found in 4. The figure shows that it takes a lot more effort to get the accuracy of ABC from 80% to around 97%, than it takes to get to 80% in the first place. However, Baykasoglu and Kaplanoglu (2008) are of the opinion that the accuracy of ABC can vary depending on its focus. The focus could be on the product or customer, or a combination of both.

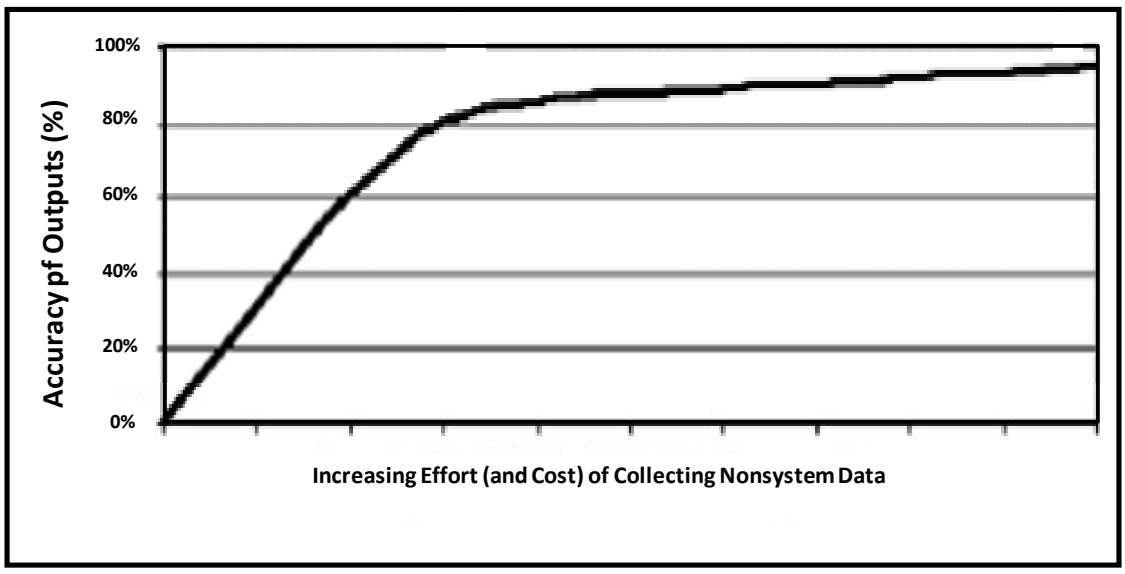

Figure 4: The relationship between complexity and accuracy in ABC

(Barrett 2004)

An aspect of ABC that could possibly contribute towards inaccuracy and precision is the fact that a lot of data has to be estimated (Neely, Gregory and Platts 2005). However, the authors do not stipulate to what degree the accuracy and precision is affected in practice. They do indicate, though, that ABC is more accurate than traditional costing methods. Other authors in this field concur with this, indicating that managers at all levels tend to perceive ABC data as more accurate than the data obtained from traditional costing methods (Geri and Ronen 2005). However, they do admit that ABC has its weaknesses. Firstly, ABC is based on arbitrary cost allocations that are subjective. ABC creates a more complex costing system, which is not necessarily more accurate or useful. Another notable weakness is that ABC does not deal with excess capacity, and regards the relation between activities and resource consumption to be linear. If production increases, this does not necessarily mean that there will be a linear decrease in the cost of production per item.

Even though the selection of the correct cost drivers seems to be a challenge for firms that implement ABC (Baykasoglu and Kaplanoglu 2008), an ABC model of low complexity, which has a relatively small number of cost drivers, is both cheaper to implement and easier for management to understand

(Merchant and Shields 1993). Homburg (2001) developed a model to support cost driver selection, which entails replacing a cost driver with a combination of the drivers selected already, thus reducing the overall number of drivers.

ABC generally assumes that the overhead costs are proportional (variable) to the cost pool's measure of activity. However, it was found that this is not necessarily the case (Noreen and Soderstrom 1997). The authors' study found that there are very little variable costs in overhead accounts in hospitals. A model that assumes that overhead costs are fixed and cannot be proportioned is generally more accurate. In their results, the proportional cost model, i.e. ABC, overstated the change in cost from one period to the next by 130%. The only question that remains is whether this would apply to other industries as well. Also, it is important to note that in cases with a low percentage of costs that are not proportional, the accuracy of ABC would be better, and the findings of Noreen and Soderstrom (1997) would probably not apply.

In analysing overhead costs, it was found that there is no relationship between overhead costs and activity in hospitals (Noreen and Soderstrom 1994). Hence, to increase the accuracy of overhead costing in ABC applications, one needs to identify as many cost drivers as possible. However, one must note that for any ABC analysis, the relative cost of each cost element to the total cost will determine the importance of the accuracy of that element (Gunasekaran, Marri and Yusuf 1999). The higher the proportion of that element, the larger the distortion would be. Therefore, this must be taken into account when deciding on the accuracy to apply in practice. Combine this with the notion that most managers resist the implementation of ABC, it is important that one gets the trade-off between accuracy and complexity when implementing ABC.

With respect to TCO analyses in particular, which is a form of ABC, the biggest barrier to successful implementation in organisations is that it is viewed merely as a philosophy as opposed to a tool. Other significant barriers include the following (Ellram and Sieferd 1998):

- Time consuming to develop – big initial investment requirement
- Difficult to understand the TCO concept

- Lack of expertise
- The business is constantly changing
- “Price” mentality is engrained in the in the culture of the organisation

A common aspect of ABC in business is that of inventory holding costs. The quantification of these costs and the accuracy thereof are considered to be critical to the running of most businesses (Holsenback and McGill 2007). The following factors should be taken into account when determining inventory holding costs: average inventory period, opportunity cost of working capital, and fixed overhead costs. When proportioning the overhead costs, it can be based on average inventory levels. Other factors that affect the allocation of inventory costs are the relative volume, the type of storage and the method of collecting the products in question (Goldsby and Closs 2000). In practice, the use of capacity is not always accurately recorded as production capacity, which is what is desired for ABC (Pirttilä and Hautaniemi 1995).

Another common aspect of ABC in all businesses is that of personnel costs. In ABC resources are proportioned based on how it is consumed or time spent on each activity (Raz and Elnathan 1999; Major and Hopper 2005). For personnel, since they are paid based on hours worked, one simply looks at the time spent on each activity. The more resources one allocates to activities, the more accurate is the cost. However, all of the allocations are estimates. Hence it is probably better to focus on the personnel that form a greater part of the total cost.

2.4.3 *Research Proposition 2*

For the TCO analysis done for imported crude oil for a South African oil refinery, the indirect cost portion will have an accuracy of around 80%.

2.5 Conclusion of Literature Review

The literature reveals that crude oil procurement and scheduling thereof are key activities in oil refineries and require optimal performance of these tasks to ensure profitability of the business. Furthermore, integration of these activities

within the rest of the business will give firms a competitive advantage. The crude oil price, which is important to oil refiners, is influenced by many factors and is difficult to model, even though it is driven mainly by the balance of demand and supply. Crude oil is procured either in fixed or variable parcel sizes, and is transported to the refinery on a VLCC. The strategy on parcel size and timing of the purchases is important to the business.

The TCO concept is being used more frequently by corporates, and is mainly used for supplier selection, supplier performance management and to drive major changes in a business. The price is the biggest element of the TCO of most goods and services. Studies reviewed for this report indicate a price component of between 56% and 98% of the TCO. The TCO takes into account all possible costs, and includes elements from pre-acquisition to post-acquisition.

ABC is a cost accounting methodology that has many advantages, which include having a positive association with the ROI of a company. However, the main challenges lie with identifying cost drivers and the trade-off between complexity and accuracy. ABC studies cannot be 100% accurate and are not easily trusted by managers when they are too complex.

2.5.1 *Research Proposition 1*

The elements of a TCO of crude oil purchased by a South African oil refinery will include the following: price, transportation, customs duty, storage costs, and administrative overhead costs.

2.5.2 *Research Proposition 2*

For the TCO analysis done for imported crude oil for a South African oil refinery, the indirect cost portion will have an accuracy of around 80%.

CHAPTER 3: RESEARCH METHODOLOGY

This section describes the methodology that was used to conduct the research. First, the preferred paradigm, method and literature thereof will be discussed; this will be followed by the design, population and sampling methodologies that were used. There will then be a discussion and analysis of the method of data collection, and the analysis thereof. This section will end with literature around validity and reliability.

3.1 Research methodology /paradigm

A quantitative methodology was used in this study to attempt to test the proposed research propositions. A quantitative methodological approach is one in which the investigator uses mainly postpositivist claims for developing knowledge, employs strategies of inquiry such as experiments and surveys, and collects data on predetermined instruments, out of which one gets statistical data (Creswell 2003).

Given that the data that was collected was ratio numeric data from archives, and only involved semi-structured interviews, a quantitative methodology is the appropriate one to use.

The data was collected from archives in the chosen company's storage facilities. The archives contain folders with data (invoices and other documentation) in respect of each parcel of crude oil that was procured since March 2006. The files did not contain all the relevant data, as certain invoices were missing. These missing documents were traced by contacting the suppliers of the service in question.

3.2 Research Design

The approach used for this study was a simple integrative approach (Dixon-Woods, Agarwal, Jones, Young and Sutton 2005). Although not exclusively, this method, as opposed to an interpretive method, is the preferred way of

synthesising quantitative data. Two methods of data collection were used in this research. First, the archival method (Yin 2006) of retrieving the data was used to gather readily available data from the chosen company. The data comprised the different elements of the crude oil TCO. This method entails performing secondary analysis on data that already exist, which can be obtained from academic, private or government archives (Whitten, Johannessen, Soerensen, Gammon and Mackert 2007). Secondly, chosen respondents from various departments were interviewed to determine the allocation of personnel costs to crude oil procurement, and the current method of applying TCO to crude oil. The interview was in a semi-structured form. An interview is a series of either open-ended or closed-ended questions that are used to obtain information from respondents (Kalof, Dan and Dietz 2008). Interview techniques can take the form of mail, telephone or in-person interviews. In this case, the interviews were either telephonic or in-person, depending on the location of the respondent.

Once all the data were collected, the first research proposition was addressed by quantifying the different elements of the crude oil TCO based on current methods used in the chosen company. The elements of the TCO were then graphically represented to indicate the make-up of indirect costs, and the location of the elements in the value chain.

To address Research Proposition two, a more accurate TCO was determined, based on methods from literature, and which were then compared to the TCO obtained in addressing research proposition one.

The main disadvantage is the concern of confidentiality. The data was disguised when being published in this report. It is assumed that this did not affect the validity of the results that were reported.

Another disadvantage was that some key pieces of information were not available from the archives, due to it not being stored in the first place, and may probably be lost.

3.3 Population and sample

3.3.1 *Population*

The population comprises the crude oil purchases that were made by a single crude oil refinery in South Africa, which will not be named for purposes of confidentiality. The population consists of parcels purchased both on the spot market and on term contracts.

3.3.2 *Sample and sampling method*

Convenience samples are data or information easily gathered by the researcher, and is also referred to as subjective sampling (Anderson 2001). This method of sampling was used to collect data for this study. The reason for this is that information about crude oil purchases is scarce. Also, the frequency of crude oil purchases is relatively low. Thus, it would take a long time to try to gather data that is not in the archives of the chosen company.

Data was collected in reverse chronological order, going back to March 2006. In conducting the interviews, the following people were approached:

- the cost accountant or person responsible for calculating the TCO of crude oil;
- the manager in charge of procuring crude oil; and
- the other personnel that spend a lot of time in crude oil procurement or the activities related to it.

3.4 The research instrument

The instrument here was existing data (archival) and semi-structured interviews. The data obtained was analysed descriptively, and from h conclusions were drawn. The questions used for the interviews were chosen from the list provided in appendix A, and will depend on the role of the person being interviewed.

3.5 Procedure for data collection

A single oil refinery in South Africa was chosen. The relevant person in the crude oil department was approached for archival data on crude oil procurement. The data was then retrieved from the company's archives and recorded into a spreadsheet for further analysis. Next, the relevant people were identified and interviewed.

3.6 Data analysis and interpretation

The data analysis techniques that were used in this analysis were those of descriptive statistics. Data analysis involves the preparation, analysis and interpretation of a collected set of data (Creswell 2003). Put another way, descriptive statistics entails summarising data either with tables, graphs or other means (Steyn, Smit, Du Toit and Strasheim 1994).

3.7 Limitations of the study

The first limitation of this study is that it was based on data that was obtained from a single organisation. Given that the crude oil market and procurement thereof is relatively old, it can be assumed that the results are representative of the industry in South Africa and are applicable to crude oil procurement managers in any other oil refinery in South Africa.

3.8 Validity and reliability

Validation is concerned with ensuring that the results of your research, or the evidence at hand, and your conclusions, capture the ideas contained in the concepts in literature (Adcock and Collier 2002; Kalof et al. 2008). Another way of explaining validity is by asking the following question: Does the conducted research measure what it was supposed to measure, and how truthful are the results? (Bollen 1989). There are usually two aspects of validity: external and internal validity.

3.8.1 *External validity*

External validity has to do with the generalisability of a study to a larger population (Kalof et al. 2008). The fact that only one company was used to collect data for this research makes this difficult to achieve. However, to cover this, data was collected spanning a relatively long time period of over two years.

3.8.2 *Internal validity*

Internal validity has to do with whether appropriate conclusions are being drawn from the research (Kalof et al. 2008). To attempt to ensure internal validity, the data that was obtained from the chosen oil refinery was read off original invoices, as far as possible.

3.8.3 *Reliability*

Reliability has to do with consistency. For findings of a study to be reliable, similar findings need to be discovered in repeated applications of the study (Kalof et al. 2008). Ensuring validity alone is not good enough, since unreliable results could still be valid (Adcock and Collier 2002).

The reliability of this study was ensured by the collection of accurate and up to date data retrieved from original documents stored in the archives of the chosen oil refinery.

CHAPTER 4: PRESENTATION OF RESULTS

4.1 Introduction

The results of this study are presented in this chapter by the use of descriptive statistics entailing time series graphs, calculation of means, standard deviations and correlation coefficients. It is presented per sub problem, and is categorised by the elements of the TCO of crude oil.

Please note that all data displayed in this report has been disguised to protect the company involved. The data can in no way be used to determine the actual cost of crude oil. However, it is assumed that the interpretation of this disguised data and results will still be relevant.

4.2 Demographic profile of respondents

Most of the data needed for this study was obtained from the archives of the chosen company. However, there were several instances where the data could not be found in any of the archives due to it either not being filed there or being misplaced. The missing data was in the form invoices. These invoices were then requested from the respective companies that issued them initially. Although this did create a delay in gathering all the missing information, all the required invoices were finally obtained.

Respondents to the semi-structured interview were from many different groups in the company. A total of 17 people were interviewed to determine the allocation of personnel costs to the TCO of crude oil. It was deemed that the contribution of the personnel in other administrative functions such as human resources and legal were insignificant, and they were not interviewed.

4.3 Results pertaining to Research Proposition 1

4.3.1 *TCO Elements*

The following elements have been identified as comprising the TCO of crude oil:

- Crude oil price: This is the price paid for the crude oil, to be picked up from the port stipulated by the supplier. This port is usually the one closest to the supplier, and is referred to as the load port.

- Freight: This is the cost of transporting the crude oil from the supplier's port to the port closest to the oil refinery, and is referred to as the discharge port.

- Demurrage: This is the cost that can be incurred if the vessel transporting the crude oil arrives later than the contractual date at the discharge port.

- Storage: Once the vessel arrives at the discharge port, the crude oil is then discharged into storage tanks. A cost is then incurred for storage of the crude oil until it is transported to the refinery.

- Transport: This is the cost incurred as a result of transporting the crude oil from the storage tanks at the discharge port to the oil refinery.

- Clearing costs: During discharge of the crude oil into the storage tanks at the discharge port, a company is appointed to supervise the discharge of the crude oil.

- Surveyors Cost: At the load and discharges ports, a company is appointed to ensure the proper loading and discharging of the crude oil onto and from the vessel respectively.

- Cargo Dues: This the amount charged by the government for importing crude oil into the country.

- Insurance cost: The cost of insuring the crude oil while in transit from the load port to discharge port.
- Inventory Holding Cost: This is the opportunity cost of holding crude oil in the storage tanks both at the discharge port and at the refinery. It was assumed the sum of the cash equivalent to the value of the crude oil could have earned returns if invested elsewhere.
- Personnel: This is the cost of labour that specifically works on crude oil procurement and any related activities.

As can be seen in **Figure 5** below, the crude oil price is 94% of the TCO. Of the other 6% of the costs, and as can be seen in **Figure 6**, freight, transport and inventory holding costs are the biggest contributors.

The mean TCO was R431 487 152 per month, with a standard deviation of R177 179 259.

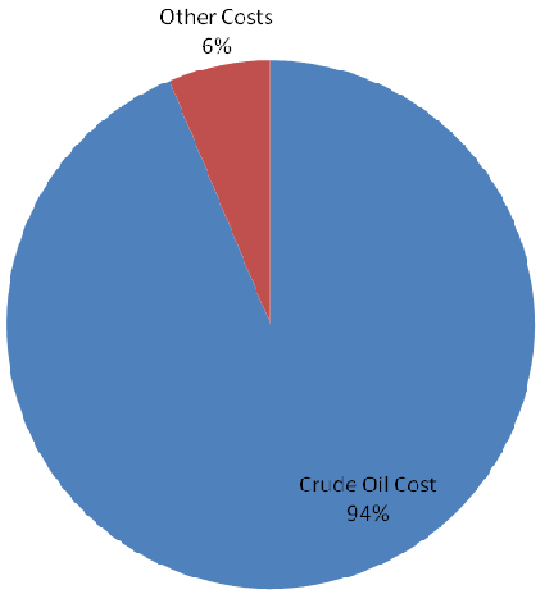

Figure 5: Make up of the Crude Oil TCO

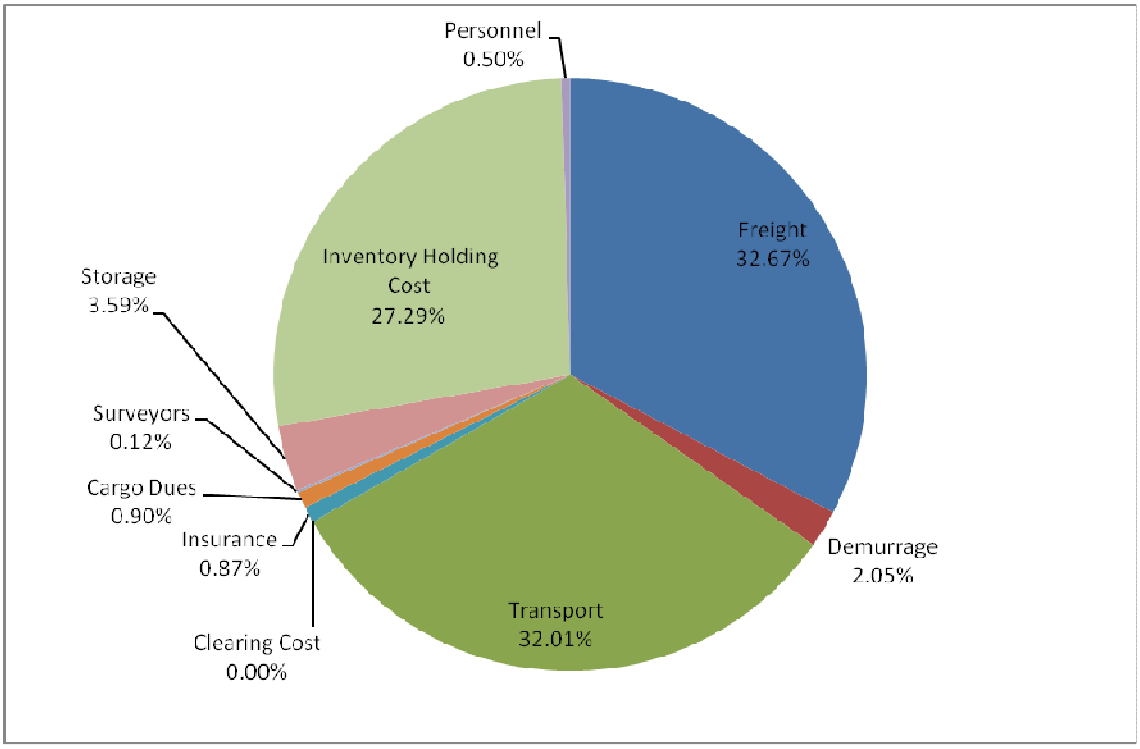

Figure 6: The elements of the crude oil TCO other than the crude oil price

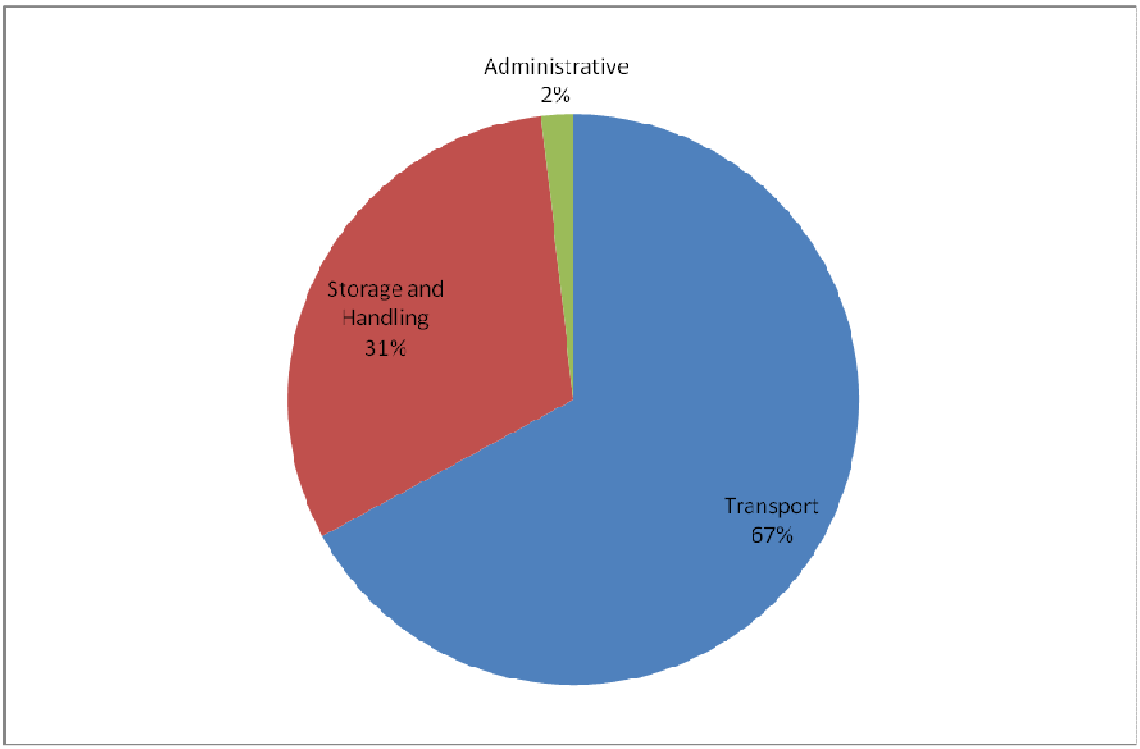

Figure 7: Categorisation of costs other than crude oil price

Table 2: Statistical Analysis of the TCO and its elements

TCO Element	Mean	Standard Deviation	Maximum	Minimum
Crude Oil Cost	R 404,575,499	R 167,115,734	R 921,186,565	R 178,516,939
Freight	R 8,793,079	R 5,522,738	R 25,322,014	R 1,637,454
Demurrage	R 552,278	R 1,285,806	R 5,515,158	R -
Transport	R 8,613,167	R 2,690,755	R 13,463,382	R 3,778,987
Clearing Cost	R 1,166	R 384	R 1,746	R 582
Insurance	R 234,782	R 116,356	R 545,050	R 96,268
Cargo Dues	R 241,263	R 90,385	R 407,530	R 46,722
Surveyors	R 33,046	R 34,050	R 174,106	R 2,392
Storage	R 965,169	R 344,739	R 1,653,389	R 345,029
Inventory Holding Cost	R 7,343,087	R 2,657,275	R 15,670,921	R 4,838,476
Personnel	R 134,617	R 60,557	R 249,530	R 45,345
Crude Oil TCO	R 431,487,152	R 177,179,259	R 983,822,432	R 191,470,266

Table 3: More statistical Analyses of the TCO and its elements

TCO Element	Mean	Standard Deviation (% of Mean)	Maximum (% of Mean)	Minimum (% of Mean)
Crude Oil Cost	R 404,575,499	41%	228%	44%
Freight	R 8,793,079	63%	288%	19%
Demurrage	R 552,278	233%	999%	0%
Transport	R 8,613,167	31%	156%	44%
Clearing Cost	R 1,166	33%	150%	50%
Insurance	R 234,782	50%	232%	41%
Cargo Dues	R 241,263	37%	169%	19%
Surveyors	R 33,046	103%	527%	7%
Storage	R 965,169	36%	171%	36%
Inventory Holding Cost	R 7,343,087	36%	213%	66%
Personnel	R 134,617	45%	185%	34%
Crude Oil TCO	R 431,487,152	41%	228%	44%

4.3.2 *Crude Oil Price*

The mean crude oil price was R404 575 499 per month, with a standard deviation of R167 115 734 which equates to 41% of the mean. The maximum and minimum prices were R921 186 565 and R178 516 939 per month respectively.

On a rand per barrel basis, the crude oil price was R591.82 with a standard deviation of R142.19, equating to 24% of the mean.

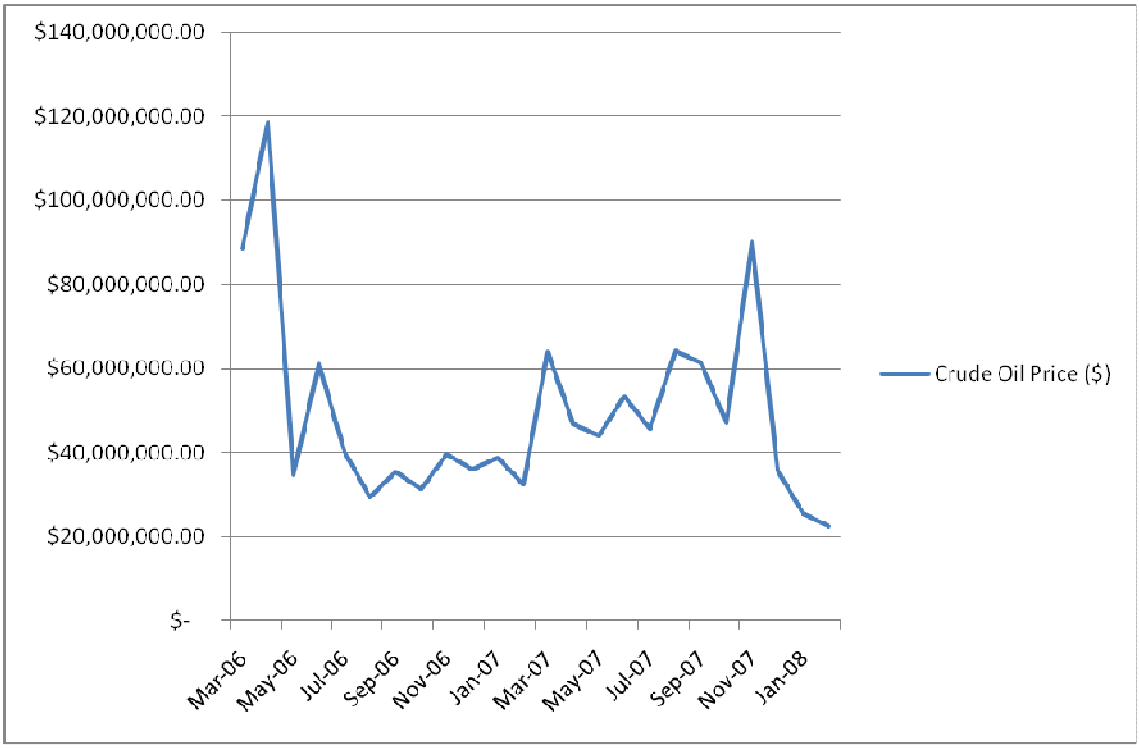

Figure 8: Crude oil price in dollars per month

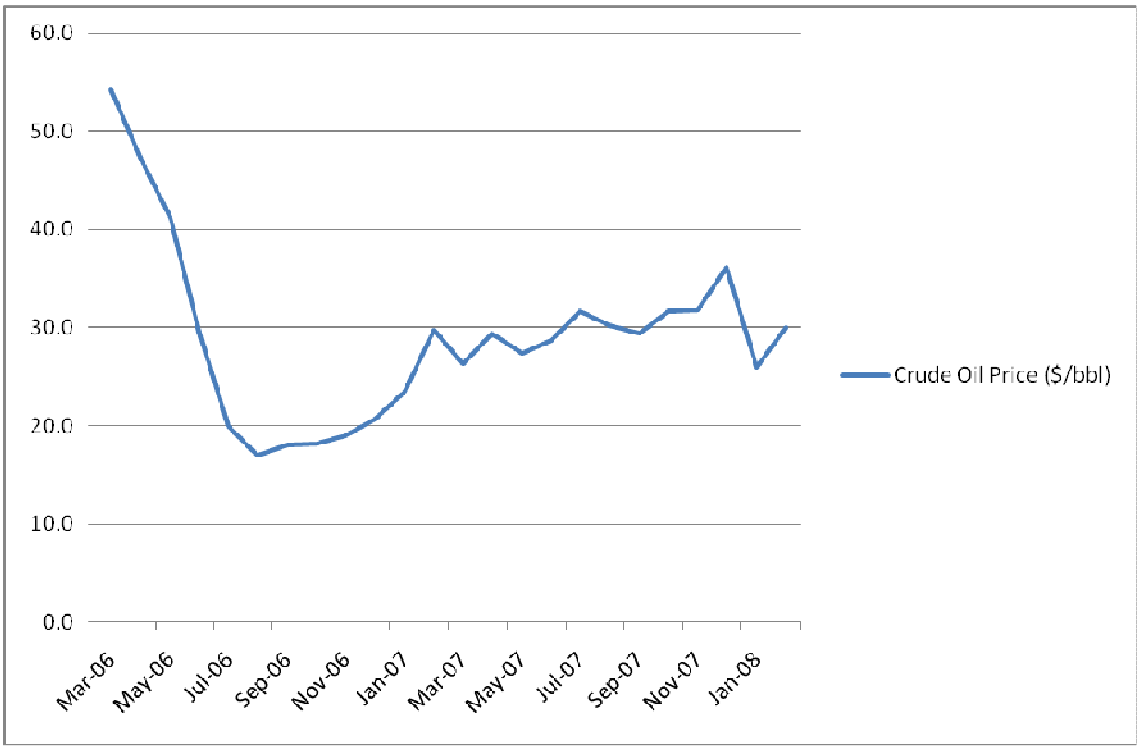

Figure 9: Crude oil cost in dollars per barrel

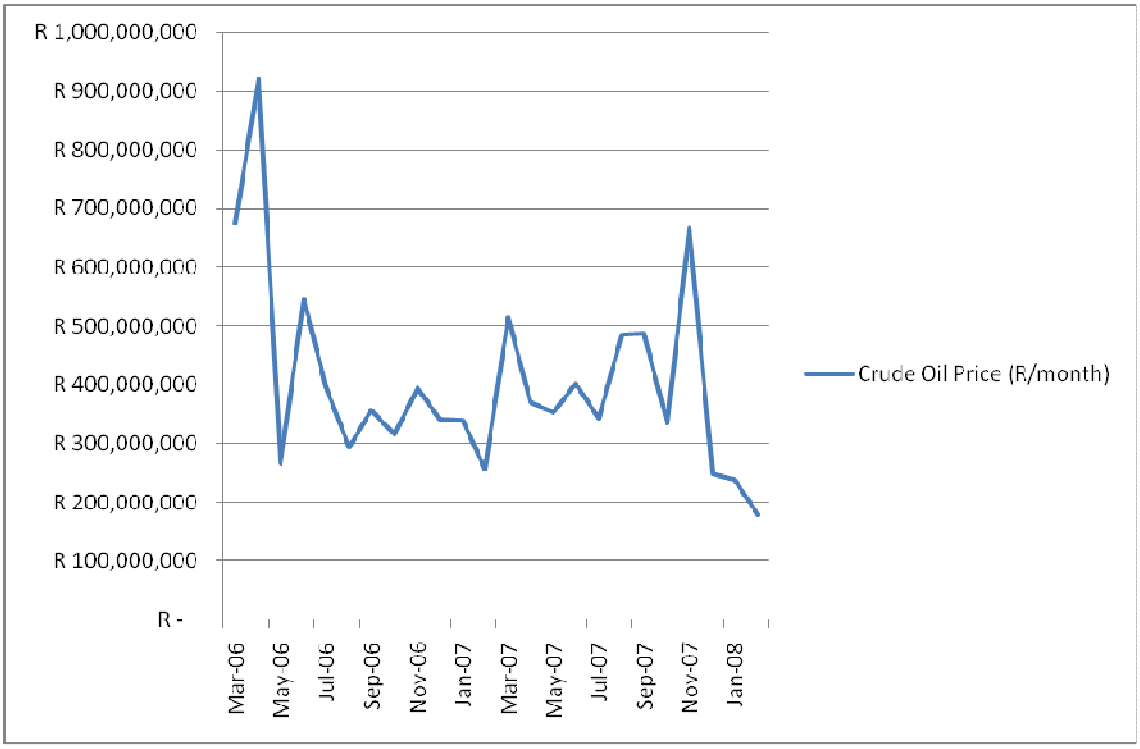

Figure 10: Crude oil cost in rands per month

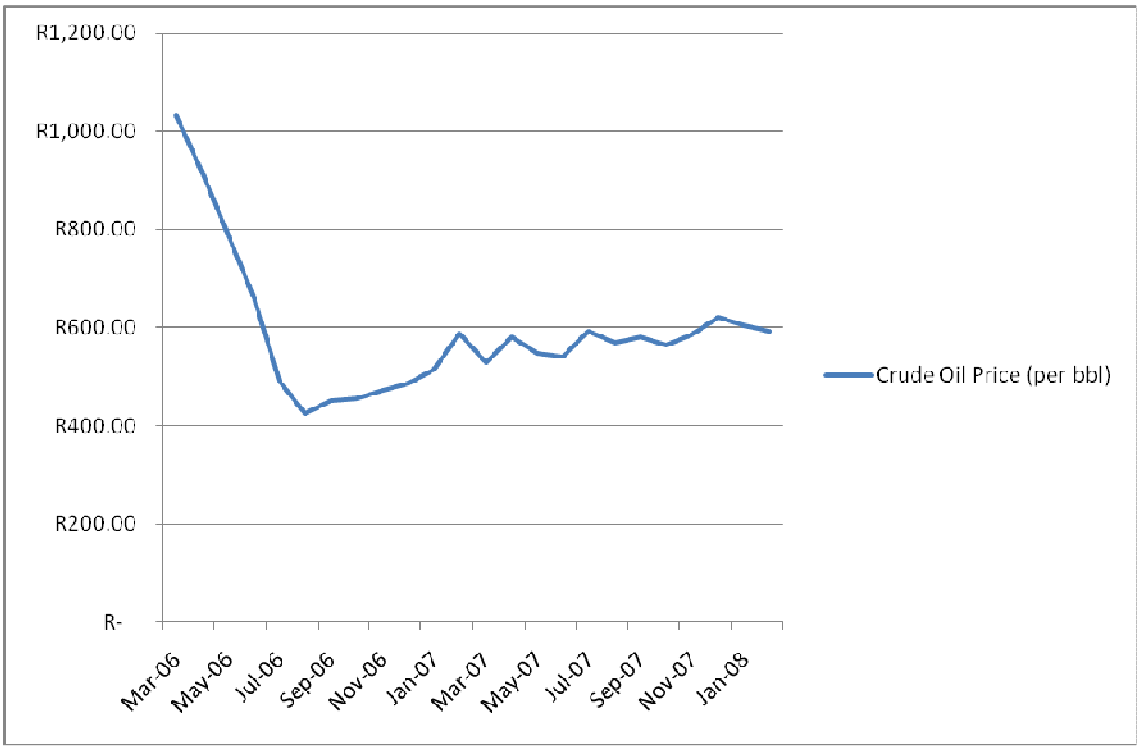

Figure 11: Crude oil cost in rands per barrel

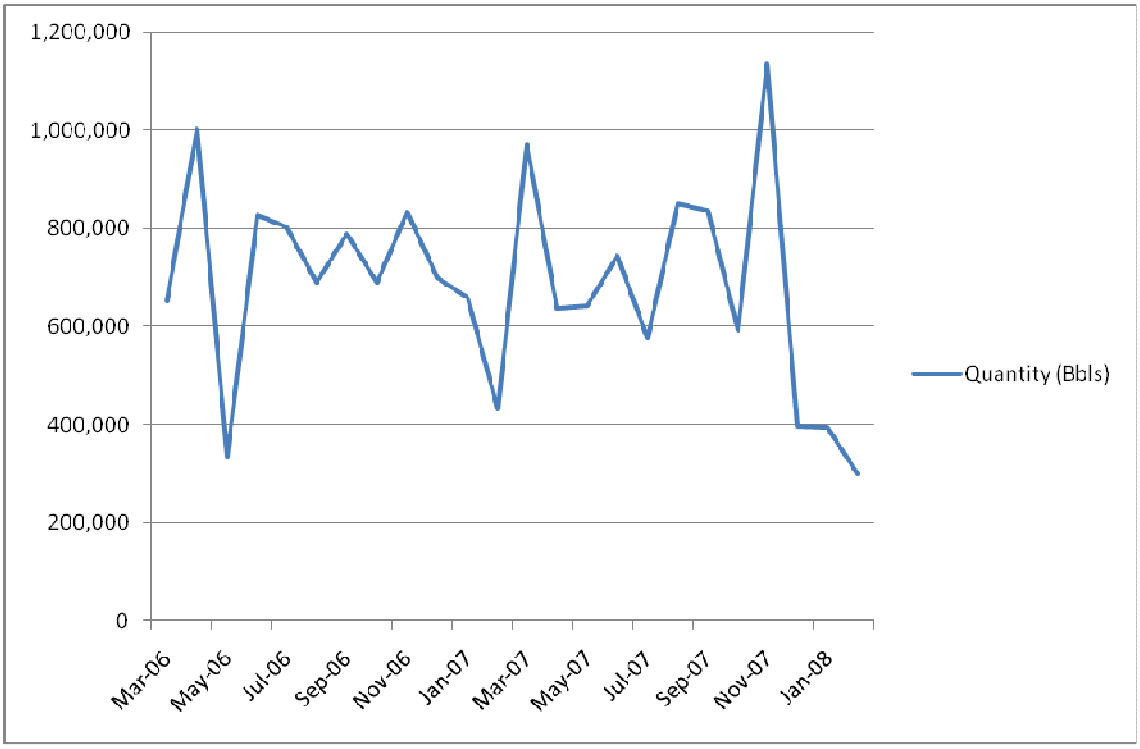

Figure 12: Quantity of crude oil purchased in barrels per month

Table 4: Statistical Analysis of crude oil price, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	404,575,499	-
Standard Deviation	R	167,115,734	41%
Maximum	R	921,186,565	228%
Minimum	R	178,516,939	44%

Table 5: Statistical Analysis of the crude oil price, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	591.82	-
Standard Deviation	R	142.19	24%
Maximum	R	1,032.18	174%
Minimum	R	9.47	2%

Table 6: Statistical Analysis of the quantity of crude oil purchased

	Mean	Standard Deviation (% of Mean)	Maximum (% of Mean)	Minimum (% of Mean)
Quantity Purchased (barrels)	687,133	31%	165%	44%

4.3.3 *Freight Costs*

The mean freight cost was R8 793 079 per month, with a standard deviation of R5 522 738 which equates to 63% of the mean. The maximum and minimum prices were R25 322 014 and R1 637 454 per month respectively.

On a rand per barrel basis, the freight cost was R12.37 with a standard deviation of R48.42, equating to 391% of the mean.

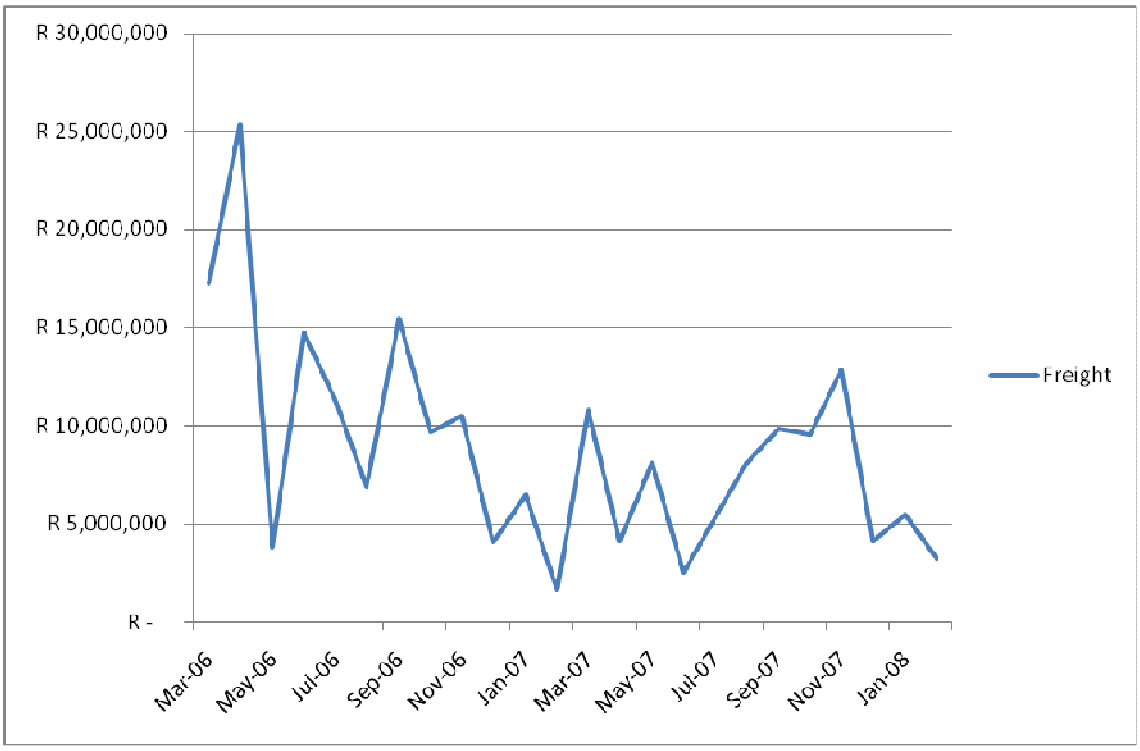

Figure 13: Freight costs in rands per month

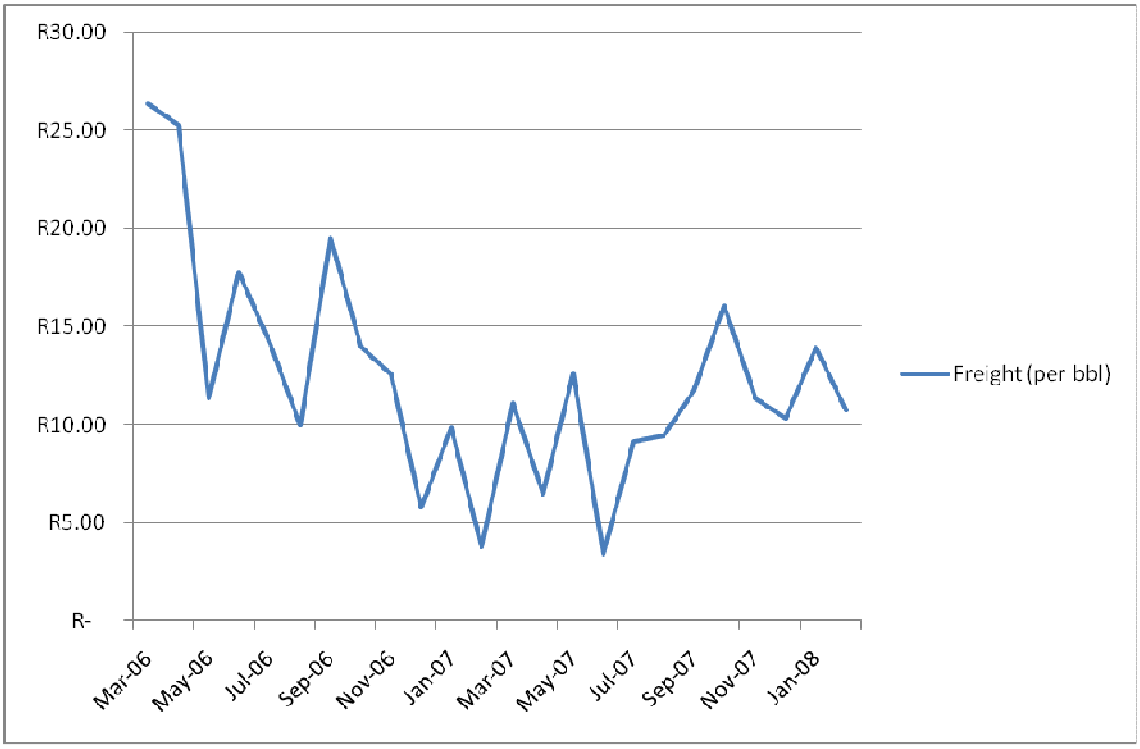

Figure 14: Freight costs in rands per barrel

Table 7: Statistical Analysis of the freight cost, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	8,793,079	-
Standard Deviation	R	5,522,738	63%
Maximum	R	25,322,014	288%
Minimum	R	1,637,454	19%

Table 8: Statistical Analysis of the freight cost, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	12.37	-
Standard Deviation	R	48.42	391%
Maximum	R	622.02	5027%
Minimum	R	1,166.04	9423%

4.3.4 *Demurrage*

The mean demurrage cost was R552 278 per month, with a standard deviation of R1 285 806 which equates to 233% of the mean. The maximum and minimum costs were R5 515 158 and R3 778 987 per month respectively.

On a rand per barrel basis, the demurrage cost was R0.70 with a standard deviation of R1.48, equating to 212% of the mean.

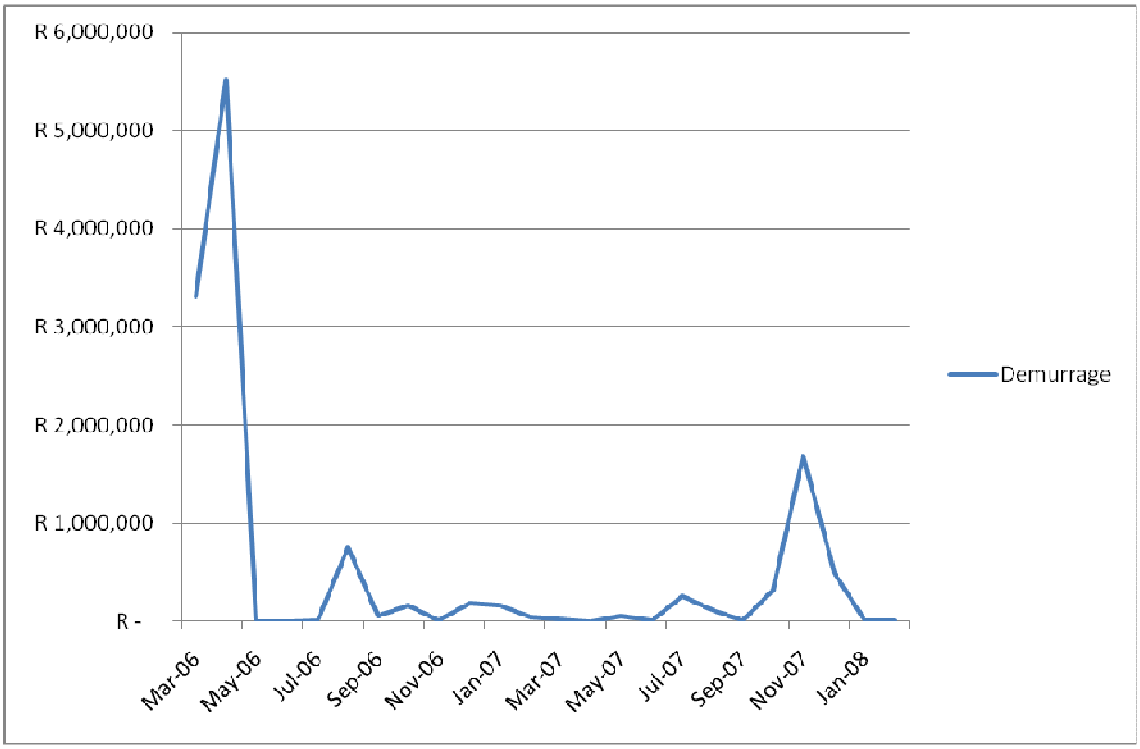

Figure 15: Demurrage costs in rands per month

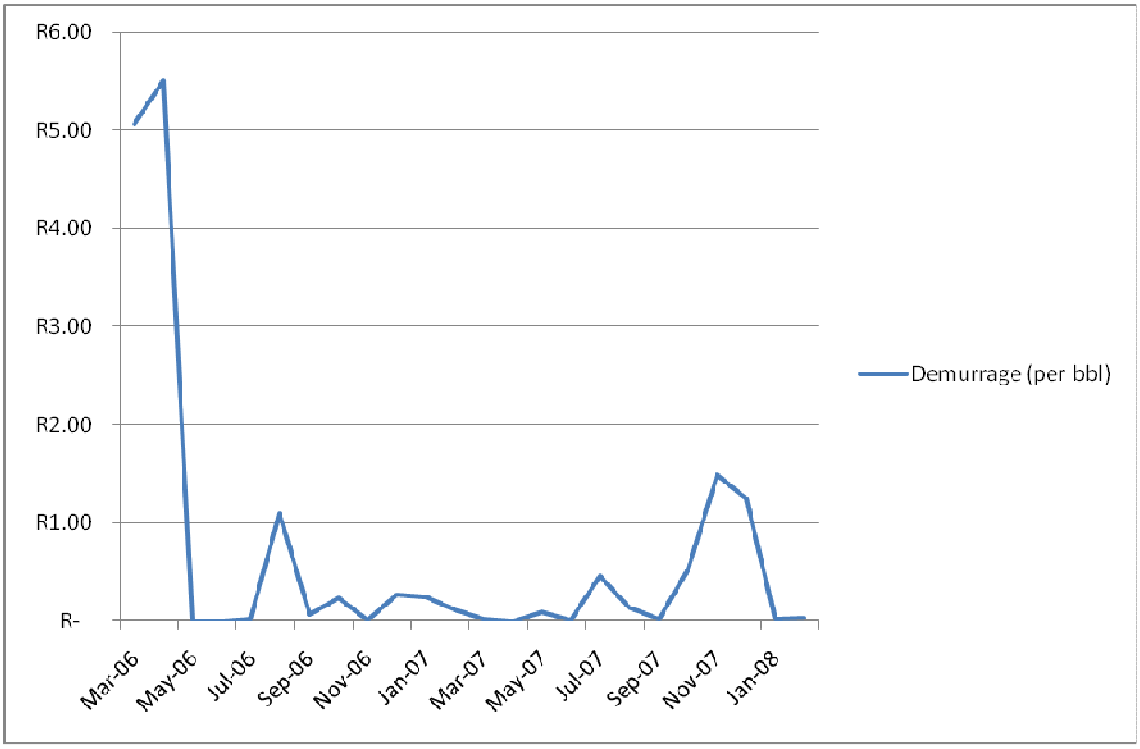

Figure 16: Demurrage costs in rands per barrel

Table 9: Statistical Analysis of the demurrage cost, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	552,278	-
Standard Deviation	R	1,285,806	233%
Maximum	R	5,515,158	999%
Minimum	R	3,778,987	684%

Table 10: Statistical Analysis of the demurrage cost, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	0.70	-
Standard Deviation	R	1.48	212%
Maximum	R	5.51	790%
Minimum	R	-	0%

4.3.5 *Transport*

The mean transport cost was R8 613 167 per month, with a standard deviation of R2 690 755 which equates to 31% of the mean. The maximum and minimum costs were R13 463 382 and R3 778 987 per month respectively.

On a rand per barrel basis, the transport cost was R12.54 with a standard deviation of R0.69, equating to 6% of the mean. The cost per barrel remains fairly constant throughout the entire period, with step changes annually in May 2007 and May 2008.

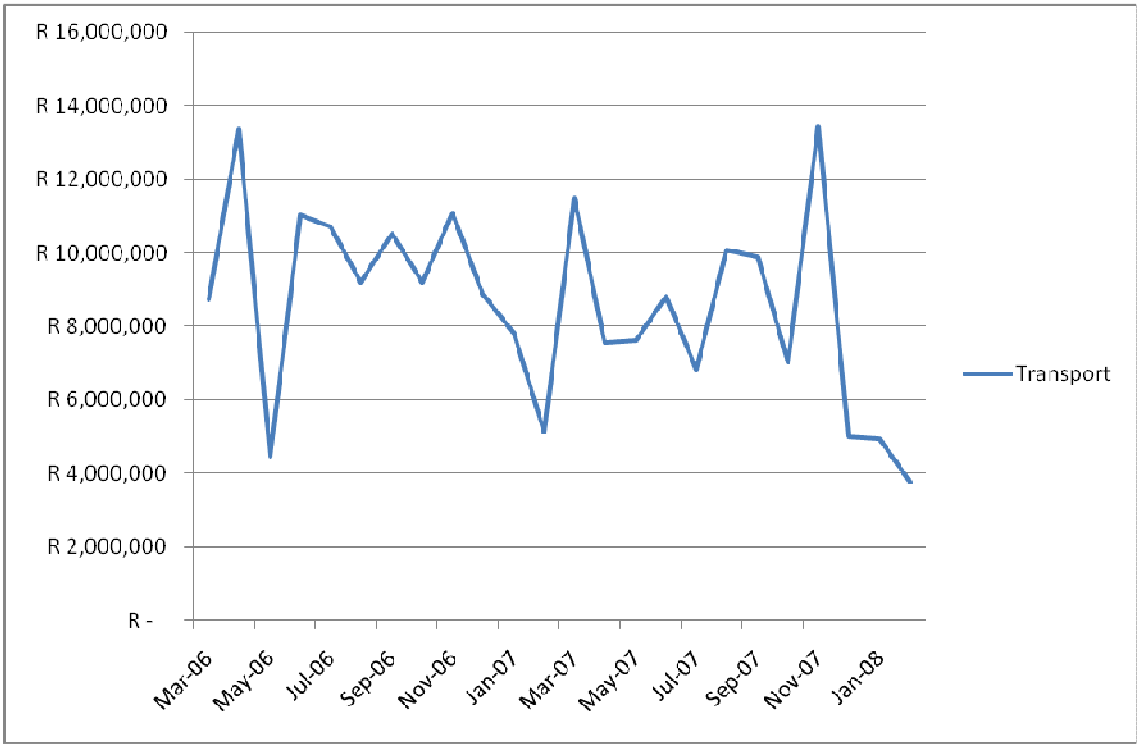

Figure 17: Transport cost in rands per month

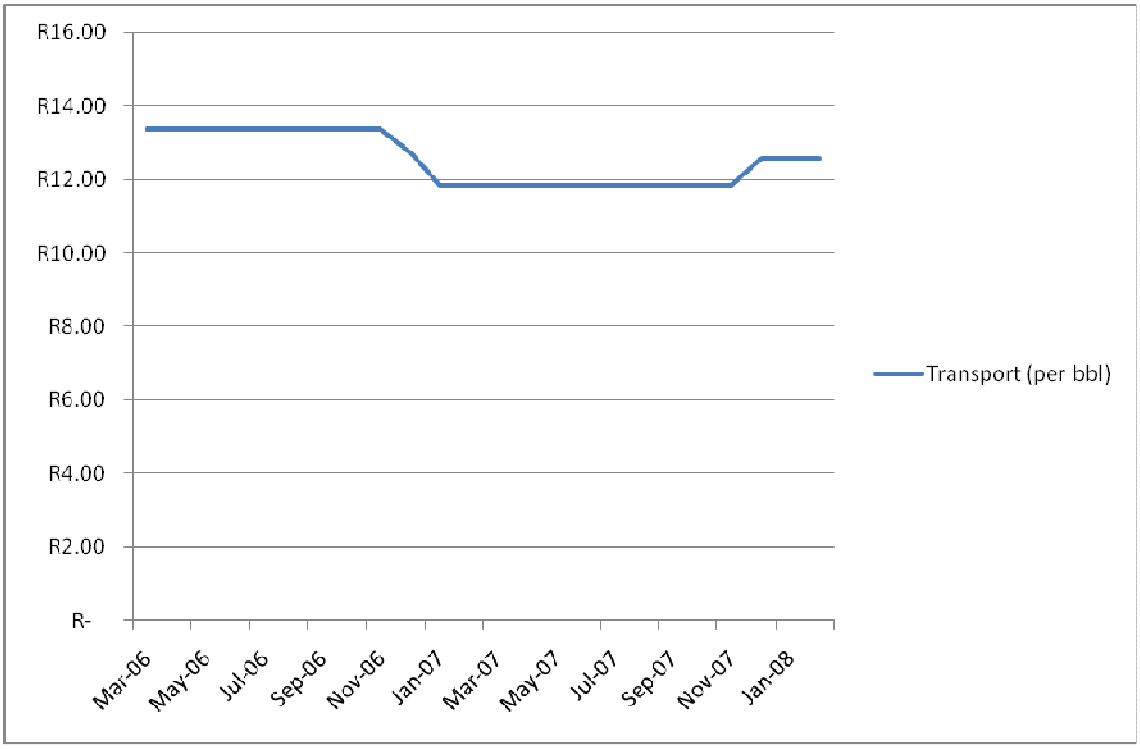

Figure 18: Transport costs in rands per barrel

Table 11: Statistical Analysis of the transport cost, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	8,613,167	-
Standard Deviation	R	2,690,755	31%
Maximum	R	13,463,382	156%
Minimum	R	3,778,987	44%

Table 12: Statistical Analysis of the transport cost, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	12.54	-
Standard Deviation	R	0.69	6%
Maximum	R	13.34	106%
Minimum	R	11.85	95%

4.3.6 *Clearing Costs*

The mean clearing cost was R1 166 per month, with a standard deviation of R384 which equates to 33% of the mean. The maximum and minimum costs were R1 746 and R582 per month respectively.

On a rand per barrel basis, the clearing cost was R0.0017 with a standard deviation of R0.0003, equating to 18% of the mean.

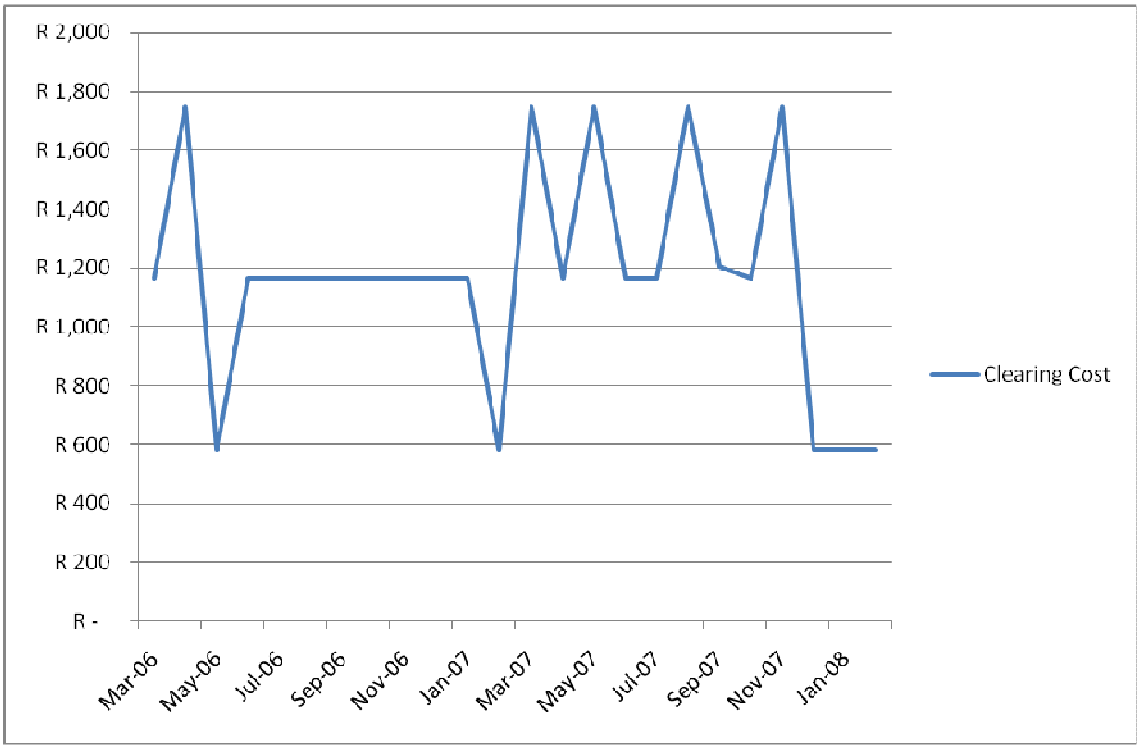

Figure 19: Clearing costs in rands per month

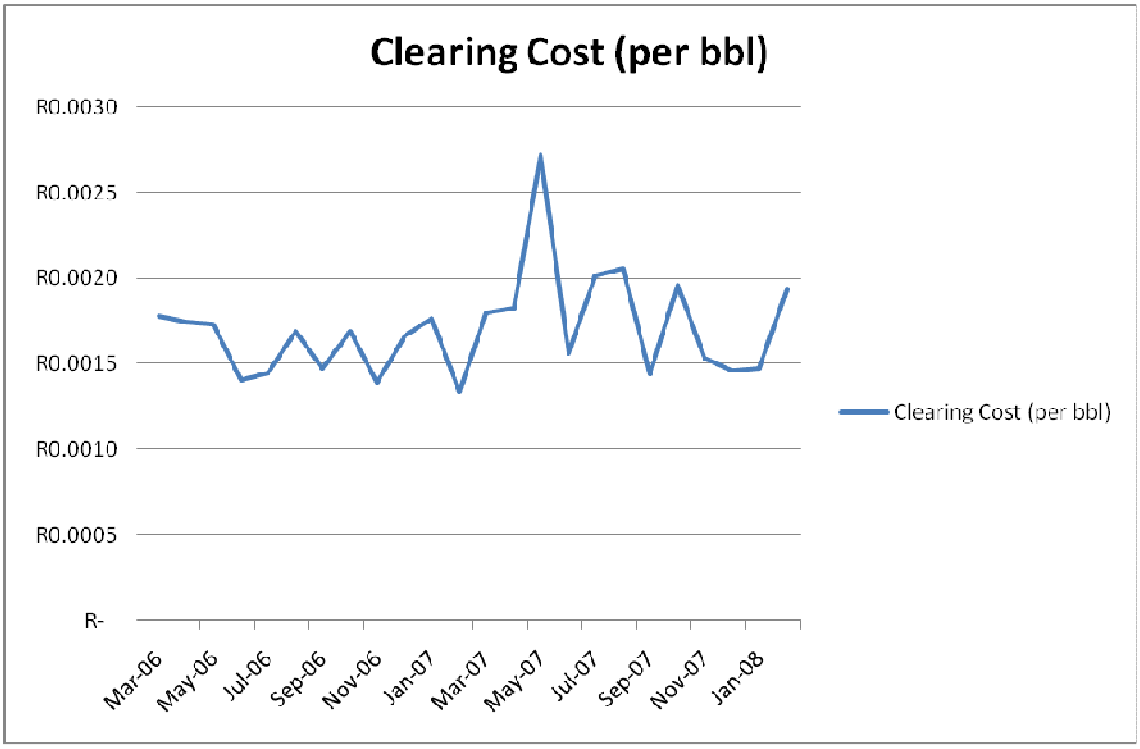

Figure 20: Clearing costs in rands per barrel

Table 13: Statistical Analysis of the clearing costs, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	1,166	-
Standard Deviation	R	384	33%
Maximum	R	1,746	150%
Minimum	R	582	50%

Table 14: Statistical Analysis of the clearing costs, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	0.0017	-
Standard Deviation	R	0.0003	18%
Maximum	R	0.0027	159%
Minimum	R	0.0013	79%

4.3.7 *Insurance*

The mean insurance cost was R234 782 per month, with a standard deviation of R116 356 which equates to 50% of the mean. The maximum and minimum costs were R545 050 and R96 268 per month respectively.

On a rand per barrel basis, the insurance cost was R0.3358 with a standard deviation of R0.1095, equating to 33% of the mean.

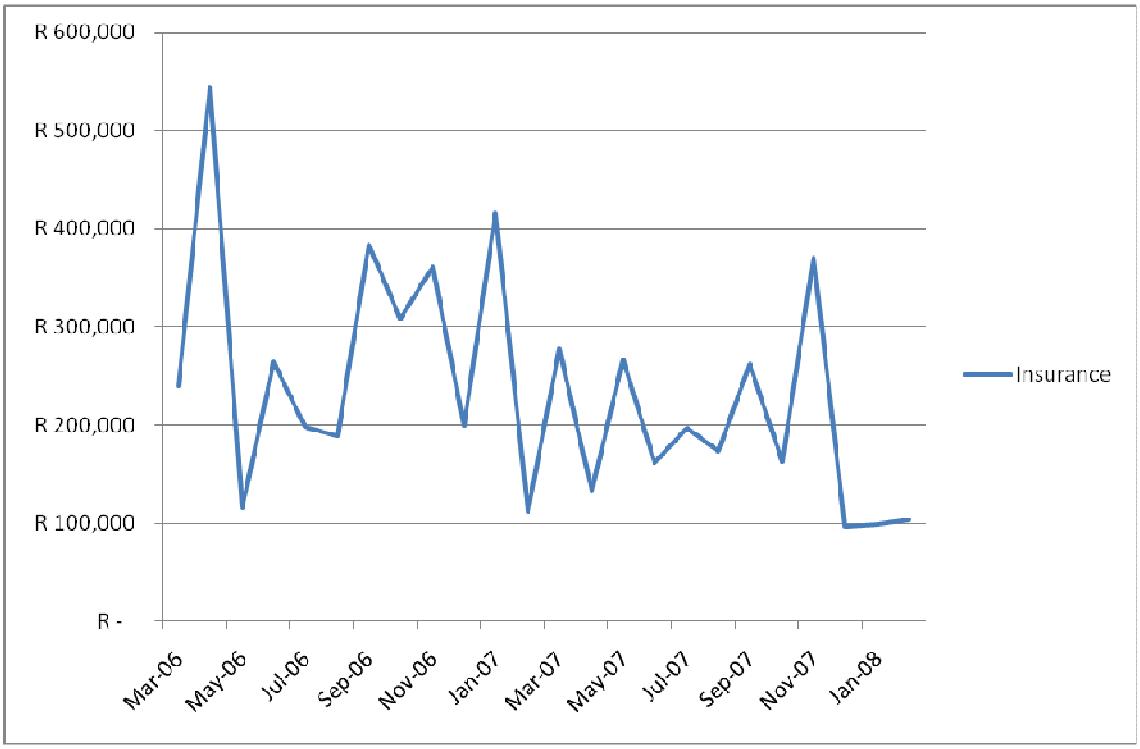

Figure 21: Insurance costs in rands per month

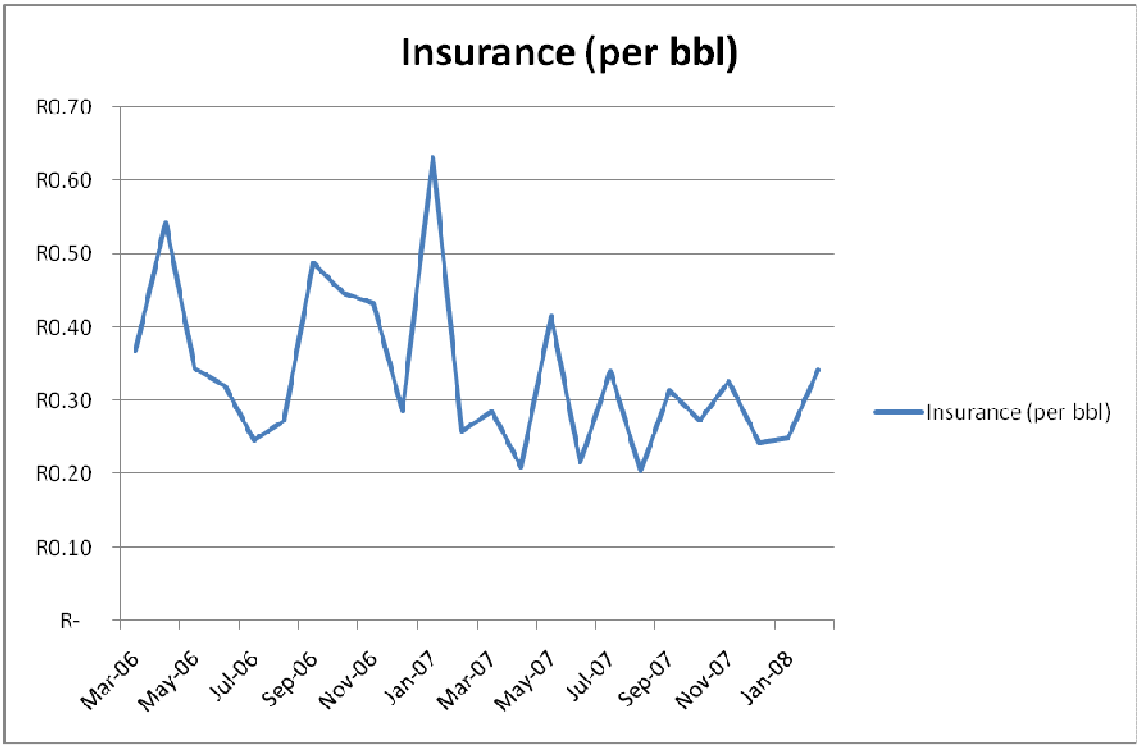

Figure 22: Insurance costs in rands per barrel

Table 15: Statistical Analysis of the insurance cost, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	234,782	-
Standard Deviation	R	116,356	50%
Maximum	R	545,050	232%
Minimum	R	96,268	41%

Table 16: Statistical Analysis of the insurance cost, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	0.3358	-
Standard Deviation	R	0.1095	33%
Maximum	R	0.6322	188%
Minimum	R	0.2035	61%

4.3.8 *Cargo Dues*

The mean cargo dues amounted to R241 263 per month, with a standard deviation of R90 385 which equates to 37% of the mean. The maximum and minimum costs were R407 530 and R46 722 per month respectively.

On a rand per barrel basis, the cargo dues were R0.3489 with a standard deviation of R0.092, equating to 26% of the mean.

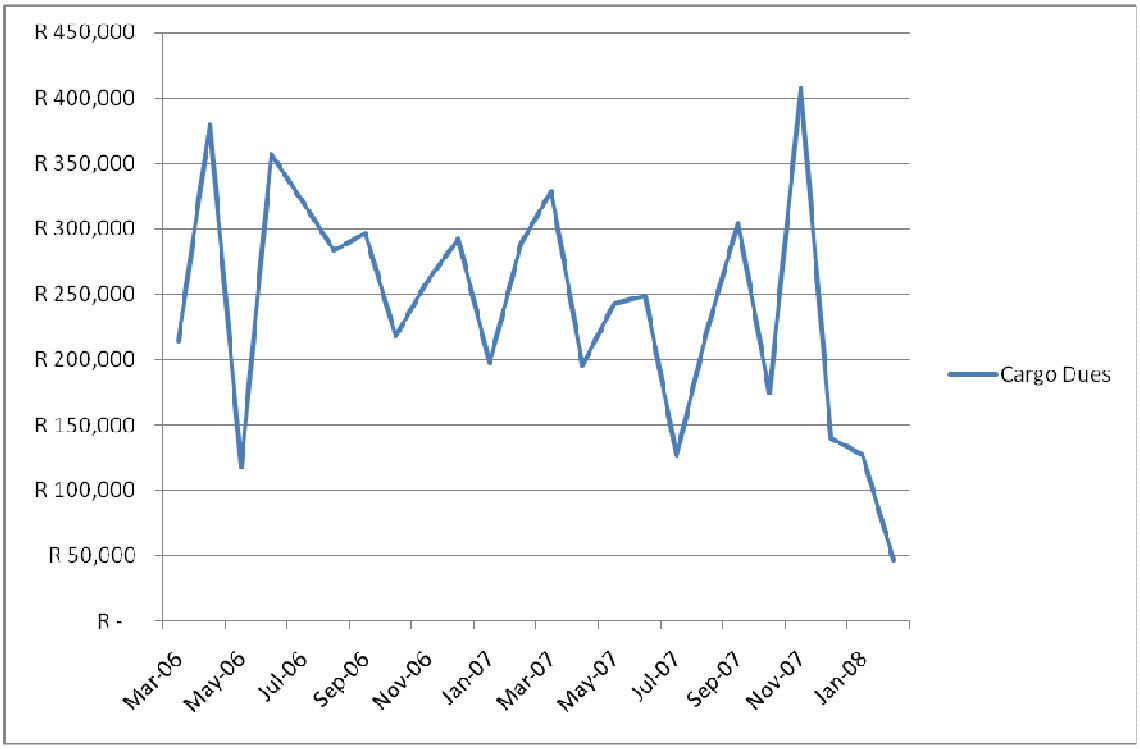

Figure 23: Cargo Dues in rands per month

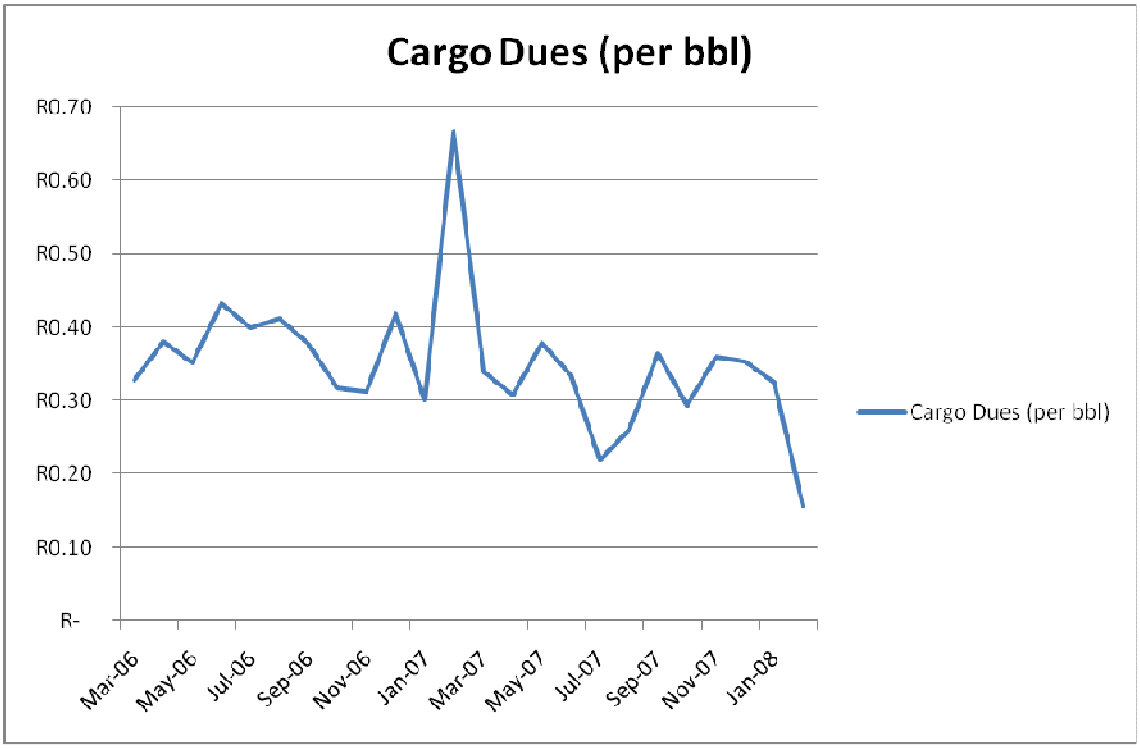

Figure 24: Cargo Dues in rands per barrel

Table 17: Statistical Analysis of the cargo dues, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	241,263	-
Standard Deviation	R	90,385	37%
Maximum	R	407,530	169%
Minimum	R	46,722	19%

Table 18: Statistical Analysis of the cargo dues, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	0.3489	-
Standard Deviation	R	0.0920	26%
Maximum	R	0.6656	191%
Minimum	R	0.1555	45%

4.3.9 *Surveyors Costs*

The mean surveyors cost was R33 046 per month, with a standard deviation of R34 050 which equates to 103% of the mean. The maximum and minimum costs were R174 106 and R2 392 per month respectively.

On a rand per barrel basis, the surveyors cost was R0.0446 with a standard deviation of R0.0313, equating to 70% of the mean.

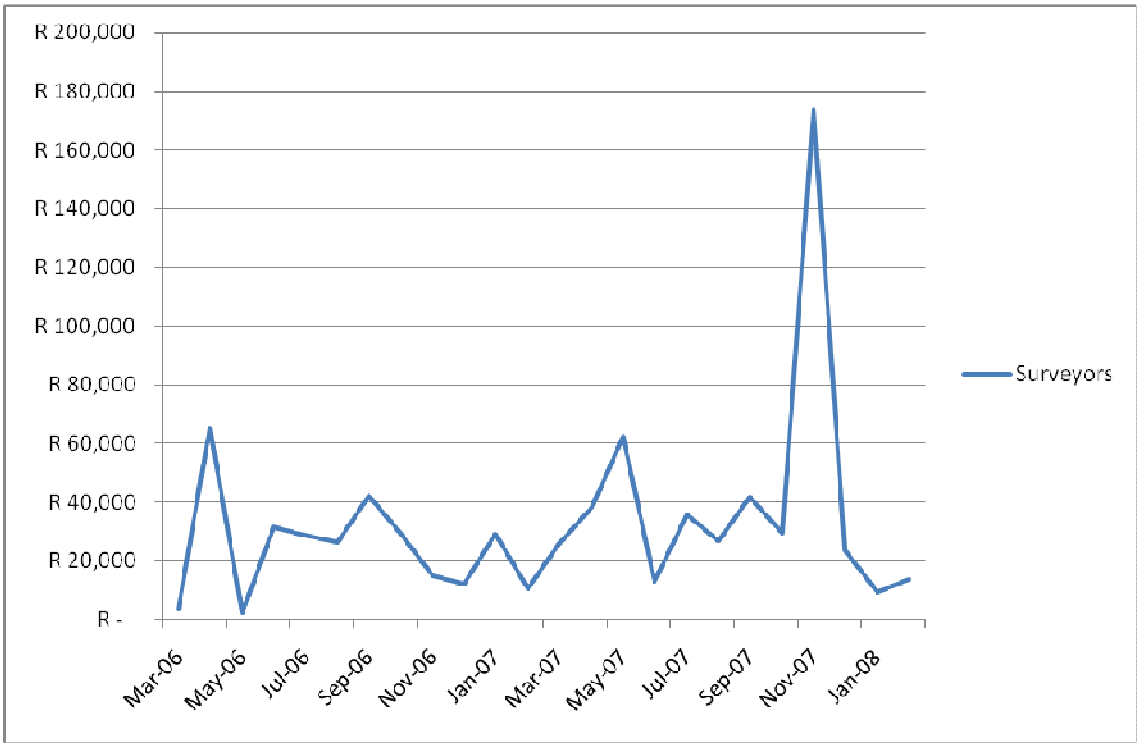

Figure 25: Surveyors costs in rands per month

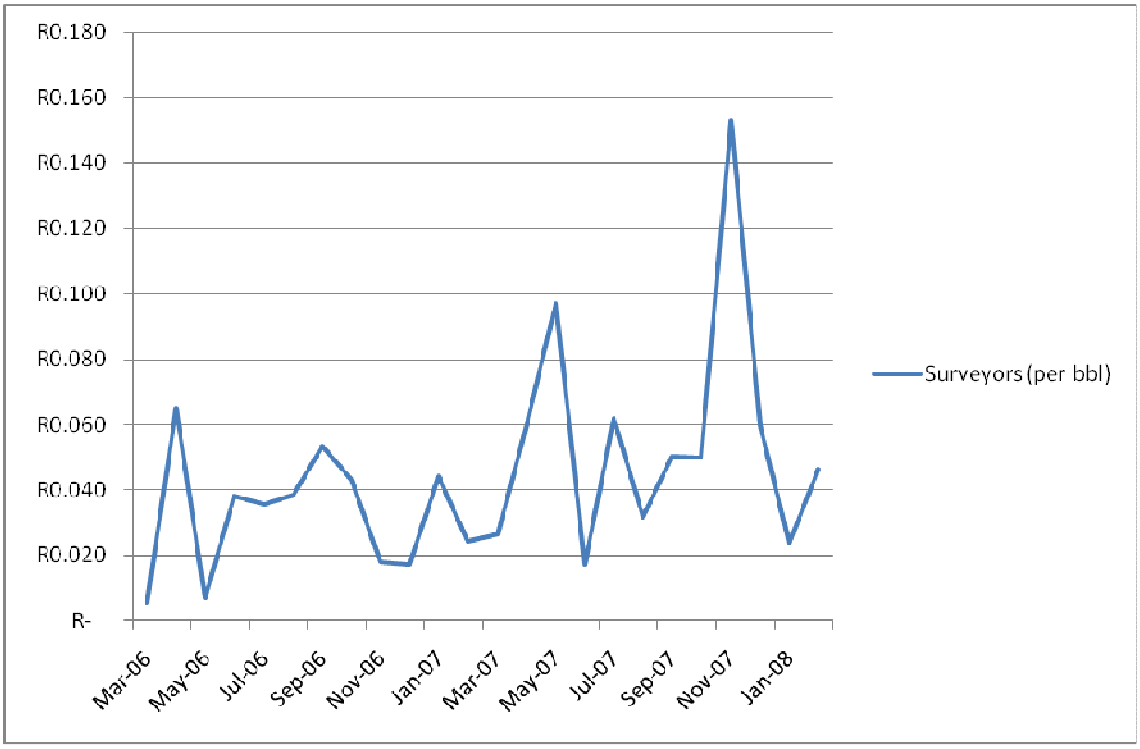

Figure 26: Surveyors costs in rands per barrel

Table 19: Statistical Analysis of the surveyors cost, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	33,046	-
Standard Deviation	R	34,050	103%
Maximum	R	174,106	527%
Minimum	R	2,392	7%

Table 20: Statistical Analysis of the surveyors cost, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	0.0446	-
Standard Deviation	R	0.0313	70%
Maximum	R	0.1533	343%
Minimum	R	0.0057	13%

4.3.10 *Storage Costs*

The mean storage cost was R965 169 per month, with a standard deviation of R344 739 which equates to 36% of the mean. The maximum and minimum costs were R1 653 389 and R345 029 per month respectively.

On a rand per barrel basis, the storage cost was R1.3996 with a standard deviation of R0.2570, equating to 18% of the mean. The cost per barrel remains constant for several months, decreases in March 2007 and then remains constant for the rest of the period.

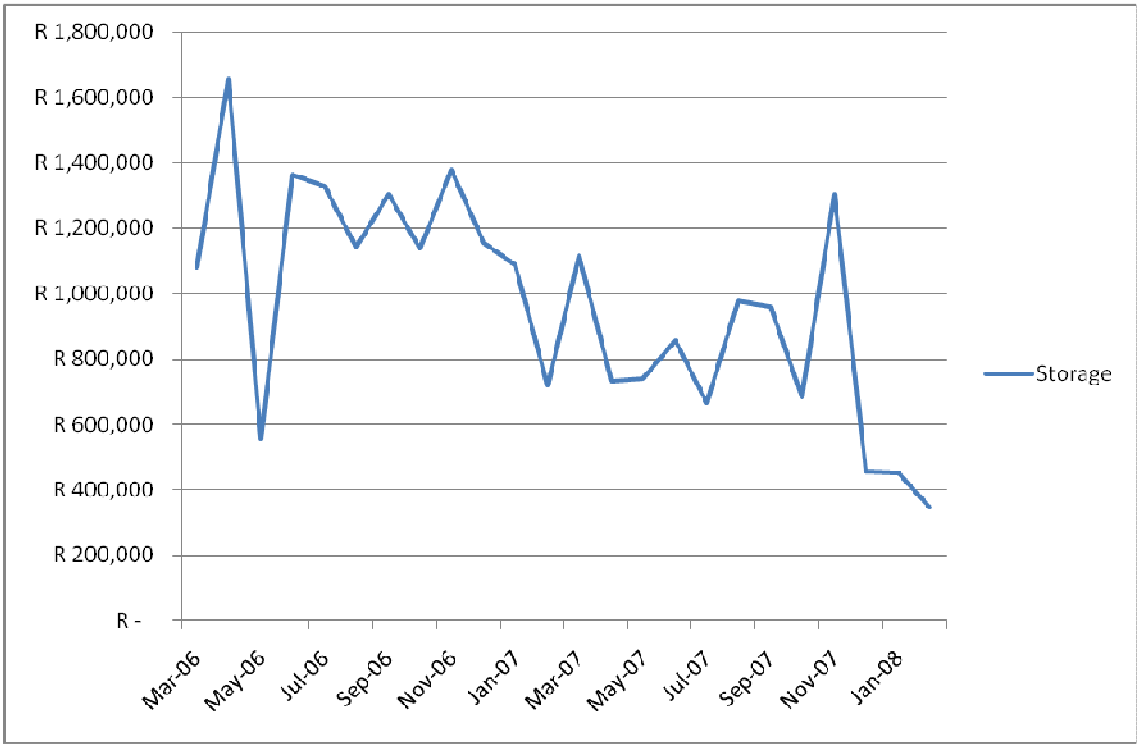

Figure 27: Storage costs in rands per month

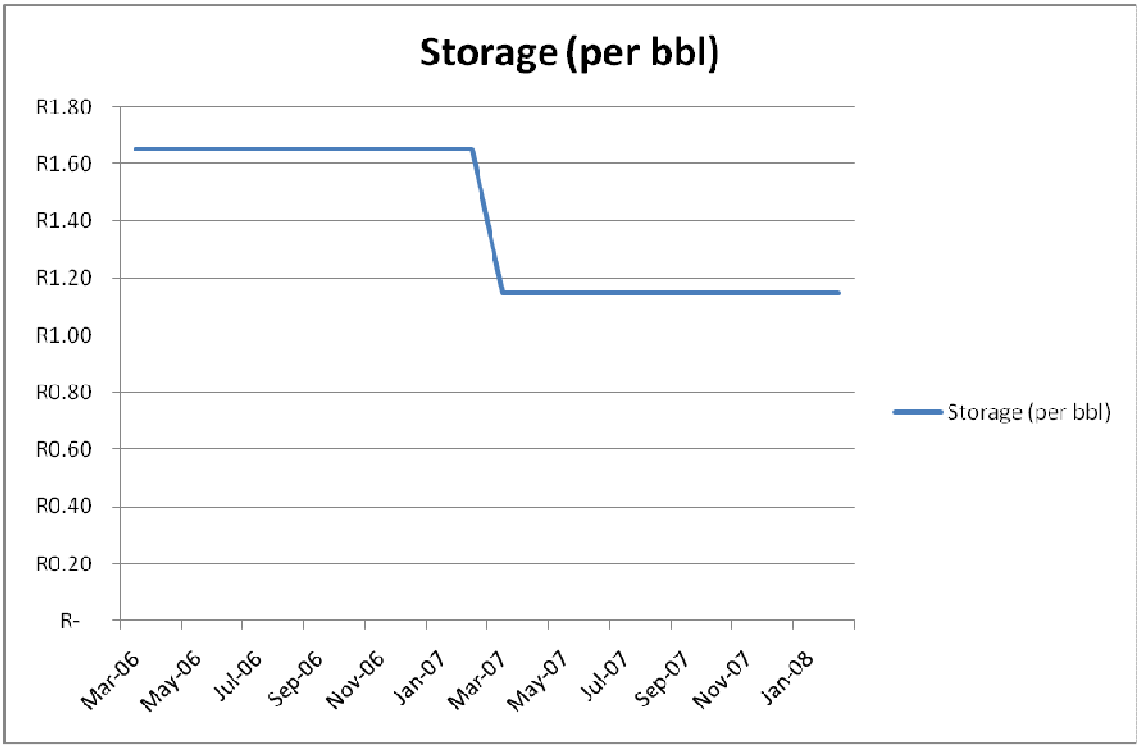

Figure 28: Storage costs in rands per barrel

Table 21: Statistical Analysis of the storage cost, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	965,169	-
Standard Deviation	R	344,739	36%
Maximum	R	1,653,389	171%
Minimum	R	345,029	36%

Table 22: Statistical Analysis of the storage cost, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	1.3996	-
Standard Deviation	R	0.2570	18%
Maximum	R	1.6512	118%
Minimum	R	1.1480	82%

4.3.11 *Inventory Holding Costs*

The mean inventory holding cost was R7 343 087 per month, with a standard deviation of R2 657 275 which equates to 36% of the mean. The maximum and minimum costs were R15 670 921 and R4 838 476 per month respectively.

On a rand per barrel basis, the inventory holding cost was R11.86 with a standard deviation of R5.977, equating to 50% of the mean.

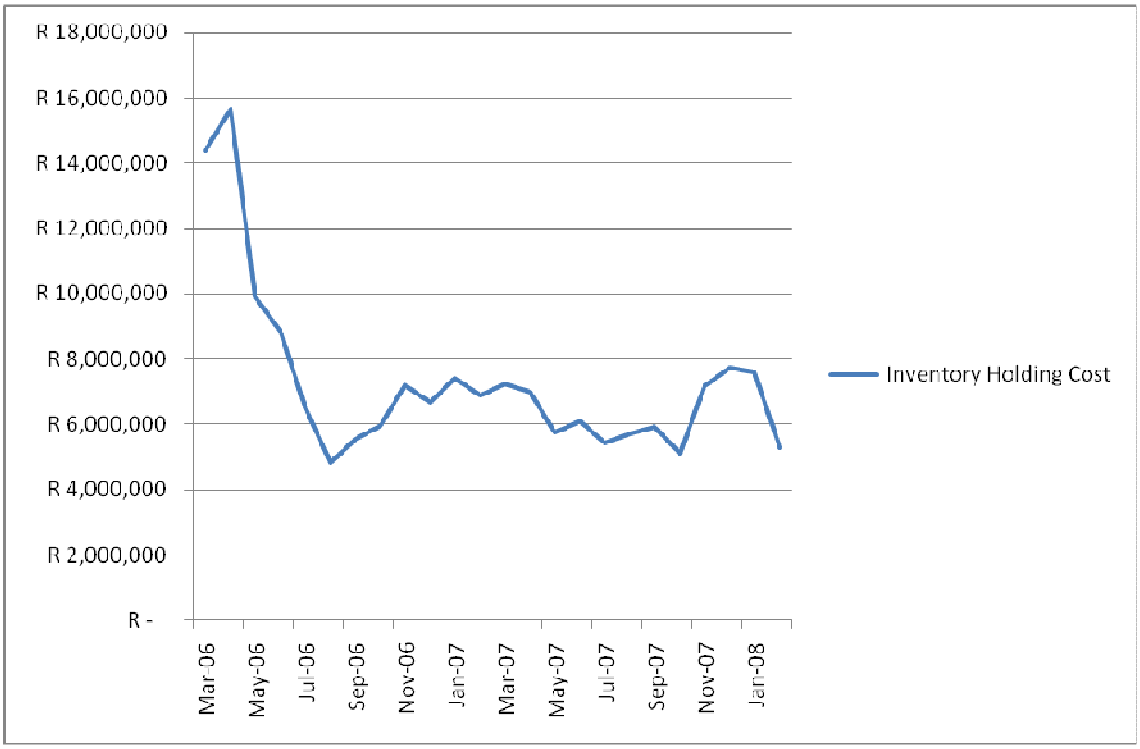

Figure 29: Inventory holding costs in rands per month

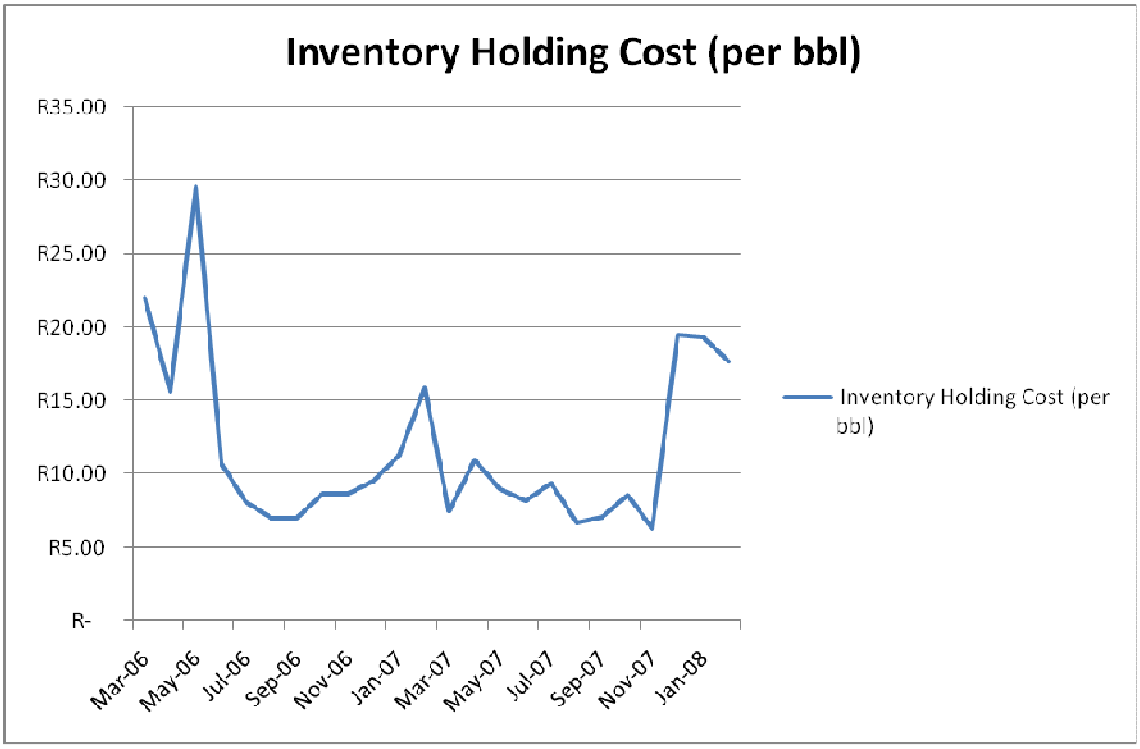

Figure 30: Inventory holding costs in rands per barrel

Table 23: Statistical Analysis of the inventory holding cost, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	7,343,087	-
Standard Deviation	R	2,657,275	36%
Maximum	R	15,670,921	213%
Minimum	R	4,838,476	66%

Table 24: Statistical Analysis of the inventory holding cost, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	11.8606	-
Standard Deviation	R	5.9772	50%
Maximum	R	29.6066	250%
Minimum	R	6.3137	53%

4.3.12 *Personnel Costs*

The mean personnel cost was R134 617 per month, with a standard deviation of R60 557 which equates to 45% of the mean. The maximum and minimum costs were R249 530 and R45 345 per month respectively.

On a rand per barrel basis, the personnel cost was R0.2214 with a standard deviation of R0.1221, equating to 55% of the mean.

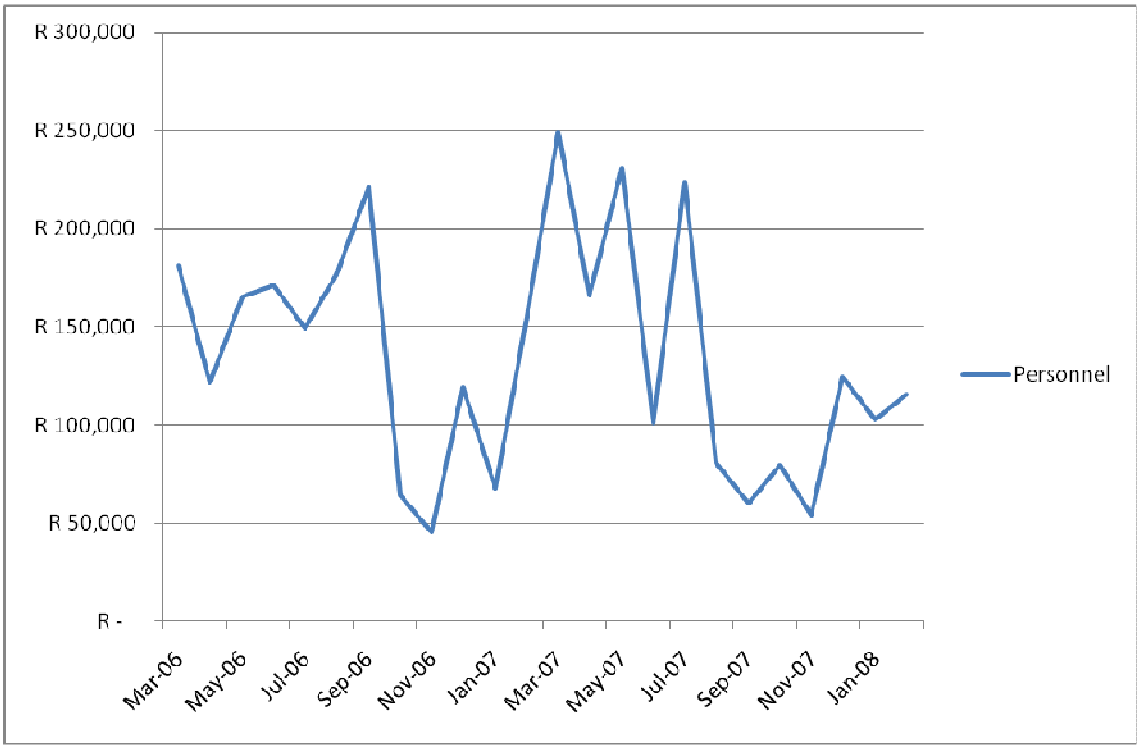

Figure 31: Personnel costs in rands per month

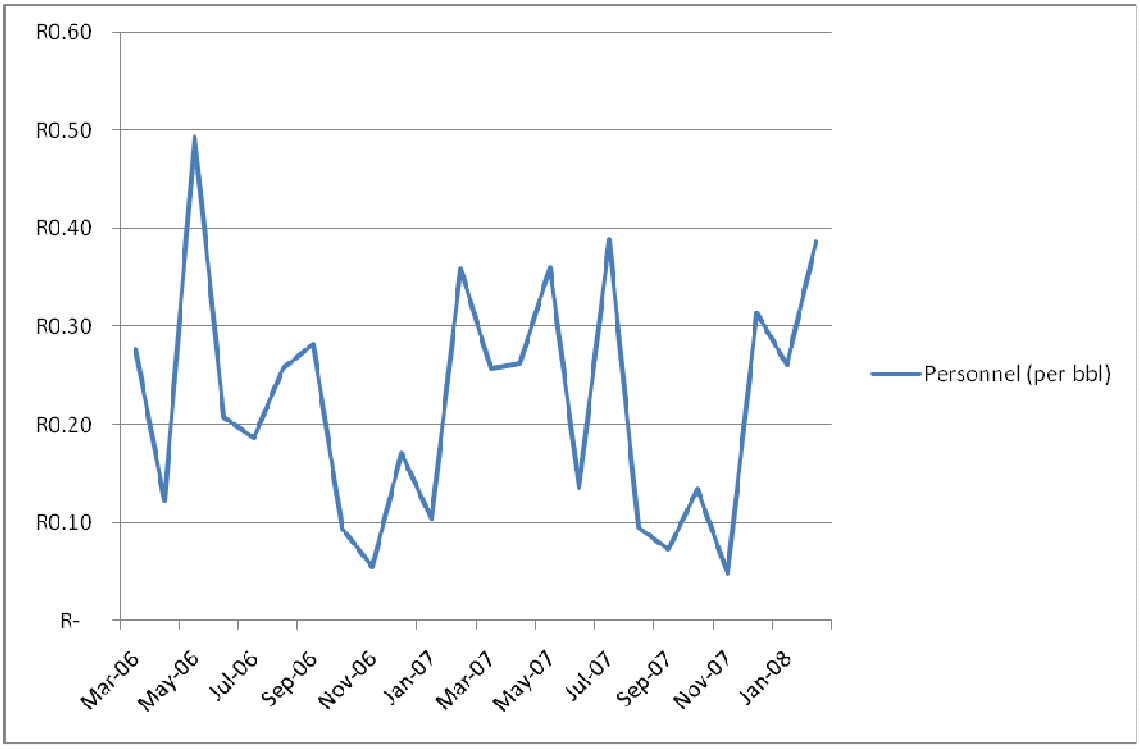

Figure 32: Personnel costs in rands per barrel

Table 25: Statistical Analysis of the personnel cost, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	134,617	-
Standard Deviation	R	60,557	45%
Maximum	R	249,530	185%
Minimum	R	45,345	34%

Table 26: Statistical Analysis of the personnel cost, in rands per barrels

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	0.2214	-
Standard Deviation	R	0.1221	55%
Maximum	R	0.4932	223%
Minimum	R	0.0477	22%

4.3.13 *Crude Oil TCO*

The mean TCO was R431 487 152 per month, with a standard deviation of R177 179 259 which equates to 41% of the mean. The maximum and minimum costs were R983 822 432 and R191 470 266 per month respectively.

On a rand per barrel basis, the TCO was R631.73 with a standard deviation of R151.12, equating to 24% of the mean.

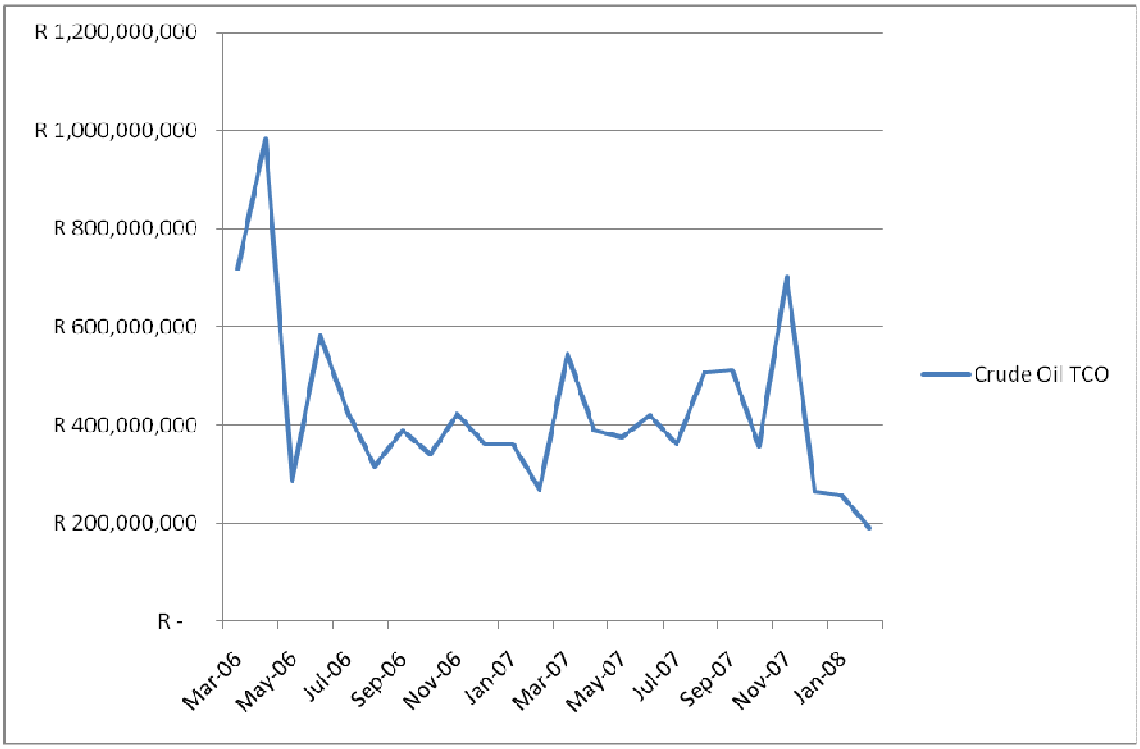

Figure 33: Crude Oil TCO in rands per month

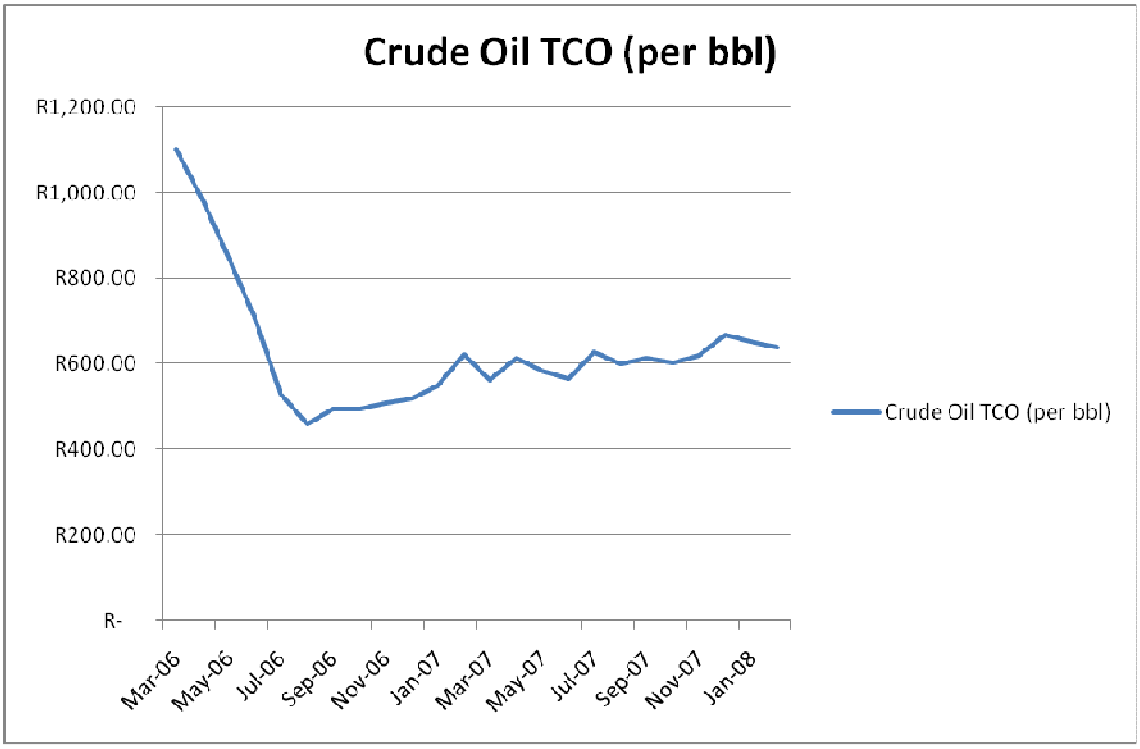

Figure 34: Crude Oil TCO in rands per barrel

Table 27: Statistical Analysis of the crude oil TCO, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	431,487,152	-
Standard Deviation	R	177,179,259	41%
Maximum	R	983,822,432	228%
Minimum	R	191,470,266	44%

Table 28: Statistical Analysis of the crude oil TCO, in rands per barrels

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	631.73	-
Standard Deviation	R	151.12	24%
Maximum	R	1,101.64	174%
Minimum	R	459.27	73%

4.4 Results pertaining to Research Proposition 2

In this section there will be two types of data presented, viz. estimated versus actual costs. The estimated values are the ones that were obtained by the personnel at the oil company, and which were not considered to be 100% accurate. The actual costs were calculated as a part of this research and are considered to be very close to the actual values of each TCO element. The estimated costs will then be compared to these actual costs in determining accuracy and precision.

4.5.1 *Personnel Costs*

Figure 35 displays the monthly personnel costs for both the estimate and actual values. As can be seen, the actual costs are more constant than the estimated costs. This is validated by the standard deviations, where the standard deviation of the estimated costs is R60 557, while that of the actual costs is R3 590. However, the means are not that far off each other, and are R134 617 and R145 605 for the estimated and actual costs, respectively.

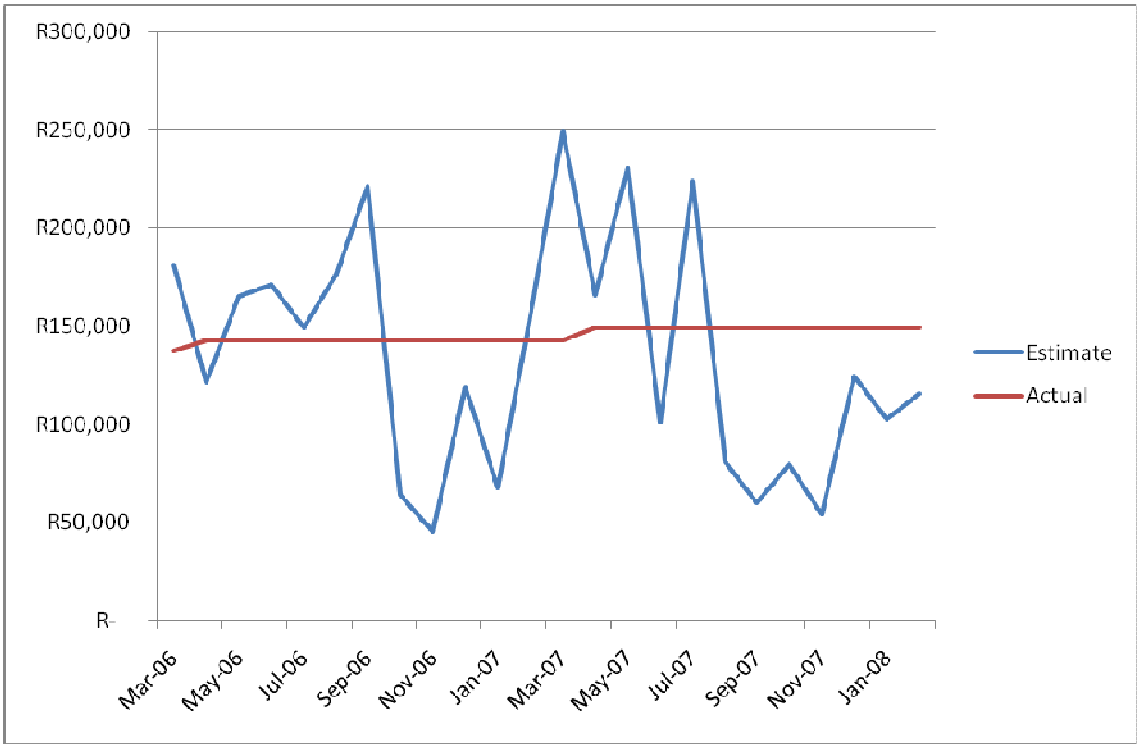

Figure 35: Comparison of estimated and actual personnel costs per month

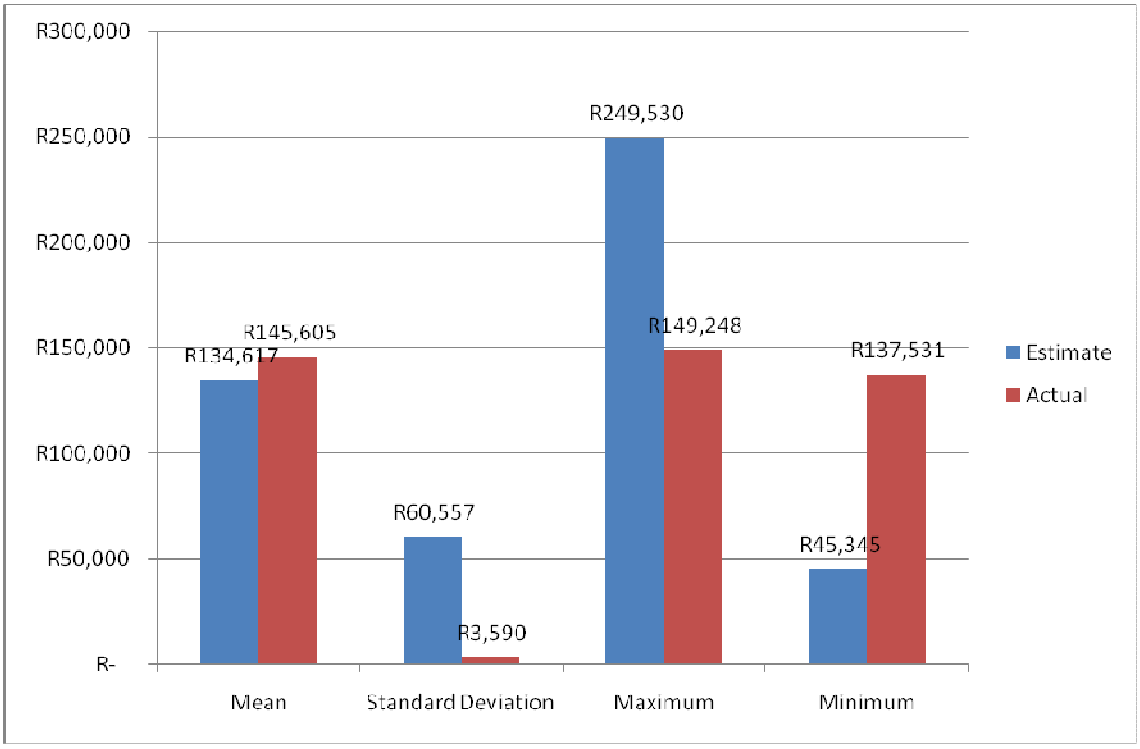

Figure 36: Statistical Analysis of estimated versus actual personnel costs

4.5.2 *Storage Costs*

As can be seen from Figure 37, the storage cost is estimated to be relatively constant over the entire period, with a mean and standard deviation of R965 169 and R344 739 respectively. The actual costs on the other hand have a standard deviation that is 27 times higher, and which is R9 389 665.

The estimated and actual storage costs remain close to each other until May 2007, when the actual costs increase by 21 times to R12 216 426 per month.

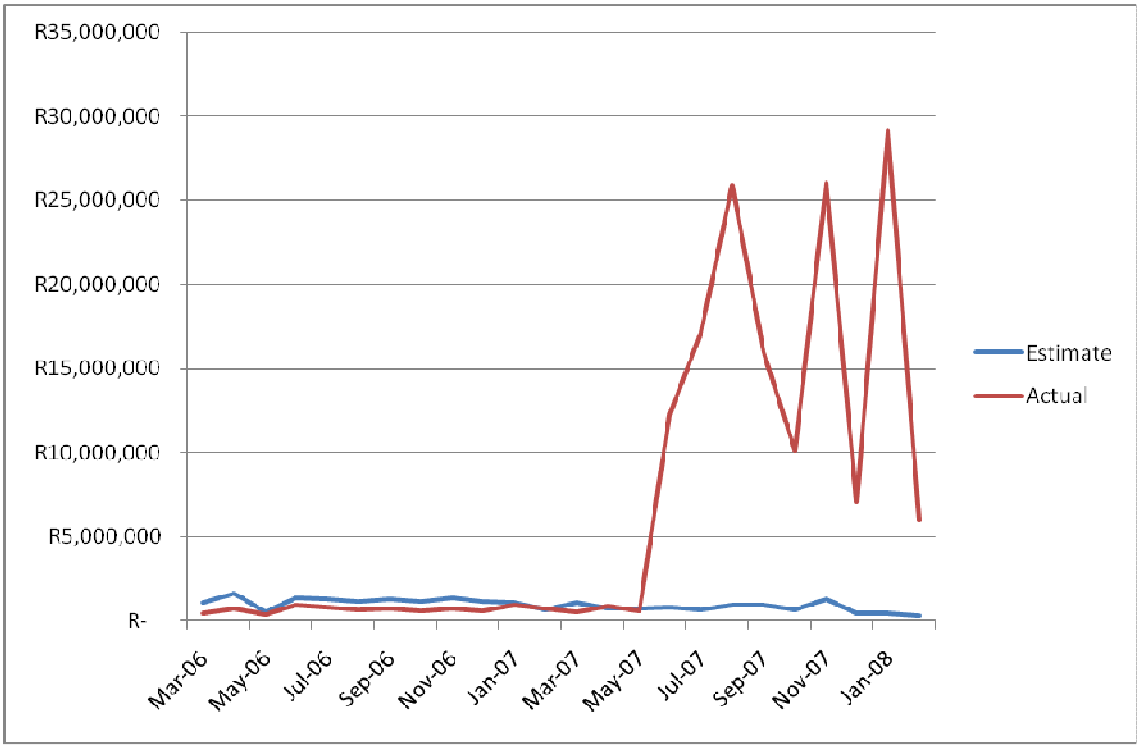

Figure 37: Comparison of estimated and actual storage costs per month

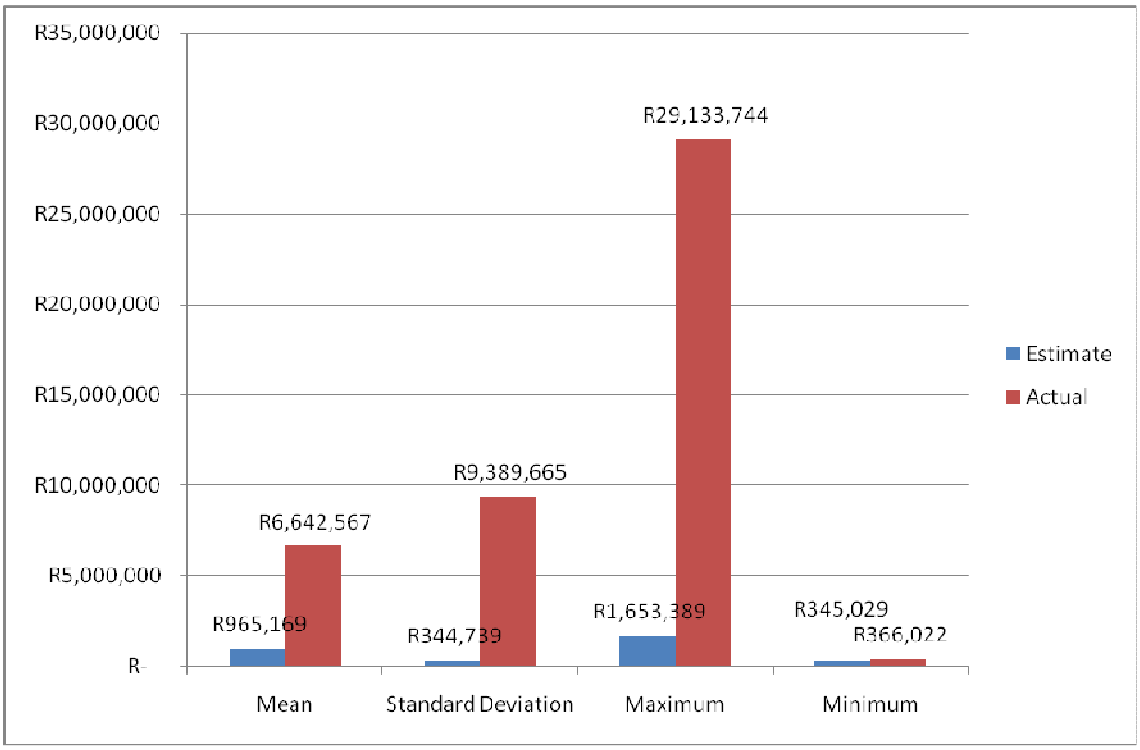

Figure 38: Statistical Analysis of estimated versus actual storage costs

4.5.3 *Inventory Holding Costs*

Both the estimated and actual inventory holding costs have the same trend, with the estimated cost being 1.83 times higher than the actual cost throughout the entire period.

The mean for the estimated cost is R7 343 087 with a standard deviation of R2 657 275. The actual mean was R4 005 320 with a standard deviation of R1 449 422.

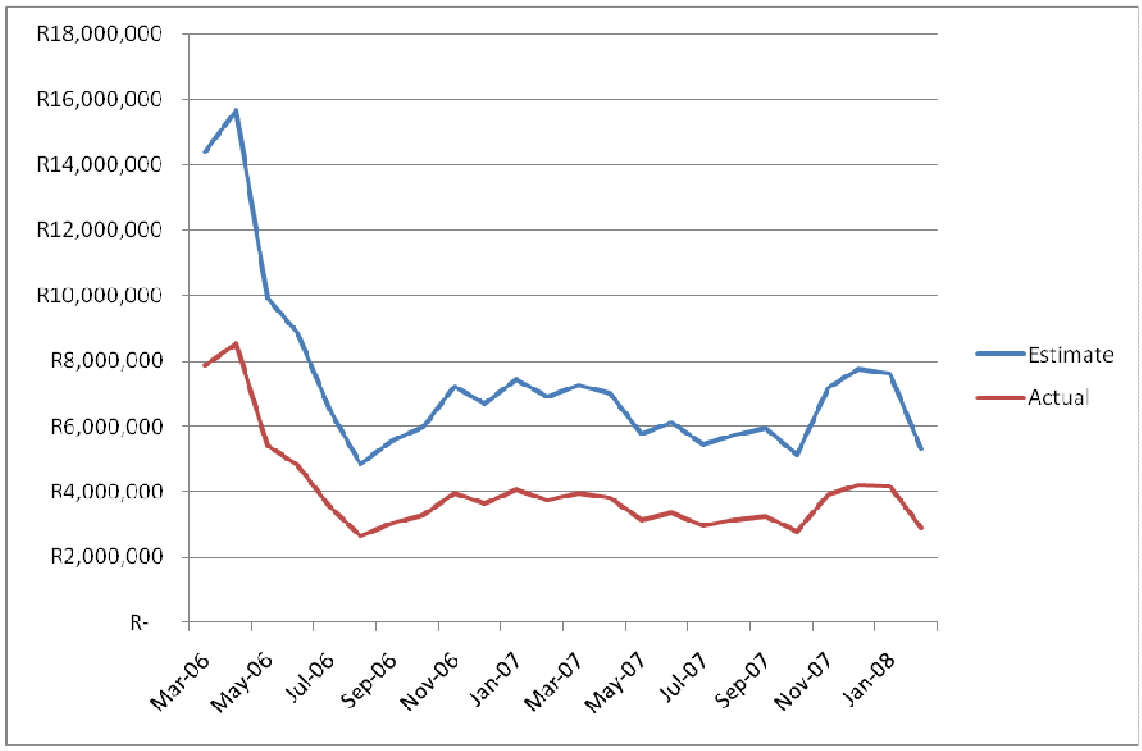

Figure 39: Comparison of estimated and actual inventory holding costs per month

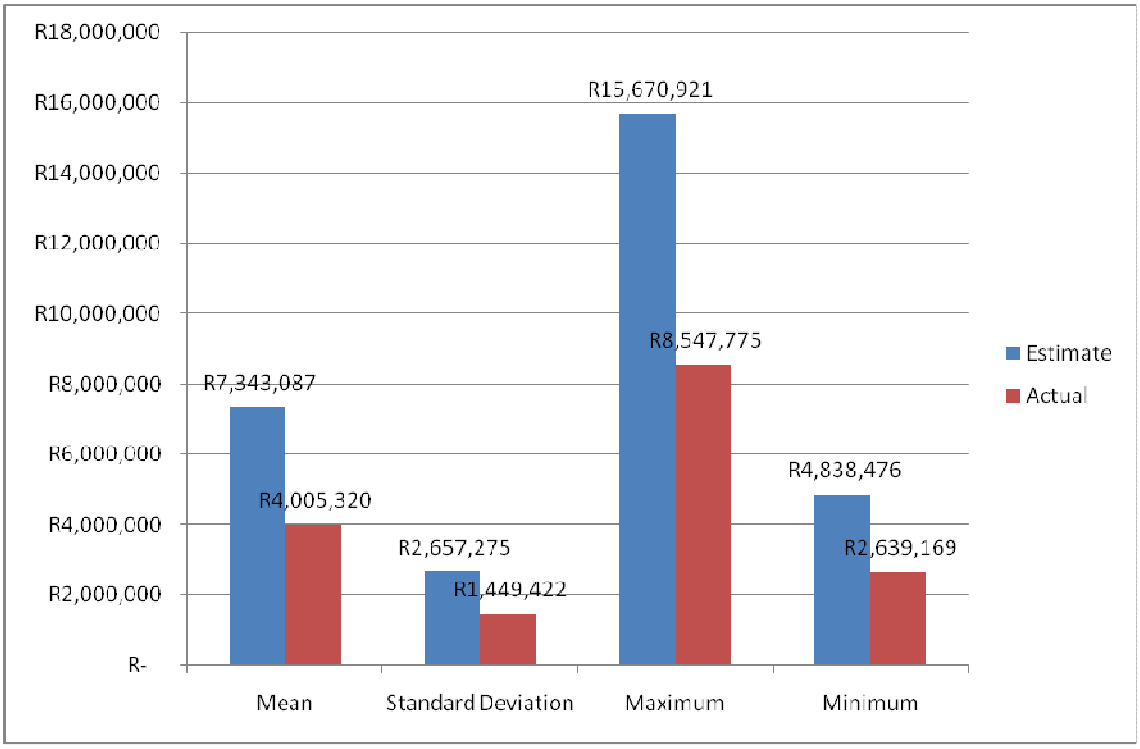

Figure 40: Statistical Analysis of estimated versus actual inventory holding costs

4.5.4 *Correlation Coefficient*

The estimated versus actual costs for storage and personnel have negative correlation coefficients, while that of inventory holding costs have a perfect correlation. Overall, these indirect costs have a correlation coefficient of -0.116.

The correlation coefficient of the estimated versus the actual TCO was very close to having a perfect correlation, viz. 0.998.

When the storage costs were separated into two periods, viz. pre-May 2007 and post May 2007, the correlation coefficients of both these periods improved to 0.36 and 0.49 respectively.

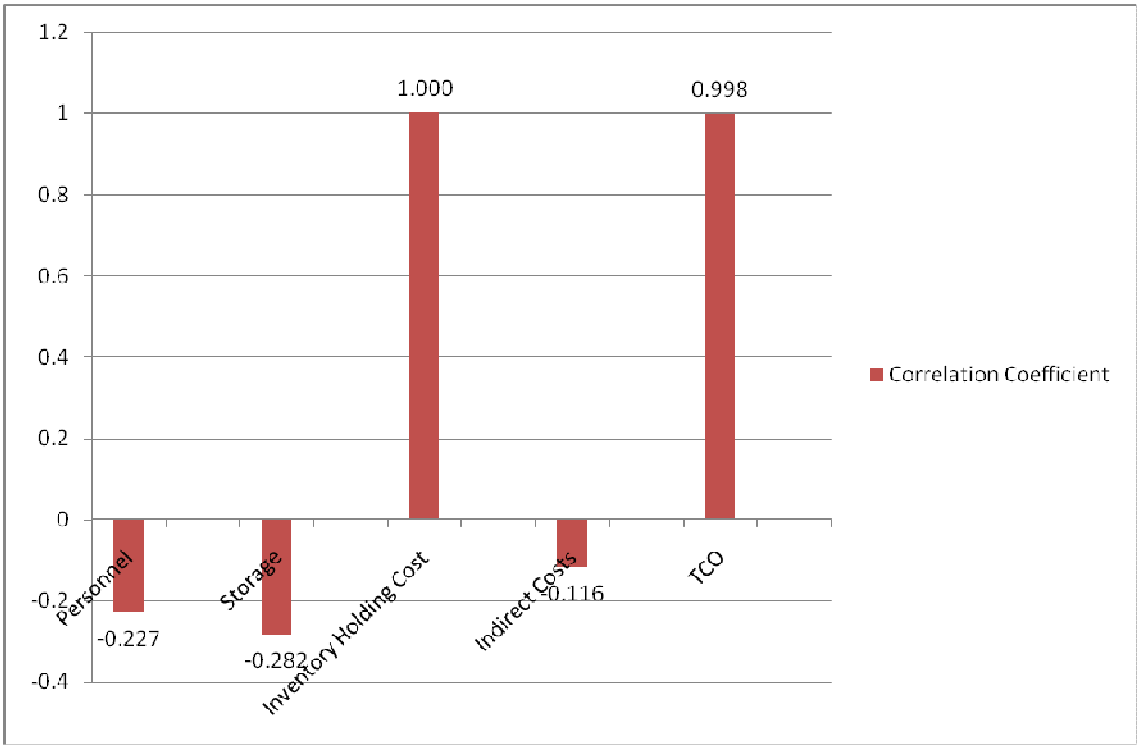

Figure 41: Correlation coefficients of the estimated versus the actual costs

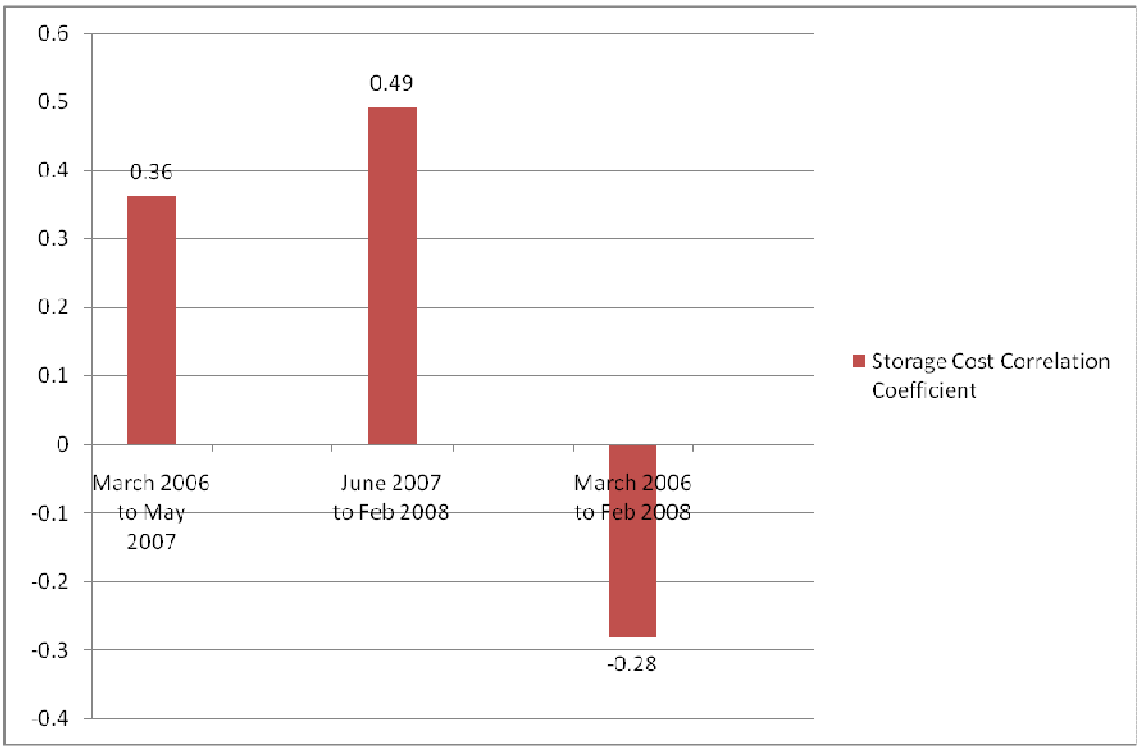

Figure 42: Correlation coefficients of the estimated versus actual storage costs for the different periods

It was found that the estimated personnel costs were the most accurate, being 92% of the actual costs. The storage cost was the least accurate, at 15% of actual costs. Inventory costs were over-estimated by 83%. The estimated indirect costs had little impact on the TCO, with the accuracy being 99% in that case.

Table 29: The accuracy of the TCO study

TCO Element	Accuracy (% of Actual)
Personnel	92%
Storage	15%
Inventory Holding	183%
Total Indirect Costs	78%
TCO	99%

4.5 Summary of the results

The results for both research questions were presented using descriptive statistics entailing time series graphs, calculation of means, standard deviations and correlation coefficients. The data were presented in the form of costs per month and costs per barrel over a 24 month period.

The elements of the crude oil TCO were identified and quantified with methods currently being used within the organisation. The more accurate values were presented for the indirect costs, viz. personnel, storage and inventory holding costs. These were then compared to the estimated costs.

All data displayed in this report have been disguised to protect the company involved. The data in no way can be used to determine the actual cost of crude oil.

CHAPTER 5: DISCUSSION OF THE RESULTS

5.1 Introduction

The intent of this research was firstly to quantify the TCO of crude oil for an oil refinery, and then to analyse its reliability. In this chapter, the discussion will take place around the TCO elements and its estimated values. It will then move on to discussing the comparison between the actual and estimated indirect costs. The aim is to compare the results obtained to literature and to attempt to explain any differences.

5.2 Demographic profile of respondents

The data collected from the archives took a longer time to collect than anticipated, mainly due to missing invoices which had to then be requested from the supplying companies. However, the literature study did reveal that one of the disadvantages of ABC is that data collection is more complicated and rigorous that traditional costing methods.

Respondents to the semi-structured interview were from many different groups in the company and from different geographic locations across the country. Telephonic interviews were conducted with certain individuals who could not be reached. The contribution of the administrative personnel, such as human resources and legal, towards the TCO were considered to be insignificant, and they were not interviewed. The reasoning behind this includes the following:

- These departments are small in comparison to the rest of the company.
- An oil refinery entails many different functions other than crude oil procurement. Thus, the time spent by these departments attending to personnel that are involved in crude oil procurement would be relatively small.

5.3 Discussion pertaining to Research Proposition 1

In analysing the data, it was presented in a set of time series graphs. This form of presentation gives one a visual illustration of how much variability there is in the value of each TCO element over the two-year period in question. The standard deviation, along with the mean, maximum and minimum for each element, were also presented to get an idea of the amount of variability that there is. However, since the data was disguised, the absolute values of these parameters were meaningless. That is why the standard deviations, maximum and minimum, were presented as a percentage of the mean. This gives one a better idea of the variability of each element.

Further to this, the mean of each element was presented as a portion on the TCO, which puts into perspective the magnitude of each element relative to the actual TCO. As a manager or someone who is in crude oil procurement, one has an idea of the elements of the TCO, other than the price, on which to focus. As can be seen, the price is by far the biggest component. Of the non-price elements, freight, transport and inventory holding are the most important elements, and should gain the most focus during the procurement process.

The literature study revealed that in most cases, the most significant element by value is the price of the product in question. In this case, the finding is in agreement with the literature, with the price of crude oil being by far the biggest element, comprising 94% of the TCO. Furthermore, literature revealed that the elements of TCO fall under the following categories:

- Acquisition costs
- Ownership costs
- Post-ownership costs

The elements of the crude oil TCO identified in this study fell in the first two categories only. Some of the acquisition costs of crude oil included the following:

- Purchase price

- Transportation
- Inspection
- Taxes

The ownership costs included the following:

- Insurance (Risk)
- Storage
- Non-value adds costs (Stock holding costs)

This study did not look at post ownership of crude oil, as it is refined into products that are then sold.

It is interesting to note that the cost of transporting the crude oil from the discharge port to the refinery, which is a relatively short distance, is almost the same as the cost of transporting it from the load port to the discharge port, which is usually a distance of several thousand kilometres. It is also interesting to note that the cost of storage and handling, the bulk of which is the holding cost, is almost equal to the cost of freight. These two observations are an indication of the economies of scale that can be achieved by using large shipping vessels to transport goods.

The element with the highest standard deviation relative to its mean is that of demurrage. This is as expected, given the nature of that cost element. Demurrage is not incurred all the time. In fact, there were no demurrage costs for 10 months out of the 24 month period.

For most elements, when the cost per barrel was analysed and compared to the statistics on a cost per month basis, it was found that the standard deviation was lower in the former case. This can be explained by the fact that volumes purchased vary from month to month. The standard deviation of volumes purchased was 31% of its mean.

This leads onto another aspect. The quantity purchased has a relatively high standard deviation, but oil refineries generally process crude oil at a fairly constant rate every month. This indicates that this oil refinery tends to keep sufficient stock on hand at all times. Maybe this is one of the areas that managers can look into to try to curb costs. This is even more important given that the cost of storage and inventory holding is one of the biggest non-crude oil costs. The literature indicates that if demand for crude oil is volatile, then the cost of storage of that crude oil tends to increase due to larger parcel sizes being purchased.

As expected, the crude oil price element and TCO have relatively high volatilities, viz. 41% of the mean. The literature study revealed that the market price of crude oil tends to be volatile, and seeing that the price is 94% of the TCO, then the TCO is bound to have a high standard deviation. What this ultimately means is that timing and the size of parcels purchased are probably the most important variables to be considered when purchasing crude oil.

Conclusion:

The crude oil price is the biggest element of the TCO of crude oil, with Transport and Storage & Handling costs being the most significant of the non-crude oil price elements.

5.4 Discussion pertaining to Research Proposition 2

As with Research Proposition 1, in analysing the data, it was presented in a time series graph, which gives one a visual illustration of how much of variability there is in the value of each TCO element over the two-year period in question. More importantly, the time series graphs give one a visual comparison of the estimated and actual trends of the entire period in question. The standard deviation, along with the mean, maximum and minimum for each element, were also presented, not just to get an idea of the amount of variability that there is, but to compare the estimated and actual values.

The estimated personnel costs are very volatile in comparison to the actual costs. The actual costs are almost constant during the entire period, which increases in value in August 2007 and August 2008. The actual costs were based on the salaries of all the people involved and the proportion of their time spent in crude oil procurement or related activities. On the other hand, the estimated costs were based on an hourly rate and the amount of crude oil procured. This is a very rough method of estimating personnel costs, especially in an environment where labour cost is considered to be fixed in the short term.

The standard deviation of the estimated cost is almost 17 times greater than that of the actual cost. Furthermore, there is no correlation between the estimated and actual costs. The correlation coefficient in this case is -0.227. Hence, the estimated personnel costs are unreliable.

Taking into account the small amount of time that goes into calculating the actual cost relative to the method used for estimating the cost, the recommendation is for the method used in calculating the actual cost to be used in all TCO calculations in the future.

The storage cost was estimated by multiplying a rand per barrel cost to the volume of crude oil purchased. This rand per barrel cost was based on a cost that was calculated in the previous financial year, and is escalated on an annual basis. The actual cost was calculated by looking at the actual invoices charged for storage over the entire year, and by dividing this by the total crude oil and other products being stored at those facilities. The invoices were available on a monthly basis, which enabled the actual storage costs to be calculated on the same basis.

From the time series graph in Figure 37, it can be seen that estimated and actual costs are fairly close to each other until May 2007. In this month the actual cost increases by around 2000% and becomes volatile thereafter, while remaining several orders of magnitude higher that the estimated cost. The reason for this jump in the actual cost is unknown, and could be explained by the sudden realisation that the wrong rate was being charged, or a renegotiation of the contract. Despite this, there is no correlation between the actual and

estimated costs, with the correlation coefficient being -0.282. Hence, the estimated storage costs are unreliable.

However, it must be noted that if the time period is broken up into two periods, viz. pre-May 2007 and post-May 2007, then there appears to be some sort of correlation in these two periods. Given these observations, the recommendation is that the storage cost must be compared to actual costs on a more regular basis, as opposed to once a year. Updates on a quarterly basis will yield a more reliable estimate.

The inventory holding cost was estimated by firstly calculating the average quantity of crude oil held at all the storage facilities. Next, the value of this stock was then calculated, based on the crude oil purchased for that month. It was then assumed that the cash, which is equivalent to value of the stock being held, is reinvested in another part of the company. The resultant return on that cash was then taken as the inventory holding cost.

The actual cost was calculated in a similar manner. Instead of assuming that the cash could be reinvested in another part of the business, it was assumed that the cash would be used to pay the bank overdraft. The interest rate was assumed to be the prime lending rate less two percent. The result was that the return from reinvesting in the business was 83% higher than the bank overdraft interest rate. This resulted in the estimated inventory holding cost being 83% higher than the actual inventory holding cost.

Given the methods used to calculate the estimated and actual inventory holding costs, it is no surprise that these two trends correlate exactly. The option of using the cash equivalent of the stock that was held to pay off the bank overdraft can be considered much less risky than reinvesting it into another part of the business. The assumed return on the latter option is not guaranteed, whereas the savings on the interest paid on the bank overdraft is virtually guaranteed. Hence, the recommendation is that one makes use of the method and assumptions that were used to determine the actual inventory holding cost when estimating this value in all future calculations.

The indirect costs were essentially taken as a summation of the personnel, storage and inventory holding costs. It was found that there is no correlation between the estimated and actual costs, with a correlation coefficient of -0.116. This was as expected, since the personnel and storage costs also gave no correlation. However, even with that being said, the indirect costs are a very small part of the overall TCO. Even though the estimated indirect costs are only 78% accurate, the accuracy of the TCO is only reduced to 99%.

However, one can argue that 1% of a very large number still gives you a large number. In this case, 1% equates to R4.3 million per month, and R52 million per annum. Hence, given the high value of crude oil TCO, one needs to ensure that the estimated costs are more accurate to ensure the reliability of a crude oil TCO study.

The literature study found that increasing the complexity of an ABC study can affect the accuracy and trustworthiness of the results by managers. However, in this case, a more complex study is required owing to the high value of crude oil. Hence, one needs to find the right balance between complexity and reliability. This can only be done by trial and error in the organisation.

In the case of crude oil, there are not many indirect costs that require estimation, i.e. only three elements. Hence, it might not be as time-consuming as with other products to get more accurate and reliable results. As was also revealed in literature, a big investment of one's time is only required upfront. Any subsequent studies done will require much less effort.

It was found during the literature study that there is a positive association between improvement in ROI and ABC implemented in firms where costs are relatively important. Since the oil refining business is a low margin business, the input costs, especially that of crude oil, are very important to the business. Hence, spending more time to improve the reliability of crude oil TCO studies in oil refineries could help the firm improve on its ROI.

Conclusion:

The indirect costs are only 78% accurate when comparing the means of the estimated and actual costs. This is in agreement with the research proposition presented in this section. However, the estimated costs have a higher standard deviation. There are perceived benefits to spending more time in increasing the accuracy and precision of a crude oil TCO study done by an oil refinery.

5.5 Conclusion

As discovered in literature, the data took a long time to capture due to the complexity of ABC over traditional costing methods. It was found that the crude oil price was by far the biggest component of the TCO, which was as expected. It was interesting to note that the cost of transporting the crude oil from the discharge port to the refinery, which is a relatively short distance, is almost the same as the cost of transporting it from the load port to the discharge port, which is usually a distance of several thousand kilometres.

As was expected after the literature study, all elements of the TCO had high standard deviations, both on a rand per month and rand per barrel basis. This was mainly due to the volatile crude oil market price and inconsistent quantities of crude oil being purchased on a monthly basis. It was surprising to note that the quantity purchased had a high standard deviation, especially in light of the fact that the quantity of fuels produced is fairly constant on a monthly basis. This partially explains the relatively high inventory holding costs incurred by the refinery.

It was found that personnel in crude oil companies in South Africa tend to estimate overall indirect cost to an accuracy of 78%. The indirect cost is made of personnel, storage and inventory holding costs. The estimated personnel and storage costs were not correlated to the actual costs, while the inventory holding cost was perfectly correlated. The estimated storage cost would have had a fairly good correlation had it not been for a sudden increase in the actual storage cost. The estimated storage cost is only compared to the actual cost on

an annual basis, and it is suggested to do this on a more frequent basis to address this inaccuracy.

Even though the estimated indirect costs are only 78% accurate, the accuracy of the TCO is only reduced to 99%. However, one can argue that 1% of a very large number still gives you a large number. In this case, 1% equates to R4.3 million per month, and R52 million per annum. Hence, given the high value of crude oil TCO, one needs to ensure that the estimated costs are more accurate to ensure reliability of a crude oil TCO study. Also, the estimated costs have a higher standard deviation. The conclusion is that there are perceived benefits to spending more time in increasing the accuracy and reliability of a crude oil TCO study done by this oil refinery.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

In this chapter, the conclusion of the entire study is summarised, along with recommendations and suggestions for further research.

6.2 Conclusions of the study

The oil refining business is one that experiences low margins in comparison to other businesses. Further to this, the product that it produces, i.e. liquid fuels, has its price regulated in South Africa. In light of this, a significant way of improving its profits is by controlling its input costs, which is mainly the procurement of crude oil. The literature study has revealed that crude oil procurement and scheduling thereof are key activities in oil refineries and require optimal performance of these tasks to ensure profitability.

It was also discovered in the literature study that the TCO concept, which is an ABC method, is being used more frequently by corporates and is mainly used for supplier selection, supplier performance management and to drive major changes in a business. The price is the most significant element of the TCO of most goods and services. Studies reviewed for this report indicate a price component of between 56% and 98% of the TCO. The TCO takes into account all possible costs, and includes elements from pre-acquisition to post-acquisition.

It was found in literature that ABC studies cannot be 100% accurate, and that it takes much more effort to increase that accuracy from 80% than it takes to get it to that point. In general, if an ABC study is too complex, it can affect its accuracy and trustworthiness by the managers.

In this study, the elements of the crude oil TCO were identified and quantified with methods currently being used within the organisation. The more accurate

values were presented for the indirect costs, viz. personnel, storage and inventory holding costs. These were then compared to the estimated costs. The results for both research propositions were presented, using descriptive statistics entailing time series graphs, calculation of means, standard deviations and correlation coefficients. The data were presented in the form of costs per month and costs per barrel over a 24 month period.

The crude oil price is the biggest component of the TCO, comprising 94% of it. Of the non-crude oil price costs, which was 6% of the TCO, transport costs made up more than 60% of this category. Storage and handling was the next biggest component, making up around 30%. It is interesting to note that the cost of transporting the crude oil from the discharge port to the refinery, which is a relatively short distance, is almost the same as the cost of transporting it from the load port to the discharge port, which is usually a distance of several thousand kilometres. This showcased the economies of scale that can be achieved by the use of very large ocean vessels. The literature study indicated that the most economical means of transporting products of relatively low value to weight ratio are via very large ocean vessels.

It was found in this study that the estimated overall indirect costs were 78% accurate. Further to this, the estimated costs had a higher standard deviation than the actual costs, thus indicating its higher degree of volatility over the 24 month period. In spite of this, the estimated TCO still had an accuracy of 99%. However, one must take note that the crude oil TCO is still a relatively high value, and 1% equates to roughly R52 million per annum. Hence, one needs to ensure that the estimated costs are more accurate to ensure reliability of a crude oil TCO study.

There are perceived benefits to spending more time in increasing the accuracy of a crude oil TCO study done by the oil refinery. This study indicates that there is room to improve the accuracy and reliability of a crude oil TCO study, which can result in improved profits for the oil refinery.

6.3 Recommendations

Given the results on the accuracy of the crude oil TCO study in the chosen organisation, the main recommendation goes out to procurement managers in oil refineries in South Africa. Crude oil TCO studies should be done to a reasonable level of accuracy. To achieve this, one needs to spend a lot of time doing the initial study, especially in identifying the cost drivers of personnel costs and determination of the actual storage costs at least once every four months, if not every month.

When determining the inventory holding costs, one should assume a risk free return on cash that is tied up in stock holding, such as paying off the bank overdraft instead of investing in other parts of the business which are of a higher risk. This is a more realistic method to use, and does not escalate a component of the TCO that is already of a relatively high value.

It is recommended that crude oil procurement managers maintain a low variability in the quantity of crude oil purchased on a monthly basis, to match the variability of the rate at which it is processed at the refinery. This would ensure that the inventory holding costs are minimised, thus improving the profitability.

Lastly, anyone who is currently looking at building a new refinery in South Africa must consider all aspects of crude oil procurement, especially the variability of the quantities purchased on a monthly basis, when looking at the economics of the venture.

6.4 Suggestions for further research

One of the recommendations of this research is to maintain a low variability of quantity of crude oil procured on a monthly basis. Further research is required to determine the actual effect on the profitability of oil refining by varying the quantities of crude oil purchased monthly.

Another aspect that can be researched further is the amount of time or effort that is required to improve the accuracy of indirect costs of the crude oil TCO closer to 100%.

In addition, the South African fuel industry will see some changes coming into effect in the near future. Some of these changes include the construction of a pipeline to transport fuel and crude oil into the inland region of the country, and the possible tightening of fuel specifications. A study can be done to analyse the effects of these changes on the input costs and profitability of a South African oil refinery. How can TCO studies assist refineries in these new environments?

Another area of research could entail investigating the entire oil refining industry in South Africa, and not just a single company. It would be interesting to see whether the same findings for the chosen organisation actually do apply to the entire industry.

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APPENDIX A

Actual Research Instrument: Questions for Interviewees

General:

1. What is your name?

2. What is your job title?

3. What is your job level in this company?

4. Which department do you work in?

5. What percentage of your time is spent on the procurement of crude oil, or activities related to crude oil procurement?

6. List the members of your department, and their respective levels.

Questions specific to Cost Accountant:

1. List the elements of the TCO of crude oil.

2. What method was used in quantifying each element?

APPENDIX B

Consistency matrix

Determine the elements of a total cost of ownership calculation done for imported crude oil for a South African oil refiner, and assess the reliability and accuracy of it.					
Sub-problem	**Literature Review**	**Hypotheses or Propositions or Research questions**	**Source of data**	**Type of data**	**Analysis**

Determine the elements of a total cost of ownership calculation done for imported crude oil for a South African oil refiner, and assess the reliability and accuracy of it.					
Sub-problem	**Literature Review**	**Hypotheses or Propositions or Research questions**	**Source of data**	**Type of data**	**Analysis**
The first sub-problem is to determine the elements of the TCO of imported crude oil for a South African oil refiner.	Davidson et al (2006) Dees et al (2007) Degraeve et al (2005) Ellram (1995) Ellram (2006) Ellram and Sieferd (1998) Guyonnet et al (2009) Janhonen (2008) Julka et al (2002) Pan et al (2009) Song et al (2007) Wouters (2008) Young et al (2009)	The elements of a TCO of crude oil purchased by a South African oil refinery will include the following: price, transportation, customs duty, storage costs, and administrative overhead costs.	Archival – data was retrieved from original invoices found in the archives of the chosen oil refinery.	Nominal (ratio data)	Descriptive statistics.

Determine the elements of a total cost of ownership calculation done for imported crude oil for a South African oil refiner, and assess the reliability and accuracy of it.					
Sub-problem	**Literature Review**	**Hypotheses or Propositions or Research questions**	**Source of data**	**Type of data**	**Analysis**
The second sub-problem is to assess the reliability and accuracy of a TCO analysis done for imported crude oil for a South African oil refiner.	Barrett (2004) Baykasoglu and Kaplanoglu (2008) Cagwin and Bouwman (2002) Homburg (2001) Noreen and Soderstrom (1997) Stapleton et al. (2004)	For the TCO analysis done for imported crude oil for a South African oil refinery, the indirect cost portion will have an accuracy of around 80%.	Archival – data was retrieved from original invoices found in the archives of the chosen oil refinery.	Nominal (ratio data)	Descriptive statistics.

Total cost of crude oil ownership for South African oil refiners

Kiren Bageloo

A research report submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Business Administration

Johannesburg, January 2011

ABSTRACT

The modern world is dependent upon the continuous production of liquid fuels, most of which are derived from crude oil. South Africa has very limited reserves of crude oil, which means that the five oil refineries located within its borders have to import most of their requirements. Adding this to the fact that fuel prices are regulated in South Africa and that oil refining is a low margin business, it then becomes evident that these companies have to do as much as they can to keep costs low in order to optimise profits.

One of the tools that can assist managers in oil refineries in identifying points of leverage in procuring crude oil, is a total cost of ownership (TCO) analysis. The literature review highlighted that TCO studies, a form of activity based costing (ABC), is more complex than traditional costing methods, which hinders it use and affects its trustworthiness in practice. Furthermore, it was found that there is a trade-off between complexity and accuracy.

The aim of this research was to identify the elements of crude oil TCO for a South African oil refinery and the accuracy and precision thereof. The method of data collection was via semi-structured interviews and archival data retrieval. The aim was firstly to determine how the TCO was calculated in the chosen organisation, and then to use the information from the semi-structured interviews and archives to determine the actual TCO. This was then used to determine the accuracy of the TCO analysis done by the chosen company.

It was found in this study that the accuracy of the indirect cost element of the TCO was only 78% and had a higher standard deviation than the actual costs. The conclusion is that although this level of accuracy compares to other studies done in practice, there is still room to improve the reliability of current crude oil TCO analyses that are carried out in the chosen organisation, simply due to the high value of crude oil. Given that there is a correlation between improvement in ROI and the use of ABC methods, the conclusion is that more accurate TCO studies are important for low margin businesses such as oil refining.

DECLARATION

I, Kiren Bageloo, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Kiren Bageloo

Signed at ……

On the …….. day of …… 2011

DEDICATION

To my wife, Kash, who supported me throughout this enduring period, and who has shown me that patience is truly a virtue. You were my pillar of strength when I needed it and an inspiration during the toughest of times.

AND

To my Parents for making me into what I am today, and for providing me with the ethically and morally sound foundation that I have used to enjoy life.

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My sincere appreciation goes out to my supervisor, Dr Anthony Stacey, for his assistance, advice and support. I truly appreciate the time that was spent in helping me get through this experience and for pushing me in the right direction when I felt lost, which was on many occasions.

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To all that have assisted me along the way, be it at my place of work or at the faculty, I thank you for your contribution.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

1.1 Purpose of the study

The purpose of this research is to identify the points of leverage that South African oil refiners have in reducing the total cost of procuring, handling and using crude oil in the manufacture of petroleum products, by looking at the elements, reliability and accuracy of such calculations. The analysis will start from the point that the crude oil is planned for and end at the point where processing of the oil into fuel begins. In doing so, data from a single South African oil refiner was collected and analysed.

The results will give management personnel at oil refineries an indication of the different elements of the total cost of ownership (TCO) of crude oil and their relative value to each other, along with the reliability and accuracy of these elements. Furthermore, this report will assist management in developing the right crude oil procurement strategy by giving them an indication of which areas of crude oil TCO to place the most emphasis on in order to reduce crude oil costs.

1.2 Context of the study

The modern world is dependent upon the continuous production of liquid fuels such as petrol, diesel, jet fuel and other heating fuels, most of which are derived from fossil fuels. Crude oil derived liquid fuels constitute the majority of the fuels produced around the world, and this is the most traded commodity (Smith 2009). This means that almost every country in the world is dependent on crude oil, thus putting the countries that have crude oil reserves in good stead. Additionally, the author points out that the majority of reserves of crude oil are concentrated in the Middle East and North Africa, whereas the United States, Europe, China and Japan account for nearly all of the imports. Thus, it is no surprise that most of the aforementioned countries are among the richest in the world.

South Africa has very limited oil reserves, which is why about 80% of its crude requirements are met by imports from the Middle East and Africa (Vanderschuren, Jobanputra and Lane 2008). The authors have also looked at the growth of fuel demand in South Africa up to 2033, and state that demand for fuel, specifically road transport fuel, will continue to grow during this period. To add to this complexity, South Africa is situated relatively far away from these countries, which increases the overall cost of procurement of crude oil for South African oil refiners.

Oil refining is a low margin business, with margins currently in the $1-10 per barrel range (Pan, Li and Qian 2009; Hardy 2010). Since crude oil is presently around $70 per barrel (Bruce 2010), this creates a situation whereby crude oil refiners are subject to a high variable cost component. Therefore it is likely that if these firms can find ways of achieving any savings on crude oil procurement costs, then this will have a positive impact on their refining margin, and hence profit. Some companies such as Total and BP already have this advantage. Both these companies own crude oil fields (Houser 2008), which means that they are not obliged to purchase all of the crude oil requirements from other companies or from the Middle East. However, there still are many other companies that do not own any crude oil fields and have to purchase all of the required crude oil from the open market.

As can be seen in figure 1 below, there are presently six refineries in South Africa. Davidson, Winkler, Kenny, Prasad, Nkomo and Sparks et al. (2006) estimate the combined refining capacity of these plants to be 676,000 barrels per day of equivalent fuel. Further to this, due to demand being higher than production, the country imports a significant quantity of fuel. It is estimated that around 10 billion litres per annum of fuel imports will be required by 2015 (PetroSA 2010).

Four of the refineries produce fuel from crude oil, with the fifth one being a coal based plant owned by Sasol (Davidson, Winkler, Kenny, Prasad, Nkomo, Sparks et al. 2006). This coal to liquids plant, along with Natref, is the only producer of fuel in the inland region where Johannesburg, the business hub of

South Africa, is located. The remaining refiner produces fuel from gas, and is located along South Africa's southern coast.

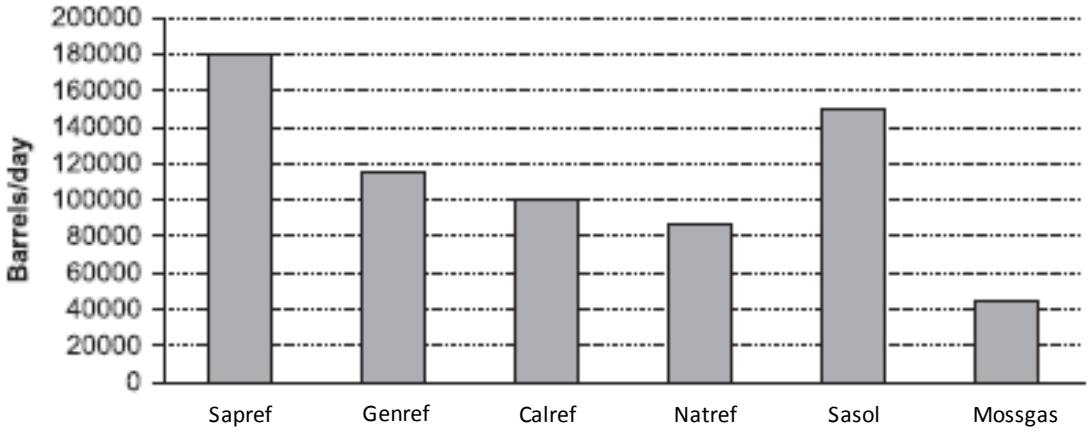

Figure 1: Sizes of South Africa's fuel production facilities

(Davidson et al. 2006: 56)

Fuel prices in South Africa are regulated by the government (DOE 2010). The prices of both petrol and diesel used at the wholesale level are regulated, while at the pump, only the retail price of petrol is regulated. Even though these regulated prices are linked to the international price of crude oil, steady profit margins are not guaranteed, due to crude oil prices fluctuating on a daily basis.

With demand for fuel continually on the increase (Smith 2009), the world is bound to see the construction of more oil refineries to meet this demand. In fact, the South African government, along with PetroSA, is currently evaluating the prospect of building another refinery in South Africa (PetroSA 2010). The government-owned fuel company further states that this refinery will process 400,000 barrels per day of crude oil and will be the largest in Africa. Even though this might be a potential solution to address the underproduction of fuel in South Africa, this new refinery will create a situation where there would be an oversupply of fuel in the country. Hence, there would be a greater need for existing refineries to find ways of cutting costs to be more competitive. One of the tools that can be used in assisting oil refiners in identifying points of leverage in reducing crude oil procurement costs is a Total Cost of Ownership (TCO) analysis.

Ellram and Siferd (1998: 56) define TCO as “a purchasing tool and philosophy aimed at understanding the relevant cost of buying a particular good or service from a particular supplier”. They further make a point of how it is an important tool that can be used to support the company’s strategic management, and that it is a complex tool that involves identifying which costs are most relevant in the acquisition, possession, use and disposition of a good or service. Young and Swan (2006) identify the elements of the landed cost, which is related to a TCO, of imported products to include price, transportation, customs duties, inventory management, administrative overheads and risk. The authors have attempted to develop a six stage model which addresses the elements mentioned above, and allows procurement departments to make informed sourcing decisions. Given this, and the fact that an average manufacturer spends around 56% of sales revenue on managing purchased goods and services (Handfield 2006), it seems that a TCO analysis could possibly be used by South African oil refiners in assisting them to identify opportunities to reduce their TCO of crude oil. An analysis of the TCO of crude oil for a South African oil refiner was, with the intention of using the results to identify points of leverage to reduce a firm’s crude oil TCO.

1.3 Problem statement

1.3.1 *Main problem*

This is to determine the elements of a total cost of ownership calculation done for imported crude oil for a South African oil refiner, and assess the accuracy and precision of it.

1.3.2 *Sub-problems*

The first sub-problem is to determine the elements of the TCO of imported crude oil for a South African oil refiner.

The second sub-problem is to assess the accuracy and precision of a TCO analysis done for imported crude oil for a South African oil refiner.

1.4 Significance of the study

The study fills a gap in that there is currently no research on the use and reliability of TCO analyses on imported crude oil or other imported commodities. Furthermore, there is no research on the aspects of crude oil TCO that South African oil refiners should focus on, in order to optimise their time and money spent on the procurement, handling and use of crude oil.

Unusually high refining margins over the recent past have resulted in oil refiners seeing increased profits (Hardy 2010). This has resulted in inefficiencies in certain parts of the business, such as crude oil procurement, being camouflaged. With the subsequent collapse of the oil price to around $36 per barrel, and a similar drop in refining margins, oil refiners were suddenly forced to find avenues to reduce costs. Hence, this study will provide guidance to managers of oil refineries in South Africa in doing so, by understanding the make-up of the TCO for crude oil that is imported; and also understanding which elements of the TCO, besides the purchase price, require the most attention.

Anyone who is looking at the prospect of building new refineries in South Africa will find this study useful when determining the feasibility of such ventures. In the analysis, all the elements of the TCO of crude oil can be identified and taken into account, thus making a more accurate financial model of the proposed business venture.

1.5 Delimitations of the study

- The data was collected from one South African company only.
- The data was collected for a period when crude oil prices were relatively high compared to the periods prior to that. If crude oil prices had to fall to levels experienced in the period prior to that used, then the recommendations to oil companies might be different.

- The TCO analysis starts at the beginning of the crude oil lifecycle, i.e. the planning phase, and ends at the point of processing. It does not include the processing of crude oil.

1.6 Definition of terms

- Total cost of ownership (TCO) - a purchasing tool and philosophy aimed at understanding the relevant cost of buying a particular good or service from a particular supplier (Ellram and Sieferd 1998).

1.7 Assumptions

- The data obtained from the oil refiner is deemed accurate.

The reason for assuming this is that the data that was collected was read off invoices containing the actual costs. These costs can only be incorrect if these invoices were tampered with, which has a very low probability. If for some reason the data is inaccurate, then the results of this research will not reflect reality and will have a degree of inherent error, in the sense that the results of the actual TCO studies done by the chosen oil company will be either more accurate or less accurate than what is concluded from this study.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

A literature review of the key themes pertaining to this study has been outlined in this section. It starts off by looking at the crude oil literature and its components, viz. price, procurement at refinery operations, transport and storage. The review then follows on to consider the concept of TCO, examining its elements, looking at barriers to implementation and at TCO studies that have already been done. It proceeds to review the concept of activity-based costing, and the accuracy and reliability thereof. It ends with a summary of the key elements learnt from this literature review.

2.2. Background discussion

Modern oil refineries are operationally complex and have four main areas of operation, viz. planning, tanker-lightering operations, sales and scheduling. Crude oil procurement is integrated across several areas of the business, and should be performed efficiently to ensure profitability of the refinery (Julka, Karimi and Srinivasan 2002; Pan et al. 2009). Scheduling at an oil refinery entails decision-making according to the times and sequences of the receiving of the crude oil, and itself is important to the running of the refinery business.

Many organisations have looked into applying the TCO concept in their procurement departments or to include it in their strategies (Ellram 1995; Ellram and Sieferd 1998; Ellram 2006; Song, Platts and Bance 2007). An average manufacturer spends 56% of its revenue on managing the purchase of goods or services (Handfield 2006). Thus, companies stand to gain a lot by placing more focus on procurement activities. Also, given the importance of crude oil procurement to oil refineries, a TCO approach might be a good way of further optimising this process.

This literature review will focus on the crude oil procurement process at oil refineries and the TCO concept, TCO analyses of products that are available in literature, along with the reliability of activity-based costing methods.

2.3. Crude Oil and Total Cost of Ownership

2.3.1 *Crude Oil*

In this section, the focus will be on the following aspects of crude oil:

- Procurement at Oil Refineries
- Price
- Transportation and Storage

There has been some documentation in literature on these aspects. In addition, the price and transportation form part of the TCO of crude oil, and it is anticipated that these two aspects will be the major contributors to the TCO, and will be reviewed in the sections that follow.

Procurement at Oil Refineries

Crude oil procurement is one of the many tasks that are involved in running a crude oil refinery. The other significant tasks include logistics, scheduling, refining and final product blending, all of which can be further broken down into many other sub-tasks (Julka et al. 2002; Guyonnet, Grant and Bagajewicz 2009; Pan et al. 2009). Furthermore, Pan et al. (2009) allude to the fact that modern refineries are operationally complex and low margin, while operating in a highly competitive industry. This makes the procurement of crude oil particularly important in ensuring that these refineries obtain good profit margins. This is further substantiated by Julka et al (2002), who state that efficient and optimal crude procurement is essential in the profitability of the refinery.

Further to this, the crude oil procurement department needs to be integrated with the other departments in the refinery supply chain to achieve a competitive

advantage in today's business environment (Julka et al. 2002). Kaufmann, Dees and Mann (2009) also talk about the oil industry supply chain. They believe that aspects of oil refining, viz. crude oil price, inventory levels and utilisation rates, are influenced by changes in the energy supply chain that are transmitted horizontally and vertically. Horizontal changes are generated by fuels at a similar stage in processing, e.g. crudes of different grades, while vertical changes are along the supply chain of a particular business, e.g. the price of crude oil being influenced by refining margins or the price of the final product.

The first aspect of procurement, and not just for crude oil, but for any commodity, is the selection of the grade to be used (Karmarkar and Rajaram 2001; Julka et al. 2002). Ultimately, the grade is selected to meet product demand. However, there are normally several choices available in doing so. Some of the decisions that are encountered include selecting the grades to be used, determining the quantity of each grade and how to blend them. According to Julka et al (2002), this is normally done periodically at fixed or variable intervals, which are typically four to five days in length. The crude is also purchased 30 to 45 days in advance, which is known as the lead time. However, this is dependent on the source of the crude oil and its relative location to the refinery. For example, it will take a longer time for crude oil to be delivered from Saudi Arabia to Germany, than to South Africa.

Price

The crude oil price has been well researched recently, especially after it spiked to over $140 per barrel in 2008 (Dees, Karadeloglou, Kaufmann and Sanchez 2007; Persson, Azar, Johansson and Lindgren 2007; Borenstein 2008). While the exchange rate and speculation might possibly be two of the causes of the oil price spike, Borenstein (2008) believes that the main reason for this is a simple one, namely that demand for oil is much greater than supply. He attributes some of the contributors to this growing demand as coming from the major developing countries, viz. China, India and others. As more people from these countries earn more money, more of them can afford automobiles, thus increasing the demand for fuel.

To add to this, supply of oil has not increased as fast as demand. It seems that certain dominant suppliers, such as Saudi Arabia, are hesitant to increase supply into the market to meet the extra demand. In fact, they have decreased supply recently. Furthermore, mismanaged oil fields, domestic conflicts and well depletions have added to the problem of too little supply (Borenstein 2008).

Dees et al (2007) does not concur with Borenstein (2008) on the main reason for the price increases. The authors allude to the fact that production of oil increased significantly between World War II and the 1970s despite a decline in the oil price, and in the 1980s when the oil price increased, production declined. They attribute these contradictions to factors such as resource depletion, technical change, economic incentives and political considerations. They do, however, agree that the OPEC countries are the dominant suppliers and can influence the oil price, and that the price is relatively volatile. These factors make it difficult to model. Even so, they did attempt to model the oil price, and found that for non-OPEC production, oil demand and oil supply is quite inelastic over the medium term, i.e. 3 to 5 years.

Persson et al (2007) have also attempted to model the oil price. They go one step further than Dees et al (2007) by including the effect of the production and supply of fuel from tar-sands, coal, hydrogen fuel cells, and also the impact of carbon taxes. As can be seen in Figure 2, oil is expected to be almost depleted by 2050, with coal, oil shale and nuclear becoming the dominant sources of energy. The assumption is that the current proven reserves of crude oil amount to 6300 EJ. The results indicate that a carbon tax will result in increased revenue for oil producers, while competing technologies such as hydrogen fuel cells will result in a drop in the oil price.

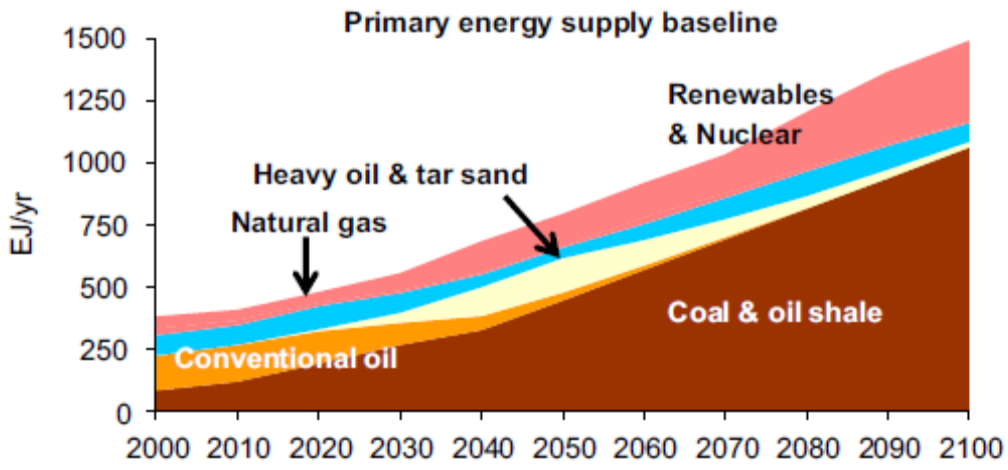

Figure 2: Assumptions of Persson et al (2007) oil price model

According to Borenstein (2008), the exchange rate is another factor that affects the price of crude oil. Thus, the strength of the US dollar affects the world supply/demand balance of crude oil. For example, a purchaser from a country that has a currency that is appreciating against the US dollar will have a relatively lower price of crude oil, which then increases the demand for oil in that country.

Borenstein (2008) also addresses the issue of the role of speculation in the oil market. There have been some commentators who blame speculators for driving up the oil price by purchasing long-term oil futures as part of a hedging strategy. These long-term futures are pulling spot prices through an intertemporal arbitrage. Borenstein (2008) disagrees with this theory, stating simply that the high oil prices were matched by real physical demand in the market. There would not have been sufficient customers in the market if the oil price were artificially high.

Transportation and Storage

Once the crude oil is purchased, it then has to be transported to the refinery, unloaded and stored before being processed. The transportation is usually done with very large crude carriers (VLCCs) which carry several parcels of different crudes, which could be for different customers (Pan et al. 2009). The decision-making process used to determine the times and sequence of the unloading

and storage of crude from several different VLCCs is referred to as crude oil scheduling. Crude oil scheduling is another important aspect of the oil refining business, and is dependent on a number of factors, such as the lead time of crude delivery, the number of storage tanks, their capacities, the number of VLCCs that can be unloaded at any time, inventory levels and the processing rates of the refinery (Julka et al. 2002; Pan et al. 2009).

According to Pan et al. (2009), the primary objective of crude oil scheduling is to maximise the total gross profit of the refinery, which is the netback from crude oil minus operating costs. One of the key operating costs is demurrage, which is incurred if the time taken by a VLCC is longer than the time stipulated in the contract between the two parties involved.

Julka et al. (2002) have developed a model that can be used for crude scheduling. This model was then used on three illustrative case studies:

Impact of Procurement Policy:

This study analysed the effect of choosing fixed crude parcel sizes over variable sizes. The result of the simulation indicated that the variable parcel size policy reduced the throughput and inventory of the refinery by 6%. However, it failed to provide enough crude oil to run the plant at maximum throughput.

Effect of Demand Fluctuation:

The results of this study indicated that volatile demand requires the purchase of larger parcel sizes. In order to accommodate these larger parcel sizes, sufficient storage capacity is required. All of these must be taken into account by the scheduler.

Benefit of Extra Storage:

The results of this study indicated that extra storage capacity can be used to accommodate the larger parcel sizes required to meet volatile demand. However, an economic analysis of the trade-off between additional capacity and increased sales must be done to validate the capital spend that is required for this extra capacity.

The nature of the transport business ensures that the heaviest goods travel via ocean, as opposed to air (Hummels 2007). Air transport is much faster than ocean and thus dictates a much higher price. Goods can be delivered as quickly as one day, while delivery by ocean takes weeks, depending on the relative locations of the source and destination. To add to this, time does not matter much for bulk commodities which have long shelf lives and are simple to manufacture (crude oil being one of them). These are the reasons why ocean shipping constitutes 99% of world trade by weight.

Hummels (2007) also points out that the value of the product relative to its weight (value/weight ratio) determines which mode of transport should be used. For example, shipping cost could be 25% of the cost of wine, while this ratio could be as low as 1% for electronic products, even though one needs to take out higher insurance policies for the electronic products. In fact, it is estimated that a 10% increase in the product price results in an 8.6% decrease in the ad-valorem transport cost (Hummels and Skiba 2004).

Another interesting point to note is that, after taking US gross domestic product (GDP) and price inflation into account, shipping cost per unit of mass of bulk commodities has been steadily declining since the 1950s (Hummels 2007). This can be attributed to changes in technology, larger and faster vessels, and the increase in loading and unloading times over the years. However, note that these findings are for commodities in general, and there is no mention of the shipping of crude oil specifically.

2.3.2 *Total Cost of Ownership*

TCO, which is a relatively new topic in the business world, has had some research done on it, and is slowly gaining momentum in terms of usage by corporate entities (Ellram 1995; Hurkens and Wynstra 2006; Song et al. 2007; Janhonen 2008). In general, when making purchasing decisions, managers weigh different alternatives based on certain criteria. In the most basic case, the only criterion is the price of the product in question (Hurkens and Wynstra 2006). In most cases, the company stands to benefit if all costs are taken into account with a tool like TCO, when making purchasing decisions.

Ellram (1995) expands on this by emphasising that the TCO concept is a complex approach, which entails the consideration of the most significant or important cost elements in the acquisition, possession, use and subsequent disposition of the goods in question.

Degraeve et al. (2005), Wouter et al. (2005) and Janhonen (2008) also give a similar view on the concept of TCO and go even further by classifying it as a concept of activity based costing (ABC).

Elements of TCO

The price of a product or service is in most cases the biggest element by value. The elements other than price may include elements such as order placement, research and qualification of suppliers, transportation, receiving, inspection, rejection, replacement, downtime caused by failure, supplier management, disposal costs, and so on (Ellram 1995; Song et al. 2007). The elements are not necessarily the same for different products or services, and have to be determined through proper investigation.

Janhonen (2008) has a similar view, and has broken up the TCO costs elements into three categories, viz. acquisition, ownership and post-ownership costs. The elements of each category have been broken down further:

- Acquisition Costs:
    - Purchase Price
    - Planning Costs
    - Quality Costs
    - Taxes
    - Financing Costs

- Ownership Costs:
    - Downtime costs
    - Risk costs
    - Cycle time costs
    - Non-value add costs
    - Supply chain or supply network costs

- Post-ownership Costs:
    - Salvage value or disposal costs
    - Environmental costs
    - Product liability costs
    - Customer dissatisfaction costs

An aspect that was not analysed in this review has to do with the elements of TCOs that cannot be quantified. One needs to determine how to deal with these elements in the TCO analysis. For example, in most cases the reputation of the supplier is an important criterion. This needs to be quantified and included in the TCO when deciding on which supplier to choose. However, it must be noted that there was mention that aspects such as flexibility and customisation are difficult to include in TCO analyses (Kumara, Anderssonb and Rehmec 2010).

Another aspect that was not identified in this review has to do with departmentalisation of organisations. One will find that the different elements of the TCO of a particular product could lie across several departments, and each department only looks at the elements that are relevant to that department. For example, in importing wheat from Europe, the TCO will include the following elements: (i) price, (ii) transport, and (iii) storage, all of which lie in different departments.

Application of TCO Analyses

TCO analyses are used for several different reasons by corporates in business today. However, there are three primary reasons for its use, as follows (Ellram 1995):

i. Supplier selection: This merely entails choosing the supplier for the right reasons.
ii. Supplier performance measurement: This relates to maintaining a relationship with a supplier over time and assistance with identification of improvement opportunities. Supplier management and supplier selection normally go hand in hand, and are the primary driving forces behind TCO adoption.

iii. Driving major process changes: When a company plans to undergo major changes, for whatever reasons, TCO can be used to determine the best way forward.

Other reasons for using TCO include the following: (i) to provide data for negotiations; (ii) to concentrate resources on the important purchases; (iii) supply base reduction/volume allocation decisions; (iv) to improve organisations' decision making; and (v) to reduce costs / cost management (Ellram 1995; Degraeve, Labro and Roodhooft 2005; Ellram 2006).

	Organization											
Reason	A	B	C	D	E	F	G	H	I	J	K	% indicating
High dollar value		X	X	X	X	X	X			X	X	73%
Ongoing, repetitive buys	X	X			X	X	X	X				55%
Important to other decisions				X						X		18%
Outsourcing potential									X	X		18%
Difficult to manage	X											9%

Categorized above based on:

Firm	Characteristics of Purchases Analyzed
A	bottleneck items, repetitive, high risk
B	$100,000 and above, ongoing
C	major purchases—all sector-level decisions, beyond that it is at the discretion of the commodity team
D	major productive capital expenditures; can also vary other input costs/yield like raw materials, supplies—see effect of differential performance over equipment life
E	all production inputs—up to teams if they actually want to use
F	commodity purchases, significant expenditures
G	repetitive, long-term buys
H	routine, repetitive purchases with a history
I	high level decision, "cost take-out opportunity" on processes
J	major purchases with a process focus, may consider many costs simultaneously
K	up to team; big dollar items, cost-benefit consideration

Table 1: General characteristics of buys considered for TCO analyses

(Ellram and Sieferd 1998)

Essentially, TCO is potentially an instrument for management of purchases, at whatever level it may be. However, in applying it in practice, one must

analyse the elements that have the largest influence on the total cost, and focus on these elements (Wouters 2008). Ellram and Siferd (1998) concur with this statement, and indicate that the best approach to TCO application is to focus on the relatively important purchases. A purchase can be important for any of the following reasons: (i) high monetary value, (ii) repetitive buy, (iii) important to other decisions, (iv) difficult to manage, or (v) possibility of outsourcing. Their study revealed that 73% of the respondents saw “high monetary value” as the most important criterion to use, as can be seen in Table 1.

Landed Costs

The Landed Cost concept is related to that of TCO. In fact, the Landed Cost is actually a part of the TCO, which consists of the following elements with regard to the importation of a particular product from another country: (i) price, (ii) transportation, (iii) customs duty, (iv) storage costs, and (v) administrative overhead costs (Young, CPM and Swan 2006; Young, Swan, Thomchick and Ruamsook 2009).

TCO Analyses

The literature does not offer many TCO analyses. There is one study that examined the TCO of cartridge and bag filters (Buehner 2009). The study found that when change-out and disposal costs were added to the cost of the filter, the cost more than quadrupled. The elements of the TCO included filter cost per annum (taking into account the number of times the filter has to be changed), labour cost, disposal cost and depreciation. The result was that the filter cost (string wound filter) was $20 160 per annum and the TCO was $35 600 per annum, which equates to 56.6% of TCO.

Ellram (1995) gives an example of a TCO of an electronic component that is imported from overseas. The free on board (FOB) price is $12 000 for 950 units. The following cost elements were then added to the FOB price: delivery, inspection, re-work of finished goods, engineering consulting and delivery delays, which took the TCO up to $14 554. Hence, the price is 82.5% of the TCO.

Another study was done on resistors, transformers and printed circuit boards (PCB) that were purchased by a European telecommunications company (Degraeve et al. 2005). Figure 3 below shows the activities in the value chain that are relevant to these products. The results of this study showed that the price element was between 92% and 98% of the TCO. The author found that the procurement policy at the time increased the TCO by ordering the same product from different suppliers, instead of making optimal use of quantity discounts.

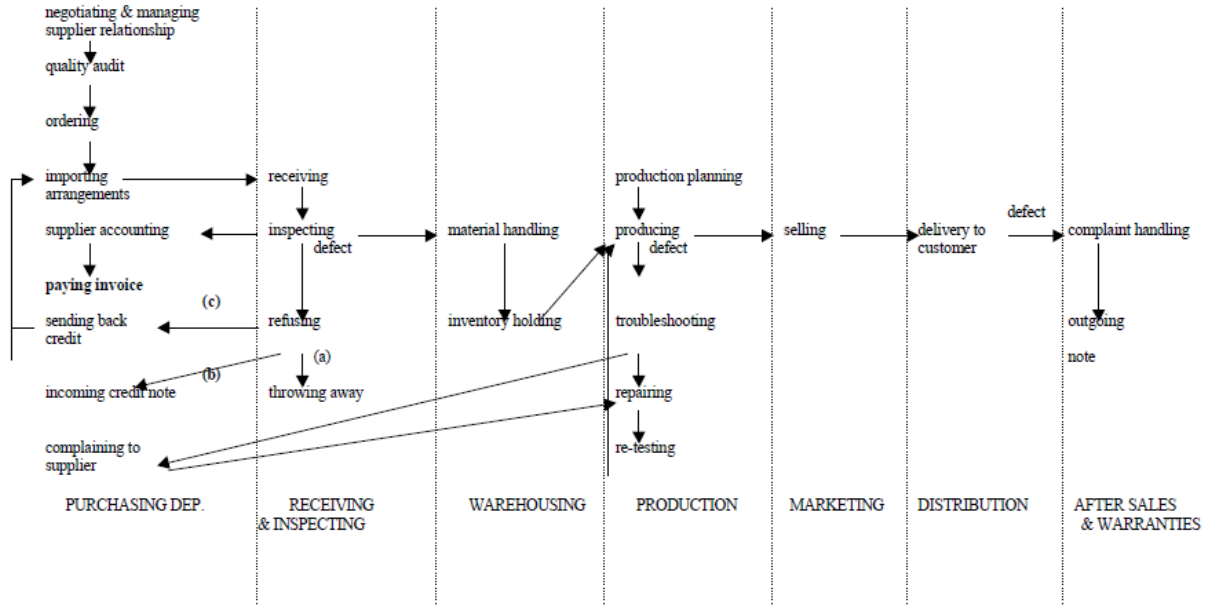

Figure 3: The value chain relevant to transistors, transformers and PCBs

(Degraeve et al. 2005)

2.3.3 *Research Proposition 1*

The elements of a TCO of crude oil purchased by a South African oil refinery will include the following: price, transportation, customs duty, storage costs, and administrative overhead costs.

2.4 Activity Based Costing

Since the TCO method is a concept of ABC (Degraeve et al. 2005), the advantages and reliability of ABC will be analysed in this section, with the assumption that this will be applicable to TCO methods.

The ABC concept, along with its advantages, have been extensively researched (Cagwin and Bouwman 2002; Stapleton, Pati, Beach and Julmanichoti 2004; Baykasoglu and Kaplanoglu 2008; Vazakidis, Karagiannis and Tsialta 2010). ABC has been defined as a costing method which takes into account all the activities and functions involved in a company, and allows accountants to assign overhead costs to a particular product or service (Vazakidis et al. 2010). These activities that are assigned, are generally referred to as the cost drivers, and understanding them can lead to a greater knowledge of the firm's business processes and underlying expenses (Stapleton et al. 2004). Another way of describing ABC is that it provides detailed cost information regarding the reasons for cost creation, which can be used for further analysis and proper decision making (Vazakidis et al. 2010).

2.4.1 *Advantages of ABC*

In comparing ABC to traditional costing systems, Stapleton et al. (2004) believe that ABC provides a good understanding of where resources are being spent, customer value is being created, and exactly where the money is being either made or lost, and is an alternative to labour-cost-based product costing. ABC can be used to identify and reduce activities that are non-value add to the business. The authors believe that ABC has assisted many companies around the world to improve the efficiency and effectiveness of their operations.

Furthermore, there is a positive association between improvement in ROI and ABC which is implemented in complex and diverse firms, where costs are relatively important (Cagwin and Bouwman 2002). Further to this, the authors found through their studies that positive synergies are realised from concurrent use of ABC and other methods.

2.4.2 *Accuracy and Precision of ABC*

Although ABC has many advantages, there are some aspects of it, or the application of it, that could possibly affect reliability. Stapleton et al. (2004) believe one of these obstacles to be that the output of ABC is more difficult to define. Furthermore, it is not always easy to define the cost drivers and activities. Also, data collection is more complicated and rigorous than traditional costing methods, which adds to the overall cost of implementing ABC. Overall, ABC can be a labour intensive exercise for a firm, with benefits of these efforts not always being realised.

ABC models tend to be too complex in general, which can affect the accuracy and trustworthiness of the results by managers, which is a major issue in implementing these systems (Homburg 2001; Barrett 2004). Even though there are some companies that offer software that can make the task of performing ABC easier by manipulating large amounts of data with ease, there is still a trade-off between complexity and accuracy. Barrett (2004) believes that ABC can never be completely accurate, and has reported results of a study which shows the relationship between complexity and accuracy in ABC, which can be found in 4. The figure shows that it takes a lot more effort to get the accuracy of ABC from 80% to around 97%, than it takes to get to 80% in the first place. However, Baykasoglu and Kaplanoglu (2008) are of the opinion that the accuracy of ABC can vary depending on its focus. The focus could be on the product or customer, or a combination of both.

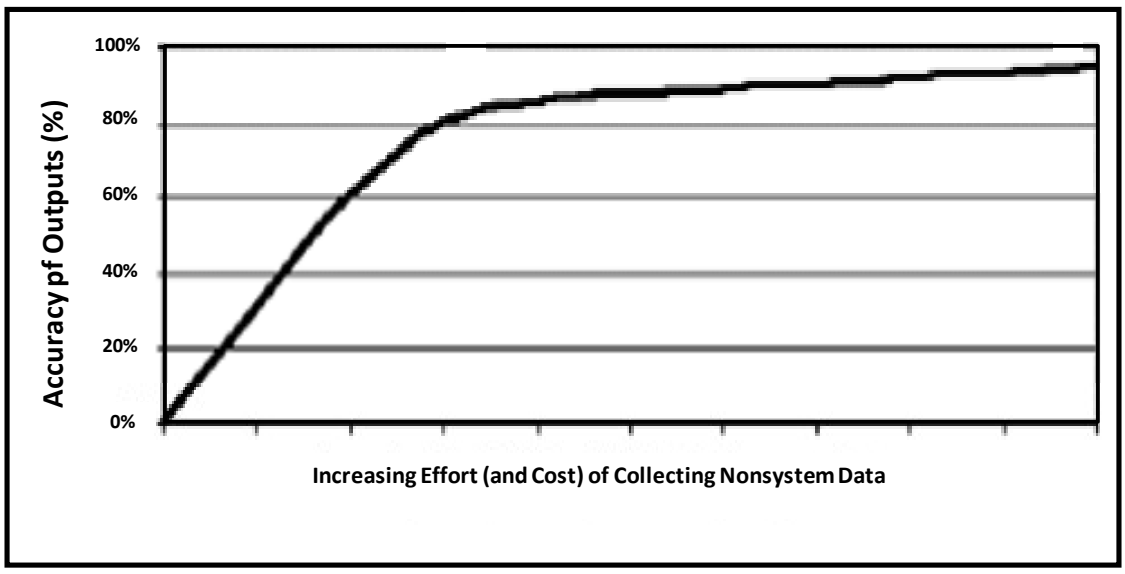

Figure 4: The relationship between complexity and accuracy in ABC

(Barrett 2004)

An aspect of ABC that could possibly contribute towards inaccuracy and precision is the fact that a lot of data has to be estimated (Neely, Gregory and Platts 2005). However, the authors do not stipulate to what degree the accuracy and precision is affected in practice. They do indicate, though, that ABC is more accurate than traditional costing methods. Other authors in this field concur with this, indicating that managers at all levels tend to perceive ABC data as more accurate than the data obtained from traditional costing methods (Geri and Ronen 2005). However, they do admit that ABC has its weaknesses. Firstly, ABC is based on arbitrary cost allocations that are subjective. ABC creates a more complex costing system, which is not necessarily more accurate or useful. Another notable weakness is that ABC does not deal with excess capacity, and regards the relation between activities and resource consumption to be linear. If production increases, this does not necessarily mean that there will be a linear decrease in the cost of production per item.

Even though the selection of the correct cost drivers seems to be a challenge for firms that implement ABC (Baykasoglu and Kaplanoglu 2008), an ABC model of low complexity, which has a relatively small number of cost drivers, is both cheaper to implement and easier for management to understand

(Merchant and Shields 1993). Homburg (2001) developed a model to support cost driver selection, which entails replacing a cost driver with a combination of the drivers selected already, thus reducing the overall number of drivers.

ABC generally assumes that the overhead costs are proportional (variable) to the cost pool's measure of activity. However, it was found that this is not necessarily the case (Noreen and Soderstrom 1997). The authors' study found that there are very little variable costs in overhead accounts in hospitals. A model that assumes that overhead costs are fixed and cannot be proportioned is generally more accurate. In their results, the proportional cost model, i.e. ABC, overstated the change in cost from one period to the next by 130%. The only question that remains is whether this would apply to other industries as well. Also, it is important to note that in cases with a low percentage of costs that are not proportional, the accuracy of ABC would be better, and the findings of Noreen and Soderstrom (1997) would probably not apply.

In analysing overhead costs, it was found that there is no relationship between overhead costs and activity in hospitals (Noreen and Soderstrom 1994). Hence, to increase the accuracy of overhead costing in ABC applications, one needs to identify as many cost drivers as possible. However, one must note that for any ABC analysis, the relative cost of each cost element to the total cost will determine the importance of the accuracy of that element (Gunasekaran, Marri and Yusuf 1999). The higher the proportion of that element, the larger the distortion would be. Therefore, this must be taken into account when deciding on the accuracy to apply in practice. Combine this with the notion that most managers resist the implementation of ABC, it is important that one gets the trade-off between accuracy and complexity when implementing ABC.

With respect to TCO analyses in particular, which is a form of ABC, the biggest barrier to successful implementation in organisations is that it is viewed merely as a philosophy as opposed to a tool. Other significant barriers include the following (Ellram and Sieferd 1998):

- Time consuming to develop – big initial investment requirement
- Difficult to understand the TCO concept

- Lack of expertise
- The business is constantly changing
- “Price” mentality is engrained in the in the culture of the organisation

A common aspect of ABC in business is that of inventory holding costs. The quantification of these costs and the accuracy thereof are considered to be critical to the running of most businesses (Holsenback and McGill 2007). The following factors should be taken into account when determining inventory holding costs: average inventory period, opportunity cost of working capital, and fixed overhead costs. When proportioning the overhead costs, it can be based on average inventory levels. Other factors that affect the allocation of inventory costs are the relative volume, the type of storage and the method of collecting the products in question (Goldsby and Closs 2000). In practice, the use of capacity is not always accurately recorded as production capacity, which is what is desired for ABC (Pirttilä and Hautaniemi 1995).

Another common aspect of ABC in all businesses is that of personnel costs. In ABC resources are proportioned based on how it is consumed or time spent on each activity (Raz and Elnathan 1999; Major and Hopper 2005). For personnel, since they are paid based on hours worked, one simply looks at the time spent on each activity. The more resources one allocates to activities, the more accurate is the cost. However, all of the allocations are estimates. Hence it is probably better to focus on the personnel that form a greater part of the total cost.

2.4.3 *Research Proposition 2*

For the TCO analysis done for imported crude oil for a South African oil refinery, the indirect cost portion will have an accuracy of around 80%.

2.5 Conclusion of Literature Review

The literature reveals that crude oil procurement and scheduling thereof are key activities in oil refineries and require optimal performance of these tasks to ensure profitability of the business. Furthermore, integration of these activities

within the rest of the business will give firms a competitive advantage. The crude oil price, which is important to oil refiners, is influenced by many factors and is difficult to model, even though it is driven mainly by the balance of demand and supply. Crude oil is procured either in fixed or variable parcel sizes, and is transported to the refinery on a VLCC. The strategy on parcel size and timing of the purchases is important to the business.

The TCO concept is being used more frequently by corporates, and is mainly used for supplier selection, supplier performance management and to drive major changes in a business. The price is the biggest element of the TCO of most goods and services. Studies reviewed for this report indicate a price component of between 56% and 98% of the TCO. The TCO takes into account all possible costs, and includes elements from pre-acquisition to post-acquisition.

ABC is a cost accounting methodology that has many advantages, which include having a positive association with the ROI of a company. However, the main challenges lie with identifying cost drivers and the trade-off between complexity and accuracy. ABC studies cannot be 100% accurate and are not easily trusted by managers when they are too complex.

2.5.1 *Research Proposition 1*

The elements of a TCO of crude oil purchased by a South African oil refinery will include the following: price, transportation, customs duty, storage costs, and administrative overhead costs.

2.5.2 *Research Proposition 2*

For the TCO analysis done for imported crude oil for a South African oil refinery, the indirect cost portion will have an accuracy of around 80%.

CHAPTER 3: RESEARCH METHODOLOGY

This section describes the methodology that was used to conduct the research. First, the preferred paradigm, method and literature thereof will be discussed; this will be followed by the design, population and sampling methodologies that were used. There will then be a discussion and analysis of the method of data collection, and the analysis thereof. This section will end with literature around validity and reliability.

3.1 Research methodology /paradigm

A quantitative methodology was used in this study to attempt to test the proposed research propositions. A quantitative methodological approach is one in which the investigator uses mainly postpositivist claims for developing knowledge, employs strategies of inquiry such as experiments and surveys, and collects data on predetermined instruments, out of which one gets statistical data (Creswell 2003).

Given that the data that was collected was ratio numeric data from archives, and only involved semi-structured interviews, a quantitative methodology is the appropriate one to use.

The data was collected from archives in the chosen company's storage facilities. The archives contain folders with data (invoices and other documentation) in respect of each parcel of crude oil that was procured since March 2006. The files did not contain all the relevant data, as certain invoices were missing. These missing documents were traced by contacting the suppliers of the service in question.

3.2 Research Design

The approach used for this study was a simple integrative approach (Dixon-Woods, Agarwal, Jones, Young and Sutton 2005). Although not exclusively, this method, as opposed to an interpretive method, is the preferred way of

synthesising quantitative data. Two methods of data collection were used in this research. First, the archival method (Yin 2006) of retrieving the data was used to gather readily available data from the chosen company. The data comprised the different elements of the crude oil TCO. This method entails performing secondary analysis on data that already exist, which can be obtained from academic, private or government archives (Whitten, Johannessen, Soerensen, Gammon and Mackert 2007). Secondly, chosen respondents from various departments were interviewed to determine the allocation of personnel costs to crude oil procurement, and the current method of applying TCO to crude oil. The interview was in a semi-structured form. An interview is a series of either open-ended or closed-ended questions that are used to obtain information from respondents (Kalof, Dan and Dietz 2008). Interview techniques can take the form of mail, telephone or in-person interviews. In this case, the interviews were either telephonic or in-person, depending on the location of the respondent.

Once all the data were collected, the first research proposition was addressed by quantifying the different elements of the crude oil TCO based on current methods used in the chosen company. The elements of the TCO were then graphically represented to indicate the make-up of indirect costs, and the location of the elements in the value chain.

To address Research Proposition two, a more accurate TCO was determined, based on methods from literature, and which were then compared to the TCO obtained in addressing research proposition one.

The main disadvantage is the concern of confidentiality. The data was disguised when being published in this report. It is assumed that this did not affect the validity of the results that were reported.

Another disadvantage was that some key pieces of information were not available from the archives, due to it not being stored in the first place, and may probably be lost.

3.3 Population and sample

3.3.1 *Population*

The population comprises the crude oil purchases that were made by a single crude oil refinery in South Africa, which will not be named for purposes of confidentiality. The population consists of parcels purchased both on the spot market and on term contracts.

3.3.2 *Sample and sampling method*

Convenience samples are data or information easily gathered by the researcher, and is also referred to as subjective sampling (Anderson 2001). This method of sampling was used to collect data for this study. The reason for this is that information about crude oil purchases is scarce. Also, the frequency of crude oil purchases is relatively low. Thus, it would take a long time to try to gather data that is not in the archives of the chosen company.

Data was collected in reverse chronological order, going back to March 2006. In conducting the interviews, the following people were approached:

- the cost accountant or person responsible for calculating the TCO of crude oil;
- the manager in charge of procuring crude oil; and
- the other personnel that spend a lot of time in crude oil procurement or the activities related to it.

3.4 The research instrument

The instrument here was existing data (archival) and semi-structured interviews. The data obtained was analysed descriptively, and from h conclusions were drawn. The questions used for the interviews were chosen from the list provided in appendix A, and will depend on the role of the person being interviewed.

3.5 Procedure for data collection

A single oil refinery in South Africa was chosen. The relevant person in the crude oil department was approached for archival data on crude oil procurement. The data was then retrieved from the company's archives and recorded into a spreadsheet for further analysis. Next, the relevant people were identified and interviewed.

3.6 Data analysis and interpretation

The data analysis techniques that were used in this analysis were those of descriptive statistics. Data analysis involves the preparation, analysis and interpretation of a collected set of data (Creswell 2003). Put another way, descriptive statistics entails summarising data either with tables, graphs or other means (Steyn, Smit, Du Toit and Strasheim 1994).

3.7 Limitations of the study

The first limitation of this study is that it was based on data that was obtained from a single organisation. Given that the crude oil market and procurement thereof is relatively old, it can be assumed that the results are representative of the industry in South Africa and are applicable to crude oil procurement managers in any other oil refinery in South Africa.

3.8 Validity and reliability

Validation is concerned with ensuring that the results of your research, or the evidence at hand, and your conclusions, capture the ideas contained in the concepts in literature (Adcock and Collier 2002; Kalof et al. 2008). Another way of explaining validity is by asking the following question: Does the conducted research measure what it was supposed to measure, and how truthful are the results? (Bollen 1989). There are usually two aspects of validity: external and internal validity.

3.8.1 *External validity*

External validity has to do with the generalisability of a study to a larger population (Kalof et al. 2008). The fact that only one company was used to collect data for this research makes this difficult to achieve. However, to cover this, data was collected spanning a relatively long time period of over two years.

3.8.2 *Internal validity*

Internal validity has to do with whether appropriate conclusions are being drawn from the research (Kalof et al. 2008). To attempt to ensure internal validity, the data that was obtained from the chosen oil refinery was read off original invoices, as far as possible.

3.8.3 *Reliability*

Reliability has to do with consistency. For findings of a study to be reliable, similar findings need to be discovered in repeated applications of the study (Kalof et al. 2008). Ensuring validity alone is not good enough, since unreliable results could still be valid (Adcock and Collier 2002).

The reliability of this study was ensured by the collection of accurate and up to date data retrieved from original documents stored in the archives of the chosen oil refinery.

CHAPTER 4: PRESENTATION OF RESULTS

4.1 Introduction

The results of this study are presented in this chapter by the use of descriptive statistics entailing time series graphs, calculation of means, standard deviations and correlation coefficients. It is presented per sub problem, and is categorised by the elements of the TCO of crude oil.

Please note that all data displayed in this report has been disguised to protect the company involved. The data can in no way be used to determine the actual cost of crude oil. However, it is assumed that the interpretation of this disguised data and results will still be relevant.

4.2 Demographic profile of respondents

Most of the data needed for this study was obtained from the archives of the chosen company. However, there were several instances where the data could not be found in any of the archives due to it either not being filed there or being misplaced. The missing data was in the form invoices. These invoices were then requested from the respective companies that issued them initially. Although this did create a delay in gathering all the missing information, all the required invoices were finally obtained.

Respondents to the semi-structured interview were from many different groups in the company. A total of 17 people were interviewed to determine the allocation of personnel costs to the TCO of crude oil. It was deemed that the contribution of the personnel in other administrative functions such as human resources and legal were insignificant, and they were not interviewed.

4.3 Results pertaining to Research Proposition 1

4.3.1 *TCO Elements*

The following elements have been identified as comprising the TCO of crude oil:

- Crude oil price: This is the price paid for the crude oil, to be picked up from the port stipulated by the supplier. This port is usually the one closest to the supplier, and is referred to as the load port.

- Freight: This is the cost of transporting the crude oil from the supplier's port to the port closest to the oil refinery, and is referred to as the discharge port.

- Demurrage: This is the cost that can be incurred if the vessel transporting the crude oil arrives later than the contractual date at the discharge port.

- Storage: Once the vessel arrives at the discharge port, the crude oil is then discharged into storage tanks. A cost is then incurred for storage of the crude oil until it is transported to the refinery.

- Transport: This is the cost incurred as a result of transporting the crude oil from the storage tanks at the discharge port to the oil refinery.

- Clearing costs: During discharge of the crude oil into the storage tanks at the discharge port, a company is appointed to supervise the discharge of the crude oil.

- Surveyors Cost: At the load and discharges ports, a company is appointed to ensure the proper loading and discharging of the crude oil onto and from the vessel respectively.

- Cargo Dues: This the amount charged by the government for importing crude oil into the country.

- Insurance cost: The cost of insuring the crude oil while in transit from the load port to discharge port.
- Inventory Holding Cost: This is the opportunity cost of holding crude oil in the storage tanks both at the discharge port and at the refinery. It was assumed the sum of the cash equivalent to the value of the crude oil could have earned returns if invested elsewhere.
- Personnel: This is the cost of labour that specifically works on crude oil procurement and any related activities.

As can be seen in **Figure 5** below, the crude oil price is 94% of the TCO. Of the other 6% of the costs, and as can be seen in **Figure 6**, freight, transport and inventory holding costs are the biggest contributors.

The mean TCO was R431 487 152 per month, with a standard deviation of R177 179 259.

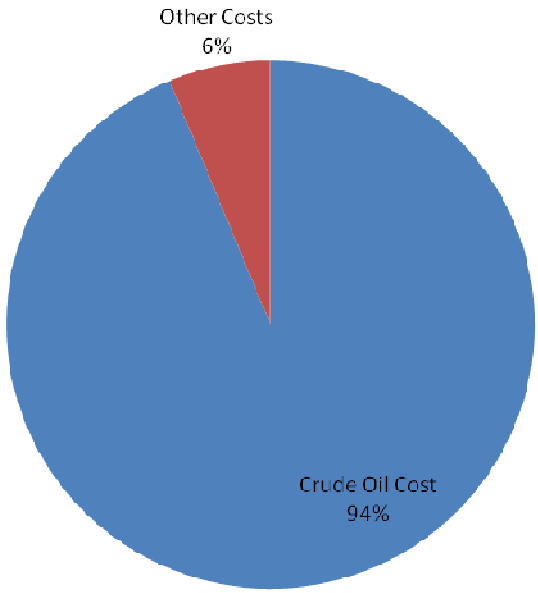

Figure 5: Make up of the Crude Oil TCO

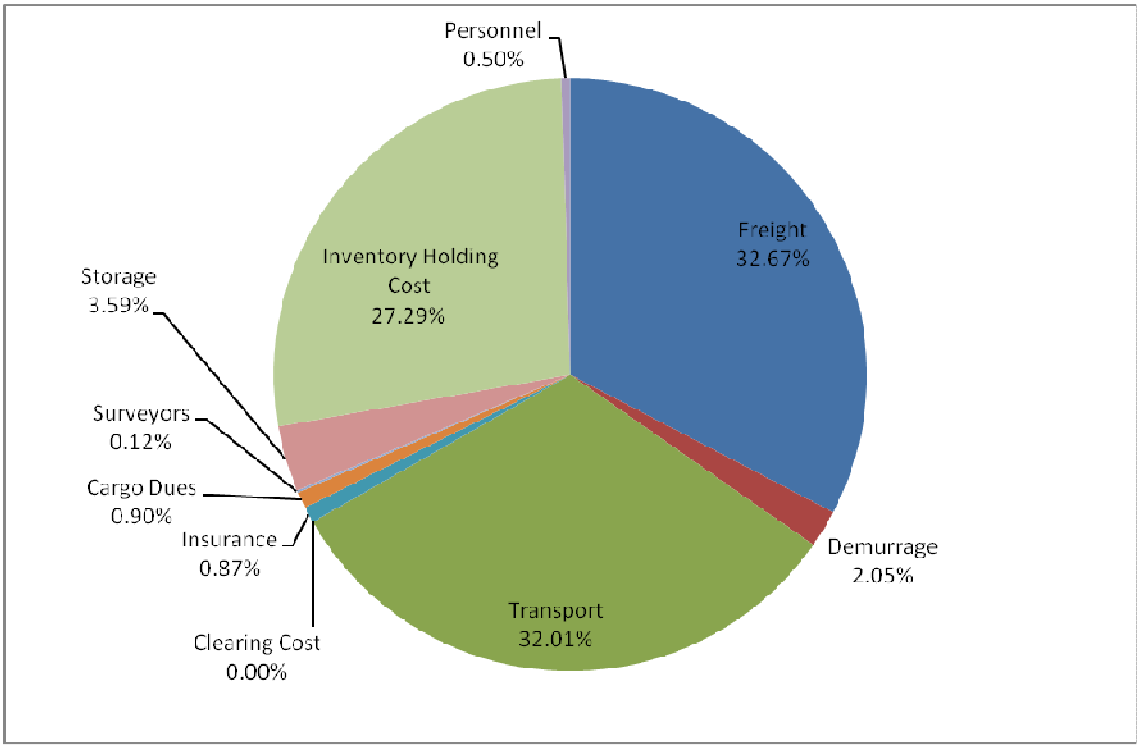

Figure 6: The elements of the crude oil TCO other than the crude oil price

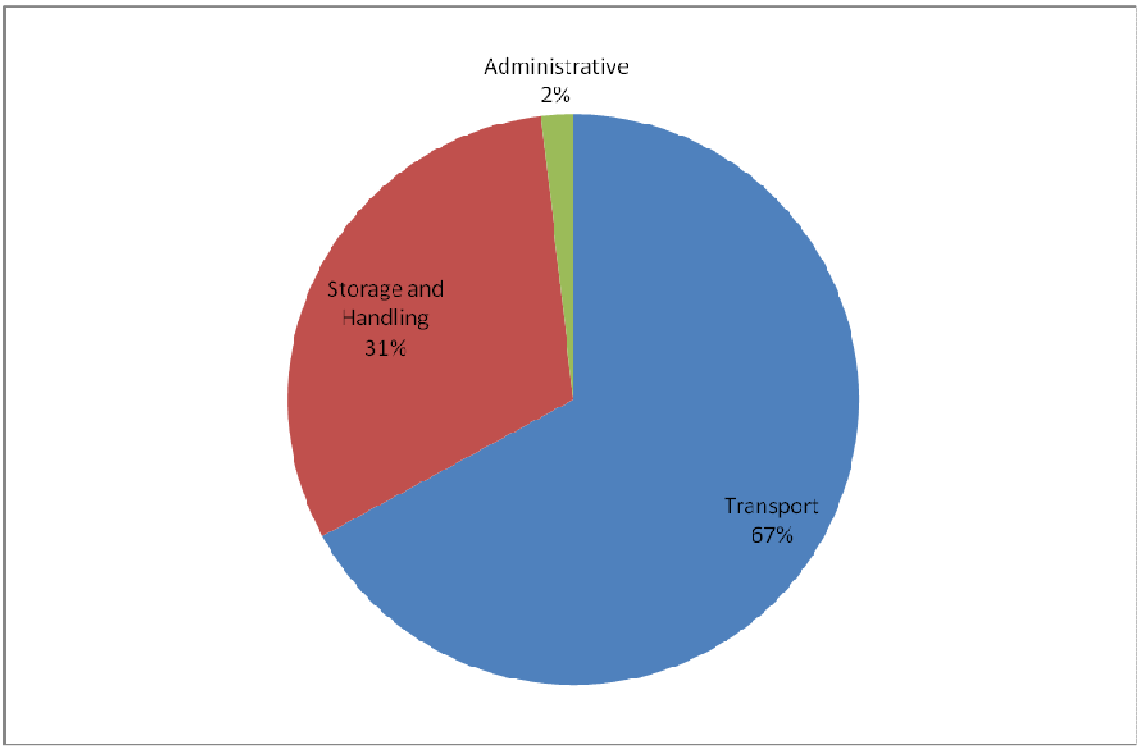

Figure 7: Categorisation of costs other than crude oil price

Table 2: Statistical Analysis of the TCO and its elements

TCO Element	Mean	Standard Deviation	Maximum	Minimum
Crude Oil Cost	R 404,575,499	R 167,115,734	R 921,186,565	R 178,516,939
Freight	R 8,793,079	R 5,522,738	R 25,322,014	R 1,637,454
Demurrage	R 552,278	R 1,285,806	R 5,515,158	R -
Transport	R 8,613,167	R 2,690,755	R 13,463,382	R 3,778,987
Clearing Cost	R 1,166	R 384	R 1,746	R 582
Insurance	R 234,782	R 116,356	R 545,050	R 96,268
Cargo Dues	R 241,263	R 90,385	R 407,530	R 46,722
Surveyors	R 33,046	R 34,050	R 174,106	R 2,392
Storage	R 965,169	R 344,739	R 1,653,389	R 345,029
Inventory Holding Cost	R 7,343,087	R 2,657,275	R 15,670,921	R 4,838,476
Personnel	R 134,617	R 60,557	R 249,530	R 45,345
Crude Oil TCO	R 431,487,152	R 177,179,259	R 983,822,432	R 191,470,266

Table 3: More statistical Analyses of the TCO and its elements

TCO Element	Mean	Standard Deviation (% of Mean)	Maximum (% of Mean)	Minimum (% of Mean)
Crude Oil Cost	R 404,575,499	41%	228%	44%
Freight	R 8,793,079	63%	288%	19%
Demurrage	R 552,278	233%	999%	0%
Transport	R 8,613,167	31%	156%	44%
Clearing Cost	R 1,166	33%	150%	50%
Insurance	R 234,782	50%	232%	41%
Cargo Dues	R 241,263	37%	169%	19%
Surveyors	R 33,046	103%	527%	7%
Storage	R 965,169	36%	171%	36%
Inventory Holding Cost	R 7,343,087	36%	213%	66%
Personnel	R 134,617	45%	185%	34%
Crude Oil TCO	R 431,487,152	41%	228%	44%

4.3.2 *Crude Oil Price*

The mean crude oil price was R404 575 499 per month, with a standard deviation of R167 115 734 which equates to 41% of the mean. The maximum and minimum prices were R921 186 565 and R178 516 939 per month respectively.

On a rand per barrel basis, the crude oil price was R591.82 with a standard deviation of R142.19, equating to 24% of the mean.

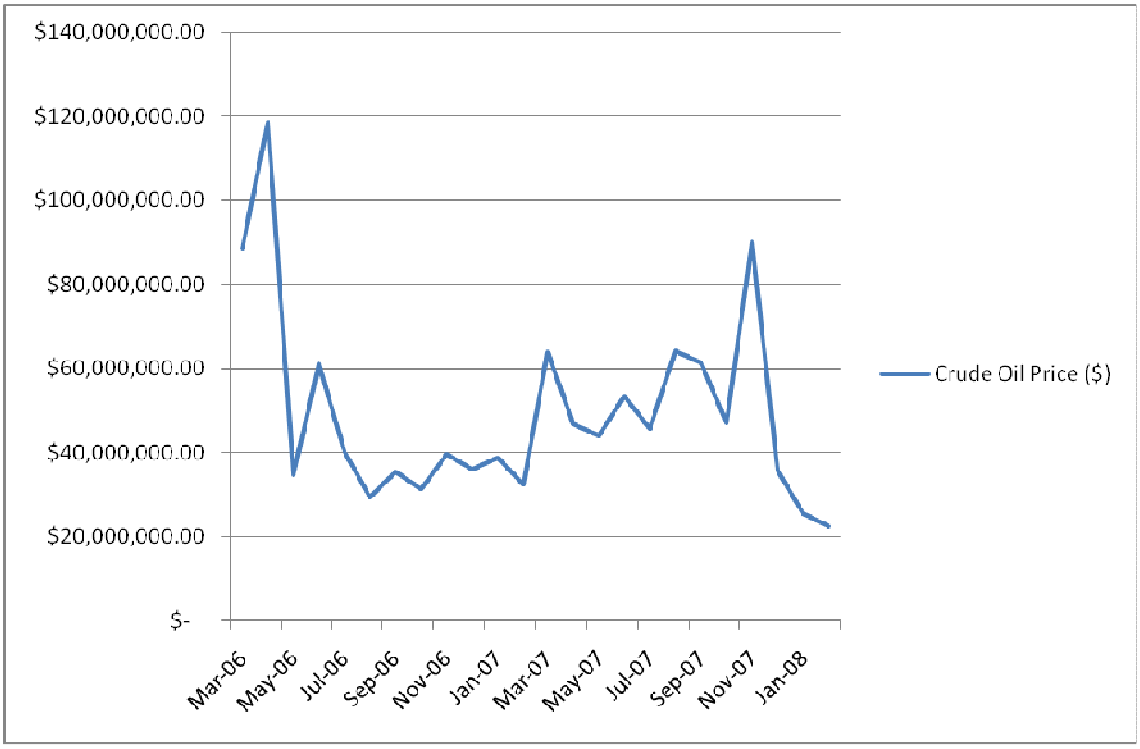

Figure 8: Crude oil price in dollars per month

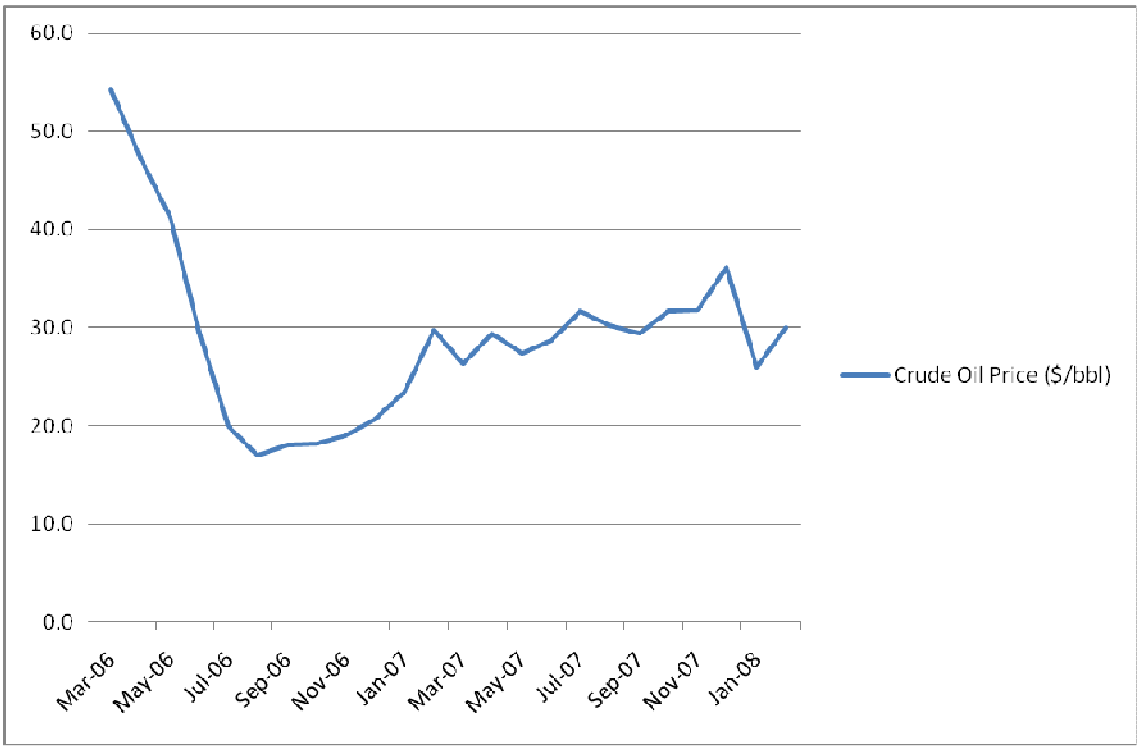

Figure 9: Crude oil cost in dollars per barrel

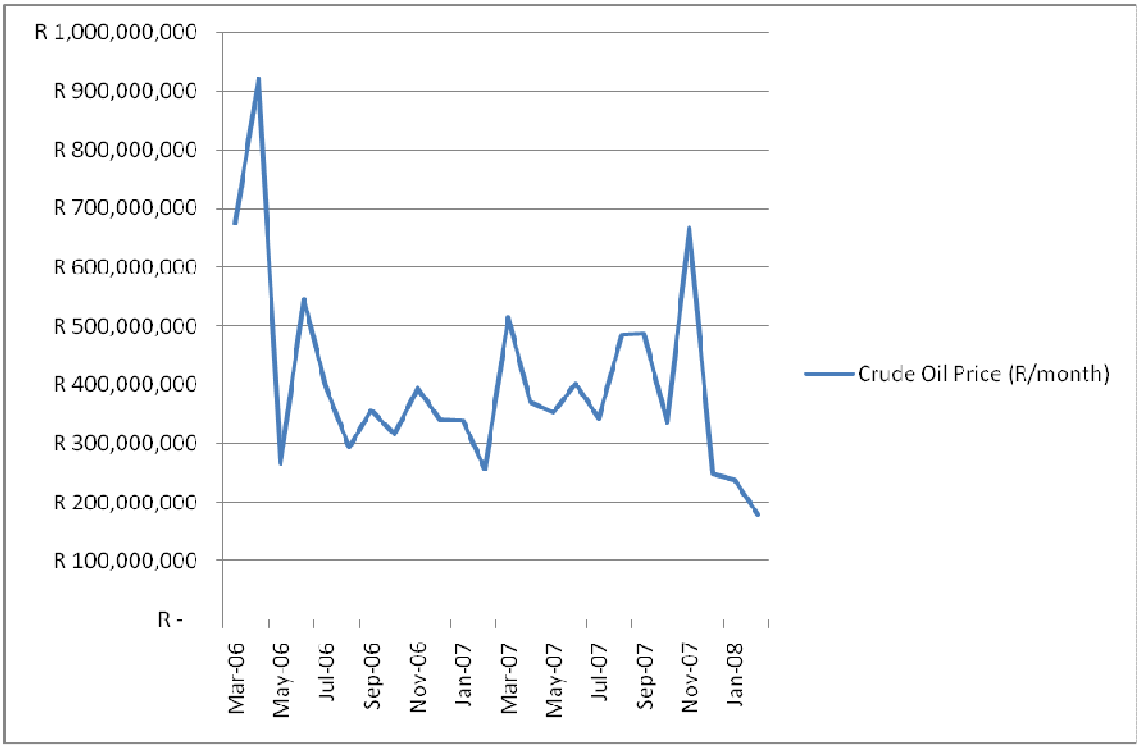

Figure 10: Crude oil cost in rands per month

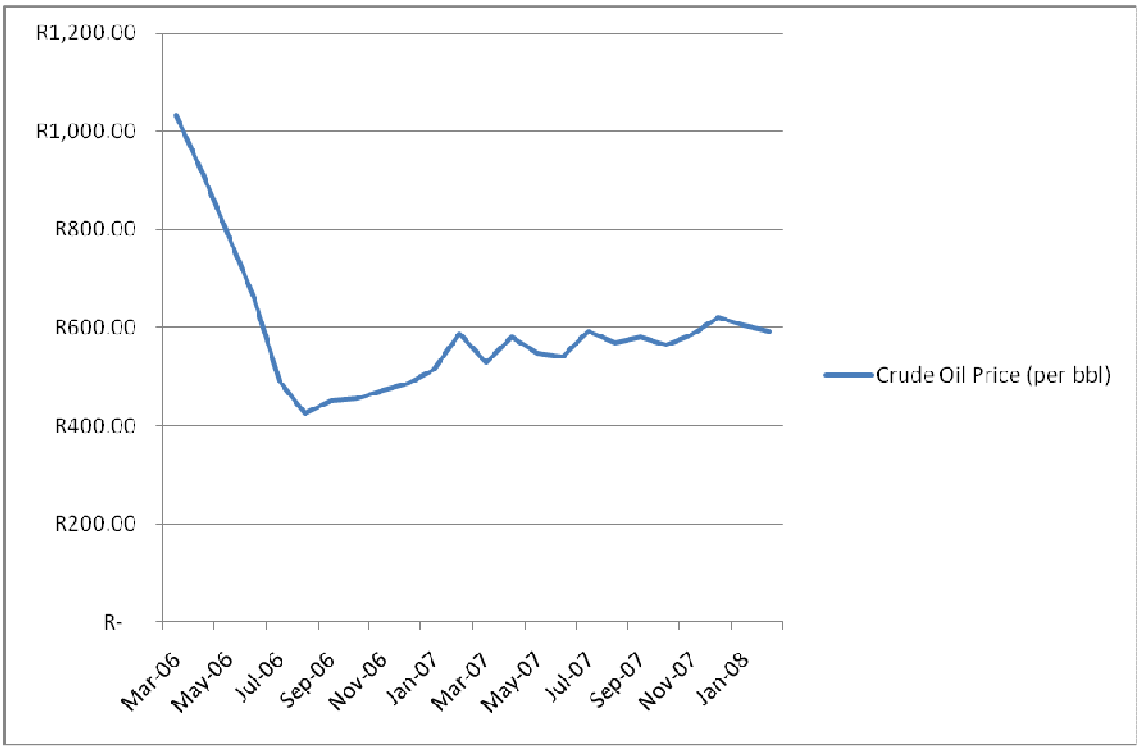

Figure 11: Crude oil cost in rands per barrel

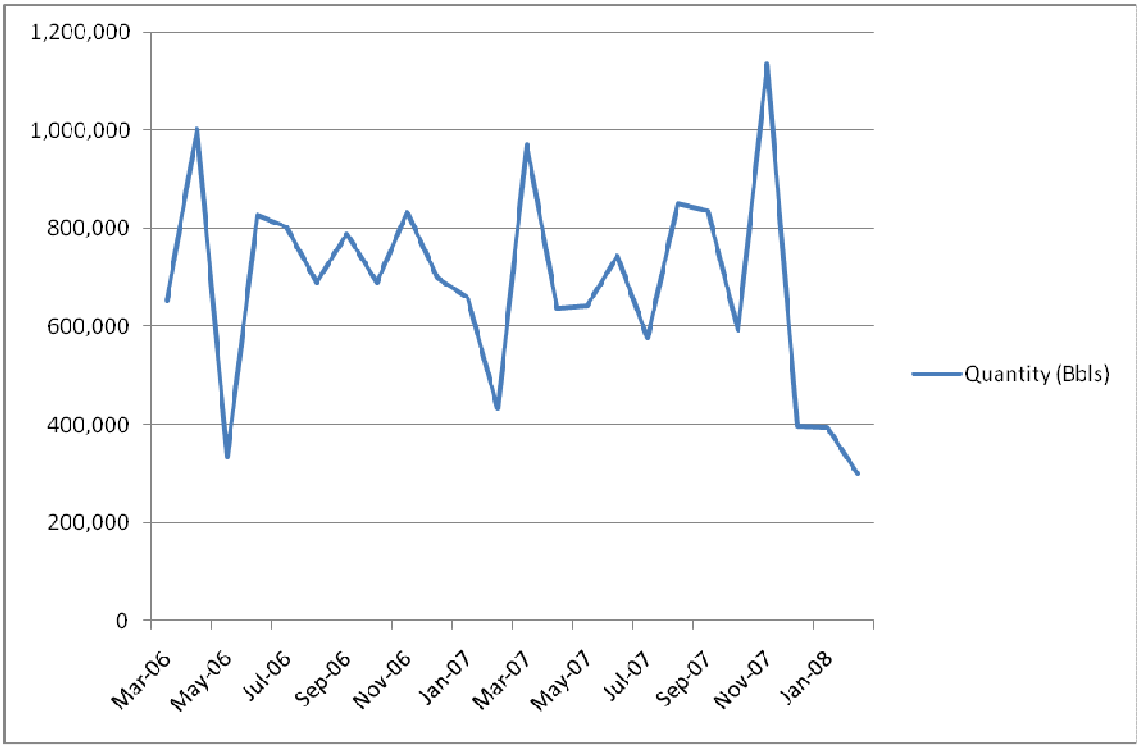

Figure 12: Quantity of crude oil purchased in barrels per month

Table 4: Statistical Analysis of crude oil price, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	404,575,499	-
Standard Deviation	R	167,115,734	41%
Maximum	R	921,186,565	228%
Minimum	R	178,516,939	44%

Table 5: Statistical Analysis of the crude oil price, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	591.82	-
Standard Deviation	R	142.19	24%
Maximum	R	1,032.18	174%
Minimum	R	9.47	2%

Table 6: Statistical Analysis of the quantity of crude oil purchased

	Mean	Standard Deviation (% of Mean)	Maximum (% of Mean)	Minimum (% of Mean)
Quantity Purchased (barrels)	687,133	31%	165%	44%

4.3.3 *Freight Costs*

The mean freight cost was R8 793 079 per month, with a standard deviation of R5 522 738 which equates to 63% of the mean. The maximum and minimum prices were R25 322 014 and R1 637 454 per month respectively.

On a rand per barrel basis, the freight cost was R12.37 with a standard deviation of R48.42, equating to 391% of the mean.

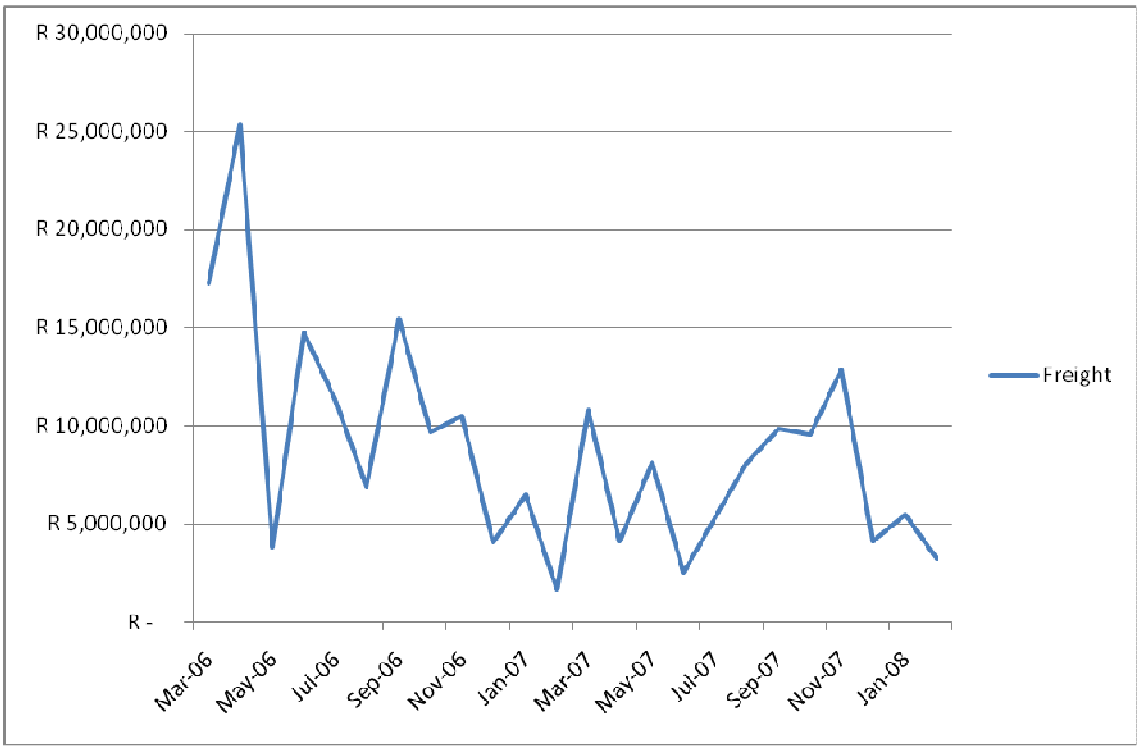

Figure 13: Freight costs in rands per month

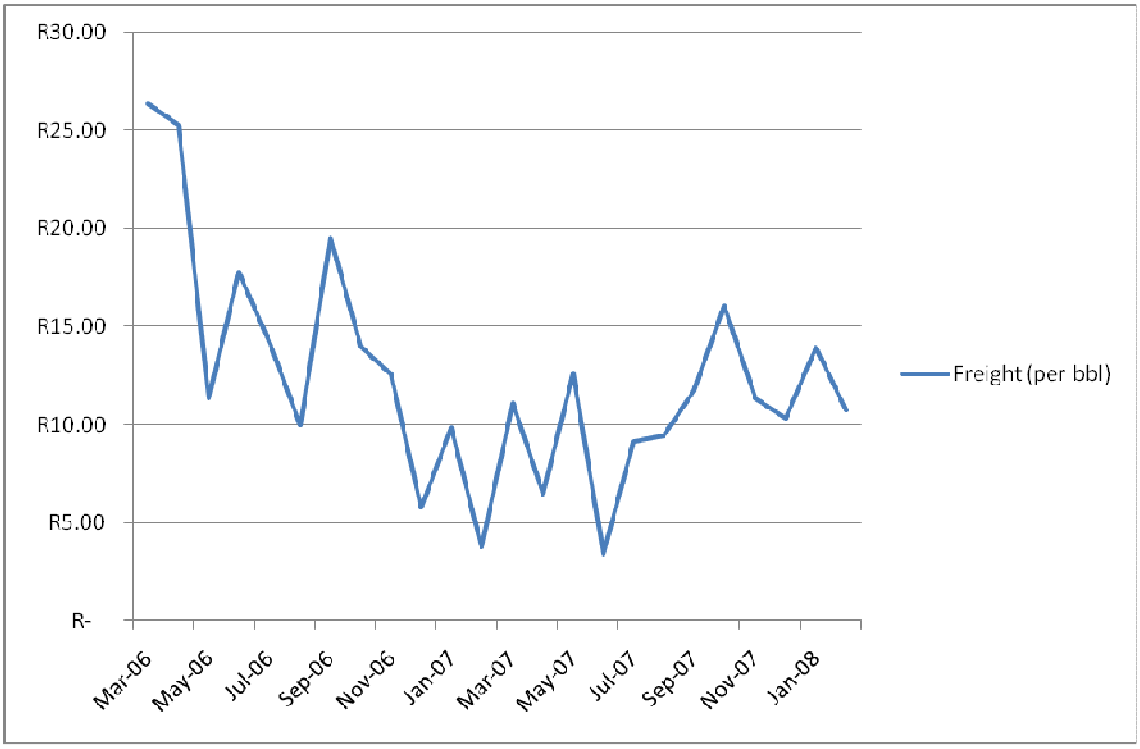

Figure 14: Freight costs in rands per barrel

Table 7: Statistical Analysis of the freight cost, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	8,793,079	-
Standard Deviation	R	5,522,738	63%
Maximum	R	25,322,014	288%
Minimum	R	1,637,454	19%

Table 8: Statistical Analysis of the freight cost, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	12.37	-
Standard Deviation	R	48.42	391%
Maximum	R	622.02	5027%
Minimum	R	1,166.04	9423%

4.3.4 *Demurrage*

The mean demurrage cost was R552 278 per month, with a standard deviation of R1 285 806 which equates to 233% of the mean. The maximum and minimum costs were R5 515 158 and R3 778 987 per month respectively.

On a rand per barrel basis, the demurrage cost was R0.70 with a standard deviation of R1.48, equating to 212% of the mean.

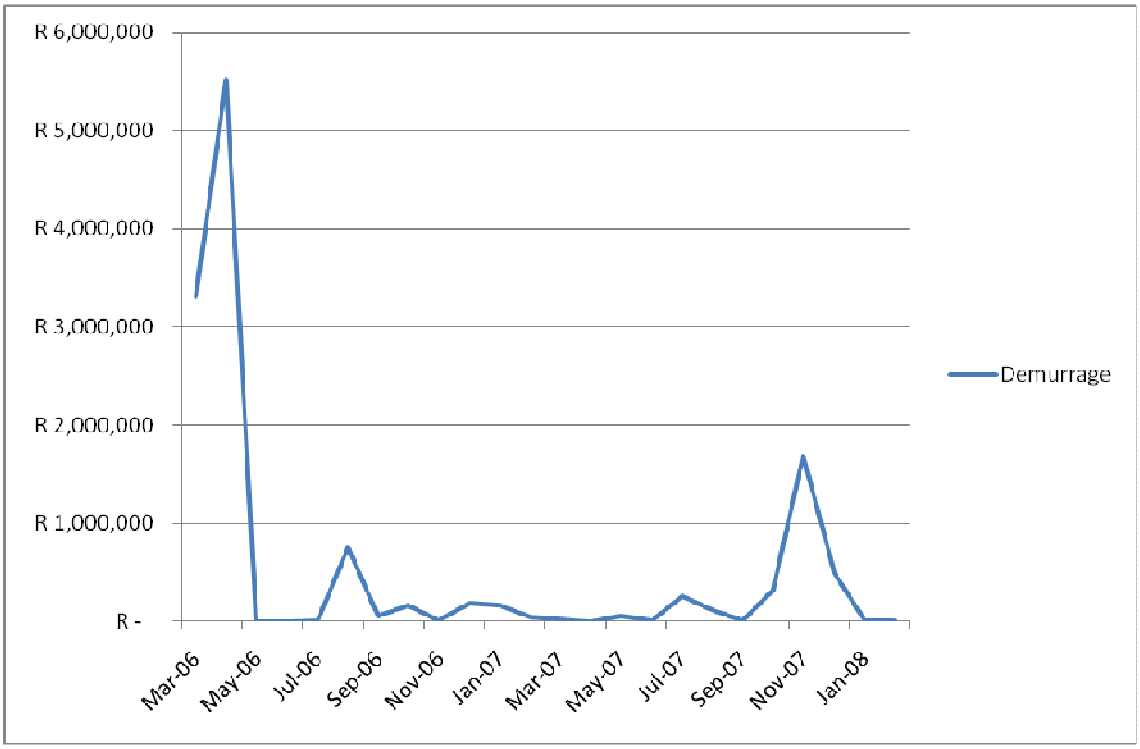

Figure 15: Demurrage costs in rands per month

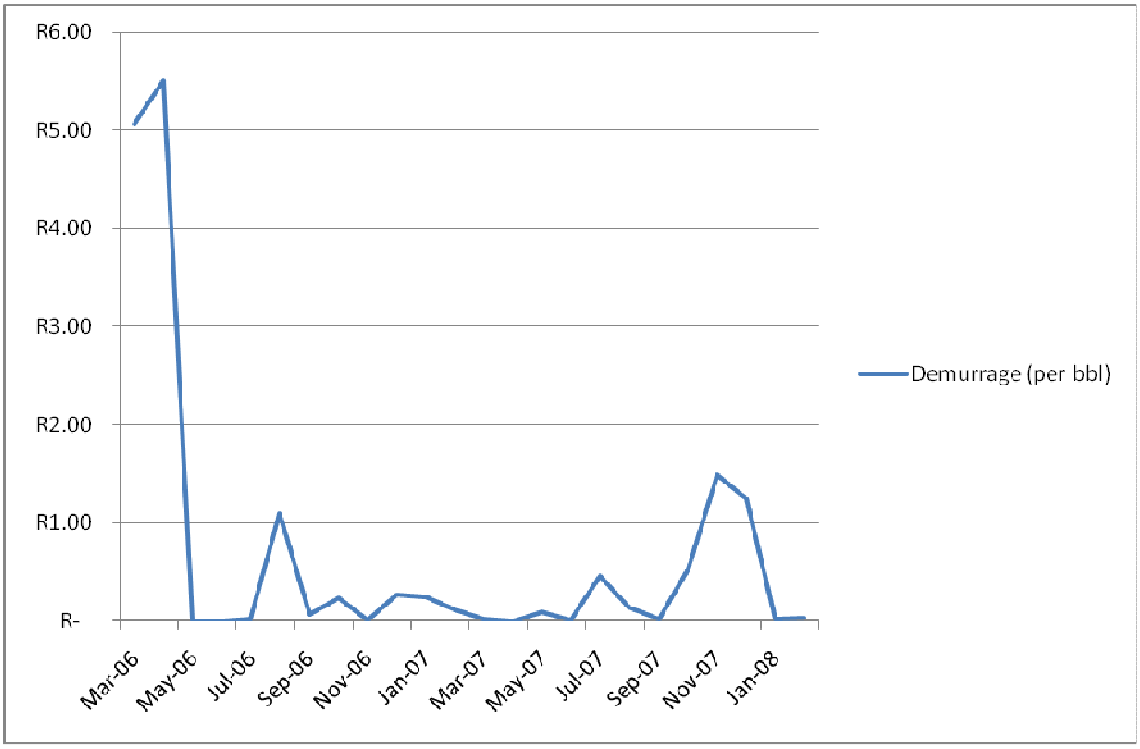

Figure 16: Demurrage costs in rands per barrel

Table 9: Statistical Analysis of the demurrage cost, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	552,278	-
Standard Deviation	R	1,285,806	233%
Maximum	R	5,515,158	999%
Minimum	R	3,778,987	684%

Table 10: Statistical Analysis of the demurrage cost, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	0.70	-
Standard Deviation	R	1.48	212%
Maximum	R	5.51	790%
Minimum	R	-	0%

4.3.5 *Transport*

The mean transport cost was R8 613 167 per month, with a standard deviation of R2 690 755 which equates to 31% of the mean. The maximum and minimum costs were R13 463 382 and R3 778 987 per month respectively.

On a rand per barrel basis, the transport cost was R12.54 with a standard deviation of R0.69, equating to 6% of the mean. The cost per barrel remains fairly constant throughout the entire period, with step changes annually in May 2007 and May 2008.

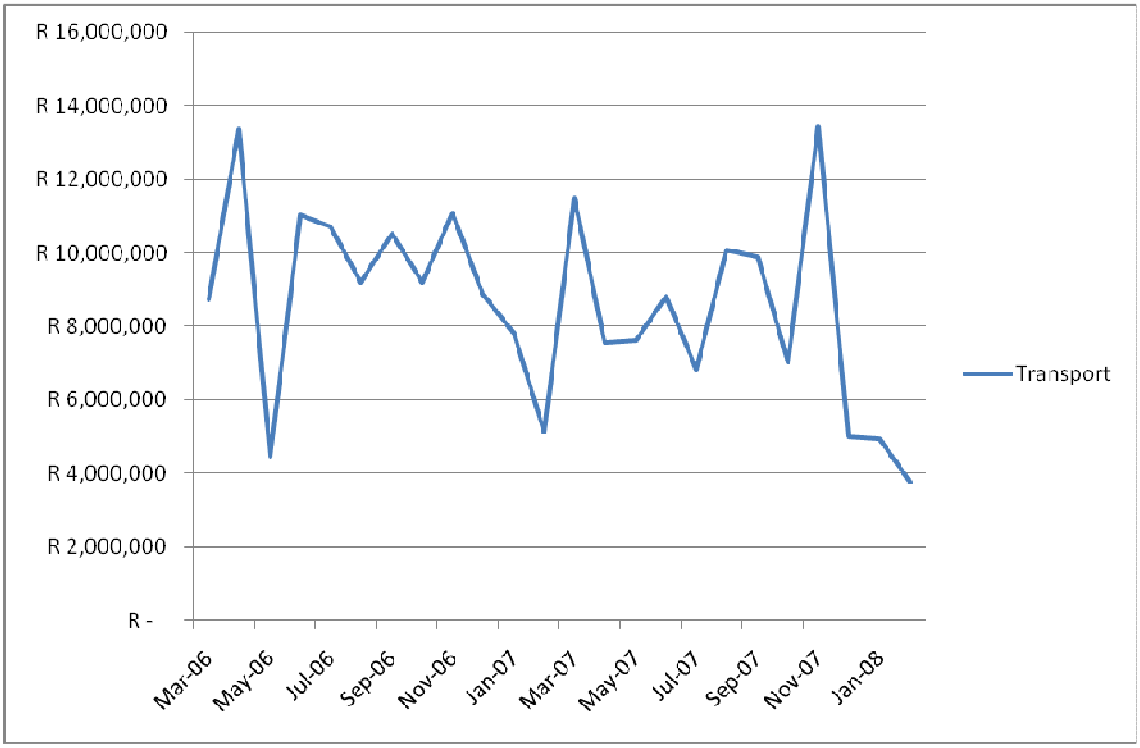

Figure 17: Transport cost in rands per month

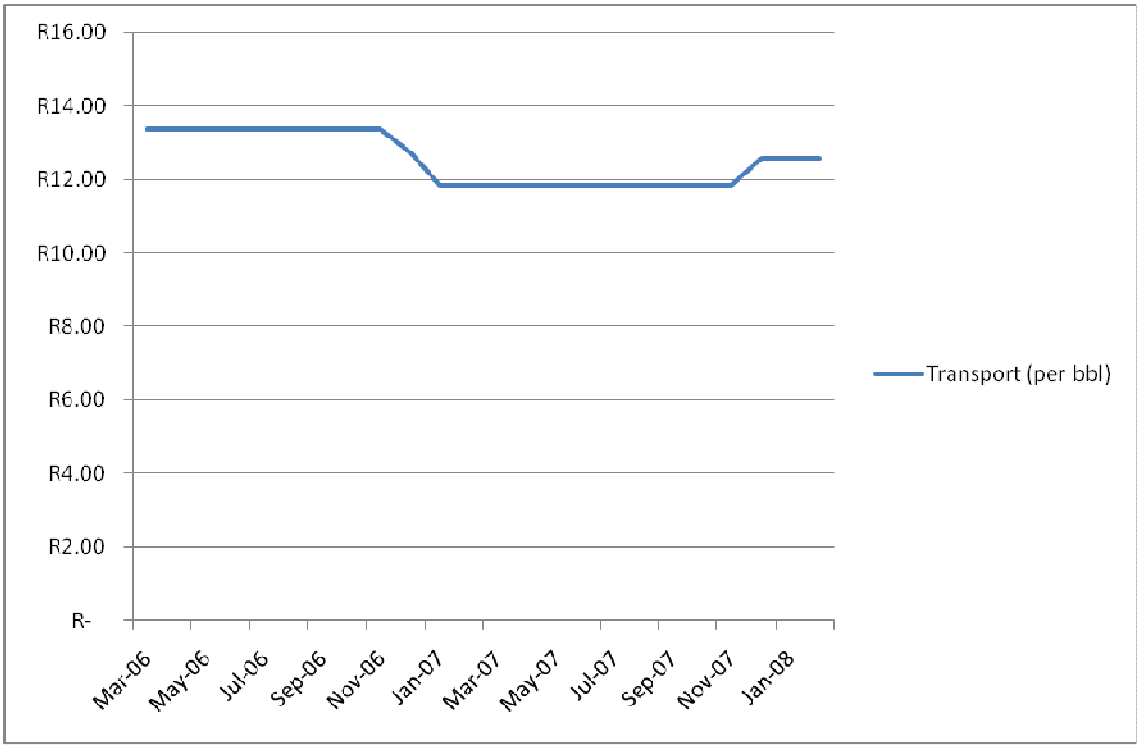

Figure 18: Transport costs in rands per barrel

Table 11: Statistical Analysis of the transport cost, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	8,613,167	-
Standard Deviation	R	2,690,755	31%
Maximum	R	13,463,382	156%
Minimum	R	3,778,987	44%

Table 12: Statistical Analysis of the transport cost, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	12.54	-
Standard Deviation	R	0.69	6%
Maximum	R	13.34	106%
Minimum	R	11.85	95%

4.3.6 *Clearing Costs*

The mean clearing cost was R1 166 per month, with a standard deviation of R384 which equates to 33% of the mean. The maximum and minimum costs were R1 746 and R582 per month respectively.

On a rand per barrel basis, the clearing cost was R0.0017 with a standard deviation of R0.0003, equating to 18% of the mean.

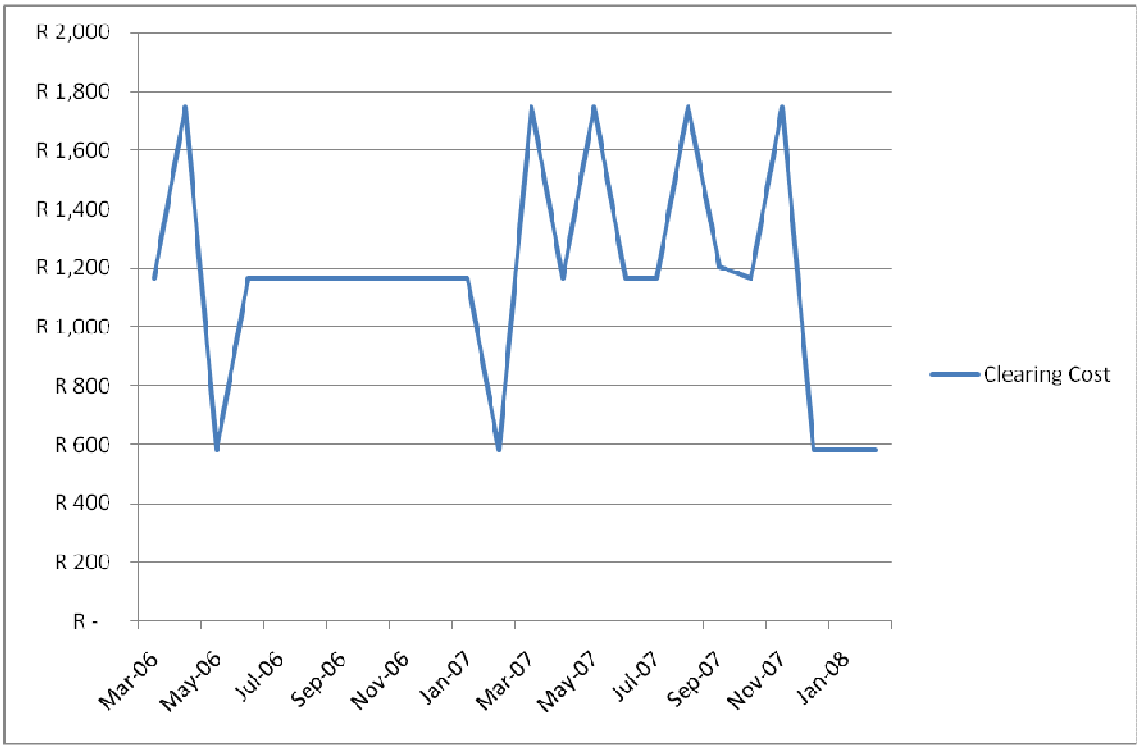

Figure 19: Clearing costs in rands per month

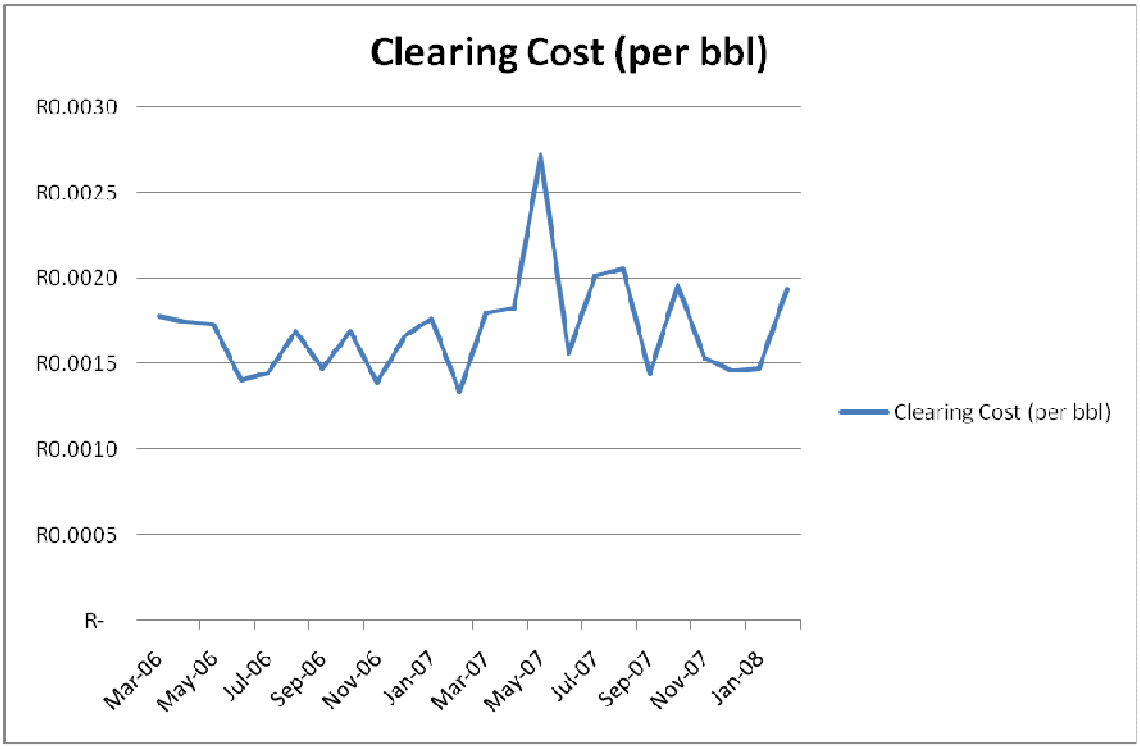

Figure 20: Clearing costs in rands per barrel

Table 13: Statistical Analysis of the clearing costs, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	1,166	-
Standard Deviation	R	384	33%
Maximum	R	1,746	150%
Minimum	R	582	50%

Table 14: Statistical Analysis of the clearing costs, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	0.0017	-
Standard Deviation	R	0.0003	18%
Maximum	R	0.0027	159%
Minimum	R	0.0013	79%

4.3.7 *Insurance*

The mean insurance cost was R234 782 per month, with a standard deviation of R116 356 which equates to 50% of the mean. The maximum and minimum costs were R545 050 and R96 268 per month respectively.

On a rand per barrel basis, the insurance cost was R0.3358 with a standard deviation of R0.1095, equating to 33% of the mean.

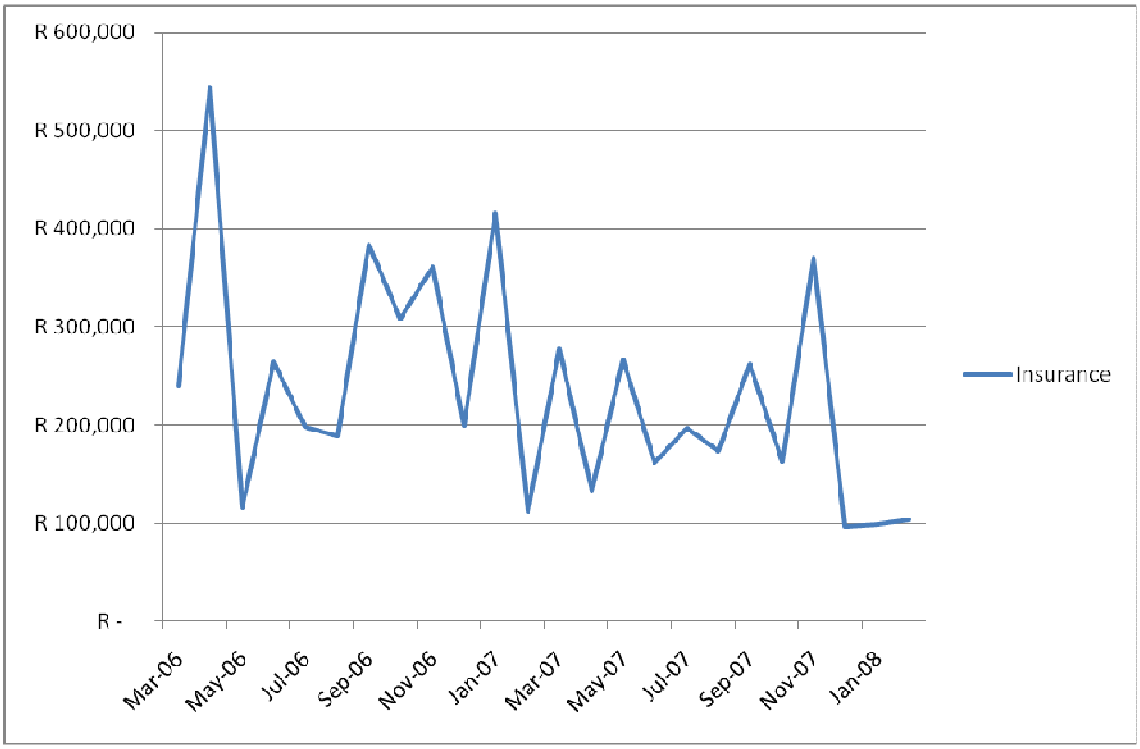

Figure 21: Insurance costs in rands per month

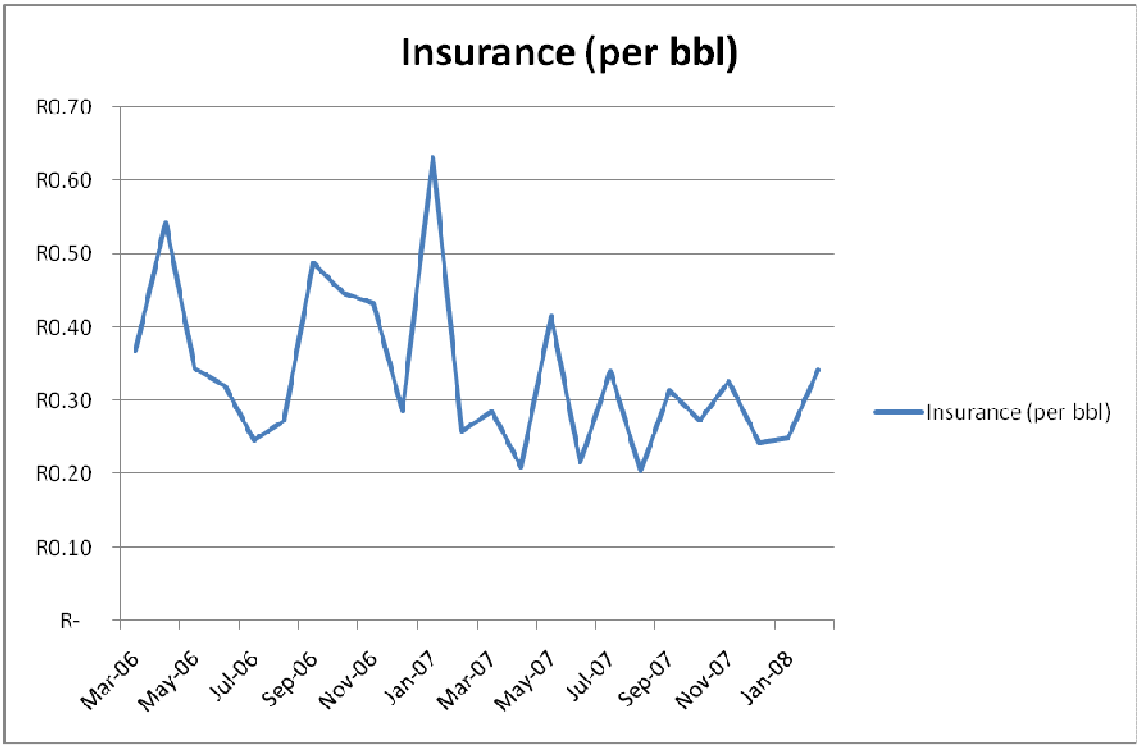

Figure 22: Insurance costs in rands per barrel

Table 15: Statistical Analysis of the insurance cost, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	234,782	-
Standard Deviation	R	116,356	50%
Maximum	R	545,050	232%
Minimum	R	96,268	41%

Table 16: Statistical Analysis of the insurance cost, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	0.3358	-
Standard Deviation	R	0.1095	33%
Maximum	R	0.6322	188%
Minimum	R	0.2035	61%

4.3.8 *Cargo Dues*

The mean cargo dues amounted to R241 263 per month, with a standard deviation of R90 385 which equates to 37% of the mean. The maximum and minimum costs were R407 530 and R46 722 per month respectively.

On a rand per barrel basis, the cargo dues were R0.3489 with a standard deviation of R0.092, equating to 26% of the mean.

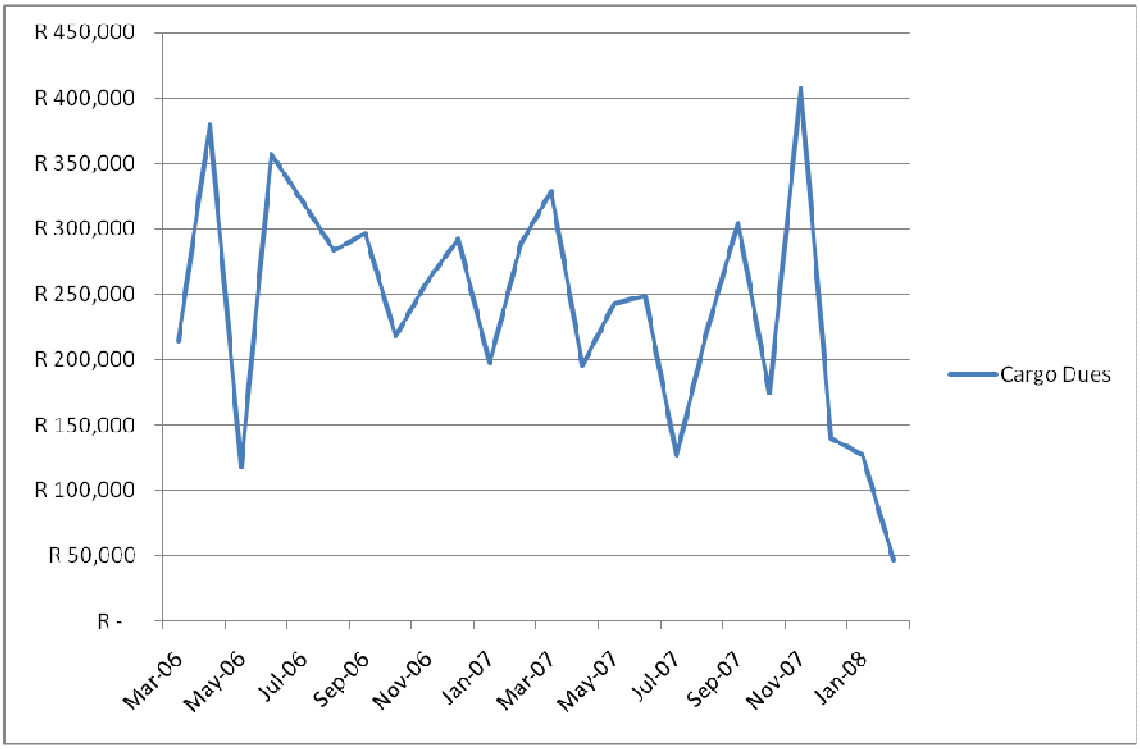

Figure 23: Cargo Dues in rands per month

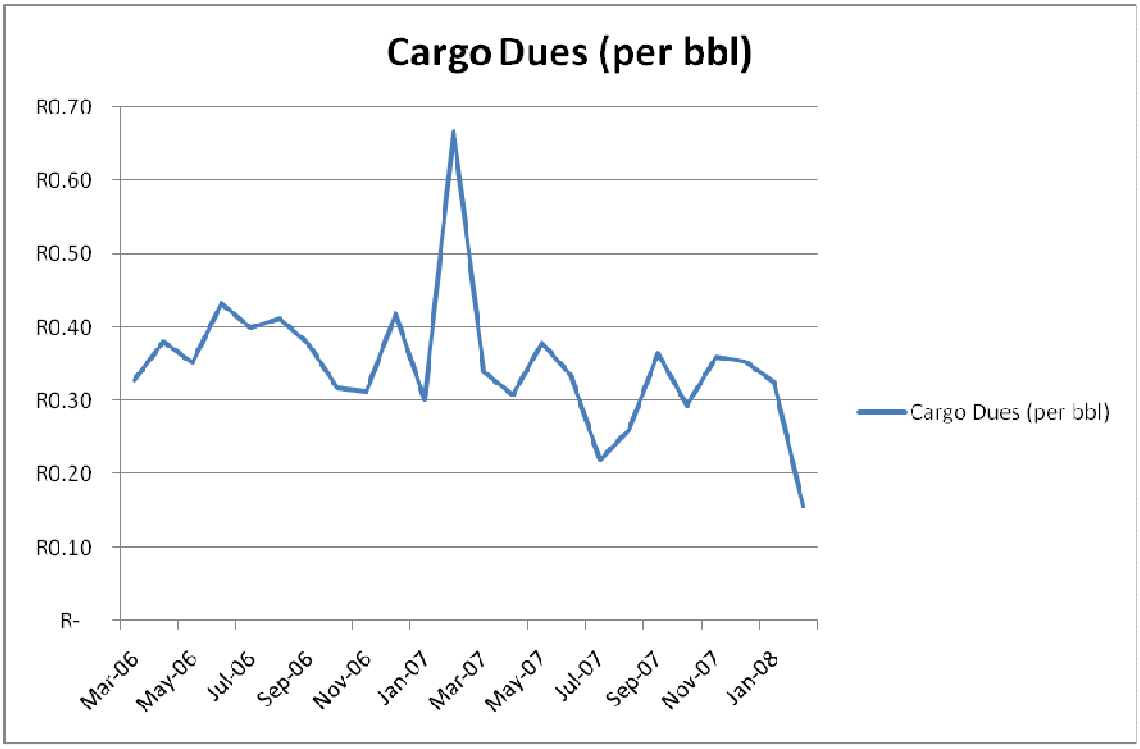

Figure 24: Cargo Dues in rands per barrel

Table 17: Statistical Analysis of the cargo dues, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	241,263	-
Standard Deviation	R	90,385	37%
Maximum	R	407,530	169%
Minimum	R	46,722	19%

Table 18: Statistical Analysis of the cargo dues, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	0.3489	-
Standard Deviation	R	0.0920	26%
Maximum	R	0.6656	191%
Minimum	R	0.1555	45%

4.3.9 *Surveyors Costs*

The mean surveyors cost was R33 046 per month, with a standard deviation of R34 050 which equates to 103% of the mean. The maximum and minimum costs were R174 106 and R2 392 per month respectively.

On a rand per barrel basis, the surveyors cost was R0.0446 with a standard deviation of R0.0313, equating to 70% of the mean.

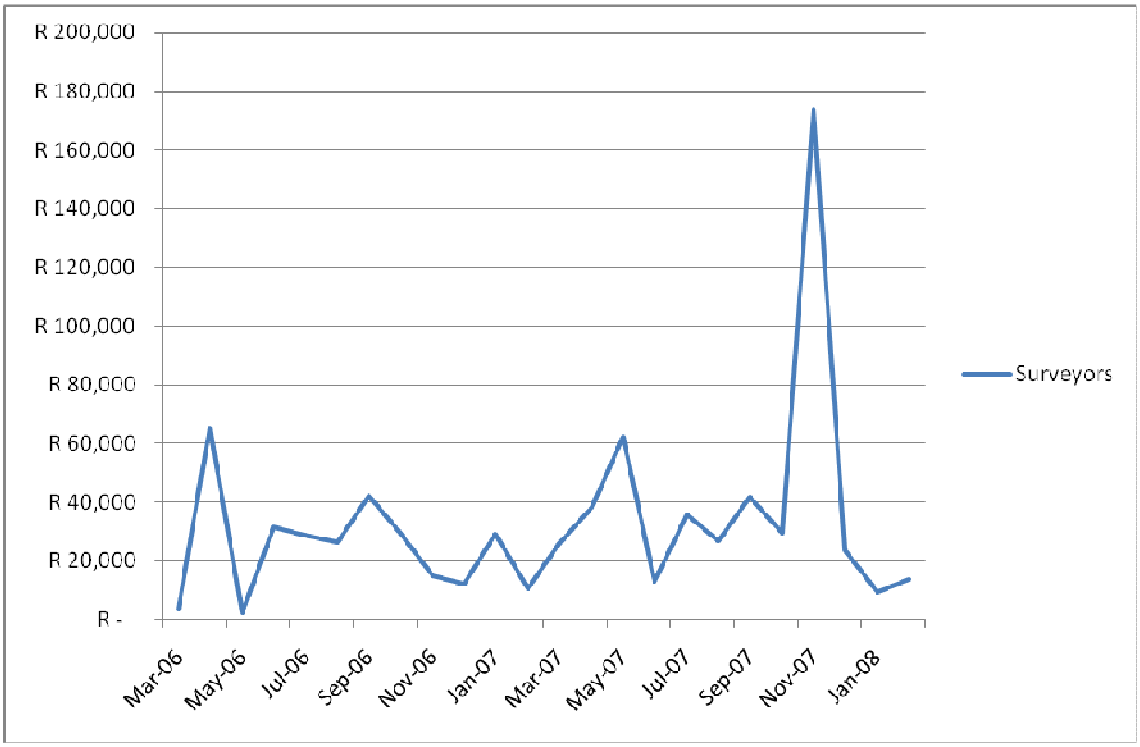

Figure 25: Surveyors costs in rands per month

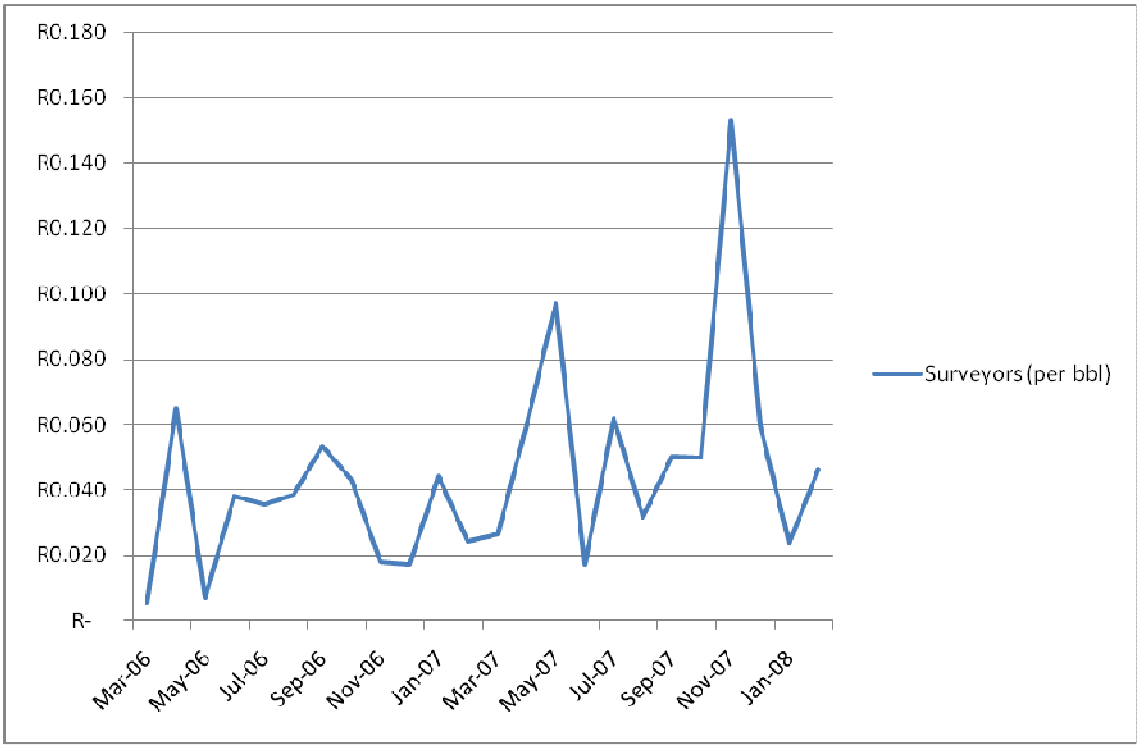

Figure 26: Surveyors costs in rands per barrel

Table 19: Statistical Analysis of the surveyors cost, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	33,046	-
Standard Deviation	R	34,050	103%
Maximum	R	174,106	527%
Minimum	R	2,392	7%

Table 20: Statistical Analysis of the surveyors cost, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	0.0446	-
Standard Deviation	R	0.0313	70%
Maximum	R	0.1533	343%
Minimum	R	0.0057	13%

4.3.10 *Storage Costs*

The mean storage cost was R965 169 per month, with a standard deviation of R344 739 which equates to 36% of the mean. The maximum and minimum costs were R1 653 389 and R345 029 per month respectively.

On a rand per barrel basis, the storage cost was R1.3996 with a standard deviation of R0.2570, equating to 18% of the mean. The cost per barrel remains constant for several months, decreases in March 2007 and then remains constant for the rest of the period.

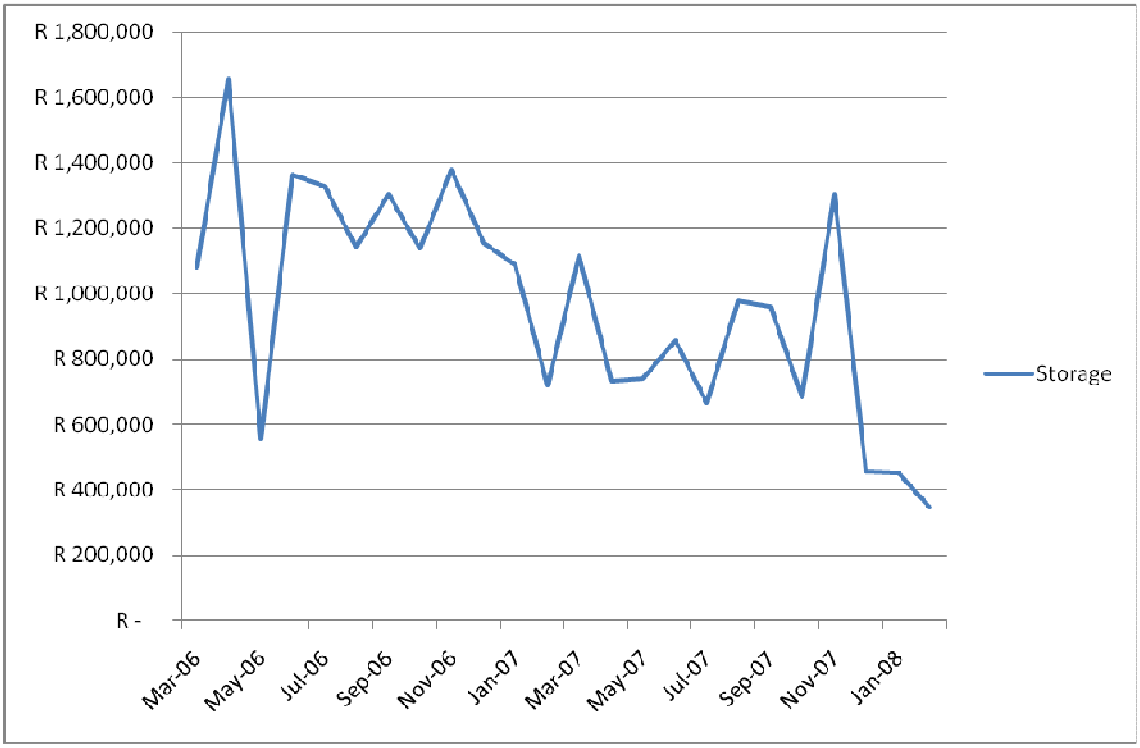

Figure 27: Storage costs in rands per month

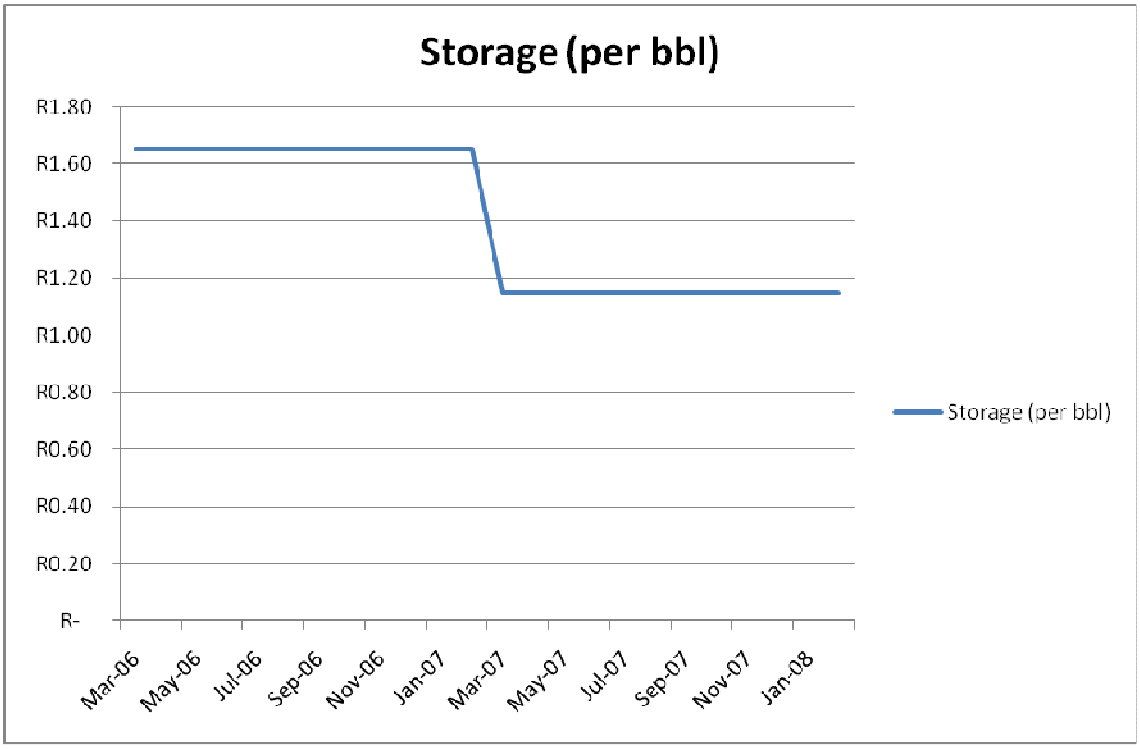

Figure 28: Storage costs in rands per barrel

Table 21: Statistical Analysis of the storage cost, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	965,169	-
Standard Deviation	R	344,739	36%
Maximum	R	1,653,389	171%
Minimum	R	345,029	36%

Table 22: Statistical Analysis of the storage cost, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	1.3996	-
Standard Deviation	R	0.2570	18%
Maximum	R	1.6512	118%
Minimum	R	1.1480	82%

4.3.11 *Inventory Holding Costs*

The mean inventory holding cost was R7 343 087 per month, with a standard deviation of R2 657 275 which equates to 36% of the mean. The maximum and minimum costs were R15 670 921 and R4 838 476 per month respectively.

On a rand per barrel basis, the inventory holding cost was R11.86 with a standard deviation of R5.977, equating to 50% of the mean.

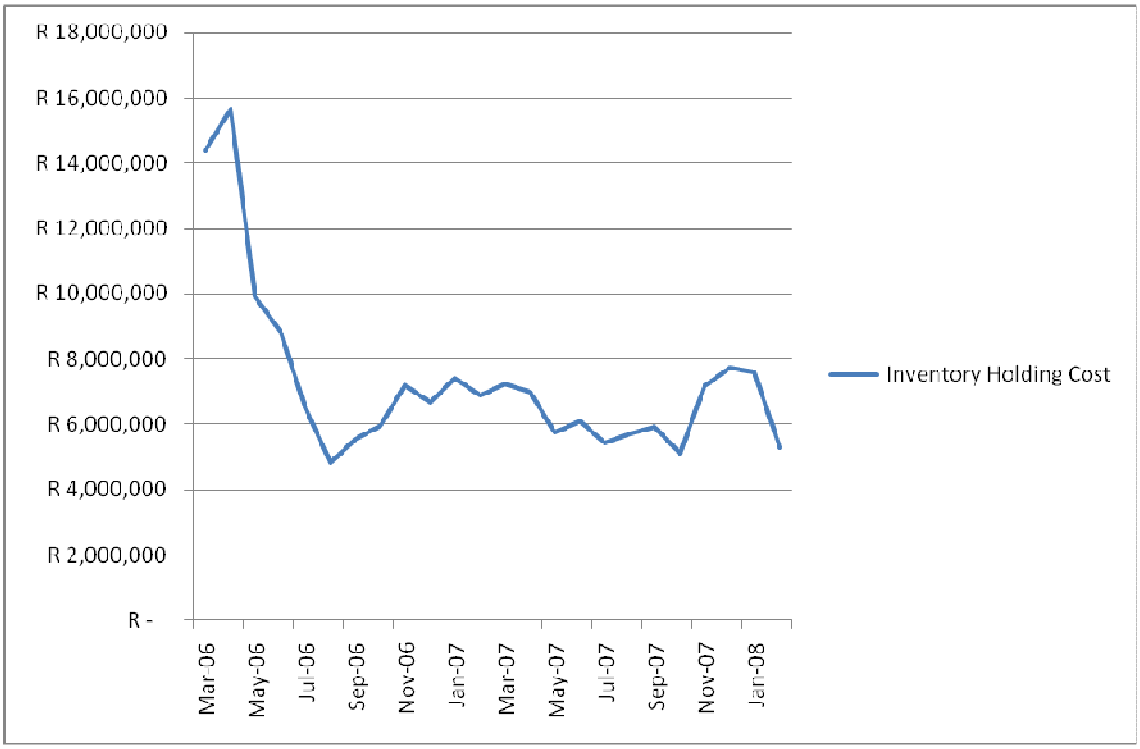

Figure 29: Inventory holding costs in rands per month

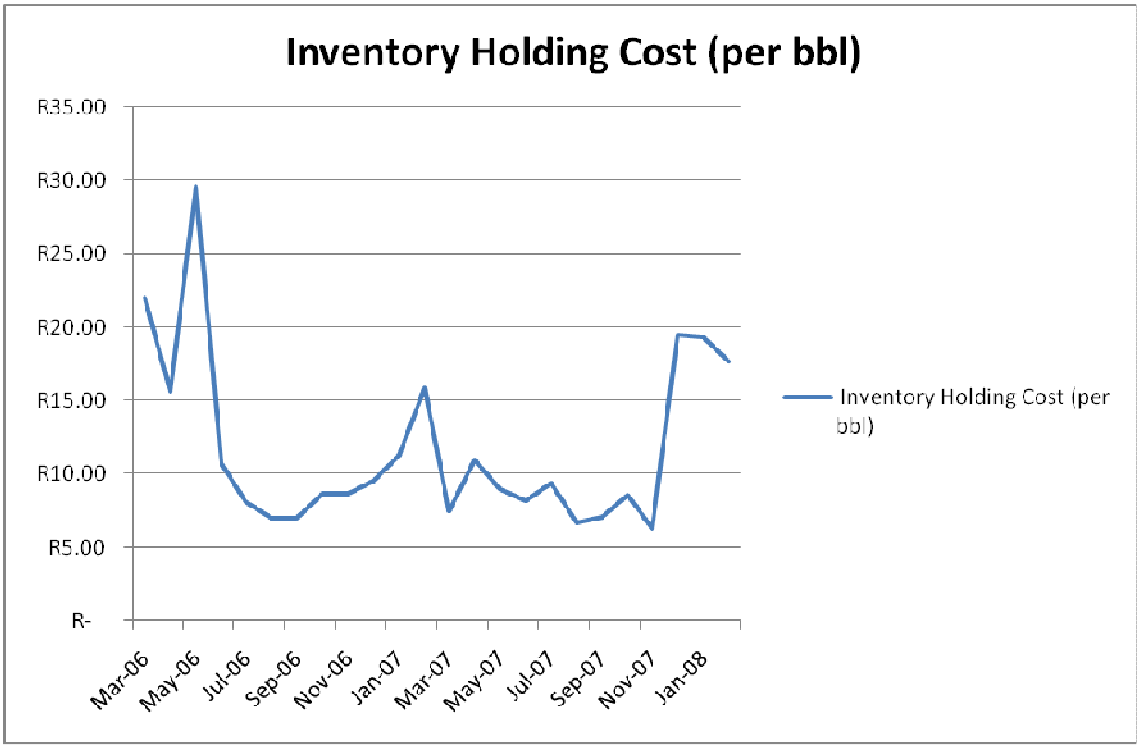

Figure 30: Inventory holding costs in rands per barrel

Table 23: Statistical Analysis of the inventory holding cost, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	7,343,087	-
Standard Deviation	R	2,657,275	36%
Maximum	R	15,670,921	213%
Minimum	R	4,838,476	66%

Table 24: Statistical Analysis of the inventory holding cost, in rands per barrel

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	11.8606	-
Standard Deviation	R	5.9772	50%
Maximum	R	29.6066	250%
Minimum	R	6.3137	53%

4.3.12 *Personnel Costs*

The mean personnel cost was R134 617 per month, with a standard deviation of R60 557 which equates to 45% of the mean. The maximum and minimum costs were R249 530 and R45 345 per month respectively.

On a rand per barrel basis, the personnel cost was R0.2214 with a standard deviation of R0.1221, equating to 55% of the mean.

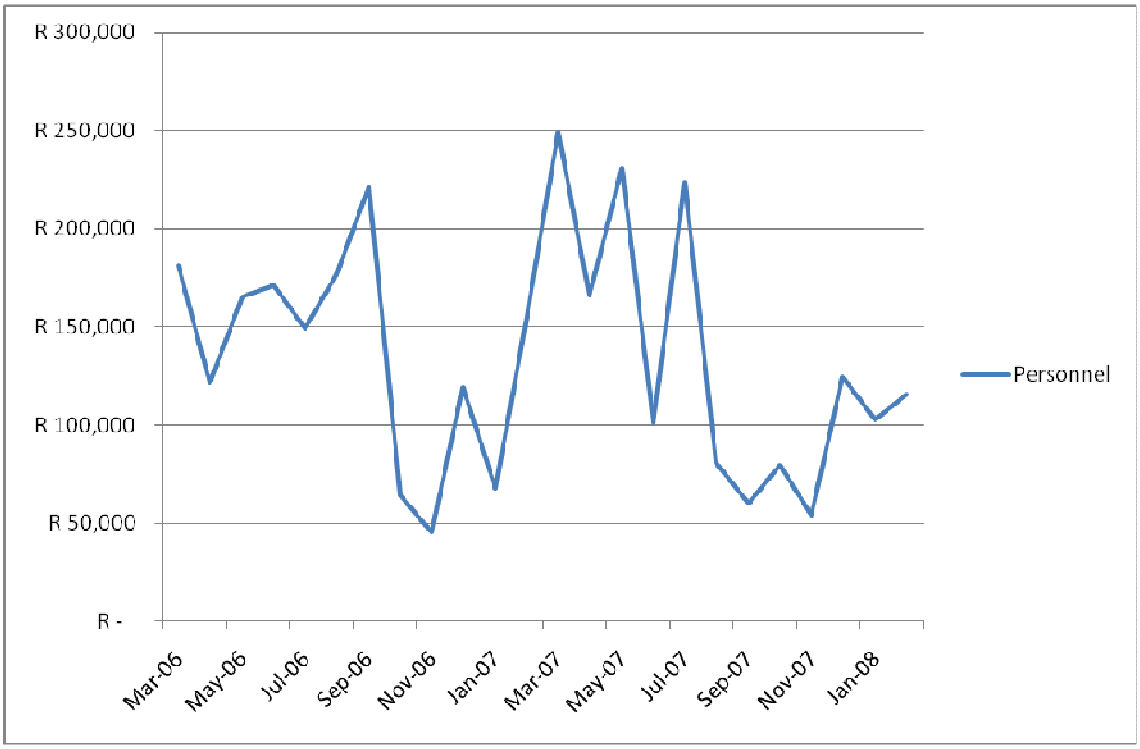

Figure 31: Personnel costs in rands per month

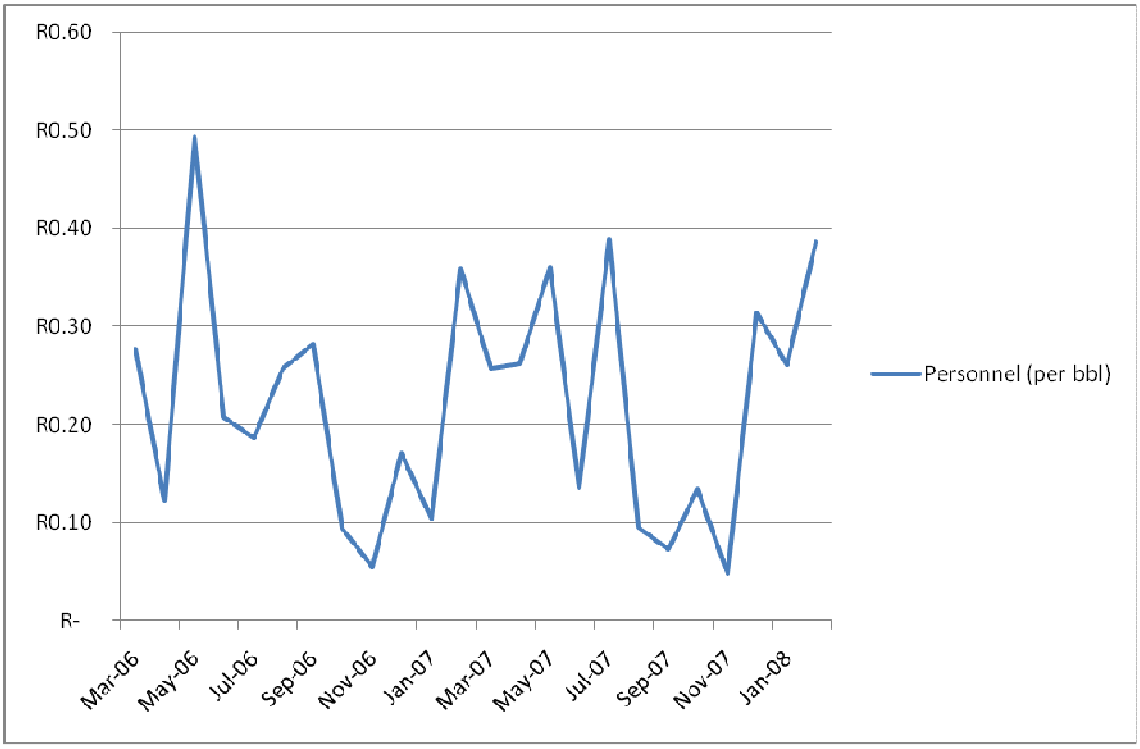

Figure 32: Personnel costs in rands per barrel

Table 25: Statistical Analysis of the personnel cost, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	134,617	-
Standard Deviation	R	60,557	45%
Maximum	R	249,530	185%
Minimum	R	45,345	34%

Table 26: Statistical Analysis of the personnel cost, in rands per barrels

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	0.2214	-
Standard Deviation	R	0.1221	55%
Maximum	R	0.4932	223%
Minimum	R	0.0477	22%

4.3.13 *Crude Oil TCO*

The mean TCO was R431 487 152 per month, with a standard deviation of R177 179 259 which equates to 41% of the mean. The maximum and minimum costs were R983 822 432 and R191 470 266 per month respectively.

On a rand per barrel basis, the TCO was R631.73 with a standard deviation of R151.12, equating to 24% of the mean.

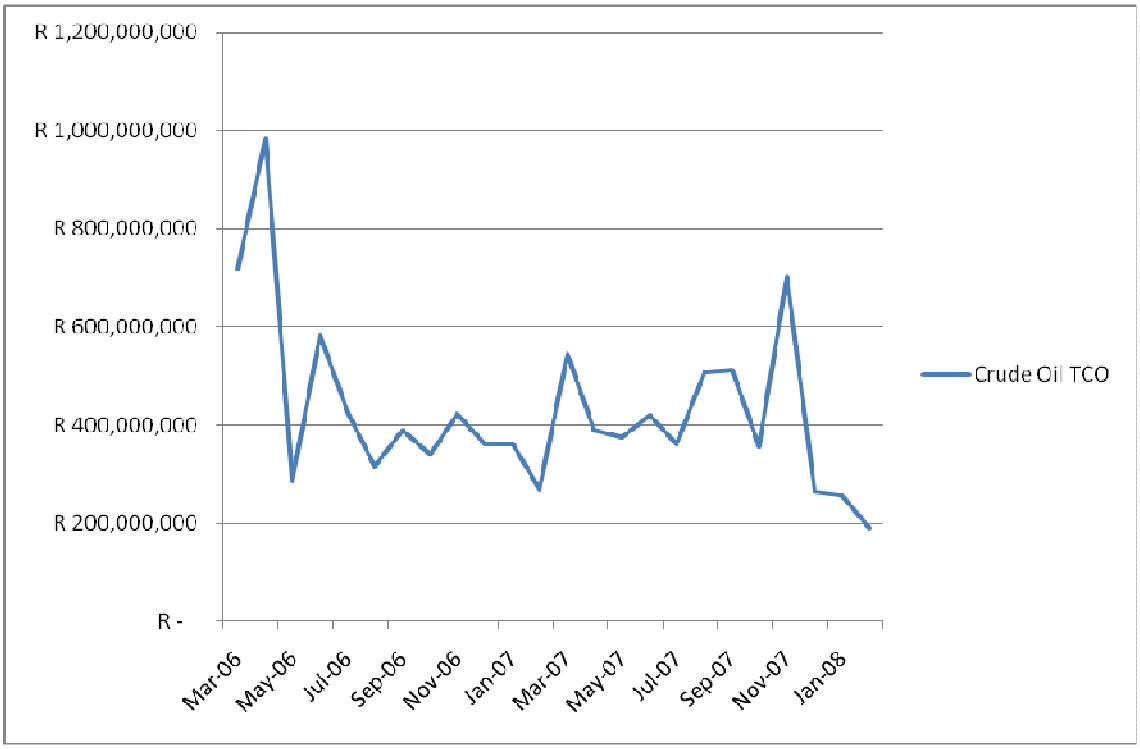

Figure 33: Crude Oil TCO in rands per month

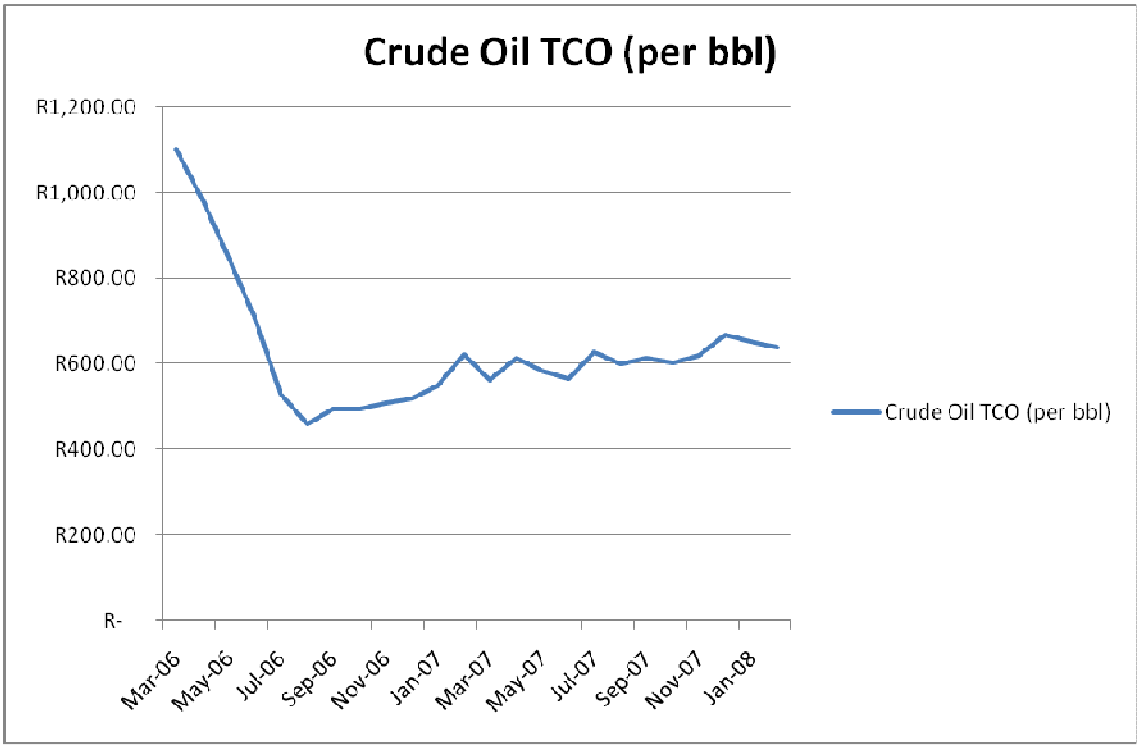

Figure 34: Crude Oil TCO in rands per barrel

Table 27: Statistical Analysis of the crude oil TCO, in rands per month

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	431,487,152	-
Standard Deviation	R	177,179,259	41%
Maximum	R	983,822,432	228%
Minimum	R	191,470,266	44%

Table 28: Statistical Analysis of the crude oil TCO, in rands per barrels

Statistical Analysis Element	Value		Value (% of Mean)
Mean	R	631.73	-
Standard Deviation	R	151.12	24%
Maximum	R	1,101.64	174%
Minimum	R	459.27	73%

4.4 Results pertaining to Research Proposition 2

In this section there will be two types of data presented, viz. estimated versus actual costs. The estimated values are the ones that were obtained by the personnel at the oil company, and which were not considered to be 100% accurate. The actual costs were calculated as a part of this research and are considered to be very close to the actual values of each TCO element. The estimated costs will then be compared to these actual costs in determining accuracy and precision.

4.5.1 *Personnel Costs*

Figure 35 displays the monthly personnel costs for both the estimate and actual values. As can be seen, the actual costs are more constant than the estimated costs. This is validated by the standard deviations, where the standard deviation of the estimated costs is R60 557, while that of the actual costs is R3 590. However, the means are not that far off each other, and are R134 617 and R145 605 for the estimated and actual costs, respectively.

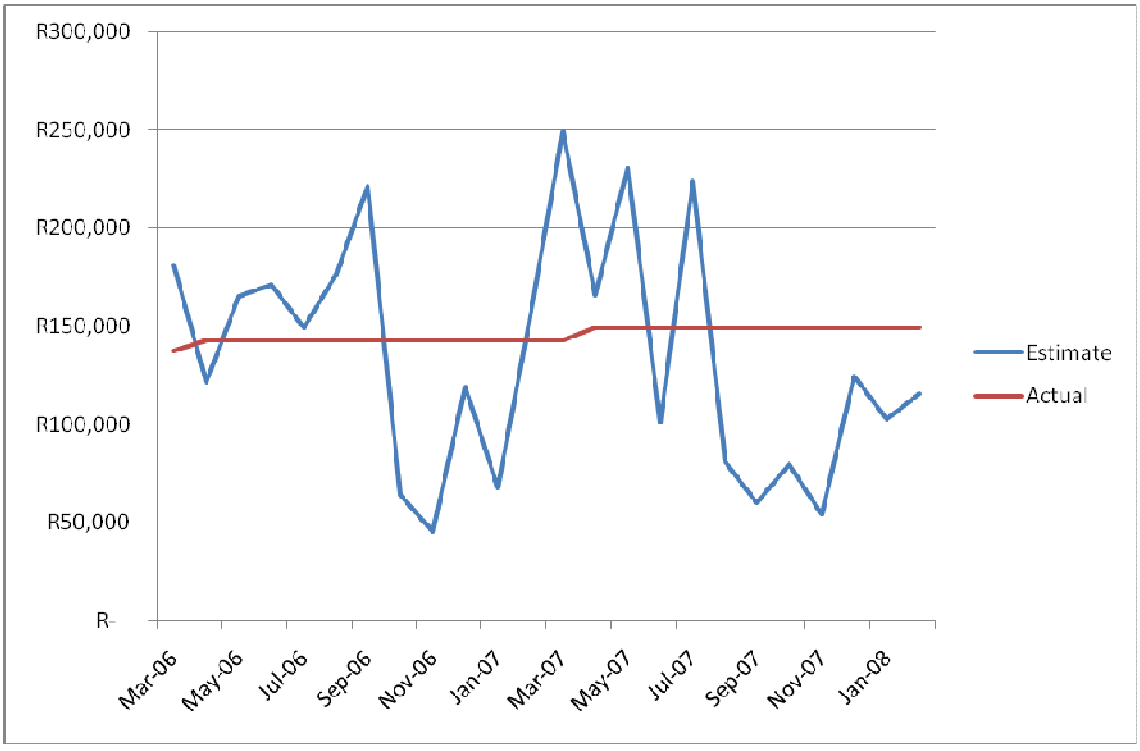

Figure 35: Comparison of estimated and actual personnel costs per month

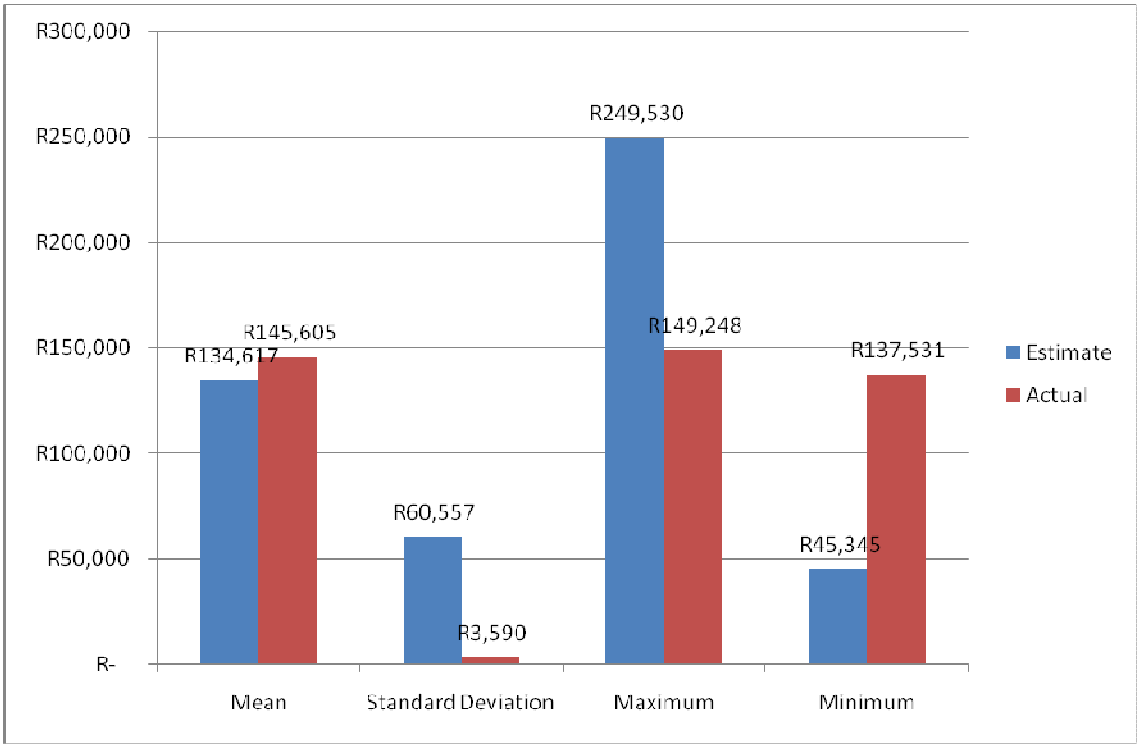

Figure 36: Statistical Analysis of estimated versus actual personnel costs

4.5.2 *Storage Costs*

As can be seen from Figure 37, the storage cost is estimated to be relatively constant over the entire period, with a mean and standard deviation of R965 169 and R344 739 respectively. The actual costs on the other hand have a standard deviation that is 27 times higher, and which is R9 389 665.

The estimated and actual storage costs remain close to each other until May 2007, when the actual costs increase by 21 times to R12 216 426 per month.

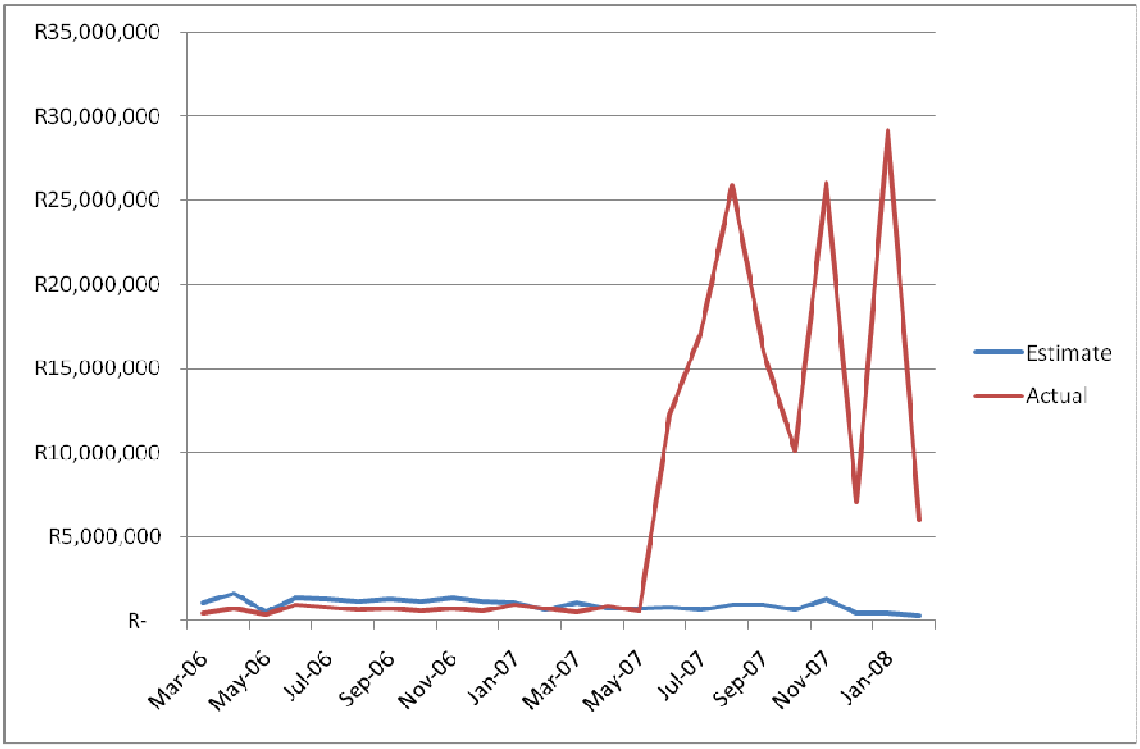

Figure 37: Comparison of estimated and actual storage costs per month

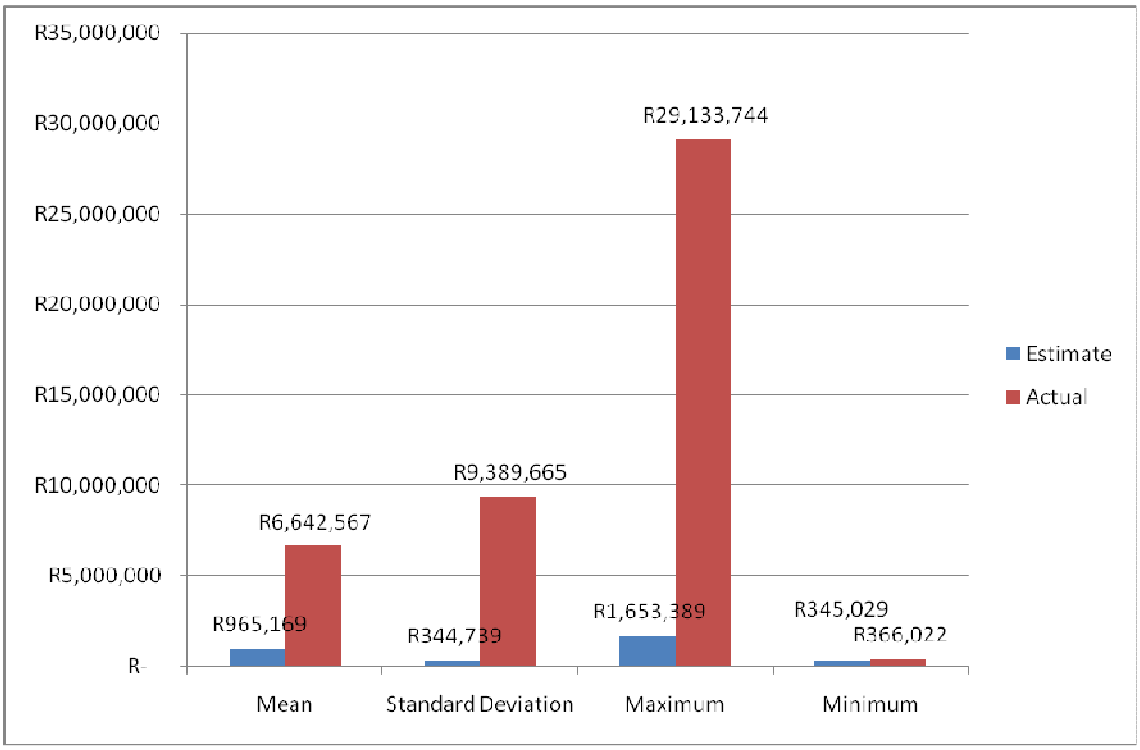

Figure 38: Statistical Analysis of estimated versus actual storage costs

4.5.3 *Inventory Holding Costs*

Both the estimated and actual inventory holding costs have the same trend, with the estimated cost being 1.83 times higher than the actual cost throughout the entire period.

The mean for the estimated cost is R7 343 087 with a standard deviation of R2 657 275. The actual mean was R4 005 320 with a standard deviation of R1 449 422.

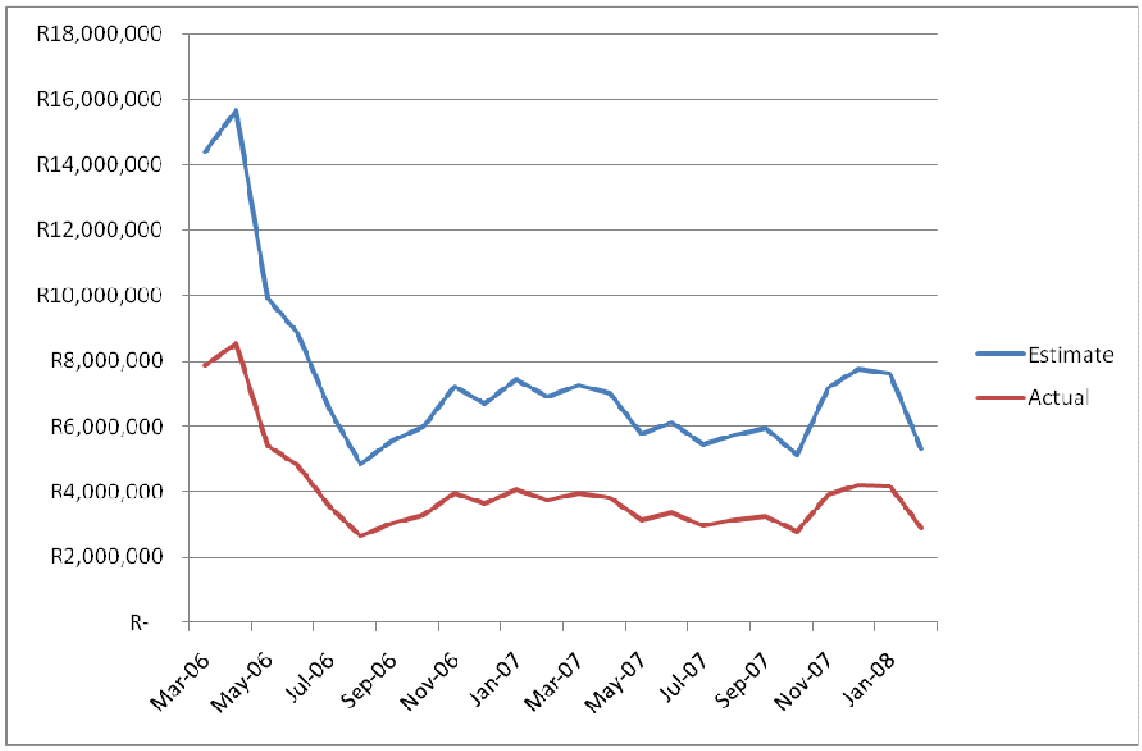

Figure 39: Comparison of estimated and actual inventory holding costs per month

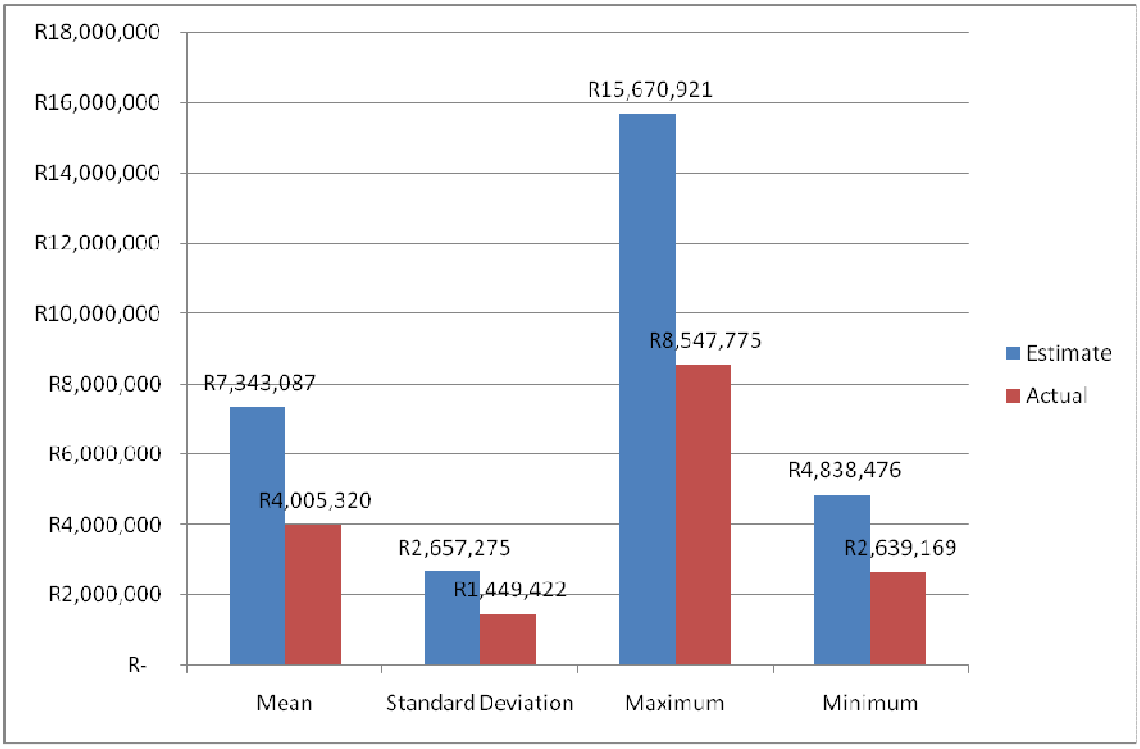

Figure 40: Statistical Analysis of estimated versus actual inventory holding costs

4.5.4 *Correlation Coefficient*

The estimated versus actual costs for storage and personnel have negative correlation coefficients, while that of inventory holding costs have a perfect correlation. Overall, these indirect costs have a correlation coefficient of -0.116.

The correlation coefficient of the estimated versus the actual TCO was very close to having a perfect correlation, viz. 0.998.

When the storage costs were separated into two periods, viz. pre-May 2007 and post May 2007, the correlation coefficients of both these periods improved to 0.36 and 0.49 respectively.

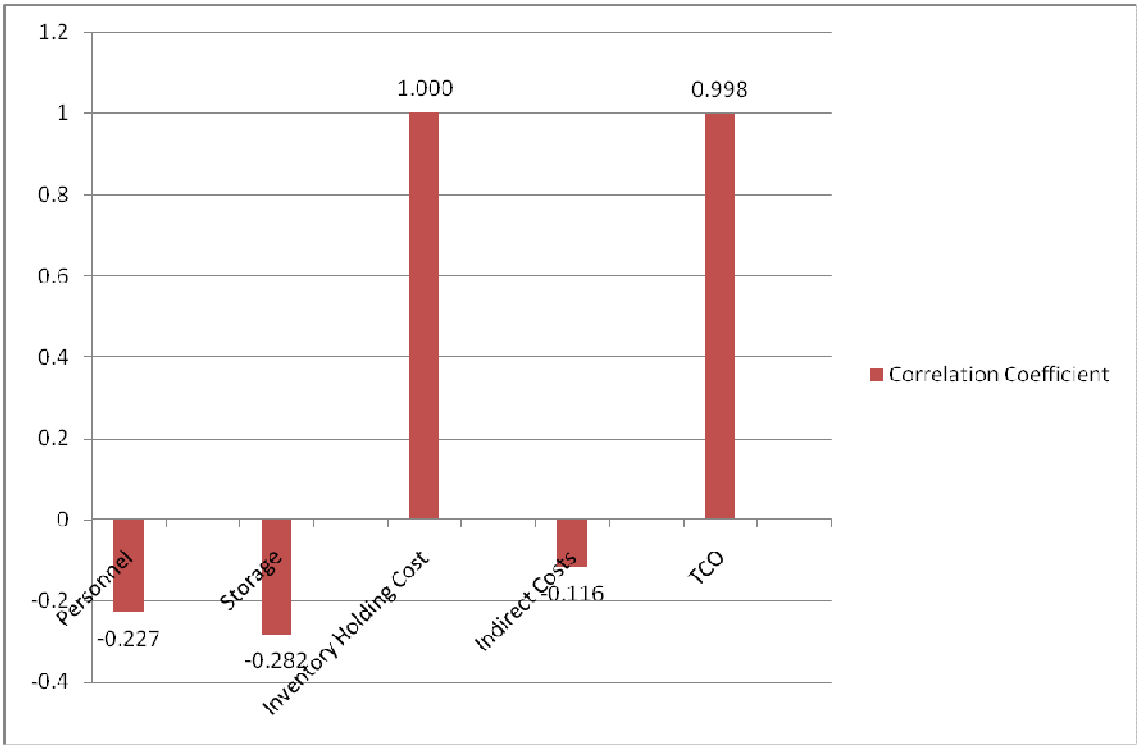

Figure 41: Correlation coefficients of the estimated versus the actual costs

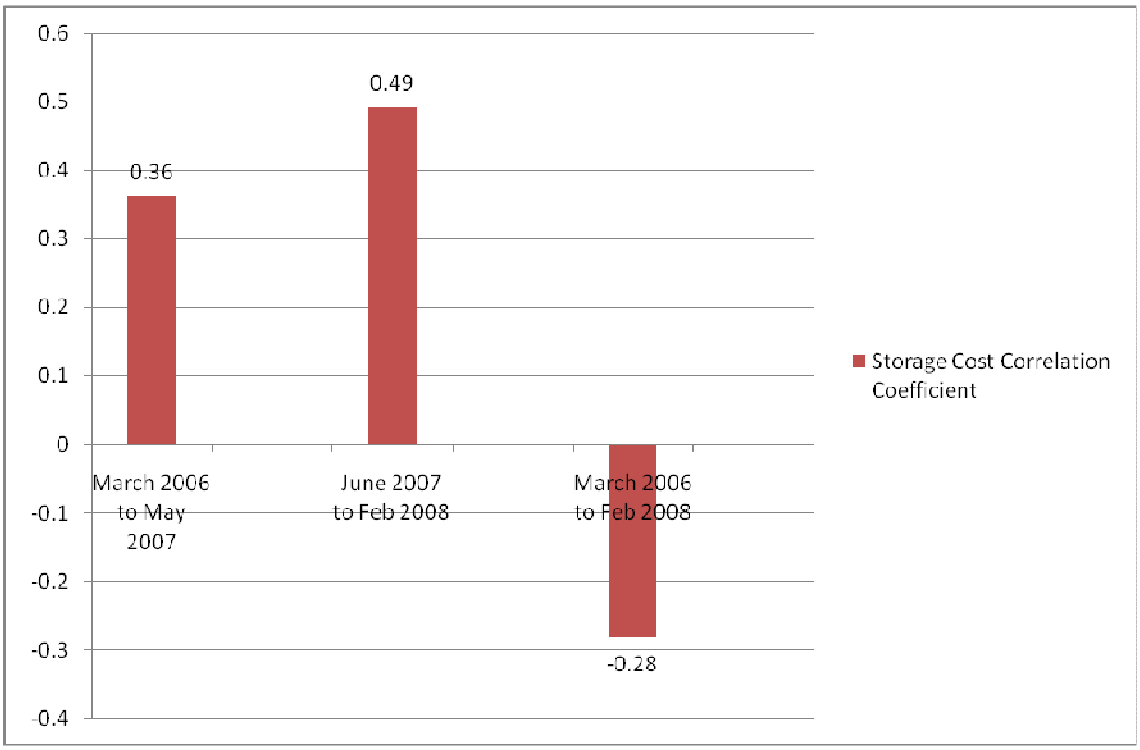

Figure 42: Correlation coefficients of the estimated versus actual storage costs for the different periods

It was found that the estimated personnel costs were the most accurate, being 92% of the actual costs. The storage cost was the least accurate, at 15% of actual costs. Inventory costs were over-estimated by 83%. The estimated indirect costs had little impact on the TCO, with the accuracy being 99% in that case.

Table 29: The accuracy of the TCO study

TCO Element	Accuracy (% of Actual)
Personnel	92%
Storage	15%
Inventory Holding	183%
Total Indirect Costs	78%
TCO	99%

4.5 Summary of the results

The results for both research questions were presented using descriptive statistics entailing time series graphs, calculation of means, standard deviations and correlation coefficients. The data were presented in the form of costs per month and costs per barrel over a 24 month period.

The elements of the crude oil TCO were identified and quantified with methods currently being used within the organisation. The more accurate values were presented for the indirect costs, viz. personnel, storage and inventory holding costs. These were then compared to the estimated costs.

All data displayed in this report have been disguised to protect the company involved. The data in no way can be used to determine the actual cost of crude oil.

CHAPTER 5: DISCUSSION OF THE RESULTS

5.1 Introduction

The intent of this research was firstly to quantify the TCO of crude oil for an oil refinery, and then to analyse its reliability. In this chapter, the discussion will take place around the TCO elements and its estimated values. It will then move on to discussing the comparison between the actual and estimated indirect costs. The aim is to compare the results obtained to literature and to attempt to explain any differences.

5.2 Demographic profile of respondents

The data collected from the archives took a longer time to collect than anticipated, mainly due to missing invoices which had to then be requested from the supplying companies. However, the literature study did reveal that one of the disadvantages of ABC is that data collection is more complicated and rigorous that traditional costing methods.

Respondents to the semi-structured interview were from many different groups in the company and from different geographic locations across the country. Telephonic interviews were conducted with certain individuals who could not be reached. The contribution of the administrative personnel, such as human resources and legal, towards the TCO were considered to be insignificant, and they were not interviewed. The reasoning behind this includes the following:

- These departments are small in comparison to the rest of the company.
- An oil refinery entails many different functions other than crude oil procurement. Thus, the time spent by these departments attending to personnel that are involved in crude oil procurement would be relatively small.

5.3 Discussion pertaining to Research Proposition 1

In analysing the data, it was presented in a set of time series graphs. This form of presentation gives one a visual illustration of how much variability there is in the value of each TCO element over the two-year period in question. The standard deviation, along with the mean, maximum and minimum for each element, were also presented to get an idea of the amount of variability that there is. However, since the data was disguised, the absolute values of these parameters were meaningless. That is why the standard deviations, maximum and minimum, were presented as a percentage of the mean. This gives one a better idea of the variability of each element.

Further to this, the mean of each element was presented as a portion on the TCO, which puts into perspective the magnitude of each element relative to the actual TCO. As a manager or someone who is in crude oil procurement, one has an idea of the elements of the TCO, other than the price, on which to focus. As can be seen, the price is by far the biggest component. Of the non-price elements, freight, transport and inventory holding are the most important elements, and should gain the most focus during the procurement process.

The literature study revealed that in most cases, the most significant element by value is the price of the product in question. In this case, the finding is in agreement with the literature, with the price of crude oil being by far the biggest element, comprising 94% of the TCO. Furthermore, literature revealed that the elements of TCO fall under the following categories:

- Acquisition costs
- Ownership costs
- Post-ownership costs

The elements of the crude oil TCO identified in this study fell in the first two categories only. Some of the acquisition costs of crude oil included the following:

- Purchase price

- Transportation
- Inspection
- Taxes

The ownership costs included the following:

- Insurance (Risk)
- Storage
- Non-value adds costs (Stock holding costs)

This study did not look at post ownership of crude oil, as it is refined into products that are then sold.

It is interesting to note that the cost of transporting the crude oil from the discharge port to the refinery, which is a relatively short distance, is almost the same as the cost of transporting it from the load port to the discharge port, which is usually a distance of several thousand kilometres. It is also interesting to note that the cost of storage and handling, the bulk of which is the holding cost, is almost equal to the cost of freight. These two observations are an indication of the economies of scale that can be achieved by using large shipping vessels to transport goods.

The element with the highest standard deviation relative to its mean is that of demurrage. This is as expected, given the nature of that cost element. Demurrage is not incurred all the time. In fact, there were no demurrage costs for 10 months out of the 24 month period.

For most elements, when the cost per barrel was analysed and compared to the statistics on a cost per month basis, it was found that the standard deviation was lower in the former case. This can be explained by the fact that volumes purchased vary from month to month. The standard deviation of volumes purchased was 31% of its mean.

This leads onto another aspect. The quantity purchased has a relatively high standard deviation, but oil refineries generally process crude oil at a fairly constant rate every month. This indicates that this oil refinery tends to keep sufficient stock on hand at all times. Maybe this is one of the areas that managers can look into to try to curb costs. This is even more important given that the cost of storage and inventory holding is one of the biggest non-crude oil costs. The literature indicates that if demand for crude oil is volatile, then the cost of storage of that crude oil tends to increase due to larger parcel sizes being purchased.

As expected, the crude oil price element and TCO have relatively high volatilities, viz. 41% of the mean. The literature study revealed that the market price of crude oil tends to be volatile, and seeing that the price is 94% of the TCO, then the TCO is bound to have a high standard deviation. What this ultimately means is that timing and the size of parcels purchased are probably the most important variables to be considered when purchasing crude oil.

Conclusion:

The crude oil price is the biggest element of the TCO of crude oil, with Transport and Storage & Handling costs being the most significant of the non-crude oil price elements.

5.4 Discussion pertaining to Research Proposition 2

As with Research Proposition 1, in analysing the data, it was presented in a time series graph, which gives one a visual illustration of how much of variability there is in the value of each TCO element over the two-year period in question. More importantly, the time series graphs give one a visual comparison of the estimated and actual trends of the entire period in question. The standard deviation, along with the mean, maximum and minimum for each element, were also presented, not just to get an idea of the amount of variability that there is, but to compare the estimated and actual values.

The estimated personnel costs are very volatile in comparison to the actual costs. The actual costs are almost constant during the entire period, which increases in value in August 2007 and August 2008. The actual costs were based on the salaries of all the people involved and the proportion of their time spent in crude oil procurement or related activities. On the other hand, the estimated costs were based on an hourly rate and the amount of crude oil procured. This is a very rough method of estimating personnel costs, especially in an environment where labour cost is considered to be fixed in the short term.

The standard deviation of the estimated cost is almost 17 times greater than that of the actual cost. Furthermore, there is no correlation between the estimated and actual costs. The correlation coefficient in this case is -0.227. Hence, the estimated personnel costs are unreliable.

Taking into account the small amount of time that goes into calculating the actual cost relative to the method used for estimating the cost, the recommendation is for the method used in calculating the actual cost to be used in all TCO calculations in the future.

The storage cost was estimated by multiplying a rand per barrel cost to the volume of crude oil purchased. This rand per barrel cost was based on a cost that was calculated in the previous financial year, and is escalated on an annual basis. The actual cost was calculated by looking at the actual invoices charged for storage over the entire year, and by dividing this by the total crude oil and other products being stored at those facilities. The invoices were available on a monthly basis, which enabled the actual storage costs to be calculated on the same basis.

From the time series graph in Figure 37, it can be seen that estimated and actual costs are fairly close to each other until May 2007. In this month the actual cost increases by around 2000% and becomes volatile thereafter, while remaining several orders of magnitude higher that the estimated cost. The reason for this jump in the actual cost is unknown, and could be explained by the sudden realisation that the wrong rate was being charged, or a renegotiation of the contract. Despite this, there is no correlation between the actual and

estimated costs, with the correlation coefficient being -0.282. Hence, the estimated storage costs are unreliable.

However, it must be noted that if the time period is broken up into two periods, viz. pre-May 2007 and post-May 2007, then there appears to be some sort of correlation in these two periods. Given these observations, the recommendation is that the storage cost must be compared to actual costs on a more regular basis, as opposed to once a year. Updates on a quarterly basis will yield a more reliable estimate.

The inventory holding cost was estimated by firstly calculating the average quantity of crude oil held at all the storage facilities. Next, the value of this stock was then calculated, based on the crude oil purchased for that month. It was then assumed that the cash, which is equivalent to value of the stock being held, is reinvested in another part of the company. The resultant return on that cash was then taken as the inventory holding cost.

The actual cost was calculated in a similar manner. Instead of assuming that the cash could be reinvested in another part of the business, it was assumed that the cash would be used to pay the bank overdraft. The interest rate was assumed to be the prime lending rate less two percent. The result was that the return from reinvesting in the business was 83% higher than the bank overdraft interest rate. This resulted in the estimated inventory holding cost being 83% higher than the actual inventory holding cost.

Given the methods used to calculate the estimated and actual inventory holding costs, it is no surprise that these two trends correlate exactly. The option of using the cash equivalent of the stock that was held to pay off the bank overdraft can be considered much less risky than reinvesting it into another part of the business. The assumed return on the latter option is not guaranteed, whereas the savings on the interest paid on the bank overdraft is virtually guaranteed. Hence, the recommendation is that one makes use of the method and assumptions that were used to determine the actual inventory holding cost when estimating this value in all future calculations.

The indirect costs were essentially taken as a summation of the personnel, storage and inventory holding costs. It was found that there is no correlation between the estimated and actual costs, with a correlation coefficient of -0.116. This was as expected, since the personnel and storage costs also gave no correlation. However, even with that being said, the indirect costs are a very small part of the overall TCO. Even though the estimated indirect costs are only 78% accurate, the accuracy of the TCO is only reduced to 99%.

However, one can argue that 1% of a very large number still gives you a large number. In this case, 1% equates to R4.3 million per month, and R52 million per annum. Hence, given the high value of crude oil TCO, one needs to ensure that the estimated costs are more accurate to ensure the reliability of a crude oil TCO study.

The literature study found that increasing the complexity of an ABC study can affect the accuracy and trustworthiness of the results by managers. However, in this case, a more complex study is required owing to the high value of crude oil. Hence, one needs to find the right balance between complexity and reliability. This can only be done by trial and error in the organisation.

In the case of crude oil, there are not many indirect costs that require estimation, i.e. only three elements. Hence, it might not be as time-consuming as with other products to get more accurate and reliable results. As was also revealed in literature, a big investment of one's time is only required upfront. Any subsequent studies done will require much less effort.

It was found during the literature study that there is a positive association between improvement in ROI and ABC implemented in firms where costs are relatively important. Since the oil refining business is a low margin business, the input costs, especially that of crude oil, are very important to the business. Hence, spending more time to improve the reliability of crude oil TCO studies in oil refineries could help the firm improve on its ROI.

Conclusion:

The indirect costs are only 78% accurate when comparing the means of the estimated and actual costs. This is in agreement with the research proposition presented in this section. However, the estimated costs have a higher standard deviation. There are perceived benefits to spending more time in increasing the accuracy and precision of a crude oil TCO study done by an oil refinery.

5.5 Conclusion

As discovered in literature, the data took a long time to capture due to the complexity of ABC over traditional costing methods. It was found that the crude oil price was by far the biggest component of the TCO, which was as expected. It was interesting to note that the cost of transporting the crude oil from the discharge port to the refinery, which is a relatively short distance, is almost the same as the cost of transporting it from the load port to the discharge port, which is usually a distance of several thousand kilometres.

As was expected after the literature study, all elements of the TCO had high standard deviations, both on a rand per month and rand per barrel basis. This was mainly due to the volatile crude oil market price and inconsistent quantities of crude oil being purchased on a monthly basis. It was surprising to note that the quantity purchased had a high standard deviation, especially in light of the fact that the quantity of fuels produced is fairly constant on a monthly basis. This partially explains the relatively high inventory holding costs incurred by the refinery.

It was found that personnel in crude oil companies in South Africa tend to estimate overall indirect cost to an accuracy of 78%. The indirect cost is made of personnel, storage and inventory holding costs. The estimated personnel and storage costs were not correlated to the actual costs, while the inventory holding cost was perfectly correlated. The estimated storage cost would have had a fairly good correlation had it not been for a sudden increase in the actual storage cost. The estimated storage cost is only compared to the actual cost on

an annual basis, and it is suggested to do this on a more frequent basis to address this inaccuracy.

Even though the estimated indirect costs are only 78% accurate, the accuracy of the TCO is only reduced to 99%. However, one can argue that 1% of a very large number still gives you a large number. In this case, 1% equates to R4.3 million per month, and R52 million per annum. Hence, given the high value of crude oil TCO, one needs to ensure that the estimated costs are more accurate to ensure reliability of a crude oil TCO study. Also, the estimated costs have a higher standard deviation. The conclusion is that there are perceived benefits to spending more time in increasing the accuracy and reliability of a crude oil TCO study done by this oil refinery.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

In this chapter, the conclusion of the entire study is summarised, along with recommendations and suggestions for further research.

6.2 Conclusions of the study

The oil refining business is one that experiences low margins in comparison to other businesses. Further to this, the product that it produces, i.e. liquid fuels, has its price regulated in South Africa. In light of this, a significant way of improving its profits is by controlling its input costs, which is mainly the procurement of crude oil. The literature study has revealed that crude oil procurement and scheduling thereof are key activities in oil refineries and require optimal performance of these tasks to ensure profitability.

It was also discovered in the literature study that the TCO concept, which is an ABC method, is being used more frequently by corporates and is mainly used for supplier selection, supplier performance management and to drive major changes in a business. The price is the most significant element of the TCO of most goods and services. Studies reviewed for this report indicate a price component of between 56% and 98% of the TCO. The TCO takes into account all possible costs, and includes elements from pre-acquisition to post-acquisition.

It was found in literature that ABC studies cannot be 100% accurate, and that it takes much more effort to increase that accuracy from 80% than it takes to get it to that point. In general, if an ABC study is too complex, it can affect its accuracy and trustworthiness by the managers.

In this study, the elements of the crude oil TCO were identified and quantified with methods currently being used within the organisation. The more accurate

values were presented for the indirect costs, viz. personnel, storage and inventory holding costs. These were then compared to the estimated costs. The results for both research propositions were presented, using descriptive statistics entailing time series graphs, calculation of means, standard deviations and correlation coefficients. The data were presented in the form of costs per month and costs per barrel over a 24 month period.

The crude oil price is the biggest component of the TCO, comprising 94% of it. Of the non-crude oil price costs, which was 6% of the TCO, transport costs made up more than 60% of this category. Storage and handling was the next biggest component, making up around 30%. It is interesting to note that the cost of transporting the crude oil from the discharge port to the refinery, which is a relatively short distance, is almost the same as the cost of transporting it from the load port to the discharge port, which is usually a distance of several thousand kilometres. This showcased the economies of scale that can be achieved by the use of very large ocean vessels. The literature study indicated that the most economical means of transporting products of relatively low value to weight ratio are via very large ocean vessels.

It was found in this study that the estimated overall indirect costs were 78% accurate. Further to this, the estimated costs had a higher standard deviation than the actual costs, thus indicating its higher degree of volatility over the 24 month period. In spite of this, the estimated TCO still had an accuracy of 99%. However, one must take note that the crude oil TCO is still a relatively high value, and 1% equates to roughly R52 million per annum. Hence, one needs to ensure that the estimated costs are more accurate to ensure reliability of a crude oil TCO study.

There are perceived benefits to spending more time in increasing the accuracy of a crude oil TCO study done by the oil refinery. This study indicates that there is room to improve the accuracy and reliability of a crude oil TCO study, which can result in improved profits for the oil refinery.

6.3 Recommendations

Given the results on the accuracy of the crude oil TCO study in the chosen organisation, the main recommendation goes out to procurement managers in oil refineries in South Africa. Crude oil TCO studies should be done to a reasonable level of accuracy. To achieve this, one needs to spend a lot of time doing the initial study, especially in identifying the cost drivers of personnel costs and determination of the actual storage costs at least once every four months, if not every month.

When determining the inventory holding costs, one should assume a risk free return on cash that is tied up in stock holding, such as paying off the bank overdraft instead of investing in other parts of the business which are of a higher risk. This is a more realistic method to use, and does not escalate a component of the TCO that is already of a relatively high value.

It is recommended that crude oil procurement managers maintain a low variability in the quantity of crude oil purchased on a monthly basis, to match the variability of the rate at which it is processed at the refinery. This would ensure that the inventory holding costs are minimised, thus improving the profitability.

Lastly, anyone who is currently looking at building a new refinery in South Africa must consider all aspects of crude oil procurement, especially the variability of the quantities purchased on a monthly basis, when looking at the economics of the venture.

6.4 Suggestions for further research

One of the recommendations of this research is to maintain a low variability of quantity of crude oil procured on a monthly basis. Further research is required to determine the actual effect on the profitability of oil refining by varying the quantities of crude oil purchased monthly.

Another aspect that can be researched further is the amount of time or effort that is required to improve the accuracy of indirect costs of the crude oil TCO closer to 100%.

In addition, the South African fuel industry will see some changes coming into effect in the near future. Some of these changes include the construction of a pipeline to transport fuel and crude oil into the inland region of the country, and the possible tightening of fuel specifications. A study can be done to analyse the effects of these changes on the input costs and profitability of a South African oil refinery. How can TCO studies assist refineries in these new environments?

Another area of research could entail investigating the entire oil refining industry in South Africa, and not just a single company. It would be interesting to see whether the same findings for the chosen organisation actually do apply to the entire industry.

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APPENDIX A

Actual Research Instrument: Questions for Interviewees

General:

1. What is your name?

2. What is your job title?

3. What is your job level in this company?

4. Which department do you work in?

5. What percentage of your time is spent on the procurement of crude oil, or activities related to crude oil procurement?

6. List the members of your department, and their respective levels.

Questions specific to Cost Accountant:

1. List the elements of the TCO of crude oil.

2. What method was used in quantifying each element?

APPENDIX B

Consistency matrix

Determine the elements of a total cost of ownership calculation done for imported crude oil for a South African oil refiner, and assess the reliability and accuracy of it.					
Sub-problem	**Literature Review**	**Hypotheses or Propositions or Research questions**	**Source of data**	**Type of data**	**Analysis**

Determine the elements of a total cost of ownership calculation done for imported crude oil for a South African oil refiner, and assess the reliability and accuracy of it.					
Sub-problem	**Literature Review**	**Hypotheses or Propositions or Research questions**	**Source of data**	**Type of data**	**Analysis**
The first sub-problem is to determine the elements of the TCO of imported crude oil for a South African oil refiner.	Davidson et al (2006) Dees et al (2007) Degraeve et al (2005) Ellram (1995) Ellram (2006) Ellram and Sieferd (1998) Guyonnet et al (2009) Janhonen (2008) Julka et al (2002) Pan et al (2009) Song et al (2007) Wouters (2008) Young et al (2009)	The elements of a TCO of crude oil purchased by a South African oil refinery will include the following: price, transportation, customs duty, storage costs, and administrative overhead costs.	Archival – data was retrieved from original invoices found in the archives of the chosen oil refinery.	Nominal (ratio data)	Descriptive statistics.

Determine the elements of a total cost of ownership calculation done for imported crude oil for a South African oil refiner, and assess the reliability and accuracy of it.					
Sub-problem	**Literature Review**	**Hypotheses or Propositions or Research questions**	**Source of data**	**Type of data**	**Analysis**
The second sub-problem is to assess the reliability and accuracy of a TCO analysis done for imported crude oil for a South African oil refiner.	Barrett (2004) Baykasoglu and Kaplanoglu (2008) Cagwin and Bouwman (2002) Homburg (2001) Noreen and Soderstrom (1997) Stapleton et al. (2004)	For the TCO analysis done for imported crude oil for a South African oil refinery, the indirect cost portion will have an accuracy of around 80%.	Archival – data was retrieved from original invoices found in the archives of the chosen oil refinery.	Nominal (ratio data)	Descriptive statistics.