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# The Impact of the Government's Hedging Strategies on Petrol Prices in South Africa

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# *The Impact of the Government's Hedging Strategies on Petrol Prices in South Africa*

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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 the Master of Business Administration

Johannesburg, 2008

# Abstract

Since 2003, petrol prices in South Africa have increased to unprecedented levels, due largely to global increases in crude oil prices. Although there are different opinions on the causes of high crude oil prices, there is consensus that high fuel prices have a negative impact on global economies, in general, and on developing economies in particular. The impact of high petrol prices on economic development has, in some countries, required that governments derive mechanisms of mitigating their impact.

One way to lessen the impact of petrol price increases and volatility is through hedging at a national level. Up until 2003, the South African government used to manage petrol price increases for the petrol consumer through use of an equalisation fund mechanism. However, in 2004 the practice was discontinued and a number of attempts to find a replacement have had limited success.

This study seeks to provide an *ex post* empirical analysis of the impact of hedging South Africa's petrol prices. The analysis shows the beneficial impact of the use of derivatives in reducing the consumer price risk. It examines the impact of the unhedged strategy against hedging petrol prices in order to evaluate the overall cost of petrol to the consumer that would result from hedging. The hedging strategy considered in this research involves purchasing artificial call options using a strategy that is known commonly as "writing reverse calls". In the study, these options are priced through use of the Black-Scholes formula. The total cost of petrol to the consumer with the hedge is then compared against the situation where there is no hedge.

The study found that the proposed hedging strategy could result in lower consumer prices and lower petrol price volatility. Lower prices also imply that the inflationary impact of fuel prices could be reduced.

# Declaration

I, Nhlanhla Gumede, declare that this research report is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

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Nhlanhla Gumede

Date:

# Dedication

In loving memory of my late brother and best friend

Siyabonga Gumede

1970 - 1990

# Acknowledgements

I wish to express my sincere thanks to:

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# 1 Introduction

Since 2003, global petrol prices have been rising at such a rapid rate that economies have not had time to sit back and consider their options properly. Prices have reached unprecedented levels, precipitating civil unrest in some parts of the globe. High fuel prices have translated into high food prices, which have had a marked negative impact on developing economies.

In this research, a possible approach to managing these high prices in South Africa is investigated. This study proposes a possible market-based approach to alleviate the impact of high petrol prices and to manage high levels of price volatility. Management of price risk is a well understood and practised discipline and, therefore, tried and tested tools exist. The tool that was investigated in this research was hedging.

One way to alleviate the impact of high fuel prices would be to hedge both the price and its volatility by means of options. If the hedging is performed at national level, it has a potential to lower consumer prices. Hedging, however, is costly and complex and requires the state to perform on behalf of its citizens.

## 1.1 Purpose of research

The purpose of the research was to evaluate the possible impact of hedging petrol prices, at national level, by the government in South Africa. The hedging strategy is investigated against the backdrop of current consumer prices, which are not hedged at all.

This study seeks to establish whether daily fuel-price changes, with an allowance for the use of a financial instrument for hedging, would provide consumers with the best pricing strategy. Therefore, the purpose of this study is to develop an appropriate petrol pricing strategy that would allow best

market performance whilst protecting the consumer from the vagaries of global petrol prices.

The South African price-setting methodology comprises a number of price elements. This study focuses only on one of the elements, the “basic fuels price” component, as the other price elements are not subject to the daily pricing variations induced by the crude oil price and exchange rate variations.

## 1.2 Context of study

This study is informed by the high crude oil prices dominating world news since the turn of this century and the impact such high prices have had on global economies. Although the problem of high and volatile prices was not only limited to South Africa, the problem was more interesting from the South African perspective because of the government’s price controls that governed the country’s liquid fuels’ sector.

Respective South African governments have tried various approaches, including the recently abandoned equalisation fund approach, to manage the impact of fuel prices on consumers. The government has even investigated the method of hedging using futures to protect consumers. Although hedging indicated that consumer prices could be successfully managed, using futures proved to be too expensive.

Governments have over decades been concerned about the impact of energy prices on consumers in general and on their economies in particular. Some governments considered subsidies, with some still subsidising household energy fuels. With the recent improvements in the energy intensity of most economies, most governments have moved away from subsidising energy carriers to allowing the markets to determine energy prices. In the cases where support is offered, there is very little research that has been conducted in the optimal design of national hedging strategies. This study investigates the use of derivatives as a possible national hedging strategy.

As in the approach used by Chen *et al* (1987), this study seeks to provide an *ex post* empirical analysis of the hedging potential on South Africa's petrol prices. The analysis seeks to show the potential for use of derivatives in reducing the consumer price risk. This study adds value to the literature on use of derivatives in South Africa. It also adds value to economic policy-making in South Africa.

## 1.3 Main problem and sub-problems

### *1.3.1 Main problem*

The main purpose of the research is to evaluate the possible impacts of the government's hedging of the petrol price in South Africa on the consumer. The main research problem is whether a mechanism could be designed that would help cushion consumers from the impact of high fuel prices. The main research question is, therefore, whether hedging petrol prices would result in lower average consumer prices than are otherwise achieved through the approved South African petrol pricing framework.

### *1.3.2 Sub-problems*

The first sub-problem is establishing whether, on average, consumers would enjoy a lower petrol price if the price of fuel was hedged, i.e. whether the price of fuel "under a hedge", excluding the costs associated with hedging, would be lower than the price without it.

The second sub-problem is establishing whether the total cost of petrol to the consumer, including costs associated with hedging, would be lower under the hedge than without it, i.e. whether the monthly average price under the hedge, including the cost of hedging, will be less than the average fuel price derived by South Africa's regulatory framework.

The research aims to answer the following two sub-questions.

*The first question*: would the cost of acquiring petrol, excluding the hedging costs, in a price-mitigation strategy be lower on average than petrol prices derived from the current South African pricing system?

*The second question*: would the total cost of petrol to consumers in a hedged environment, including the costs associated with hedging, be lower on average than that in an environment without hedging?

## 1.4 Significance of study

It is envisaged that the outcomes of this study could guide governments in their quest for market-based strategies that could lessen the impact of the prevalent high petrol prices on consumers and the economy in general.

There is no shortage in literature of studies on oil prices and factors that affect the prices. There is also enough material in literature on programmes adopted by governments aimed at subsidising fuel costs for the poor masses. There is even more material on hedging strategies adopted by companies to protect their profits. However, there is very little research that has been conducted on the market-based strategies that could be adopted by governments to protect consumers from high fuels costs.

Governments have regulatory powers and therefore generally pass laws or decrees when confronted with pricing problems. However, if legislation does not solve the pricing problem, they generally resort to subsidies. The vice-president of the World Bank, Mr Serageldin once said, "Let us not overlook the fact that developing countries are subsidising energy at the rate of US$230 billion per year. That is more than five times the current total of development assistance payments from North to South" (Metschies 2007:70).

This study provides an alternative, market-based approach to oil price risk mitigation. The learning from this study should provide a theoretical basis for governments who seek to develop market-based interventions aimed at reducing the impact of fuel prices on consumers and the economy.

## 1.5 Limitations and delimitations

Whilst it is important to understand the issues this study sought to investigate, it is just as important to understand which issues were considered to be out of scope of this study.

### *1.5.1 Delimitations*

It is not the intention of this study to pass judgement on the merits or demerits of South Africa's petrol price control system. Therefore, the investigation does not test whether there would have been a need for any intervention had prices not been controlled.

In the study, it is assumed that the daily quoted prices are prices that would have been realised by the market. The assumption seems a fair one considering that South Africa imports a significant amount of its oil requirements and its price structure has, like all other oil importing economies, a significant import parity component. It is however possible that, due to some unique local demand-supply situations, prices in South Africa could be different from those derived through the basic fuels pricing formula, particularly considering the current supply constraints to the inland region, which have little to do with global demand-supply dynamics. This research therefore assumes that South African prices are correct prices and appropriate prices.

It is also not the intention of this study to investigate risk-mitigation strategies that could be adopted in the commercial (large business) sector of the liquid fuels industry. The study only focussed on development of a risk-mitigation strategy for the fragmented part of the liquid fuels industry, viz the motoring segment. The motoring sector is also the biggest consumer of petrol in South Africa – hence, the relevance of the study outcome (Horvei *et al* 2002).

### *1.5.2 Limitations*

The cost of the options that are considered in the proposed hedges for the motoring public is evaluated through the use of the Black-Scholes (BS) formula. The use of the BS formula assumes that the number of assumptions that underpin the formula do hold (Hull 2003:245). The applicability of the BS formula potentially limits the accuracy of the results obtained from this study. However, the research does not intend to obtain 100% accurate costs that would be associated with a derivative instrument but rather to, within a reasonable degree of confidence, obtain reasonable cost estimates.

It is therefore important that, in considering the merits and the demerits of the findings of this study, these limitations be taken into account.

## 1.6 Definition of terms

Where possible, every attempt was made to use standard terms but, due to the technical nature of the study that was undertaken, it was impossible not to use terminologies that had specific meaning to the topic. These terms, unless otherwise so stated in the context, have the meaning attributed to them in this section.

The term *basic fuels price (BFP),* as defined by the Department of Minerals and Energy (2008), means deemed costs of importing a significant portion of finished petroleum products into South Africa. It is determined on a daily basis but only changed once a month at the pump. In calculating the average basic fuels price (BFP) for the price determination periods, and the resultant average unit over- or under-recoveries for the fuel price review period preceding the fuels price adjustment on the first Wednesday of each month, only weekdays (i.e. Monday to Friday) are used. Where any weekday happens to be a public holiday of South Africa or in the relevant overseas country, the data, as at the previous workday, are carried forward and deemed to be applicable for that public holiday.

*Margins* are wholesalers' and retailers' outputs measured by the value of trade margins realised on the goods they sell, i.e. the difference between the sale value of products sold and the cost of purchasing these products.

*Retail price* means the final price charged to consumers for petrol, which includes all importing costs, logistical costs (transport and storage), taxes and levies and all relevant margins.

*Retail price maintenance* refers to the system of petrol price setting that is used in South Africa to set the price of petrol at the pump. This system is empowered by a regulation (Regulation 1100 of 1996), which itself is empowered by Section 2 (1) *(c)* of the Petroleum Products Act, 1977 (Act No 120 of 1977).

# 2 Literature review

In defining the problem, it is important to properly locate it in both micro- and macro-economic landscapes and in both regional and global geopolitical maps (Dées *et al* 2008). This is even more important when the subject is oil and especially the oil price. Oil "oils the engines of all economies" (Longo *et al* 2007; Ahdoot *et al* 2001; Gumede *et al* 2007).

The focus of this research is on affordability of oil and is arranged as follows: the initial discussion is on energy security. This is followed by a review of the impact of the high prices of energy on economies. The causes of high oil prices are investigated. The South African oil pricing framework is then reviewed as well as the country's history of oil pricing risk mitigation. The review concludes with a discussion of hedging approaches.

## 2.1 Re-emergence of energy security

Securing the energy landscape is securing our future. The terrorist attacks on the United States of America on 11 September 2001 saw the re-emergence of the concept of energy security with major emphasis being on the impact of energy prices on global economies (Barton *et al* 2004). The concept of energy security means a number of things to different people: its definition depends on one's vantage point (Barton *et al* 2004; Gumede *et al* 2007).

In South Africa, energy security is defined as "ensuring that diverse energy resources, in sustainable quantities and at affordable prices, are available to the South African economy in support of economic growth and poverty alleviation, taking into account environmental management requirements and interactions among economic sectors," (Gumede *et al* 2007:5).

According to Barton *et al* (2004:4), "the term 'energy security' has a particular resonance in the United States. Energy security has been a part of national policy making since the 1970s. Energy security emphasizes the connection between energy policy and national security." Energy security in the US has

for many years, been about “energy independence” (Barton *et al* 2004; Ames *et al* 2004).

Barton *et al* (2004:5) say energy security is “a condition in which a nation and all, or most, of its citizens and businesses have access to sufficient energy resources at reasonable prices for the foreseeable future free of major disruption of service.”

As can be seen in both Barton *et al* (2004) and Gumede *et al* (2007) definitions, energy security has a number of pillars, namely –

- diversification of energy resources;
- sustainability of quantities, which is an explicit link between supply and demand;
- affordability of energy prices, which is an indication of the non-elasticity of energy demand;
- requirements for effective environment management practices, recognising the fact that energy contributes disproportionately to global warming; and
- recognition of interactions between energy and economic sectors.

This research is concerned with the economy’s ability to withstand high oil prices and oil price volatility.

## 2.2 Impact and significance of oil prices

The impact and the significance of the price of oil in the economy, varies from economy to economy (Ahdoot *et al* 2001; Barton *et al* 2004; Brook *et al* 2004). What is certain however is that, for most economies, oil will certainly, in the longer term, retain its importance as a fuel and increasingly for transportation purposes (Barton *et al* 2004; Brook *et al* 2004).

The importance of oil in any economy is dependent on the structure of that economy (Williams 2006). In the words of President Hugo Chavez as quoted by Forefront (2000), “[w]hether the price of oil is too high or too low depends

on the point of reference being used. The industrialized countries want oil producing countries to think that the price is high, but today it is lower in real terms than it was 20 or 30 years ago. Meanwhile we cannot afford to overlook the reality that inequalities between the richest and poorest nations are deepening and the fact that the poorest people in the world are struggling for survival. In considering our future path, we need to fight for a world of equals…"

The high oil prices do not seem to be bringing only good news to oil-producing countries either. An Arab Gulf merchant banker disputes the notion that high oil prices bring riches to the Arab world. He says: "[r]ich is education … expertise … technology. Rich is knowing. We have money, yes. But we are not rich. We are like the child who inherits money from the father he never knew. He has not been brought up to spend it. He has it in his hands; he doesn't know how to use it. If you do not know how to spend money, you are not rich. We are not rich. Without this knowledge, this understanding, we are nothing. We import everything. The bricks to make houses, we import. The men who build them, we import. You go to the market, what is there that is made by Arabs? Nothing. It is Chinese, French, American … it is not Arab. Is a country rich that cannot make a brick, or a motorcar, or a book? It is not rich, I think." (Landes 1998:409)

Many wars, especially in the previous century, were fought over oil (Heinberg 2006). Russia, by cutting supplies to the Ukraine, showed that energy or those that control energy resources are ready and willing to use energy as a source of power (Heinberg 2006). As Heinberg (2006) wrote, "while Russian president Vladimir Putin re-established gas shipments as soon as the Western countries complained (they did so because they were running short, due to Ukraine's skimming off of gas being trans-shipped to Europe through its territory), Western officials saw this as Russia unsheathing its 'gas weapon'."

According to Simon (2004), although Africa's contribution to both oil supply and demand is relatively small, it serves as a balancing power and, hence, it is important. Africa, at the beginning of this century, supplied only about 18%

of all US net oil imports (Brodman 2004). Africa stands to become an increasingly important US energy supplier in the next decade. However, Brodman (2004), cautioned that "continued investment would depend on political and economic stability, on the existence of transparent regulatory regimes, and on a continuation of competitive fiscal terms capable of attracting international capital."

South Africa, as with all oil consuming countries, is at the mercy of oil producing countries (Forefront 2000; Hamilton 2005; Williams 2006). The advent of democracy in the country led to a more secure and dependable supply of crude oil and less dependence on sanction busters but has still left the country exposed to the high global prices of this necessity good (Horvei *et al* 2001; Gumede *et al* 2007).

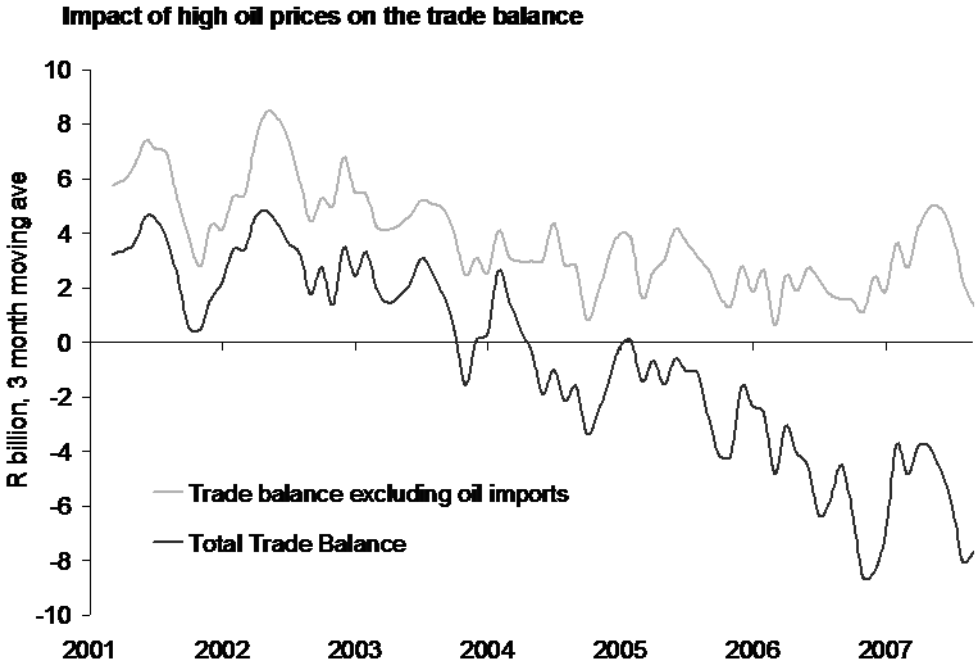
Maghyereh and Al-Kandari (2007) argued that fuel price increases impact on all economic activity. Reserve Bank governors, who are custodians of monetary policy, are primarily concerned with the impact of ever-increasing fuel prices on inflation (Kganyago 2007; African Development Bank 2006). For South Africa, the impact of increases in the petrol price is further felt through its trade figures (African Development Bank 2006). Figure 1 shows the impact of increasing finished oil product imports on South Africa's trade account.

Over the years, different writers (Dees *et al* 2008; Kooros *et al* 2006; Heinberg 2006) have asked whether a need exists for governments to intervene in fuel price increases. Anderson (2000:4) argued that "intervention in the market can cost far more than it saves." Underlying Anderson's (2000) concerns are questions on finding of appropriate means of regulating the industry that would ensure the greatest public good.

Brook *et al* (2004) contend that global dependence on oil is set to continue and the price of oil and its volatility is set to increase; whilst Anderson (2000) says that there is no need for governments to develop price-mitigation strategies for their economies. As stated by Williams (2006), oil demand is virtually inelastic, especially in the short-term, which limits the market's ability

to respond to price signals, (Brook *et al* 2004). As Anderson (2000) and Williams (2006) point out, most oil price increases are passed through to consumers [resulting in reduced consumer buying power (Anderson 2000; African Development Bank 2006)]. Brook *et al* (2004:3) however concluded that "the link between the oil price and core inflation has weakened."

**Figure 1 - Impact of oil imports on South Africa's balance of payment**




*Source*: Kganyago (2007:14)

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For economies with high levels of taxes on fuels, the impact of changes in the basic fuel cost is low and perhaps less important (Brook *et al* 2004). According to Brook *et al* (2004), high taxes on oil products help to insulate an economy from higher oil prices. The significance of price increases on inflation is also low due to the general weight of oil in inflation indices (Brook *et al* 2004). The African Development Bank (2006) however argued that high petrol prices have impacted detrimentally on African economies.

Brook *et al* (2004) showed that even though oil demand is inelastic, an increase in oil price leads to a reduction in purchasing power of consumers thereby resulting in lower aggregate demand and eventually lower economic output. African Development Bank (2006) and Kooros, Sussan and Semetesy (2006) showed that petrol price increases have negative impacts on employment. In respect of producers of consumer goods, higher oil prices imply higher input costs and therefore lesser profits and, in respect of consumers, it means lesser buying power (Forefront 2000, Brook *et al* 2004; African Development Bank 2006). Brook *et al* (2004) and Schill (2004) showed that oil price risks result in lower investments not only in the oil sector but in the economy in general.

Rising oil prices affect all global economies, some positively (mainly oil exporters) and others negatively (mainly oil importers) (Observer 2004; African Development Bank 2006, Maghyereh and Al-Kandari 2007).

## 2.3 Factors affecting oil prices

To understand the need and the approach that one would take to mitigate oil price risks, one might need to understand the factors driving such price changes (Antill and Arnott 2004; Observer 2004; Hamilton 2005; Heinberg 2006). Causes of oil price movement are of concern not only to companies but to governments also (Cobbs and Wolf 2004; Barton *et al* 2004).

The blame for high oil prices has traditionally been put on the Organization of Petroleum Exporting Countries (OPEC) but in recent times it has also been

placed on speculators. From the writings of Michaletos (2007), Duffie and Gray (1995), Rasmussen (2005), Dées *et al* (2008) and Anderson (2000), it is clear, however, that there are a number of factors that drive the oil price and most of them are beyond the control of any one government.

Some writers like Brook *et al* (2004) and Dées *et al* (2008) put the blame on OPEC for high crude oil price; others like Hamilton (2005) and Michaletos (2007) argue that the entrance of major banks into the oil trade in the form of futures and options trading has lowered the ability of OPEC to manipulate price but has introduced even higher oil price volatility.

Williams (2006) and Heinberg (2006) argued that the formation of the Organisation of Petroleum Exporting Countries (OPEC) in 1960, was devised as the solution to overcome competition amongst oil producing countries, to increase the value of the commodity, to bring about stability of oil prices and a steady income for producer countries while at the same time providing a regular and economical supply to consuming nations**.** Although some measure of discipline has been enforced within OPEC, its relationship with other producers is contentious, as most still do not agree on the need to stabilise the prices (Williams 2006; Gülen 1996).

Despite the cartel, OPEC has, in the past, made investments in the sector that have resulted in highly depressed prices and hence their reluctance to invest in the new fields that has been evident in the past few years (Gülen 1996; Williams 2006; Antill and Arnott 2004**).** During the last quarter of 1997, for example, crude oil was priced at $25 per barrel (Verster 2007; Williams 2006). OPEC estimated that, in the following years, demand would increase due to the oncoming winter as well as due to the fact that the United States economy was growing steadily (Williams 2006). The cartel increased its production capacity by 10%, however, by November 1998, the price of crude oil had reached a low of $10.00 per barrel (Williams 2006) (see Figure 2). OPEC has since then been careful not to repeat the same mistake of oversupply (Forefront 2000; Williams 2006).

According to Dées *et al* (2008) and Brook *et al* (2004), OPEC has had some success in increasing the price of crude oil. According to Brook *et al* (2004), OPEC achieved this despite the opposition it faced but Michaletos (2007) argued that it could not have achieved this without help from the same players who sought to limit that power (Heinberg 2006; Williams 2006). Michaletos (2007:2) wrote “the entrance in the past few years of all the major investment brokers into the oil trade in the form of futures and options has lowered OPEC’s ability to manipulate prices.” Geopolitical instability and the entry of speculators have done more to increase the price of oil than OPEC could ever achieve (Williams 2006).

Antoniou and Foster (1992) also did not find evidence that emergence of speculators resulted in increased prices but that their emergence provided producers with opportunities to hedge their production.

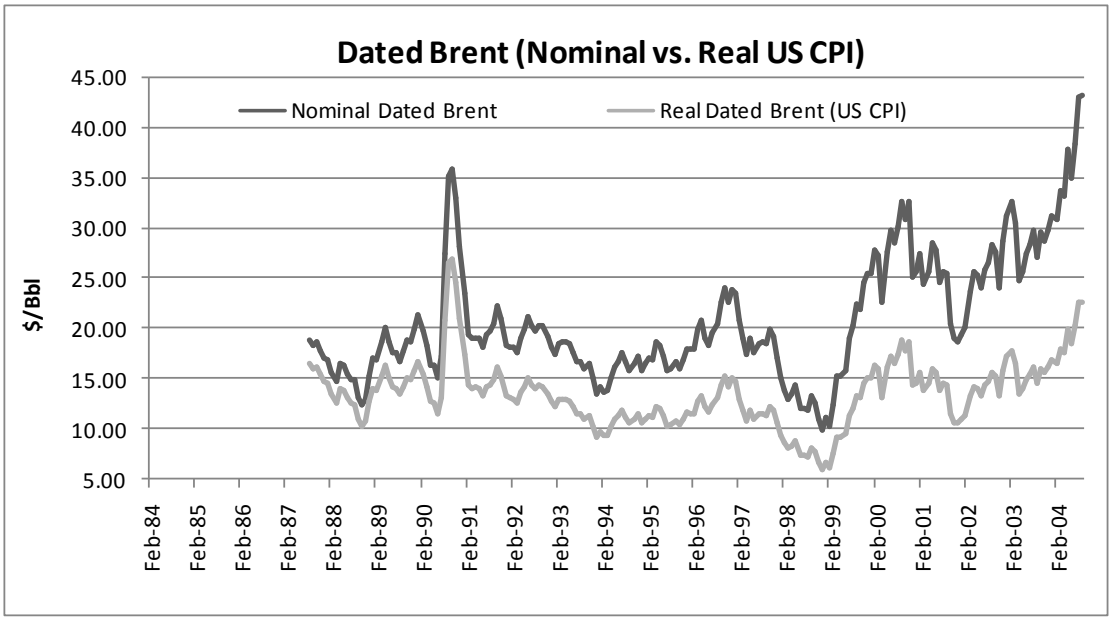
The key factor driving oil price, according to Dées *et al* (2008) and Williams (2006), is the devaluation of the US Dollar, which at the height of the oil price increases had lost as much as 50% of its value compared to the Euro.

Geopolitics clearly plays a significant role, say Brook *et al* (2004), Heinberg (2006) and Dées *et al* (2008). Oil production from Iraq, for instance, has not been flowing sufficiently to assure a steady flow of oil to the market (Williams 2006).

According to Schill (2004), Heinberg (2006), Williams (2006) and Michaletos (2007), global instability and volatility in oil markets has limited investments in both upstream and downstream sectors of the industry. Schill (2004) concluded that the level of volatility in the market is feeding the oil price level by not facilitating the much required investments in the petroleum value chain. Dées *et al* (2008:17) in their review said, however, that “higher refinery utilisations depress crude oil prices”. A number of writers concluded that increased demand, predominantly from China and India, was exerting pressure on the already limited supply (Brook *et al* 2004; Heinberg 2006; Williams 2006; Simmons 2008).

It has become clear from the analysis of factors behind oil price increases that answers to high oil prices cannot be found only in the trade of physical oil but also in trading of 'paper' (Brook *et al* 2004; Michaletos 2007; Schill 2004).

**Figure 2 - Dated Brent crude oil price over time**




Source: Verster (2007)

The concept of causality is based on the premise that *x* is said to Granger-cause *y* if the forecast of *y* using past *y* and past *x* is better than that which just uses past *y* (Gülen 1996). Gülen (1996) showed that in

(1) $$x_t = \sum_{j=-\infty}^{j=\infty} \beta_j \, y_{t-j} + \varepsilon_t$$

$\beta_j$=0 for all j<0 if and only if *x* does not Granger-cause *y.* Using this concept of causality, Gülen (1996) concluded that prior to the OPEC's output-rationing era, there is unambiguous evidence that market price of crude oil was influenced by OPEC output. Gülen (1996) argued that the decline in demand for oil and an increase in non-OPEC supply would hurt OPEC countries far more than a decrease in price of crude oil.

Duffie and Gray (1995) and Michaletos (2007) argue that the emergence of arbitrageurs and speculators in the oil industry has achieved what OPEC has

failed to achieve, i.e. sustained high prices. Published oil production data have indicated that the high crude oil prices cannot be solely attributed to the withholding of crude oil by the cartel (see Table 1).

**Table 1 - Recent oil demand and supply**

| *Mb/d* | *2003* | *2004* | *Q1 2005* | *Q2 2005* | *Q3 2005* | *Q4 2005* | *2005* | *Q1 2006* | *Q2 2006* | *Q3 2006* | *Q4 2006* | *2006* | **2007 fore-cast** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Demand | **79.3** | **82.4** | **84.5** | **82.4** | **83.3** | **84.1** | **83.6** | **84.8** | **83.0** | **83.9** | **86.2** | **84.5** | **85.9** |
| Production | **79.8** | **83.2** | **84.1** | **84.8** | **84.3** | **84.7** | **84.5** | **85.2** | **84.9** | **85.5** | **86.2** | **85.5** | **85.9** |
| Non OPEC | **49.1** | **50.1** | **50.5** | **50.6** | **49.8** | **50.2** | **50.3** | **50.7** | **50.5** | **50.9** | **51.7** | **50.9** | **52.6** |
| OPEC | **30.8** | **33.1** | **33.7** | **34.2** | **34.5** | **34.5** | **34.2** | **34.5** | **34.5** | **34.7** | **34.5** | **34.5** | **33.3** |
| Change in stock | **0.6** | **0.8** | **-0.4** | **2.4** | **1.0** | **0.6** | **0.9** | **0.4** | **1.9** | **1.6** | **0.0** | **1.0** | **0.0** |
| OPEC breakdown | | | | | | | | | | | | | |
| Condensates NGL | **3.7** | **4.2** | **4.4** | **4.4** | **4.5** | **4.5** | **4.5** | **4.6** | **4.7** | **4.7** | **4.7** | **4.7** | **4.9** |
| Iraq | **1.3** | **2.0** | **1.8** | **1.8** | **2.0** | **1.7** | **1.8** | **1.7** | **2.0** | **2.0** | **2.0** | **1.9** | **2.0** |
| **OPEC 10 crude oil** | **25.8** | **26.9** | **27.5** | **27.9** | **28.0** | **28.3** | **27.9** | **28.1** | **27.8** | **27.9** | **27.8** | **27.9** | **26.4** |

Source: Le Louët (2007:17)

Some commentators have previously attributed high prices to the "peak oil[1]" theory. Currie *et al* (2004:1) however wrote "The industry is not running out of oil – reserves are large and continue to grow. What the industry is running out of is the ability to access this oil. To develop these reserves, massive infrastructure projects need to be completed, even within the OPEC countries. In Iraq, there is a very significant amount of oil reserves, but the existing infrastructure, which was built in the early 1970s, is old, inadequate and cannot be expanded without significant investment and, more importantly, time. Energy infrastructure is rapidly becoming a major limiting factor on growth. If the core infrastructure does not improve, energy crises are likely to become progressively more frequent, more severe and more disruptive of

[1] According to Hedler *et al* (2007), in the 1950s a petroleum geologist named M King Hubbert postulated that oil production from an oil deposit follow a bell shaped curve. A number of oil geologists predict that the world oil production has peaked or will peak in 2010, after which the world's production will begin to decline.

economic activity." What is clear is that the oil industry needs a high enough price to justify the over $2.4trillion investment required in the next few years (Currie *et al* 2004; Heinberg 2006; Williams 2006).

It is apparent now that increases in oil prices are driven by a number of factors. OPEC plays a role but so does the emergence of speculators. Geopolitical factors have also contributed to the recent price increases.

## 2.4 South Africa's liquid fuels pricing framework

The South African petroleum industry has a number of unique fixtures that emanate largely from its significantly tainted past and its geographical location (Horvei *et al* 2002; du Plooy *et al* 2006). Although the country does not have oil and gas reserves, it has significant coal reserves that were used effectively by the previous apartheid government to fight off international sanctions (Horvei *et al* 2002). That strategy resulted in the formation of Sasol and Mossgas (now PetroSA), which produced petroleum products from coal (150 000 barrels per day crude equivalent) and gas (45 000 barrels per day crude equivalent) respectively (Horvei *et al* 2002; Goosen 2004; du Plooy *et al* 2006; Gumede *et al* 2007). The total synthetic fuels production amounted to 27% of oil consumed in South Africa at the beginning of this century (Horvei *et al* 2001; du Plooy *et al* 2006).

The country imports the rest of its oil requirements that come almost exclusively from the Middle East (du Plooy *et al* 2006; Gumede *et al* 2007; SAPIA 2008). What is of importance to oil prices in the Republic of South Africa is the fact that the South African oil industry is highly concentrated, with most players enjoying some form of regional dominance (Horvei *et al* 2001). Sasol's production dominance in the inland region, combined with the inland region's limited logistics infrastructure, has been a subject of intense debate (Lewis 2006). However, Sasol is not the only dominant player in South Africa. Most industry participants, through use of varying strategies, dominate either the retail sector or the commercial sector (Horvei *et al* 2001). The South

African petroleum industry, by design, size and location, is monopolistic – hence, the continued interest by the regulators (Horvei *et al* 2001).

The current regulatory framework for the liquid fuels industry is a combination of mechanisms and interventions that are mutually interdependent (Horvei *et al* 2002). It consists of the following key elements: price control, import and export control and marketing arrangements (Horvei *et al* 2002).

Importation of petroleum products is controlled in terms of the International Trade Administration Act, 2002 (Act No 71 of 2002). The Act is administered by the Department of Trade and Industry with the Department of Minerals and Energy acting in an advisory capacity (Department of Minerals and Energy 2008). According to Gumede *et al* 2007, the active import/export control policy was developed in an attempt to promote local refinery capacity utilisation. It is only when local refiners cannot meet demand that importation of refined products is recommended (Department of Minerals and Energy 2008). Limitation of importation of finished petroleum products has been justified on the basis of the need to promote security of supply, protect local jobs and minimise the impact of oil on the trade balance (Gumede *et al* 2007).

The price of petrol is prescribed at retail level (Retail Price Maintenance) in terms of the Petroleum Products Act, 1977 (Act No 120 of 1977) (Department of Minerals and Energy 2008). Retail diesel and jet fuel prices are however not prescribed but are incorporated into the regulatory and administrative dispensation through publication of maximum wholesale prices by the Department of Minerals and Energy. In determining fuel prices, there is recognition that liquid fuel prices cannot be determined independent of global trade (Horvei *et al* 2001 and 2002 and Department of Minerals and Energy 2008). If an attempt was made to force South African companies to sell their products cheaper in South Africa than at prices they would otherwise obtain elsewhere in the world, supplies would be diverted to other parts of the world, thus impacting on security of supply in RSA (Horvei *et al* 2002 and Gumede *et al* 2007).

The South African Cabinet approved, in September 1994 that the retail prices of all grades of petrol and the wholesale prices of diesel and illuminating paraffin be adjusted, if and when necessary, on the first Wednesday of each month (Department of Minerals and Energy 2008). This transparent methodology has gained wide acceptance from economic commentators and motorists and despite some recent large petrol price increases, popular unrest has not arisen as it did before this system was introduced (Department of Minerals and Energy 2008).

Table 2 shows the elements that make up the quoted price of all petroleum products in South Africa. Individual price elements are discussed in detail in the sections that follow.

**Table 2 - South African petrol price structure**

| Price element | Petrol 95 ULP c/l | Petrol 93 ULP & LRP c/l | Petrol 91 ULP c/l | Diesel * 0.05% S c/l | Diesel * 0.005% S | Illuminating Paraffin c/l |
|---|---|---|---|---|---|---|
| *Wholesale margin* | 39.49 | 39.27 | 39.05 | 39.26 | 39.26 | 39.47 |
| *Service cost recoveries* | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 | 14.40 |
| *Storage, handling & delivery costs* | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 |
| *Distribution cost* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.40 |
| *Dealer's margin* | 59.70 | 59.70 | 59.70 | 0.00 | 0.00 | 0.00 |
| *Zone differential in Gauteng* | 13.90 | 13.90 | 13.90 | 13.90 | 13.90 | 24.10 |
| *IP Tracer levy* | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 |
| *Fuel levy* | 121.00 | 121.00 | 121.00 | 105.00 | 105.00 | 0.00 |
| *Customs & excise duty* | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 0.00 |
| *RAF levy* | 41.50 | 41.50 | 41.50 | 41.50 | 41.50 | 0.00 |
| *Petroleum Pipelines levy* | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.00 |
| *Slate levy* | 4.81 | 4.81 | 4.81 | 4.81 | 4.81 | 0.00 |
| *DSML* | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *Equalisation Fund Levy* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *Sub-total* | 301.59 | 291.37 | 291.15 | 215.67 | 215.67 | 77.97 |
| *Contribution to the Basic Fuel Price* | 523.41 | 519.63 | 516.85 | 594.63 | 598.03 | 578.13 |
| *Retail Price* | 825.00 | 811.00 | 808.00 | | | |
| *Wholesale price* | | | | 810.30 | 813.70 | 656.10 |

Source: Department of Minerals and Energy (2008) - *March 2008 prices*

The principle underpinning the determination of South Africa's petrol prices is import parity, which forms the basis for the determination of the Basic Fuels Price (BFP), transport and storage costs (Horvei *et al* 2002). The individual cost elements represent the most realistic, market-related costs (Horvei *et al* 2002 and Department of Minerals and Energy 2008). Although the pricing framework is import-parity based, South Africa only used to import finished

products at times when local refineries could not supply (SAPIA 2008). Since 2006, however, the demand for fuels has exceeded capacity of local refineries and hence imports of finished products have substantially increased (Department of Minerals and Energy 2008 and SAPIA 2008).

The price of fuel in South Africa comprises of international components [determined by external factors] and domestic components [determined by domestic factors] (Horvei *et al* 2002 and Department of Minerals and Energy 2008). Due to the limited amount of finished products imports, international components of the petrol price are largely "deemed" but based on realistic costs that would be incurred if substantial finished products were imported into the country (Horvei *et al* 2002 and Department of Minerals and Energy 2008). The domestic component can be divided into industry and transport related costs and Government imposts (Department of Minerals and Energy 2008).

The petrol price in South Africa is accordingly directly linked to the price of petrol, quoted in US dollars, at the export-orientated refining centres in the Mediterranean and Singapore (Department of Minerals and Energy 2008). Domestic prices of fuels are therefore influenced by (a) international crude oil prices, (b) international supply and demand balances for petroleum products and (c) the Rand/US Dollar exchange rate (Department of Minerals and Energy 2008).

The elements used in the Basic Fuels Price (BFP) as indicated by the Department of Minerals and Energy (2008) are briefly described in the paragraphs that follow. The first elements in BFP are Free-on Board (FOB) values - these values are Platt's quoted petroleum product prices quoted on a daily basis by export orientated refining centres situated in the Mediterranean area, the Arab Gulf and Singapore (Department of Minerals and Energy 2008).

The next important element is freight, which according to Department of Minerals and Energy (2008) reflect the cost of transporting refined petroleum products from the pre-defined export refining centres to South African ports.

The freight rates used in the BFP calculation are based on freight rates published by London Tanker Brokers Panel on 1 January each year (Department of Minerals and Energy 2008). These freight rates are adjusted on a monthly basis in line with the so-called Average Freight Rate Assessment (AFRA).

Other BFP related items are demurrage, insurance and other costs such as letters of credit, hedging costs, surveyors' and agents' fees and laboratory costs (Department of Minerals and Energy 2008). According to Department of Minerals and Energy (2008), ocean losses are accounted through a factor based on the sum of the FOB, freight and insurance values for products. This factor provides for typical uninsurable losses during transportation of fuels.

South African harbour facilities are utilised to offload petroleum products from ships into on-shore storage facilities (SAPIA 2008). The costs associated with the use of the harbour facilities are calculated based on the tariff set by the National Ports Authority of South Africa and are called cargo dues or Wharfage (Department of Minerals and Energy 2008).

The last component in BFP is coastal storage, which is an allowance for costs associated with providing storage and handling facilities at coastal terminals (Department of Minerals and Energy 2008). In 2002, the typical international storage rate was assessed as US$3 per ton or 2.5 SA cents per litre per month. According to Department of Minerals and Energy (2008), BFP makes provision for 25 stock days, which at the date of commencement of BFP amounted to 2.083 c/l. in accordance with Department of Minerals and Energy prescripts, this element is adjusted on an annual basis by indexing to Producer Price Index (Department of Minerals and Energy 2008). Linked to storage is the allowance for stock financing cost, which is based on (i) the landed cost values of refined petroleum products, (ii) 25 days of stockholding and (iii) the ruling prime interest rate less 2 percent (Department of Minerals and Energy 2008). Appendix A gives a graphical overview of the South African basic fuels pricing framework.

In order to complete the picture, BFP, which is quoted in USD/barrel or USD/ton is converted to US cents/litre by applying international conversion rates (barrels to tons, tons to gallons and gallons to litres) and is then converted to South African cents/litre by applying with an applicable Rand/US Dollar exchange rate (Department of Minerals and Energy 2008). As illustrated in Table 2, the BFP contributes approximately 63% to the price of petrol and hence its importance.

To arrive at the final petrol pump price for the different fuel pricing zones (magisterial district zones), domestic costs, imposts, levies and margins are added to BFP (Department of Minerals and Energy 2008). Most of these costs are fixed in a particular year, only modified on the 1st of April of each year. As can be estimated from figures in Table 2, the tax components add up to 22% of the final price and other logistical and marketing costs add a further 15% to the price. These logistical and marketing costs, taxes and levies are not discussed in this report as they do not vary with changing crude oil price and Rand-Dollar exchange rates.

## 2.5 South Africa's history of "hedging" petrol prices

The one domestic element however that requires some discussion is the "equalisation fund levy". South Africa is not new to attempts of managing consumer fuel price increases. For many years prior to 2004, funds were collected from consumers and saved into the equalisation fund (Department of Minerals and Energy 2008). According to Department of Minerals and Energy (2008), a levy, determined by the Minister of Minerals and Energy, in concurrence with the Minister of Finance, was incorporated in the fuel pricing system. Funds were collected from the consumers during times when prices were on a downward trend, and accumulated in the equalisation fund which was managed by the Central Energy Fund (Pty) Ltd. During times when prices were on the increase, the funds from the equalisation fund were used to 'cushion' price increases (Department of Minerals and Energy 2008). This method of cushioning petrol prices had limited success largely because of the

limited amount of funds which were available in the equalisation fund (Department of Minerals and Energy 2008). This can be largely attributed to the fact that historically, there have been more price increases than decreases.

In 2004, National Treasury and the Department of Minerals and Energy undertook a study to investigate mechanisms that could assist in 'smoothing' fuel prices. From the study, it was recommended that one or more of the following options could be implemented to smooth the fuel price:

1. Reduce the time between month-end and the next price adjustment to three working days;

2. Implement a three-month moving average pricing approach for petrol and a four-month moving average for diesel and illuminating paraffin prices; and

3. Cap fuel price increases between 12c// to 25c// by utilising funds collected from motorists for this purpose, to subsidise increases outside of these caps.

The three working day optimisation technique was implemented with effect from 2 March 2005. According to the Department of Minerals and Energy (2008), the technique brought about a 5% reduction in fuel price volatility.

The challenge with the second recommendation was that implementing the three-month rolling average would have required significant interference with the pricing framework thus reducing the transparency of the pricing system. There was also a risk that consumers would have grown to expect that government would have always restricted price changes to 15c// even in cases when such changes would have been of a magnitude that such intervention would have been impractical. This could have returned government to the pre-transparency situation when significant price increases were met with civil unrest. Due to the number of potential problems with the system, it was never implemented (Department of Minerals and Energy 2008).

The size of the fund that would be required to give effect to recommendation 3 proved to be unaffordable. The implementation of such a fuel price adjustment "cap" would have required funds in the order of R3 billion (Department of Minerals and Energy 2008).

Although there have been continued and growing calls for the government to develop a strategy to alleviate the impact of high fuel costs on consumers and the economy; in this regard, success has been limited.

## 2.6 Hedging approaches

As Brown (1990) said, making decisions that depend on volatile oil prices, without any financial risk management tools, can be devastating to both oil producers and end-users. Financial journals, however, focus on the use of financial instruments by oil producers, traders and large commercial consumers rather than by governments who might be attempting to protect their economies (Anderson 2000; Ames, Corridore and MacAvoy 2004; Duffie and Gray 1995; Pai 1995; Schneider and Mason 1999; Schill 2004; Hamilton 2005).

Some producer countries have chosen to subsidise petroleum products consumed by their citizens from revenues derived from oil sales (Metschies 2007). Oil importing countries do not have the same ability to subsidise (Forefront 2000; African Development Bank 2006; Metschies 2007). Even if importing countries could find resources to dispense subsidies, the question is whether subsidising petrol or diesel would be the best way of utilising state revenues (Metschies 2007). Some writers like Anderson (2000) and Brook *et al* (2004) argue that the negative impact of high oil prices does not justify state intervention.

This study's first problem is to determine whether, on average, the consumer would have a lower price if the price of fuel were hedged, i.e. whether the price of fuel "under a hedge" would be lower than the price without it. The first challenge is to identify an appropriate instrument to use (Doherty and Smith

1993, Edwards 1995; Culp and Heaton 2005). In accordance with Brown's (1990:49) contention, "in the futures market, oil hedging involves taking a reverse oil futures position from one held in the spot market." Use of collars, floors, caps and swaps offers extended terms and coverage to commodities that could not be hedged through futures because of limited term lengths and scope of commodities (Brown 1990).

Kyte (2002) contends that market price risks can never be removed and therefore need to be managed. Some commentators like Anderson (2000) and Fin24 (2008) however consider government responses in the attempt to manage fuels prices as not only futile but wasteful of the resources of the country.

The collapse of Metallgesellschaft (Edwards 1995) and Barings Bank (McNeil, Frey and Embrechts 2005) showed the world what could potentially go wrong if an inappropriate risk-mitigation strategy is adopted. Schill (2004) and McNeil, Frey and Embrechts (2005) argued that problems with hedging emerge when hedgers begin to "play the market" and take positions in the market that are not intended to protect them but are intended to benefit from some arbitrage in the market (Joyce 1999).

As Edwards (1995), Charupat and Deaves (2002) and McCann and Nordstrom (1995) pointed out, it was through its expectation that the market will be in backwardation[2,3] that caused Metallgesellschaft to adopt the position it adopted. It appears that there is an element of luck when one plays the "speculative" game (Brown 1990; Joyce 1999; Charupat and Deaves 2002). Had Metallgesellschaft's contracts expired a few months later, they probably would have been profitable (Brook *et al* (2004:26). The 'principle' that

[2] The market is said to be in backwardation when the price of crude oil for four months' contracts is less than the price for the near month's contract.

[3] McCann and Nordstrom (1995) noted that energy producers have a genuine need to hedge their products against falling prices – hence, the markets being largely in normal backwardation. This need counters the cost and carry model which predicts that energy prices will always be in contango.

underpinned the Metallgesellschaft's speculative (Joyce 1999) strategy was that "if speculators are risk averse as a whole in the futures market, hedgers must pay a risk premium to speculators as compensation for the risk-sharing in the futures market," Yoo and Maddala (1991:165). The assumption that the oil futures market is always in backwardation is based on an assumption that hedgers are always net short (Yoo and Maddala 1991).

McNeil, Frey and Embrechts (2005) concluded that since the emergence of oil crises and the general move away from a system of fixed exchange rate, both the energy prices and foreign exchange rates have become highly volatile, requiring customers to find appropriate instruments to hedge them.

However, it is important that whatever the tools used for risk mitigation might be, they are used properly. As McNeil, Frey and Embrechts (2005:6) wrote: "So great was the role played by the Black-Scholes-Merton formula in the growth of the new options market that, when the American stock-market crashed in 1978, the influential business magazine, Forbes, put the blame squarely onto that one formula. Scholes himself has said that it was not so much the formula that was to blame, but that market traders had not become sufficiently sophisticated in using it."

**Swap Talk**

Here's how a swap works: Imagine a bank agreeing to help a producer fix his price of oil at $18 a barrel for a year. The producer will relinquish his up-side potential for a guaranteed $18. In turn, the bank agrees to pay the producer $18 times 1000 barrels on the last day of the month.

The producer continues to sell his product on the open market but pays the market price he receives on the set volume of 1000 barrels to the bank. The end result is $18 per barrel to the producer regardless of whether the actual market price during the term was $17 or $19. The bank absorbed the price risk – and in a situation where the price had risen above the designated level to $19, it has profited by $1 per barrel. If the price were to fall to $17, the bank would have to pay the dollar-per-barrel price difference to the producer. (Brown 1990:51)

McNeil, Frey and Embrechts (2005) defined risk as any event or action that may adversely affect an organisation's ability to achieve its objectives and execute its strategies. McNeil, Frey and Embrechts (2005) identified types of risk and among them the concept of *model risk*, which McNeil, Frey and Embrechts (2005) defined as the risk of using inappropriate models to measure and to counter risk. It is this risk that resulted in companies ending up with a "*naked cover*" (Edwards 1995, Brown 1990). The market has never been short of ideas, nor lacked creativity in coming up with innovative financial instruments (Schneider and Mason 1999) but the challenge has been in the inappropriate use of those tools (Edwards 1995).

McNeil, Frey and Embrechts (2005) argued for continued but properly managed use of financial derivatives (options) to cover risk. The collapse of Barings, the oldest merchant banking group in the UK (established in 1761), after it incurred losses of some £700 million, through improper use of a "*straddle*[45]" position, is still fresh on some people's minds although it happened in 1995 (McNeil, Frey and Embrechts 2005). Use of swaps can also present significant risk management opportunities as "you don't have to worry about margin calls, you aren't faced with a temptation of taking your hedge off and trading out of a futures contract, you don't have the high premiums of an option strategy," (Brown 1990:50). A strategy that involves giving away your upside is however not prudent (Brown 1990).

Culp and Heaton (2005) state that risks can be retained, neutralised or transferred. Considering the risks associated with petrol price, using Culp and Heaton's (2005) theory, it is possible to use finite risk reinsurance to finance the petrol price volatility and increases. Following Culp and Heaton's (2005) assessment, it could however be argued that this approach would not be

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[4] Yoo and Maddala (1991:171) defined the risk premium, $r_t$, as the risk premium hedgers pay for a certain futures contract, calculated as follows: $r_t = \alpha + \beta\Phi_t + \varepsilon_t$, where $\alpha$ & $\beta$ are regression parameters, $\Phi_t$ is variance of the futures price and $\varepsilon_t$ is a residual term.

[5] A straddle is a combination which involves a purchase of call and put option with the same strike price and expiration date. It is a position taken by an investor who is expecting a large move in the market but is not sure which direction the move will be (Hull 2003:194).

different from the equalisation fund approach that has previously been used in South Africa. From the possible corporate risk management choices put forward by Culp and Heaton (2005), it is clear that the price risk cannot be neutralised (Brook *et al* 2004; Anderson 2000; Dées *et al* 2008), the only choice left would be to transfer it to someone else (Culp and Heaton 2005).

In considering the option of transferring the risk, it is important to guide against "trading dollars" (Doherty and Smith 1993:4) i.e. "simply exchanging known dollars of premium for roughly equivalent and known dollars of loss settlement". Transferring risk requires counter parties (Goodman and Ho 1999; Joyce 1990; Smith 1990). As Doherty and Smith (1993) argued, one should only really transfer risk to someone who has a comparative advantage of bearing that kind of risk and even has the capacity to handle the risk. In the case of petrol prices, there seem to be no better parties that are better suited to take on the risk than multinational oil companies (Doherty and Smith 1993).

Multinational oil companies have the capacity because these companies are generally very large with some of them reporting billions of dollars net profits per annum and having the comparative advantage to be able to manage the oil price risk better (Doherty and Smith 1993). As Antill and Arnott (2004:24) argued that "with many of the major companies boasting higher credit ratings than the countries in which they operate, the role of the major often becomes that of an international financier with the ability to fund major projects relatively cheaply", oil majors are arguably the best counter parties.

Joyce (1999:26) says "hedging is fairly straightforward. First, two closely related assets are found. Then one asset is purchased and the other sold, in proportions that minimize the risk of the net position." Joyce (1999:29) states categorically that "speculation is foolish unless you have good reason to believe that the odds are stacked in your favour. If you are not better informed than the highly paid professionals in the banks and other institutions, you should use derivatives for hedging and not for speculation."

The optimal hedge ratio for any hedge $h^*$ is $h^* = \rho \frac{\sigma_S}{\sigma_F}$ where ρ is the coefficient of correlation between ΔS and ΔF, $\sigma_S$ is the standard deviation of ΔS and $\sigma_F$ is the standard deviation of ΔF. ΔS and ΔF are changes in spot prices and futures prices respectively, during a period of time equal to the life of the hedge (Hull 2003:79; Chen *et al* 1987; Horsnell *et al* 1995).

In summary, literature suggests that there are valid reasons for businesses to manage price risk. Literature indicates that risk could be retained, transferred or neutralised. Literature also shows that the probability of neutralising oil price risk is low. Retention is possibly not the appropriate strategy for consumers. Literature therefore suggests that the price risk should, through appropriate financial instruments, be transferred to major oil companies, who have a comparative advantage in this area. It is obvious that if used correctly, derivatives can assist in management price risks but if used incorrectly could be disastrous.

The next question that emerges from the problem statement is whether the costs associated with the mitigation of petrol prices could be lower than the benefits associated with the strategy. As argued by Culp and Heaton (2005), there are a number of advantages of hedging the price risk. The only question is whether the benefits from such hedging justify costs associated with the strategy. Some instruments, like swaps, costs less than others (Brown 1990) but are problematic in the sense that they provide cover but do not allow an end-user to enjoy the full upside benefit of lower prices (Brown 1990; Joyce 1999).

Linked to the question of costs and benefit is whether consumers would not be better placed to buy the cover themselves. Hull (2003:73) wrote: “one argument sometimes put forward is that the shareholders[6] can, if they wish, do the hedging themselves. They do not need the company[7] to do it for them.

[6] To be read as “consumers” in this case.

[7] To be read as “government” in this case.

This argument is, however, open to question. It assumes that shareholders have as much information about the risks faced by a company as does the company's management. In most cases, this is not the case…. Hedging is therefore likely to be less expensive when carried out by the company than by individual shareholders." Stulz (1984:127) also indicated that "shareholders do not decide the hedging policy of the company, but managers do".

Any risk-mitigation strategy comes at a cost but the biggest cost, of course, is a "naked cover", which costs money to acquire but is not much of a cover (Edwards 1995; McNeil, Frey and Embrechts 2005). McNeil, Frey and Embrechts (2005) wrote that one commentator, referring to the Black-Scholes formula, asked: "is this really the key to future wealth? Win big, lose bigger." He went on to say: "Thus it is imperative that mathematicians take a serious interest in derivatives and the risks they generate. Who has not yet considered a prepayment option on a mortgage or a change from a fixed-interest-rate agreement to a variable one, or vice versa (a so-called swap)? Moreover, many life insurance products now have options embedded." It was therefore possible that an option or some form of options could be considered for the possible hedging of South African petrol prices.

According to Pai (1995) and Hull (2003), the biggest challenge for hedging is the basis risk. Pai (1995) defines the basis risk as the risk that the value of a hedge may not move up or down in tandem with the value of the actual price exposure that is being risk managed. Pai (1995) concludes that basis risk is largely due to mismatches emanating from product, time and locational bases. As indicated by Hull (2003:75) "if the asset to be hedged and the asset underlying the futures contract are the same, the basis should be zero at the expiration of the future contract". This is the case in the proposed hedging strategy.

In summary, literature suggests that it is possible to design a cover that would (at a price) reduce both petrol price increases and volatility. Literature indicates that producers are reluctant to cover their exposure when the price reaches historical low levels but at high prices, refiners could be willing to

cover their price exposure (Doherty and Smith 1993; Culp and Heaton 2005). According to Pai (1995), oil is a mean-reverting asset, which means that any high oil price level serves as an incentive for oil companies to want to participate, in an event that prices were to revert to their historical lows. However, this oil price behaviour could serve as a disincentive for consumers.

## 2.7 Conclusion of Literature Review

Literature, in general, suggests that there is merit for government to develop and implement a petrol mitigation strategy for consumers. At the observed high prices, it seems possible that producers, particularly oil majors, could be interested in being counter parties to the transactions. Although there are a number of options that are available to consumers, it was concluded from the literature that reverse writing a covered call could be a good strategy.

## 2.8 Proposition

Petrol prices, in South Africa, are changed once a month through a process of passing through over- or under-recoveries on the basic fuels price. It is however possible that more appropriate consumer prices could be achieved through a different mechanism. The study proposes a possible different strategy of management of prices in South Africa.

The study proposes that South African petrol prices can be better managed through use of an appropriate hedging strategy.

From literature, the proposition that was formulated is that *hedging petrol prices with an appropriate price risk-mitigation strategy would result in lower average prices than there would have been if petrol prices were not managed i.e. the total cost to the consumer of petrol under a price-mitigation strategy would be lower than it would have been if the price was not managed*.

# 3 Research methodology

Based on existing observed petrol price performance, the study, through use of an appropriate theory, attempts to describe how South African petrol prices could have performed, had a different petrol pricing approach been adopted.

## 3.1 Research paradigm

Historical data, which was appropriately modified for comparison purposes, was used for the research. Research based on historical data (as part of analytical research) “is not concerned so much with the collecting new information, as it is with finding new explanations for, or interpretations of, existing information” (Welman 2004:20).

## 3.2 Research design

The research essentially compared South African prices in a particular period, to prices that would have been obtained had a different pricing strategy been adopted. Historical pricing data were used as a baseline. The same price data were used to define parameters required by the Black Scholes formula for the price of the options. Fuel costs to consumers under the hedged scenario were determined based on the same historical data but using published daily BFP figures, with the cost of the hedge being added to determine the total cost that would be paid by the consumer. Risk-free rates data, required by the Black Scholes formula, were collected from the South African Reserve Bank. Section 4.3 of this report details the methodology that was used in calculating the costs associated with hedging the petrol price.

## 3.3 Population and sample

Data corresponding to the period after the introduction of BFP were sourced from the Central Energy Fund (Pty) Ltd (CEF). It comprised all petrol pricing data for the period April 2003, when a new pricing approach was introduced,

till March 2008. The complete data set was used during the study, which eliminated the need for sampling.

During the period under review, fuel prices moved from a relative low level to very high levels not only in terms of absolute prices but also in terms of volatility, that it would be argued, rendered the study generally applicable to all South African pricing scenarios.

## 3.4 Data collection

Daily petrol price data was collected from CEF. These data were collected electronically to minimise corruption and to ensure that the integrity of the data was maintained. R153 government bond data were also electronically sourced from the South African Reserve Bank (SARB).

The price data that were collected were split into distinct six-month periods to correspond with the longest possible call options that would be offered by counter parties. It was assumed that the average price volatility within each six-month period would remain constant so as to allow the use of the Black-Scholes formula. “At-the-money” call options, with different times-to-maturity periods were “purchased” at prices that were determined using the Black-Scholes formula. Differences in petrol prices obtained under the hedged environment and the real price obtained under the normal South African pricing regime were computed. These differences, between the two pricing regimes, over the six-month period, as well as over the full data period, were averaged to establish if there was any benefit in hedging. The data split resulted in 10 distinct hedging periods.

To answer the second sub-question, the Black-Scholes formula was used to calculate the cost of the artificial call option that would be bought to hedge the petrol price. The BS formula required knowledge of the “spot” price, the strike price, time to expiration, volatility and risk-free rate. So as to keep the petrol price constant, for the duration of each six-month hedging period, at the same level as at the start of the period, the strike price was taken as equal to the

price at the beginning of that period. The risk-free rates used in the study were R153 government bond rates corresponding to each period. During each six-month period, six options with six different times-to-maturity, ranging from one to six-month maturity periods, were considered. The complete data set and the analyses performed on them are attached as Appendices B and C respectively.

## 3.5 Validity and reliability

### *3.5.1 Validity*

As indicated by Leedy and Ormrod (2001), validity takes different forms, namely: face, content, criterion and construct validity. Sourcing primary data through questionnaires and surveys presents problems with the reliability of both data sources and data.

For this study, only secondary data was used. Although secondary data also present challenges such as data integrity, especially if the source of such data is unreliable, secondary data are still considered to be much more reliable. This study only used real historical data, which increased the validity of the study.

### *3.5.2 Reliability*

According to Leedy and Ormrod (2001), reliability of measuring instruments is the extent to which they yield consistent results when a characteristic being measured has not changed. Because of the use of secondary data, data reliability was not a problem.

## 3.6 Data analysis and interpretation

The basic assumption in the study is that consumers are concerned with both price increases and the level of prices and they would prefer to have a

predictable, fixed petrol price for a period. A hedging methodology that seeks to keep the price constant for the selected six-monthly periods was adopted. The strategy of “buying” artificial call options, with different times to maturity to cover the six-month period, was adopted. Using the Black-Scholes formula, the costs of such call options were determined.

The petrol price under the hedge scenario was allowed to vary during each six-month period up to a maximum price equivalent to the strike price through exercise of these call options that had different expiry periods to cover the whole six-month period. The prices achieved under the hedge scenario were compared with their corresponding historical South African petrol pump BFP prices.

The South African daily price movements are reported in the press each day and this has contributed to an increased understanding of what the following month’s price adjustment can be expected to be. These monthly fuel price adjustments to the Basic Fuels Price are implemented by the Minister of Minerals and Energy in terms of a set of Working Rules, as indicated by equation (2).

(2) $$\boldsymbol{BFP_j = BFP_{j-1} + \sum_{i=1}^{n}\left(BFP_{j-1} - BFP_i\right)}$$

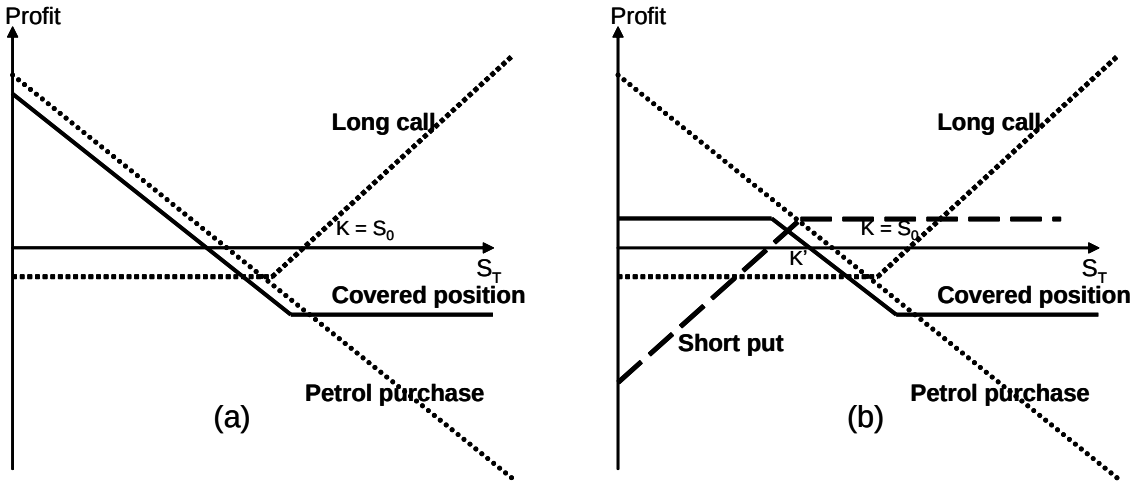
Where $BFP_{j-1}$ is the previous month’s petrol pump price BFP, $BFP_i$ is the daily BFP for each working day of the current month, n is the number of working days in the current month. $BFP_j$ is the current month’s average BFP that will be reflected in next month’s pump price. Therefore, South Africa’s pump prices lag market prices by a month.

There are a number of different trading strategies involving a physical asset and one or more options that are offered by Hull (2003) and Mason and Jones (1995). The position in which consumers found themselves – one where petrol price are increasing – was similar to the position in which producers who forward sell their produce found themselves. As in the case of reverse writing a ‘covered call’ (see Figure 3(a)), the consumer could purchase a call with a strike price the same as the current spot price (Pai 1995; Hull 2003).

Consumers have an added concern, which is management of the volatility of the petrol price. To address volatility, it was considered possible that consumers could sell a put option to oil companies of sufficiently low enough strike price to result in a small band of price fluctuation but generate sufficient funds to fund the long call position (Pai 1995; Hull 2003). According to Pai (1995), a combination of the 'short' put and a 'long' call could generate a "zero-cost collar" (see Figure 3(b)). According to Hull (2003), a range of exotic options is also available to consumers. This would not only provide desired cover but could generate some profit as well (Pai 1995).

The payoff for the proposed hedge, the call option is the max ($S_0 – K e^{-rT}$ , 0), where $S_0$ is the current stock price, K is strike price of the call option, T is time to expiration of the option and r is the continuous compounded risk-free rate of interest for an investment maturing in time T (Hull 2003:171).

**Figure 3 - proposed hedge(s)**




Source: Hull (2003:186)

The next problem was the valuation of the options that would be adopted as hedging instruments. Sclavounos (2007) suggested that because energy prices are mean-reverting, seasonal, and have sharp and asymmetrical spikes, they require more advanced models and derivative valuation methods. However, largely because of its simplicity, the Black-Scholes formula (Hull 2003:246) was considered appropriate for pricing the artificial call options used to cover the purchase of fuel:

(3) $\text{Call} = S_0 N(d_1) - K \exp(-r T) N(d_2)$

Where $d_1 = \frac{\left|ln\left(\frac{S_0}{K}\right)+\left(r+\frac{\sigma^2}{2}\right)T\right|}{(\sigma\sqrt{T})}$ and $d_2 = d_1 - \sigma\sqrt{T}$

Where $N(d_1)$ and $N(d_2)$ are the cumulative probability distribution functions for a standardised normal distribution, $S_0$ is the petrol price at time zero, r is the continuously compounded risk-free rate, which in the analysis was estimated as the R153 bond rate, σ is petrol price volatility, period T is time to maturity of a particular option and K is the strike price, at time T.

The intention of the study was to maintain the petrol price at price $S_0$, K was made equal to $S_0$ for each period in the analysis, meaning that "at-the-money" call options were purchased. Within each six-monthly period into which the data was split, it was assumed that six call options with different time to maturity but same strike price would be purchased. That is the reason why T ranged from 0.08 to 0.5 years in each period.

Using the methodology defined by Hull (2003:238), volatility was determined as follows:

(4) $s = \sigma\sqrt{\tau}$

Where s means is the standard deviation of all $u_i$'s and $\tau$ means length of time measured in years. In determining s, the following was considered:

$u_i = \ln(S_i/S_{i-1})$, for i = 1, 2, 3…n,

Where $S_i$ means price at the end of an $i^{th}$ interval (i = 0,1,2,...,n) and $u_i$ means a natural logarithmic different between consecutive price $S_i$ and $S_{i-1}$. Taking into account that s is normally given by the following equation:

(5) $s = \sqrt{\frac{1}{n-1}\sum (u_i - \bar{u})^2}$ where $\bar{u}$ is the mean of all $u_i$'s.

,

By rearranging equation (4), taking into account equation (5), considering that petrol price volatility can be estimated by the following equation:

$\hat{\sigma} = \frac{s}{\sqrt{\tau}}$ , where $\tau$ is the length of time interval in years = $\frac{1}{252}$ in the analysis as daily petrol prices were used and there are on average 252 working days in a year, volatility was hence calculated as follows:

$$\hat{\sigma} = \left[ \sqrt{\frac{1}{(n-1)} \sum (\mu - \bar{\mu})^2} \right] / \sqrt{\tau} \quad (6)$$

According to Antoniou and Foster (1992:476), volatility can also be estimated using the following equation:

$$V_T = \sqrt{\frac{1}{N} \sum_{t=1}^{N} (P_t - P_{t-1})^2}, \quad (7)$$

Where V is volatility in a period T, P is spot price on day t and N is the number of days per period. In this study, however, equation (5) was used to estimate volatility.

The differences in petrol prices achieved in the two different pricing regimes (historical and proposed) for each period were then computed. To test the significance of the differences in the overall results that were obtained, a t-test defined by Albright, Winston and Zappe (2003) and Spiegel (2008) was used on the differences between the two pricing strategies.

# 4 Analysis of Results

Data that were collected from CEF were collated and analysed and the analysis is presented in Appendix B. The rest of the section focuses on presenting the results from the analyses that were performed on the data. The results are largely presented in a graphical manner. The results of the analyses are presented and discussed in the following sequence:

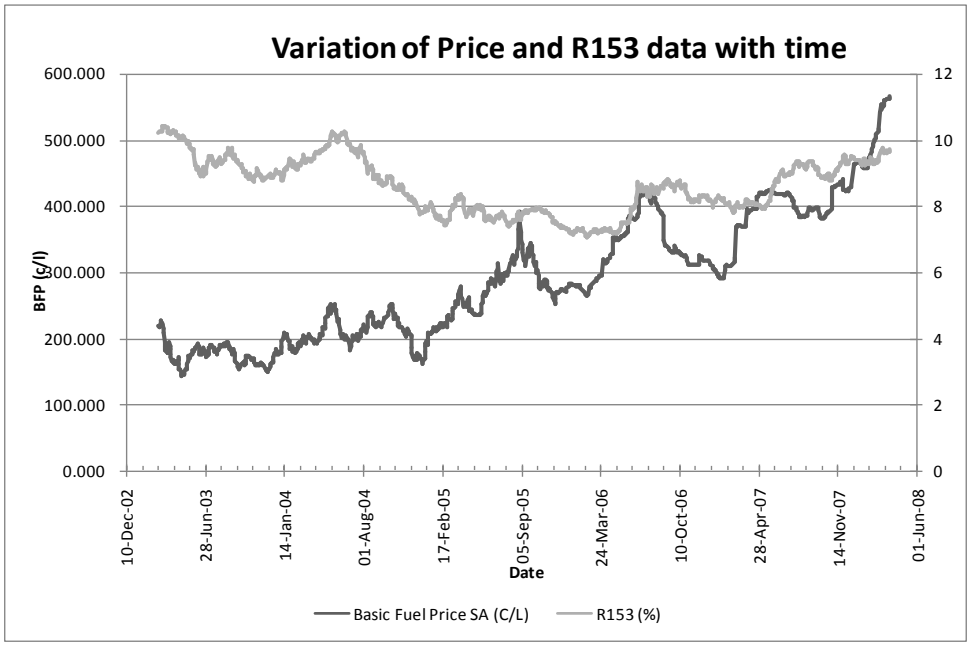
1. variations in original data;
2. comparison between the daily and South African pump prices;
3. comparison between hedged and South African pump prices;
4. comparison between hedged and South African pump prices considering the cost of hedging; and
5. testing of the significance of the results of the analysis.

## 4.1 Original data trends

Derivatives' trading is essentially about trading in volatility. Therefore, for any option to have value there must be volatility in the pricing data set that is considered. Daily movements of the petrol BFP pricing and R153 data were recorded and are presented in Figure 4.

It is clear from Figure 4 that petrol prices are very volatile. The level of volatility and the liquidity of the petrol price confirm that options derived from this underlying asset could be developed and traded. It appears that not only has the price of petrol increased almost three-fold since 2003, but its volatility has also been increasing. As intimated by some commentators, the price of petrol is mean-reverting, although the mean does go through structural changes and shifts that are generally upwards.

**Figure 4 - Daily BFP and R153 data variations**




## 4.2 Comparison between daily and pump prices

Figure 5 shows the variation of South African pump prices as set by the Department of Minerals and Energy compared to the daily BFP prices, as recorded by CEF used to calculate over- and under-recoveries. Pump price trends before 2006 were characterised by kinks, a trend which is not evident in the period starting from January 2006.

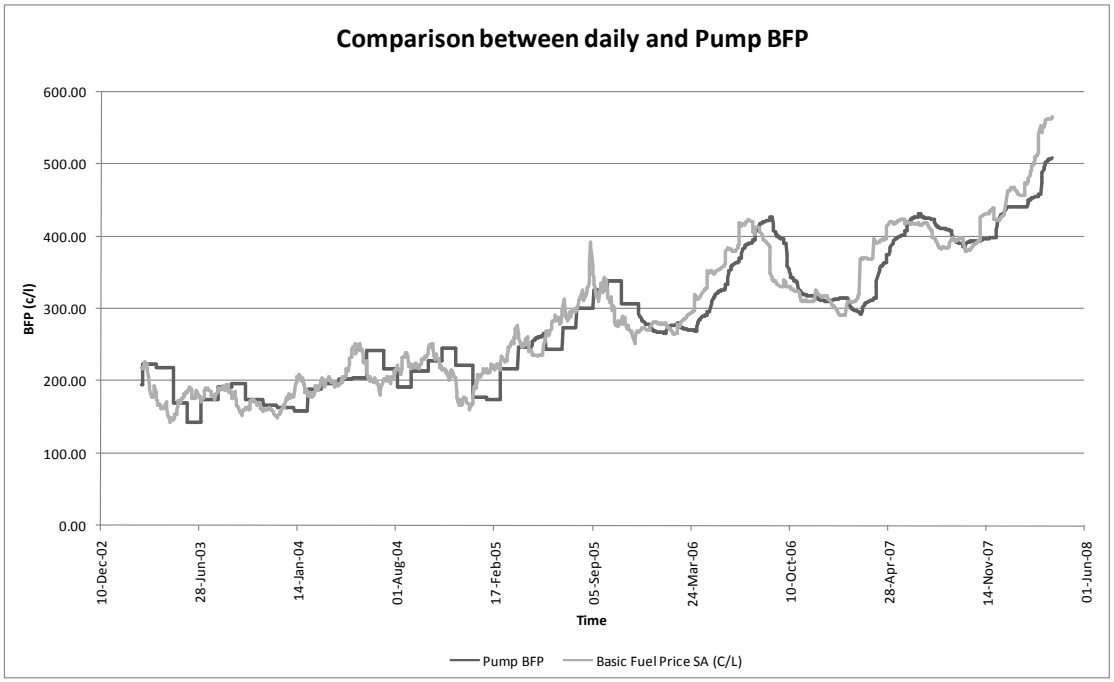
From the Department of Minerals and Energy (2008), the period from January 2006 corresponds to the period when the time between month-end and the next price adjustment were reduced to three working days. The change effectively reduced the time between month closure and price change to three working days. This change however does not explain the absence of the distinctive kinks in the pump price that characterised South African petrol prices prior to January 2006.

Figure 5 shows the benefit (although limited) of the current petrol pricing methodology to consumers. The absence of characteristic kinks in the graph from 2006 raises some concerns about the integrity of the data and even the

accuracy of application of the BFP pricing model. It is not clear, from the model, in which BFP is still changed once a month, albeit within a shorter period, why the kinks disappeared to the extent that they have. Petrol prices still remain constant throughout each petrol month.

Nonetheless, the shorter period between the closing of the slate account and changing of the price resulted in a reduced lag and better correlation between daily and monthly BFP prices. The lag between real time prices and pump prices is however still evident. The price setting methodology does not reduce the volatility nor does it protect consumers against price increases; it merely delays the inevitable price changes.

**Figure 5 - Pump vs. daily BFP prices**




## 4.3 Comparison between hedged and pump prices

This section tests the validity of the first proposition. Figure 6 compares South Africa's pump BFP prices against the prices that would have been achieved under a hedged system. In this case, petrol BFP prices in the hedged scenario do not include the cost of hedging. The differences between the two pricing regimes were computed and results are presented in Figure 7.

**Figure 6 - Hedged and pump prices**

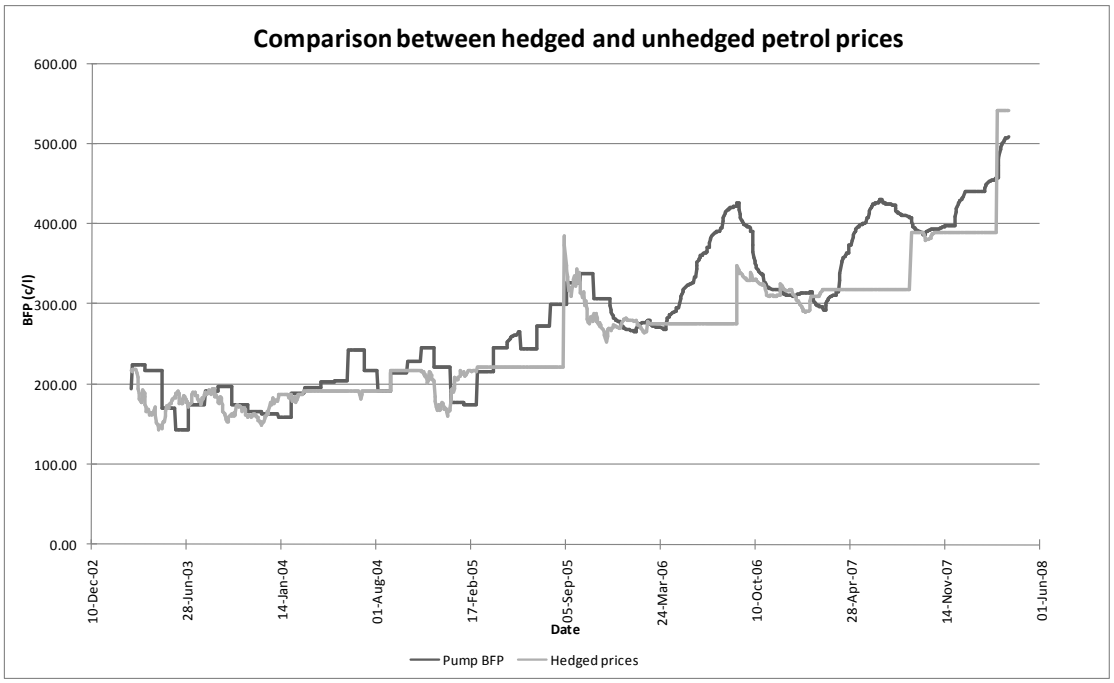



Figure 6 postulated by our proposition, clearly shows improvement in both the volatility and level of petrol prices. During the earlier period of the analysis, the period of lower prices, it is clear that the proposition is true. Although, the strategy introduces high price changes at the end of each hedging period, it is clear that the proposition is also true at high price levels too.

**Figure 7 - Nominal differences between hedged and unhedged prices**

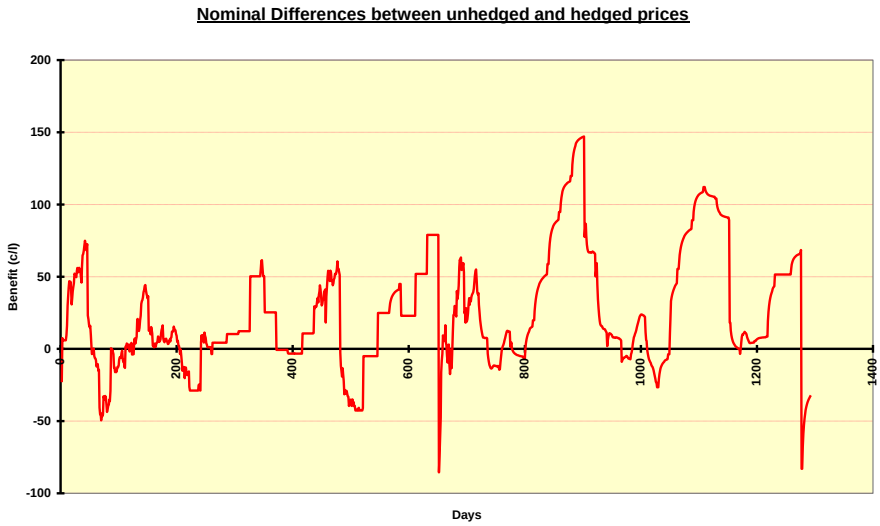



Figure 7 shows that average prices under the normal South African petrol pricing system are generally much higher than average prices under a hedged environment. There are many fewer times when the difference between the pump prices and hedged prices is negative, indicating that, on average, hedging would indeed be beneficial to the consumers.

**Table 3 - Comparison of average differences in prices for each heging period**

| | Benefit (cost) in cents per litre | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Period 1 | Period 2 | Period 3 | Period 4 | Period 5 | Period 6 | Period 7 | Period 8 | Period 9 | Period 10 | Overall |
| Average prices in the period | 180.333 | 173.372 | 212.221 | 210.197 | 271.454 | 288.992 | 363.351 | 316.463 | 401.352 | 434.168 | 287.272 |
| Average Hedging benefit | -11.80 | -11.13 | 1.90 | -10.79 | 16.41 | -14.01 | 51.05 | -1.47 | 49.20 | 7.81 | 6.74 |
| Average nominal hedging benefit | 7.21 | 2.77 | 17.67 | 5.72 | 32.79 | 11.63 | 65.72 | 17.15 | 68.30 | 27.70 | 24.53 |

Table 3 shows that for all pricing periods under review, hedged petrol prices were, irrespective of the price levels, on average lower than South Africa's pump prices. These results confirm the proposition that the average prices under the current pricing system would be much higher than average prices under a hedged environment. Conversely, average prices under a hedged environment would be lower than those under the current pricing environment.

## 4.4 South African pump prices and hedged prices (with hedging costs)

This section tests the validity of the second proposition. Figure 8 shows a comparison between the South African pump BFP prices and the prices that would have been obtained under a hedged environment. In this comparison, the cost of hedging has been included. The benefits of hedging are presented in Figure 9.

**Figure 8 - Pump vs. hedged prices (with costs)**

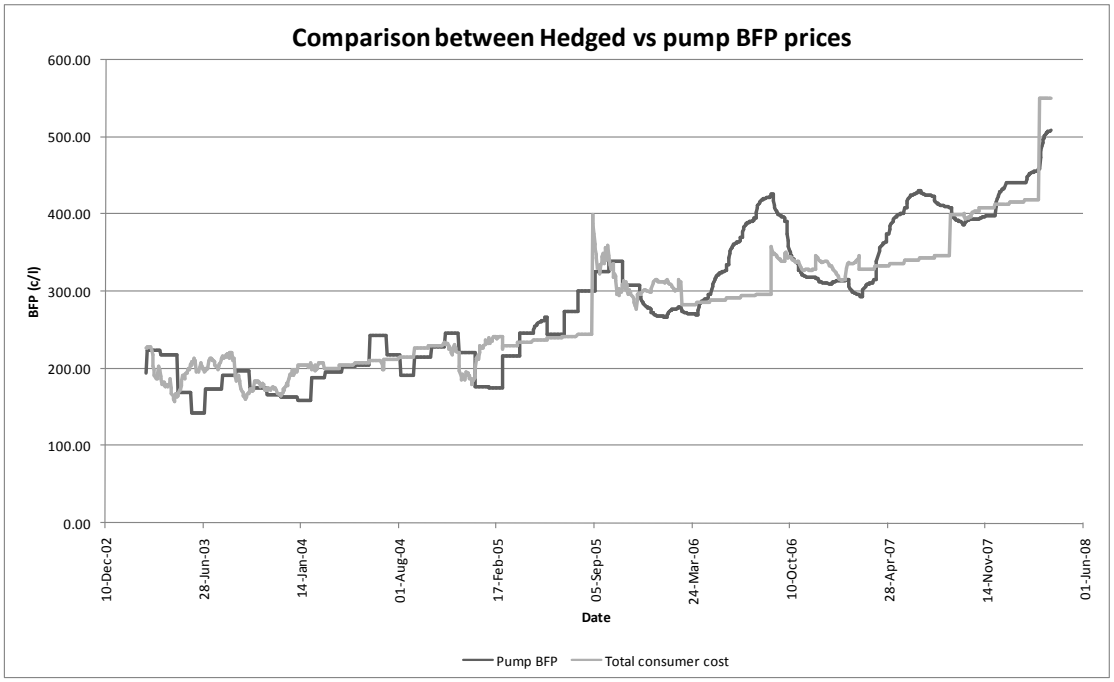



Figure 10 is the plot of benefits of hedging in a histogram format.

**Figure 9 - Benefits of hedging, taking costs into account**

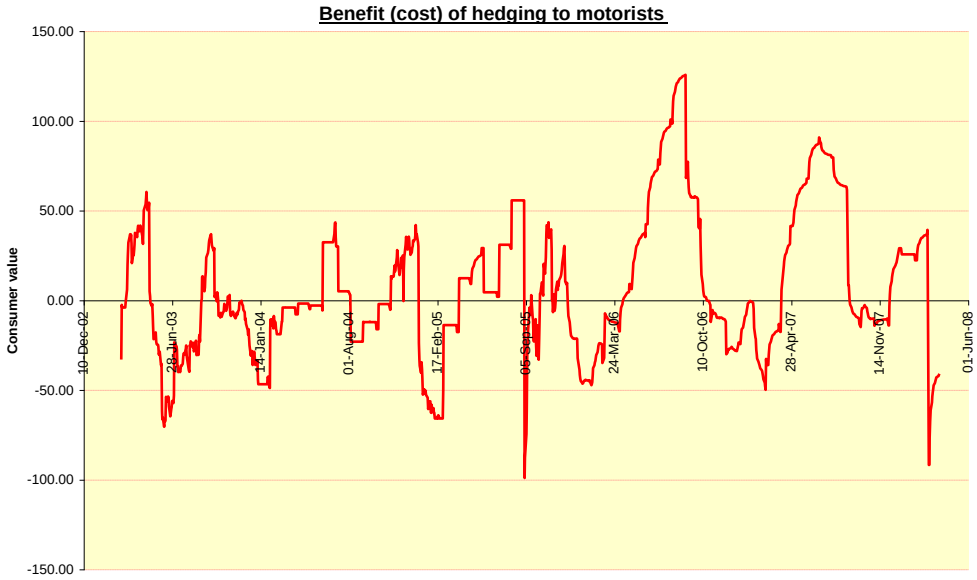



**Figure 10 - Histogram of benefits**

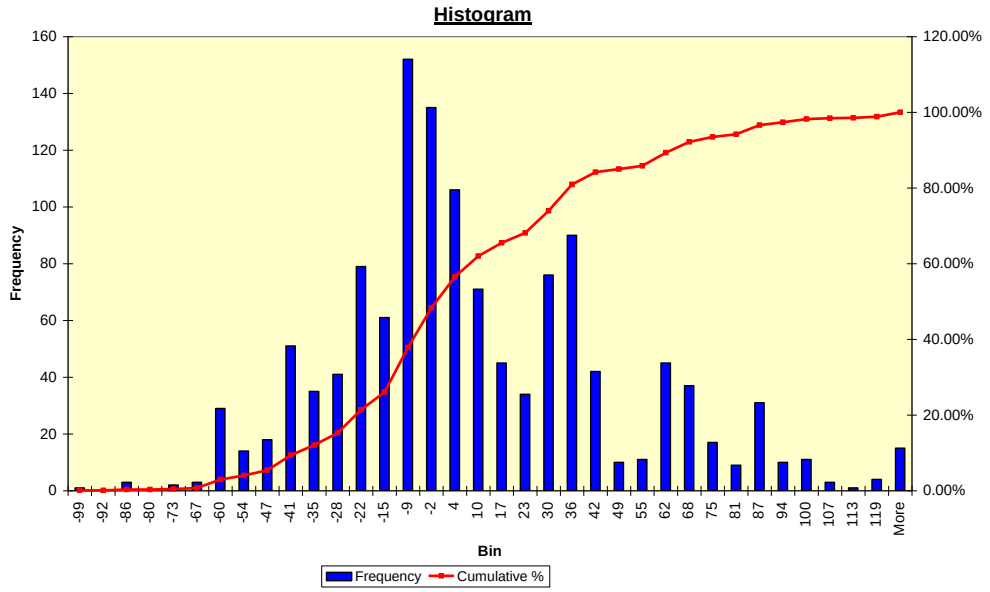



Figure 10 shows the overall benefit for the whole period under review but data were analysed in periods and the histograms for each period are grouped together and presented separately in Appendix D. To check for any

differences between different pricing periods that were reviewed, Table 4 was constructed.

**Table 4 - Analysis of benefits of hedging per period**

| | Period 1 | Period 2 | Period 3 | Period 4 | Period 5 | Period 6 | Period 7 | Period 8 | Period 9 | Period 10 | Overall |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Mean*** | -11.8 | -11.1 | 1.9 | -10.8 | 16.4 | -14.0 | 51.0 | -1.5 | 49.2 | 7.8 | 6.7 |
| ***Standard Error*** | 3.2 | 1.9 | 1.5 | 3.0 | 2.0 | 2.5 | 4.3 | 2.8 | 3.4 | 1.6 | 1.1 |
| ***Median*** | -23.8 | -8.5 | -2.7 | -5.1 | 12.5 | -18.9 | 42.6 | -9.0 | 64.1 | -2.3 | -1.9 |
| ***Mode*** | -3.8 | -46.6 | -22.8 | -11.9 | 55.9 | - | 42.6 | - | -35.9 | 25.8 | 25.8 |
| ***Standard Deviation*** | 35.8 | 21.7 | 17.4 | 33.9 | 22.9 | 27.8 | 48.3 | 31.5 | 38.6 | 18.3 | 39.0 |
| ***Sample Variance*** | 1278.7 | 469.2 | 303.3 | 1148.1 | 525.5 | 771.8 | 2329.3 | 990.5 | 1487.4 | 336.6 | 1517.3 |
| ***Kurtosis*** | -0.9 | -0.2 | -0.1 | -1.2 | -0.4 | 0.0 | -1.4 | 0.1 | -0.4 | -1.6 | 0.4 |
| ***Skewness*** | 0.4 | 0.1 | 0.7 | -0.3 | 0.2 | 0.0 | 0.1 | 1.0 | -1.0 | 0.3 | 0.6 |
| ***Range*** | 130.9 | 85.8 | 66.5 | 107.8 | 105.5 | 142.5 | 143.0 | 127.2 | 126.9 | 54.3 | 224.7 |
| ***Minimum*** | -70.3 | -48.7 | -22.8 | -65.7 | -49.6 | -98.8 | -17.1 | -49.7 | -35.9 | -14.7 | -98.8 |
| ***Maximum*** | 60.6 | 37.1 | 43.7 | 42.1 | 55.9 | 43.7 | 125.9 | 77.4 | 91.0 | 39.5 | 125.9 |
| ***Sum*** | -1509.9 | -1446.9 | 250.5 | -1392.2 | 2149.1 | -1765.3 | 6381.0 | -182.9 | 6199.5 | 968.7 | 8705.8 |
| ***Count*** | 128 | 130 | 132 | 129 | 131 | 126 | 125 | 124 | 126 | 124 | 1292 |

Figure 8 clearly reveals the smoothing effect of hedging on petrol prices. During the low petrol price period, the price is kept at an almost constant level. During high petrol price periods, the hedging strategy also appears to be able to contain price increases. However, the hedging strategy, during high petrol price periods, results in much steeper increases at the end of one hedging period and the beginning of another. Both Figure 9 and Figure 10 confirm that the proposition is valid i.e. the total consumer costs of fuel under the current pricing system would be higher than the total cost of fuel under the hedged environment.

## 4.5 Significance of results

The significance of the benefits of hedging when the costs of hedging have been included was tested using a student t-test and the results are presented in Table 5. Analysis tested the significance of the differences between mean pump prices and average hedged prices. The average pump prices are the average petrol prices obtained using the current South African regime. Hedged prices are the average petrol prices plus the cost of hedges that would have been obtained had South African petrol prices been allowed to change on a daily basis and hedged using a derivative instrument.

Table 5 shows that the observed benefits are significant with both the one-tail and two-tail t-tests yielding zero p-values at 95% confidence levels. From the table, it can be seen that firstly the mean petrol price was reduced from R2.83 per litre to R2.53 per litre and, secondly, variance in petrol price was also reduced from 8207 to 5906, indicating a significant reduction in volatility of petrol prices under the hedged scenario. It is therefore possible to state, with 95% confidence, that the level of petrol prices can be managed through formulation of an appropriate hedge, which would result in lower average prices as well as reduced price volatility.

**Table 5 - Signifance of the benefits of hedging the petrol price**

| t-Test: Paired Two Sample for Means | | |
|---|---|---|
| | *Pump prices* | *Hedged prices* |
| Mean | 283.079 | 258.547 |
| Variance | 8206.825 | 5905.998 |
| Observations | 1292 | 1292 |
| Pearson Correlation | 0.901 | |
| Hypothesized Mean Difference | 0 | |
| Df | 1291 | |
| T Stat | 22.295 | |
| P(T<=t) one-tail | 1.033E-93 | |
| T Critical one-tail | 1.6460 | |
| P(T<=t) two-tail | 0.0000 | |
| T Critical two-tail | 1.9618 | |

# 5 Conclusions

The price of petrol has, for a few years now, been increasing almost unabated. Although different commentators differ on the causes of such high prices, there is consensus on the impact of such high fuel prices on world economies. There is, however, disagreement amongst commentators on the need and the types of intervention that could be adopted by different governments to alleviate the impact of these high prices on their economies.

It is clear that since consumer price risks cannot be neutralised, they can either be retained as per South Africa's normal pricing arrangement or transferred to other parties. Literature pointed to major oil companies as possible counter parties in any risk-mitigation strategy that could be adopted. Writing a reverse call option was proposed as a possible risk-mitigation strategy. The proposed hedging strategy was expected to allow consumers to enjoy the benefits of low prices, during low price periods, at limited costs to them.

The research proved that the proposed hedging strategy is beneficial to consumers and the economy. It could lead to better management of petrol price volatility and also achieve lower average consumer prices. Hedging would result in lower fuel prices for consumers, thereby benefiting the overall economy by reducing fuel price inflationary pressures. However, it would also mean that increases in petrol prices, at the end of each six-month period, would be more pronounced. Based on the outcomes of this study, it would be recommended that the South African government considers hedging the petrol price through purchasing call options on behalf of consumers.

Although the results of the study have proved positive, in arriving at the results the Black-Scholes formula was assumed to be applicable. This assumption, although justifiable, does raise concerns about the accuracy of the option prices. It is therefore possible that the estimated hedging costs could prove to have been slightly exaggerated (or understated).

It is clear that the biggest short-coming of the proposed hedging strategy was the choice of fixed period call options. To improve on this strategy, the purchase of six-monthly rolling call options would need to be considered. Having shown the value of hedging consumer petrol prices, a number of hedging strategies including use of more exotic options should be considered. It would be useful if other hedging strategies, like swaps, caps, floors and collars, for managing the fuel price were to be investigated. Other more sophisticated methods of evaluating the adopted options should also be considered.

Notwithstanding the possible shortcomings in the research, this study still indicates that hedging petrol prices with an appropriate price risk-mitigation strategy would result in lower average prices than there would have been if petrol prices were not managed. Consequently, the total cost to consumer of petrol under a price mitigation strategy would be lower than it would have been if the price were not managed.

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# 7 Appendices

Appendix A – Republic of South Africa BFP Petrol Pricing Mechanism (separate attachment)

Appendix B - Analysis (separate attachment)