INTRODUCTION

1.1 Background

The exposure of business concerns to the risks of commodity price fluctuations is nothing new; neither are the techniques of managing such risks by those so exposed.

For South African manufacturers in the plastics packaging industry, exposure to main raw materials price volatility is becoming a matter of concern as the local economy becomes more integrated with the world economy. This exposure is accentuated by the increasing relaxation of government regulation and protection of industries. Godfrey & Espinosa (1998, p108) highlight the impact of these international forces on local economies when they say,

> The globalization of commerce and the transformation of financial markets have changed dramatically the risks that corporations face. Today, companies' costs, revenues and earnings are subjected to complex patterns of risks from the interaction of global business and financing decisions, on the one hand, and volatile commodity prices, exchange rates, interest rates, and equity values on the other.

The severe impact of these price risks on cash flows and margins of businesses makes it difficult for manufacturers to continue absorbing the effects, particularly in the light of competitive challenges that demand major improvements in their organisations' operational efficiencies, skills development and technological upgrading.

As the isolation of and sanctions against South Africa and import protections were gradually disappearing, opportunities for importing raw materials increased. This placed significant pressure on local suppliers to sell their materials at prices that mirror global polymer price trends. While it is advantageous now for local manufacturers to demand world competitive prices, the volatility of these global commodities bring risk exposures that were not previously experienced. A review of the price history of world polymers from 1989 to date indicates unstable and wildly fluctuating trends that are common among world polymers (see figure APP1, in the appendix).

For many plastics packaging manufacturers, raw material prices comprise 50 to 60% of the total sales in an industry whose margins are in constant decline. Therefore exposure to such price volatility introduces serious cash flow instability.

In the past manufacturers could easily pass any raw material price fluctuations on to their customers. That is, the pricing of final products by manufacturers could be calculated on a cost-plus basis. This was possible because levels of volatility were relatively low. However, manufacturers are now experiencing growing resistance from major customers who account for about 60%

of the total business. Customers refuse to accept regular or frequent price reviews that would take into account the variability of polymer prices. The reason for this resistance is that customers are not able to adjust prices as frequently in the consumer markets. The dominant preference in the South African plastics packaging industry, which results from stiff competition for a limited customer base, is for a price structure based on agreements that are reviewed only once annually.

The local converter of packaging plastic raw materials therefore experiences increased exposure to a situation in which input costs are volatile. This presents a price risk that needs management, and in which customers insist on fixed price contracts.

While it is not industry practice for converters to secure profit opportunities from raw materials, neither is it viable that manufacturers be subjected to severe cash flow fluctuations. As an industry in which a commitment to sustained strategic improvement is needed, the timing of the availability of necessary funding is crucial.

Possibilities within the industry, therefore, need to be explored regarding the management of the price risk exposures experienced. One such possibility is in the area of hedging with contracts from the futures market.

This research focused on the hedging of plastics raw materials with oil futures contracts. Four polymer producing regions in the world, namely, North Western Europe, the United States Gulf, Asia and South Africa were studied. South Africa is the main supplier to local manufacturers at present. However, possibilities for importing polymers do exist.

1.2 Research Problem

The purpose of this study was to investigate the question of whether packaging polymers can be cross-hedged with oil-based futures contracts.

Review of previous research work revealed that manufacturers, and especially in South Africa, were fearful of hedging commodities. This fear for the riskiness of hedging was even greater when it came to cross-hedging. Although literature correctly confirmed that a cross-hedge would be effective if the correlations of the main commodity and the hedge instrument were high, no research evidence could be found that showed that in reality cases of successful cross-hedging, including polymers and oil, existed. It was also found that previous research on the possibility of cross-hedging only went to the extent of analysing correlations and concluding that, because of the high correlations obtained, great opportunities for cross-hedging existed. This fear of manufacturers was based on lack of evidence that such a cross-hedge, even on polymers and oil, could work. This study aimed to answer this question through a simulated hedge.

1.3 Research Objectives

The specific objectives of the study were as follows:

- to determine whether an effective cross-hedge for polymer prices can be simulated using brent crude futures based on historical data;

- to assess the risks associated with this synthetic hedge;

- to simulate the creation of a buffer or standby fund as an alternative solution to absorb the polymer price risks, and to compare the effectiveness of such a system with the futures cross-hedge.

1.4 Importance of the Research

The results of this study were intended to be of use to manufacturers in the plastics industry. The results were expected to help determine whether volatile plastics prices (which do not have futures contracts in international commodity exchanges) could be cross-hedged with oil based futures contracts. In addition, the results of the study would help manufacturers, in general, to appreciate the critical issues that need to be considered in hedging commodities. This would be of particular value to a comprehensive and integrated approach to risk management, including considering commodity price risk or any other risk.

1.5 Scope of the Research

The study investigated the possibility of hedging major raw materials in the plastics industry. The focus of the research was limited to :

- performing a cross-hedge test on a few selected polymers; and

- assessment of the need for such a hedge with respect to cost-effectiveness.

2 LITERATURE REVIEW

2.1 Introduction

Awareness and understanding by manufacturers of the impact of commodity price risk on the cash flow stability and performance of their organisations increased substantially over the years (Froot, 1994). For example the collapse of world oil prices by more than 50% in the first half of 1986 and the subsequent decline of energy prices, led to disastrous performances by oil producers. According to Froot (1994) companies such as Dresser, which supplied equipment to oil producers, experienced massive declines in profit in 1995 (US $292 million) and in 1996 (US $149 million). Their share price fell by 48%, and capital expenditure dropped from US $122 million to US $71 million. Such experiences with commodity price risk, as well as other risks including interest rate and foreign exchange, led to an increased use of derivatives by corporations (Froot, 1994).

2.2 Critical Success Factors of a Hedging Strategy

While the knowledge of corporations in the use of derivatives to hedge their risk exposure increased significantly, it is clear that serious losses have been experienced from such activities (Stultz,1996). As opposed to dealing with corporate risk exposure from a coherent and effective strategy that identifies the most critical areas of concern that can put the company in financial distress, corporations tend to hedge selectively guided by their own personal views of the future trends of various risks (Stultz,1996).

Based on the findings of the Wharton-Chase Study that was updated in 1995, Stultz (1996) points out that a third of all the derivatives users interviewed said they sometimes actively take positions that reflect their market views of interest rates and exchange rates. He also points out that a similar survey by Walter Dolde in 1992 found that managers tend to take speculative positions in hedging based on their personal view or opinion of market trends.

Froot, *et al.*(1994) emphasize the need for a strategic approach to hedging. Concern is expressed about current practices as follows, "Unfortunately , the insights of financial engineers do not give managers any guidance on how to deploy the new weapons most effectively. Although many organisations are involved in risk management, it's safe to say that there is no single, well-accepted set of principles that underlies their hedging programs" (Froot *et al*,1994: 22). What they find lacking is a comprehensive risk management strategy that is integrated with the corporate strategy. They argue that a corporate risk management strategy, using derivatives, should rest on three premises, as follows:

- the key to creating corporate value is making good investments
- the key to making good investments is generating cash internally to fund those investments

- cash flow, which is crucial to strategic investments, can be disrupted by erratic movements in commodity prices, interest rates and foreign exchange

They note that a risk management programme should have a single overarching goal: to ensure that the company has the cash available to make value-enhancing investments. This approach will enable managers to answer the fundamental question of risk manament: which risks should be hedged and which should be left unhedged?

Froot, *et al.*(1994) base their argument on the theory of Modigliani and Miller that value is created only when companies make good investments that ultimately increase their operating cash flow. They however disagree with one aspect of the theorem, which goes on to say that it does not matter how these investments are financed. The premise of their argument is that external sources of funds, such as equity and debt, can be costly to the organisation. Empirical evidence shows that acquisition of funds through equity often results in the company share price dropping by about 3% (Froot, 1994). Debt, depending on the financial health of the company, can be made very expensive by creditors (Froot,1994). The most reliable way to guarantee the future funding of critical investments is by having available retained income. Some corporations prefer internal funding rather than external funding (Froot,1994)

Bauman, Saratore & Liddle (1994) point out that while derivative instruments can be used to reduce the volatility of corporate earnings and cash flows, the inappropriate use of these tools can have quite the opposite effect. He argues that an organisation must have a practical framework for managing corporate exposure based on the following fundamental steps: exposure identification, senior management planning, policy implementation and control and evaluation. Such a framework would assist senior managers in identifying the right questions to ask in order that the company's financial policies are truly aligned to the long-term strategic goals of the company. Formalisation of the strategic overview of the industry environment in which the company operates assists in identifying and evaluating the impact of interest rates, foreign exchange and commodity prices on the performance of the company.

Seidel & Ginsberg (1983) in their discussion on hedging and correlatations had the following to say, "The theoretical criterion that defines a market to be a good hedging market is one where prices of the hedge instrument are highly correlated with the price of the commodity" (1983, p33). They further point out that the underlying of the hedge instrument and the commodity being hedged need not necessarily be the same. However, what they do stress is that in the case of cross-hedging the underlying of the hedge instrument and the commodity invariably have a *production* or *financial* linkage.

2.3 **Rationale for hedging a particular risk**

Froot, *et al.*(1994) state that a company may not have to hedge all the risks that it is exposed to. When a particular risk occurs, for example , when world oil price drop to significantly low levels, it is important to determine whether the critical investments, such as oil production capacity expansion, planned by the company will still be needed. If the need to proceed with the project declines when the risk exposure of the company and the industry as a whole rise and the need grows when the exposure declines, then Froot, *et al.*(1994) argue that there is no need to hedge that risk, since it is a self-hedging risk. If on the other hand, the need for the investment remains high whether the risk rises or falls, then it is critical to look after the cash flows. Understanding these basic principles is essential to development of an effective risk management strategy (Froot *et al*, 1994).

Shapiro (1992) states that the ability to secure funds in order to undertake profitable projects is a major factor in corporate growth. While highlighting the importance of other sources of finance such as debt and equity, he emphasises the advantage of the flexibility achieved by a firm with excellent cash flow status and low leverage. This facilitates the required responsiveness when the firm is faced with fierce competition. The situation also enables strong debt capacity by the firm which attracts creditors as well as potential shareholders (Shapiro, 1994).

Culp, Furbish & Kavanagh (1994) point out that it is necessary for corporations to hedge only if the special conditions set in the Modigliani and Miller I theory are violated. One of these conditions is that corporate investment decisions are not influenced by financing choices, such as decisions to hedge various price risks. Culp, *et al.*(1994) confirm that in reality these conditions are violated.

Perfect markets do not exist. However, they warn that corporations should not automatically choose to hedge. In making the hedging decision, they need to consider the demand for such derivative instruments. Culp, *et al.*(1994) conclude that, in such cases, corporations may not only have to decide what hedging vehicle to choose, but also whether it is necessary to hedge with these instruments.

Froot, *et al.*(1994) point out that companies in the same industries may not have to adopt the same hedging strategies. This may depend to a large extent on how expensive it is to pursue the investment projects. The management of a company whose projects are too expensive may have to abondon such projects when the risk exposure worsens. Hence companies with less expensive projects may hedge. They argue that investments need not be in the area of equipment and production facilities only. The projects may be on 'softer' but critically important investments like human resource or special skills development. These kinds of projects can often be funded from retained income only.

In their research of risk trends in the USA markets of interest rates, commodity prices and foreign exchange, the Indian Government Research Committee (IGRC, 1998) concluded from empirical evidence that the highest volatility was observable in the commodities market. Ultimately for these companies to be protected against internal risk exposure their management focus should be on commodities.

From a modern finance perspective, Stultz (1996) points out that in efficient and liquid markets such as those of interest rates, foreign exchange and some heavily traded commodities including oil and gold, industrial companies had no comparative advantage in bearing these risks. He further comments, " if the concept of market efficiency should discourage corporations from creating corporate exposure to financial market risk, the companion concept of diversification should discourage some companies from *hedging* financial exposures incurred through their normal operations" (1996, p12). He asserts that most corporate financial exposures represent 'non-systematic' or 'diversifiable' risk that shareholders can eliminate by holding diversified portfolios. It is also argued that the risk-management tools available to shareholders are relatively inexpensive (Stutlz, 1996).

Hull (1995) challenges the above argument by indicating that it implies firstly that shareholders have much information about the risks faced by the company. He argues that managers of the company may understand the risks facing the company much better than shareholders. Secondly, he argues that the commissions and transaction cost per dollar of hedging are less expensive for large volumes or transactions than for small volumes. Hence, the individual shareholders will pay more in contrast to the company dealing with the total volume. However, Hull (1995) supports the view that shareholders with well-diversified portfolios can be well protected from many of the risks facing the corporation. He asserts that shareholders can diversify their portfolios more easily than corporations.

Hull (1995) also points out that in certain industries where commodity hedging is not the norm, it is not necessary for one company on its own to hedge. In this unhedged industry the markets will absorb or adjust to the commodity price variability. In fact the company that hedges alone will achieve the direct opposite of its intention: its profit margins will fluctuate. The unhedged company will achieve stable prices (Hull, 1995).

2.4 Comparative Advantage in Hedging

Stultz (1996) suggests that management should not expect their companies to profit by taking positions on the basis of information that is publicly known. This argument is reversed, however, when in situations where a company's management has special knowledge, which is unknown to others. In these cases the company has a comparative advantage over others and can exploit the situation (Stultz, 1996). Instead of assuming the standard guidelines of acceptable hedging stipulated by the company's corporate risk policy, Stultz (1996) accepts that the hedge ratio may be adjusted according to the management's view of the market. However, it is also admitted that there is an element of risk in this selective hedge. One of the causes of the failure of the hedging strategy in the case of Metallgesellschaft (1993) was their assumption of having comparative advantage, which encouraged them to take exposed positions.

Culp, Miller & Neves (1998) indicate that firms whose management deliberately choose to hedge selectively do so because of comparative advantage. They seek to manage their exposures to risks in which they do not have comparative informational advantage.

2.5 **Current hedging practices**

Dolde (1993) established that firms practice corporate risk management in a manner that seemed to contradict theoretical expectations. His conviction was that smaller companies, due to their high equity stake and relatively low debt, should tend to hedge more extensively. Conversely, large corporations, because of their diversified stock holdings, should hedge less. His findings, however, were to the contrary: that there are no systematic patterns.

2.6 **Prior research on hedging**

Johnston (1983) warns that correlation results must be interpreted with great care. He found that high correlation results obtained from the calculations do not necessarily guarantee that the price movement of the futures contract coincides well with the price movement of the commodity being cross-hedged. He had found a high positive correlation between the krugerrand futures prices versus those of wool, platinum and nickel. However, the movement of the prices were not similar. For example, platinum showed a correlation of 0.74. However, a careful observation of the krugerrand futures prices graph relative to the platinum prices graph showed many dissimilar rises and drops (Johnston, 1983).

Analysing the results of hedging South African gold with the 12-month Comex Gold Futures Contracts, Overton (1985) found that it was not possible to protect or secure profits by hedging with futures contracts. He indicates that in different periods good profits or heavy losses would have been made by gold producers, depending on whether the gold spot price was rising or falling continuously.

Merrifield (1998) found that the use of derivatives in South Africa was lowest in managing commodity price risk as compared to other risks facing corporations. Seventy nine percent (79%) of derivatives users were found to focus on foreign exchange risk, fourty four percent (44%) on interest rate risk and only fifteen percent (15%) on commodity price risk. He further suggests from his findings that South African companies, which rely heavily on commodity sales, may derive benefits from greater derivatives-based commodity price risk management.

2.7 **Unintended Speculation in Hedging**

The Indian Government Research Committee (1998) suggest that while the intention of hedging with futures contracts may be to reduce risk, the very circumstances of hedging can expose the corporation to risk. They point out that there are two modalities of reducing risk with futures contracts: an Offset-Hedge and a Price-Fixing Hedge. The former nullifies price risk that has arisen from a physical contract with a customer. The latter is an opportunist action designed to lock in an attractive price level for a buyer. It is an attempt to secure or protect profits. IGRC (1998) argue that this, superficially, appears to be speculation. However, it is a justifiable hedging practice because the manufacturer is removing the speculative element from the business by buying or selling goods at prices that will allow them to make profits. They argue that this is important, especially in cases of manufacturers who produce in advance for unconfirmed sales volumes in the future, which will be subjected to future spot prices. They warn, however, that massive losses can arise from this strategy due to the possibility of being over-hedged. By hedging unconfirmed volumes there is a risk that demand may fall drastically and the manufacturer may remain with a massive open position in the futures market. The second risk in the case of price fixing, is that the manufacturer is essentially locking in the selling price by hedge-buying raw materials. If raw material spot prices fall drastically over a long period of time the losses could be severe.

2.8 Exchange Traded Derivatives versus Over The Counter Contracts

The IGRC (1998) point out the advantages and risks of hedging with institutions that offer exchange traded futures contracts or over-the-counter (OTC) contracts. They argue that exchange traded futures may not be specifically suitable for the commodity being hedged, as these involve standard contracts. A perfect hedge, which eliminates the entire commodity price risk, is generally not possible. This is even worse in situations where the physical commodity and the underlying asset of the futures contract are not the same. However, futures exchanges are very liquid and dangers of unexpected liquidations are remote. On the other hand, OTC contracts can be customised to the client's requirements to the extent that almost perfect hedging is achievable. It is indicated, however, that the private institutions providing OTC deals are very small relative to international futures exchanges, thus exposing the hedger to increased liquidity risk.

According to Orlosko (1998) there are only two organisations world-wide that offer OTC contracts for the plastics packaging industry. These are Koch Chemicals of the USA and Shell. Although the consumption of polymers globally has grown exponentially and the market is sufficiently liquid to justify the existence of futures markets, there exist none to date for this commodity. Orlosko (1998) points out that for the American market where volumes are large and liquid enough, it is viable to sell OTC contracts in order for their local manufacturers to hedge packaging material costs. He argues that it is more viable to hedge plastics with a mechanism that is based on a local (USA) plastics price index. This index is more reliable than a cross-hedge that is based on a high correlation between futures prices and the polymer spot prices.

2.9 **Hedging Long-dated Obligations with Short-dated futures**

Culp & Miller (1995) warn that it is not wise generally to 'borrow short' and 'lend long', because by doing so exposure is made to a long term commitment. However in the case of futures hedging they argue as follows: " Counter-intuitive as it may seem, a firm can use short-dated futures to hedge its own long-term delivery commitment against spot oil price increases simply by purchasing a 'stack' of short-dated futures equivalent to its remaining delivery obligations" (1995, p64). 'Stack' means that as the expiration period of the short-hedge nears, the contract is closed out and contracts are bought again which are equivalent to the size of the remaining exposure (Culp et al1995). They point out that with such a strategy the firm is faced with risk other than its price exposure. This is basis risk. They point out that basis risk is less serious than spot price risk. They indicate that the decision of Metallgesselschaft to liquidate the hedge when faced with cash flow problems arising from the basis was not wise as it exposed the firm to long term price risk.

Hull (1997) states that if the expiration date of the hedge is later than the available contracts date, the hedger must roll the hedge forward. However, two points need to be taken into account. Firstly, there will be as many basis risks as the number of times the hedge is rolled forward. Secondly, rolling the hedge forward can lead to excessive margin calls or cash flows, if the spot prices move in the undesired or unexpected direction.

2.10 **Personal Interviews**

Nel (1999) points out that in attempting to determine whether oil-based futures contracts can successfully hedge polymer prices, it will be very important to distinguish between: poor hedging results which, on the one hand result from a poorly designed or planned hedging scheme, and poor results which on the other result from the fundamental reason that oil futures contracts are not a good or appropriate hedging instrument for polymer prices. The possibility of the first reason or cause needs to be eliminated in order to meet the objectives of the study. This is not always easy and could be beyond the scope of this research as the analysis would entail involved computational work. A more practical approach could be to consider several hedging schemes and choose the one that yields the best hedging results, thus guaranteeing that the results of the research are not influenced by external factors.

Mahl (1999) points out that there are several situations where oil prices and polymer prices have moved in completely unrelated directions. These periods have sometimes been as long as two years – a period long enough to suggest that the cross-hedging of polymer prices with futures contracts could be risky. He illustrates this by pointing out the 1994-95 period during which oil prices were falling continuously (from ± US $25/barrel to below US $11/barrel) while polymer prices were simultaneously rising against expectation (from ± US $800/ton to $1500/ton). This he attributes to the mismatch between the two markets of polymers and oil. Each one has its own supply and demand patterns which dictate the movement of prices (Mahl, 1999). He explains this 1994-95 problem by indicating that during this period there was an over supply of oil which caused price decline. At the same time, polymer manufacturers had not planned for increasing their production capacity due to the Gulf war that had just come to an end. Hence an increase in demand for polymers pushed prices up while oil was in abundance (Mahl, 1999).

Supporting the views of Mahl, the bi-weekly reports from Platts (1999) and ICIS-LOR (1999) discuss how the trends of polymer price movement are predominantly driven by supply and demand factors of the global polymer markets. Platts (1999) and ICIS-LOR (1999) point out how the fluctuating demand for polymers by China, which is a major consumer of polymer raw material, determines the direction of prices. Sometimes these movements do not correspond to the oil price movement (Mahl, 1999).

RESEARCH PROPOSITIONS

3.1 **Introduction**

There are no futures contracts based on polymers as an underlying commodity. This implies that a cross-hedge had to be set up in order to hedge polymer prices with futures contracts. The overall objective of the study was to determine the effectiveness of cross-hedging plastics prices with brent crude futures contracts. The following constituted the propositions of the study:

3.2 **Proposition 1**

The brent futures contracts of the IPE correlate highly with the polymer spot prices of HDP, LDPE and PP for the four polymer producing regions of North West Europe (NW E), South East (SE) Asia, the United States (US) Gulf and South Africa. A threshold correlation level of $r = 0.8$ was assumed to be the minimum required to consider a polymer for cross-hedging in this study.

3.3 **Proposition 2**

The spot prices of South African polymers correlate with international spot prices. The proposition was tested in order to determine whether SA polymers, coming from a newly opened market, are more correlated to oil or to global polymers.

3.4 **Proposition 3**

The impact of the variability of the spot prices of HDPE, LDPE and PP can be reduced by the IPE brent futures cross-hedge. That is, the gains and losses experienced in both the polymer spot market and the futures market cancel each other such that the overall effective price paid by the manufacturer is stable and constant. The testing of this proposition made it possible to determine whether a threshold correlation of $r = 0.8$ was high enough, or whether higher levels of correlation should be achieved.

3.5 **Proposition 4**

The cross-hedge will not generate excessive margin call risk. That is, the margin account that is to be maintained by the hedger generates gains and losses as the futures prices fluctuate daily. These cash flows, or margin calls, will not be excessive.

3.6 **Proposition 5**

Using a cross-hedge based on the International Petroleum Exchange brent futures contracts is more cost-effective than using a standby or buffer fund to absorb the polymer price risk exposure.

4. RESEARCH METHODOLOGY

4.1 Introduction

The analysis was based on historical or secondary data. The key elements of the analysis were correlations and hedging simulations. They were directly related to the propositions put forward in chapter 3 and the results obtained were used to confirm or refute these propositions.

4.2 Data Sources

4.2.1 Brent Crude Futures and Spot prices

The IPE was chosen for this study mainly because of the availability of data. In addition, the brent crude, whose futures contracts are with the IPE, is regarded as the standard guiding price for all oil prices globally.

4.2.2 Polymer Spot Prices

The spot prices for plastics were obtained from Platts Polymerscan, an international data services organisation based in the United Kingdom. They were obtained for the three regions of NWE, SE Asia and the US Gulf. An additional set of polymer data was obtained from Bloomberg Data Services. This data was not specific to any region or area, but represented average global polymer prices.

For the South African region spot prices and total polymer consumption data were obtained from the Plastics Federation of South Africa (PFSA) and BMI Food Packaging. BMI is a South African organisation that compiles statistics on South African Commodities. Platts was chosen because of the availability of data required for the study.

4.2.3 The US Interest Rates

The United States interest rate figures were obtained from Bloomberg Data Services. These were used to calculate Net Present Values when comparing the cost effectiveness of a standby fund or unhedged position with a hedged position.

4.3 **Sampling Method**

4.3.1 Data Selection

The population for this study was all global polymers that corresponded to polymers used in South Africa. However, the variety of polymers used was wide, and the availability of data limited. Therefore the samples for the study were selected according to the availability of data. Time and cost limitations also restricted the number of polymer types and the number of regions in the world that were considered.

Brent crude spot prices and brent crude futures prices

The list of oil futures contracts available from the IPE were the brent crude futures. Six contracts, ranging from the one-month to the six-month futures were considered for hedging. Only six contracts were chosen from among as many as 12 available contracts. This was to reduce the size of the computational task for this study. In addition to this, the seven-month to 12-month contracts were not heavily traded in the exchange.

Polymer Spot Prices

The global polymers that were selected included PP, HDPE and LDPE. AS shown in appendix 2 these packaging polymers were found to be the most widely consumed in South Africa. Global data comprised the weekly prices from 1983 to 1999. For South Africa, only monthly data ranging over the same period could be obtained.

4.3.2 Sample Size

The basic requirement for considering the possibility of cross-hedging polymers with brent crude futures is the existence of a high correlation between the price movements of the two (Seidel & Goldberg, 1983). It was important, therefore, to show that the correlation analysis results of the samples of this study were inferable to the population of the parent polymers.

In order to increase the validity of the correlation analysis results, data with the longest time range available from sources were chosen. This ensured that the sample sizes were the largest available and that they spanned a reasonably long period.

The validity, which was dependent on sample size, was determined by subjecting the results to the statistical hypothesis test for correlation analysis. In accordance with Hanke & Reitsch (1994), the t-test was performed to test the null hypothesis that no correlation existed between the samples. The acceptance or rejection of the hypothesis was based on a significance level of 0.05. The calculated t-value, t_{cl}, was defined as follows:

$t_{cl} = S_r/r$ where S_r and r are the standard error of correlations and the Pearson product-moment correlation coefficient respectively.

This was compared to the critical t-value, t_{cr}. At a significance level of 0.05, the critical t-values were $-t_{cr} = -1.98$ and $+t_{cr} = 1.98$.

The acceptance, rejection criteria were as follows:

- if t_{cl} was between $-t_{cr}$ and $+t_{cr}$, the assumption that no correlation exists will be accepted. Otherwise, the null hypothesis would be rejected;
- the finding would be accepted as valid and inferable to the parent polymer population;
- the same method of testing would be applicable when determining the correlation of South African polymer prices with international prices.

4.4 **Research Tools**

Correlation analyses for the different polymers with the brent futures were carried out on the figures over the full period of the collected data. The hedging simulation, on the other hand, was carried out over shorter time intervals that corresponded with the consecutive hedge periods (see section 4.5.2). The calculations and processing of data was carried out in Microsoft Excel.

4.5 **Method of Analysis**

4.5.1 Correlation Analysis

Two sets of correlation analyses were carried out.

The first correlation analysis was between polymer prices of the different regions and the brent crude futures prices. The purpose of calculating these correlations was to determine if brent futures could be considered for cross-hedging polymers. For this study, it was assumed that a minimum correlation level of *r = 0.80* had to be achieved.

The results were analysed to determine if there were any significant differences if :

- different periods are compared, and
- different global regions are compared
- the time lag between brent furutres and polymer spot prices varied.

For the last aspect of the correlation analysis above, it is generally known that polymer prices lag oil prices. What was of importance in this study was to determine how far below the thresh-hold correlation of 0.8 the lag between the two reduced the correlation levels. The correlations were analysed assuming a lag period ranging from one week to eight weeks. The results of this set of analyses were used to support or reject Proposition 1.

The second correlation analysis was between South African and global polymer prices. The purpose of this was because South Africa, at the time of this study, had just opened up to the global polymer markets. It was important to determine whether South African polymer prices were correlated more to the IPE brent futures or global polymer prices. The South African polymer price indices, which were South African Rand based, had to be converted to equivalent dollar prices to calculate correlations with the global polymer prices. The results of this analysis were used to support or reject proposition 2.

4.5.2 Hedging Simulation

The purpose of the simulation was to assess the effectiveness of the hedge. Effectiveness of the hedge, in this context, referred to the fact that the impact of the polymer price volatility on the cash flows of the manufacturing concern were reduced as compared with the situation when the price was unhedged. The hedge was simulated only for polymers whose correlation results were equal to or greater than 0.8. Only one polymer type per region was selected from the ranges of HDPE, LDPE and PP. The results of this analysis were used to support or reject Propositions 3 and 4.

The hedge included the following key elements :

Hedging period

A six month hedging period was considered. This was based on the assumption that a fixed selling price agreement for six-monthly periods existed between the manufacturer and the customer. That is selling prices were reviewed bi-annually.

Polymer purchasing periods and volumes required

For purposes of this hedge simulation it was assumed that purchases were made every week. This was chosen deliberately so that the manufacturer was exposed to the most severe fluctuations as frequently as possible (that is, weekly).

Contract Size and Number of Contracts

During each hedge period of six months (26 weeks), there would be several liquidations of old contracts and simultaneous purchases of new contracts taking place. (see section 2.9 – hedging long dated obligations with short dated futures contracts)

The futures contract structure or scheme for the model was a stacked hedge (Culp *et al*, 1995). At the beginning of each hedge period, the first contract would be purchased to cover the full volume of polymer. At the expiration date, the contract is closed out and a new one is bought on the volume corresponding with the remaining part of the six month period. This was repeated until the end of the six moth period, that is the expiry date of the manufacturer's delivery contract.

The number of contracts to be bought was calculated according to the following formula :

$$N_{fc} = \frac{(Q_p * P_{p1}) * h}{P_{fb} * B_c} \qquad \text{(Hull, 1997)}$$

Subscript 1 denotes the starting time of the contract and N_{fc}, Q_p, P_{p1}, h, P_{fb} and B_c represent the number of futures contracts, the quantity of polymer to be purchased in tons, the price of polymer per ton, the minimum variance hedge ratio, the futures price per barrel and the number of barrels per futures contract respectively.

The contract size, represented by the symbol B_c above, was fixed by the futures exchange for any commodity.

For oil, which applied to this study, the contract size was 1000 barrels per contract. In order to standardise calculations, it was assumed that the manufacturer bought a fixed weekly quantity of polymer equal to 5000 metric tons.

The Margin Account Cash Flows: Proposition 4

For the futures hedge to exist, the manufacturer has to open a margin account through a broker in the futures exchange. This is just a mechanism employed by the futures exchange to ensure that contract defaults by investors are minimised. An initial margin or amount is deposited into the account at the start of the contract. As the futures prices fluctuate daily, the margin account balance fluctuates or is adjusted accordingly to reflect gains or losses made by the investor – that is, it is marked to market. The margin account balance has to be maintained above a certain minimum level, called a maintenance margin, below which a margin call (or a topping up call) will be made on the investor (the manufacturer in this case). Thus the margin account does have cash flow implications for the manufacturer.

A manufacturer who whishes to fix the future buying price of raw materials has to take a long position in the futures market and conversely, one who wishes to fix the future selling price of finished goods has to take a short position. The investor with a long position loses a certain amount of cash from the margin account balance as the futures price drops and gains some money into the account as the futures price rises. The opposite effect would result for an investor who takes a short position.

The margin account adjustment depends on four factors, as follows:

- the amount of change in the futures price
- the direction of the change (price increase or decrease)
- the contract size
- the number of contracts purchased (sold)

The adjustment is calculated as follows :-

Adjustment = (Futures Price Change)*(Contract Size)*(Number of Contracts)

$$= (P_{fb2} - P_{fb1}) * B_c * N_{fc}$$

where subscripts 1 and 2 denote the start and end of the contract period.

This adjustment is normally done daily. For this study the calculations were done on a weekly basis because of the limitations imposed by the fact only weekly data was available.

To assess the severity or excessiveness of the cash flow impact on manufacturers arising from the margin account, the weekly margin account adjustment was calculated as a percentage of the weekly polymer spot price paid by the manufacturer over the full hedge period. The calculation was according to the formula:

Margin Account Excessiveness = $\{ [(P_{fb2} - P_{fb1}) * B_c * N_{fc}] / P_{p2}\} * 100\%$,

where P_{p2} is the spot price that has to be paid at any time during the hedge period and all other variables are as previously defined.

While the manufacturer intends to use hedging to stabilise operational cash flows by reducing the volatility of raw material input costs, it will be unacceptable if such a hedge creates new cash flow instability through the margin account that is to be maintained. The calculation of the margin account excessiveness above helped to assess the level of these cash flows. For this study, it was decided that a general trend of margin account adjustment that was above a 5% of the polymer spot price would be unacceptable. Any trend below 5% would confirm Proposition 4 – that is the likelihood of excessive margin calls is very low.

Over the full period of the hedge, the maintenance of the margin account leads to no loss or gain, that is the sum of all losses balance out with sum of all the gains. However, the day to day (and in the case of this model week to week) margin account adjustment can create excessive positive or negative cash flows. This situation would not be ideal for a manufacturer.

Volatility Reduction : Proposition 3

If the hedge was successful, the effective price paid should be constant throughout the hedge period. That is, a gain in the spot market, $Q_p * (P_{p2} - P_{p1})$, was offset by a loss in the futures market, $[N_{fc} * B_c (P_{fb2} - P_{fb1})]$, and *vice versa*. Subscripts 1 and 2 represented the start and closing out dates of the contract respectively and, the other variables were as previously defined.

The effective price paid by the manufacturer, as a result of the hedge, should be equal to the polymer spot price at the time of the purchase, plus the gain or loss made in the futures market (Hull, 1997). In the test model, the polymer purchases were made weekly.

The effective price was calcualted according to the following formula:

$$P_{eff} = (Q_p * P_{p2}) - [(P_{fb2} - P_{fb1}) * N_{fc} * B_c]$$

The standard deviations of both the hedged and unhedged positions were calculated over all the individual hedge periods. These were taken as a measure of price volatilities. The acceptance criterion for proposition 3 was as follows: If the fluctuation of the effective hedged price (that is P_{eff}) was found to be less volatile than that of the unhedged spot price (P_p) for the same hedge period, then proposition 3 would be deemed valid; otherwise the proposition would be rejected.

<u>The Standby Fund Alternative : Proposition 5</u>

The standby fund was used as an alternative to hedging. A budget was provided at the beginning of each hedge period (every six months) to absorb the unhedged polymer spot price fluctuations. For every weekly rise or drop in the polymer spot price, the standby fund was respectively reduced or incleased with an equivalent amount to ensure that the raw material price to the manufacturer is constant.

The total gain or loss in the standby fund (that is for the unhedged position) was compared to the cost of the hedged position. The comparison calculations were carried out as follows:

- At the end of each week the change in the standby fund, that is the final fund value (Fv_{i+1}) – the initial fund value (Fv_i) indicates the cost (or gain) incurred.

- The total cost incurred over the hedge period is:

$$Cost_{sb} = \sum_{i=1} (Fv_{i+1} - Fv_i) x\ NPV_{i+1},$$

where 1 = time at beginning of hedge period, and NPV_{i+1} is the net present value factor which brings the values of all the weekly fund changes back to the time value of money at the beginning of the hedge period.

- The total cost of hedging per contract will be:

$$(Pf_{i+1} – Pf_i) * B_c * Nc_i \ ,$$

where *i* denotes the i'th contract in the hedge period and all other variables are as previously defined.

- The total hedge cost for the entire hedge period will be :

$$Cost_{h\,g} = \sum_{i=1} [(Pf_{i+1} – Pf_i) * B_c * Nc_i] \times NPV_{i+1},$$

where $Cost_{hg}$ is the total hedge cost and all other variables are as previously defined.

- If $Cost_{hg} < Cost_{sb}$ for all the hegde periods then proposition 5 is accepted as correct, otherwise the proposal is rejected.

4.6 Limitations and Key Assumptions

Ideally all polymers used in the South African packaging industry should have been included in the study. However, in this research, the following practical limitations applied:

- The available data for some of the polymers did not span a period long enough to justify a reasonable sample size
- It was not possible to obtain data for the same polymer in the four different regions
- Polymers could be obtained in a number of regions outside South Africa. However, due to limitations of time and cost, data was sourced from only three international regions which included: North West Europe (NW E), South East (SE) Asia and the US Gulf.

The following key assumptions were made:

- The transaction costs of the futures contracts are negligible, and therefore excluded;
- The delivery time of polymers from each of the three regions to the South African manufacturer is one week. This assumption eliminated the complications introduced by shipping distances , while allowing the study to be based on weekly data. Weekly data, as opposed to averaged monthly or 3-monthly data, are a more realistic representation of the polymer price fluctuations.
- The quantity of polymer or purchase price was fully hedged. In reality, only the price commitments of major customers need to be hedged. Smaller customers do not insist on fixed-price contracts, and they generally buy at market prices – that is a partial and less expensive hedge is possible in practice;

- The quantity of polymer required for weekly production is a fixed amount throughout the hedge period (A fixed amount of 5000 tons was assumed);
- There is certainty about the full six month's required production – otherwise over-hedging could occur;
- The contracts are closed out on the same day of the contract expiration or delivery of the polymer, depending on which of the two comes first. In practice an earlier date would be chosen;
- Expiration dates and delivery dates shall be assumed to correspond with the dates of the data on the polymer prices. In reality the dates will not necessarily correspond. In this event separate data will have to be obtained from the sources for these dates;
- The risk of the Rand/Dollar exchange rate volatility will not be considered in this study. All local prices are in US Dollars.
- A 5% adjustment in the margin account that has to be maintained for the hedge is the maximum that would be acceptable to manufacturers. Anything above this standard could result in unacceptable margin calls.

4.7 **Presentation of Results**

In order to address the propositions made in chapter 3 the results have been presented in the following format:

Correlation Analysis

- *Sample Size Validity:* Are the results of the analyses, based on the sample sizes of data tested, generally applicable to the population of these polymers?
- *Correlations of Polymers to Oil Brent Futures:* Are the results of the correlations high enough to make a cross-hedge feasible?
- *Correlations of South African polymer prices to Global Prices:* As the South African economy integrates with the global economy, are South African prices following international trends?

Hedge Analysis

- *Effectiveness of the Cross Hedge:* Polymer prices, as most commodity prices behave, are volatile in nature. Does cross-hedging reduce the level of volatility?
- *Margin Account Cash Flow Risk:* The margin account fluctuates in accordance with the futures contracts fluctuations. As the balance of the funds held in the margin account dips below the maintenance margin, the investor receives a margin call to top up the account. How unstable and excessive are these cash flows? Do they present a risk to the hedger? Does the cross-hedge expose the manufacturer to a new risk?

Unhedged Option

- *Standby Fund Anternative:* Is it better to remain unhedged? Is it more cost-effective to provide for a standby fund that can absorb the commodity price risks, instead of cross-hedging?

5. RESULTS

5.1 Correlations

5.1.1 Hypothesis Testing for the Correlations of Global Polymers with Brent Futures

Table 1 below show summarised results of the hypotheisis tests for the correlations of global polymers with brent futures ranging from 1-month to 6-month contracts.

TABLE 1 **HYPOTHESIS t_{cl} Values for all Polymers v/s Brent Futures**

Polymer	**Region**	**Type**	**1 month futures**	**2 month futures**	**3 month futures**	**4 month futures**	**5 month futures**	**6 month futures**
HDPE	NWE	Blow	13.04	12.42	11.86	10.69	9.27	10.30
	Asia	Film	12.96	12.01	11.24	10.69	10.07	9.76
	US	Injection	10.77	10.16	9.61	8.66	7.61	8.02
LDPE	NWE	Injection	13.24	12.58	11.99	10.78	9.37	10.36
PP	NWE	Copolym	14.46	13.80	13.29	12.37	10.84	11.84
	Asia	Copolym	15.71	14.64	13.87	13.38	12.88	12.75
	US	Copolym	17.08	16.59	16.23	16.11	15.69	15.79

For all the global polymers, the test statistic values were found to lie well outside the acceptance range for the Null Hypothesis (that is outside the range –1.98 to +1.98). Under each global polymer, these findings were true for all polymer grades and in all the regions. The statistic values ranged from a minimum of 7.61 (for HDPE, US Gulf, Injection moulding grade) to a maximum of 17.08 (for PP, US Gulf, Copolymer grade). Hence the correlation results for the samples of the global polymers with IPE brent futures contracts could be assumed to represent the population of polymers that were tested. The calculations of the hypothesis t-test values for the individual polymers by type, region and period are shown in appendix 3.

5.1.2 Correlation of Global Polymer prices with Brent Futures Prices:

The results of the correlation analysis showed that the correlation of global polymers with brent futures varied from period to period and region to region. Tables 2 and 3 below showed clearly how inconsistent the correlation levels were as the variables of time and region were taken into account.

From table 2 it could be distinctly seen that correlations were very poor for the earlier period of 1980 to 1995. Correlations for all polymer types during this period ranged from 0.25 to 0.63. For the later period of 1995 to 1999, correlations improved to a range of 0.45 to 0.87.

<u>TABLE 2</u> **Summarised Correlations by Period**

Polymer Type	Region	Period 1980 - 1999	Period 1995 – 1999
HDPE	NW E	0.37 – 0.55	0.45 – 0.66
	US Gulf	0.27 – 0.43	0.69 – 0.87
	SE Asia	0.47 – 0.63	0.78 – 0.85
LDPE	NW E	0.38 – 0.50	0.58 – 0.66
	US Gulf	-	-
	SE Asia	-	-
PP	NW E	0.33 – 0.54	0.74 – 0.81
	US Gulf	0.25 – 0.39	0.64 – 0.77
	SE Asia	0.39 – 0.52	0.63 – 0.74

From table 3 no region showed distinctly higher correlation levels between polymers and brent futures contracts. The US Gulf had the least correlation result for PP at 0.25 and the highest correlation result at 0.87 for HDPE. Similarly the NW E and SE Asia regions showed ranges of 0.33 to 0.81 and 0.39 to 0.85 respectively. However, for each polymer type in a given time period, the results showed that correlations varied from region to region. For example, during the 1995 to 1999 period, HDPE was least in North West Europe at 0.45 to 0.66 correaltion levels and highest in the US Gulf at 0.69 to 0.85.

Hence, in general it could not be stated conclusively that global polymers were highly or poorly correlated with brent futures.

<u>TABLE 3</u> **Summarised Correlation Results by Region**

Polymer Type	Period	NW E	SE Asia	US Gulf
HDPE	1980-1999	0.37 – 0.55	0.47 – 0.63	0.27 – 0.43
	1995-1999	0.45 – 0.66	0.78 – 0.85	0.69 – 0.87
LDPE	1980-1999	0.38 – 0.50	-	-
	1995-1999	0.58 – 0.66	-	-
PP	1980-19999	0.33 – 0.54	0.39 – 0.52	0.25 – 0.39
	1995-1999	0.74 – 0.81	0.63 – 0.74	0.64 – 0.77

Figures 1 to 3 for 1990 to 1999 and also figures 4 to 6 for 1995 to 1999 below showed the correlations of global polymers with brent futures contracts in greater detail.

5.1.3 Shifted Correlations (Lead-Lag)

The weekly polymer prices were shifted relative to the brent futures contracts and correlated so as to determine the extent to which global polymers lagged oil in time response. It was found that PP and HDPE price movements responded immediately to any brent futures price movement. LDPE , on the other hand, was found to take some time to respond to any movement.

Table 4 below showed HDPE to have the highest correlation when there is no shift with reference to brent futures. This suggested an instantaneous response to the oil price movement. PP showed a 0 to 3 weeks response time. LDPE had the best correlation when the polymer data was delayed or shifted back by 6 to 8 weeks.

For hedging purposes, this suggested that PP and HDPE are reliably correlated because of their quick response to oil price movement. The correlation results of LDPE were found to be unreliable. For good correlations and reliable hedging between polymers and brent futures, the movements between the two prices have to be almost simultaneous.

Figures 7 to 9 showed the maximum shifts required in weeks to get the ideal correlation between each global polymer and the brent futures.

The hypothesis tests for correlation for all the shifted correlations were found to be well outside the null hypothesis rejection area of –1.98 to 1.98. Thus the findings above regarding samples of the shifted correlations could be assumed to hold for the polymer and brent futures populations. Table 5 showed that the test static value for the hypothesis testing ranged from a minimum of 14.01 for PP to a maximum 23.93 for HDPE, across the different number of week shifts.

5.1.4 Correlations of South African Polymers with Brent Futures Prices

The South African polymer prices were found to be poorly correlated with the global oil price index. Figure 10 showed the correlations to range from a minimum of 0.53 for PP to a maximum of 0.58 for HDPE. These correlations were far below the threshold of 0.8 to justify the consideration of South African polymers for cross-hedging.

These results could be assumed to apply for the full population of South African polymers because the hypothesis test for the correlation of the polymers with the oil index were outside the null hypothesis range of –1.98 to 1.98. Table 6 below showed hypothesis static values ranging from 3.71 for PP to 4.31 for HDPE.

5.1.5 Correlations of South African Polymers with Global Polymer Prices

The correlation of South African polymers with global polymers were found to range from poor to moderately high. Figure 11 showed a minimum of 0.34 for PP SA with HDPE Blow Moulding grade US Gulf, to a maximum of 0.70 for LDPE SA with PP Copolymer grade North West Europe.

The South African polymers had the highest correlation with the NW E polymers, showing a range of 0.60 to 0.70. Se Asia and the US Gulf respectively rated second and third at 0.60 0.64 and 0.34 to 0.43.

Comparing results of section 5.1.5 and 5.1.4, it could be concluded that the South African polymers followed the trends of North West European polymer pricing more closely than they did the global oil price trend.

The results of the correlations for these samples applied to all the populations of the polymers because the hypotheiss test reslts for the correlations lay outside the null hypothesis rejection range of –1.98 to 1.98. Table 7 below had the hypothesis test statistic values ranging from 2.19 for PP to a maximum of 5.47 for PP.

5.2 **Hedging Simulation**

The basis for cross-hedging polymers with oil or brent futures contracts was that the correlations between the two should be very high (that is greater than 0.80 according to this study). Table 8 below summarised the correlation results.

TABLE 8 Oil/Brent Futures Correlations with Different Polymers

Polymer	1990 – 1999	1995 - 1999	Highest Correl. Polymer
HDPE Global	0.27 – 0.63 figure 1	0.35 – 0.87 figure 4	HDPE, Injection, US Gulf
LDPE Global	0.38 – 0.50 figure 2	0.58 – 0.66 figure 5	LDPE, NW E
PP Global	0.25 – 0.54 figure 3	0.63 – 0.81 figure 6	PP Copolymer, NW E
HDPE, LDPE & PP Bloomberg Data	_	0.77 - 0.84 No Shift, Figures 7, 8, 9	HDPE
HDPE, LDPE & PP South Africa	0.53 – 0.58 figure 10		HDPE

HDPE Injection grade, US Gulf polymer was selected for the cross-hedge because it had the highest correlation with brent futures contracts. It had a correlation of 0.87. Several other polymers showed correlations above 0.80 as well.

Three aspects of the hedge effectiveness were looked at regarding this polymer. These included :

- Stabilisation of the polymer price volatility by cross-hedging
- Margin Account (Hedge) Cash Flow Stability, and
- Standby Fund (Unhedged Position) v/s Hedged Options

5.2.1 Stabilisation of the Polymer Price Volatility

At a correlation level of 0.87, the effective hedged price of HDPE Injection US Gulf was found to be more unstable than the unhedged price. By cross-hedging the spot price of HDPE Injection grade US Gulf, the overall price paid by the manufacturer for the input cost became more volatile or difficult to predict than if the manufacturer had remained exposed to the spot price only. This was showed in figures 12 and 13 showed in the following two ways:

Qualitative Assessment: Figure 12 showed that the amplitude of the effective hedged price was generally higher than that of the unhedged price throughout the different hedging 6-month periods of 1995 to 1999. The 1995 to 1996 period showed that this instability or risk could be extremely exaggerated relative to the unhedged position.

Quantitaive Assessment: Figure 13 showed that the standard deviations of the effective hedged price could be magnified several times more than the standard deviation of the unhedged price. The worst instability was experienced in the 1995 to 1996 period. The standard deviation of the effective hedged price was three times higher than that of the unhedged price from 21 July 95 to 18 January 1996. In the hedge period of 19 January 1996 to 17 July 1997 it increased to 9.8 times higher than the unhedged price. In the periods that followed, the standard deviations were still higher than those of the unhedged price.

Hence, the manufacturer, when hedged, had a higher risk on input raw material costs. This meant that the input raw material costs could drop or rise by a significantly higher margin when hedged. This was found to produce the opposite of what is desired. The manufacturer desired to create more certainty on input costs by reducing the instability of polymer raw material prices.

5.2.2 Margin Account Cash Flows

By hedging polymers with brent futures contracts, the manufacturer had to maintain a margin account in the futures exchange. It was found that the maintenance of such an account created a second risk exposure for the manufacturer. The fluctuations of the margin account as a percent of the spot HDPE Inj US Gulf were found to reach extremely high levels ranging from –2861 to 1350 % during unstable periods. Margin account fluctuations of this nature exposed the manufacturer to excessive margin calls. Figure 14 showed that the margin account fluctuation generally exceeded the 5% cut-off range above or below the spot price throughout the period of 1995 to 1999.

5.2.3 Cash Flow Comparison of Standby Fund v/s Hedged Options

For the period that was considered, that is 1995 to 1999, the costs of maintaining the hedge were generally higher than those of remaining unhedged. However, it could not be proven that this would be the case in general, that is for all periods after 1999.

Figure 15 showed that huge losses were experienced on the hedged option during 1995 to 1996. This was during the hedge periods indicated as 2 and 3. The hedged option costed a maximum of US \$ 98,430,891 above the agreed fixed price in period 2, compared to a maximum of US \$ 11,707,004 for the standby option in the same period.

During period 1 and beyond period 6, on the other hand, the maximum savings on the hedged option exceeded those of the unhedged option. This was largely so because of the change in the correlations of the polymer with brent futures in these periods.

From the attached excel file, "Standby Fund vs Hedged Fund" and worksheets "Standby Fund Calculations" and "Hedged Fund Calculations", it could be seen that the last period (that is, period 7) had the polymer prices less volatile than the brent futures. Such a reversal in relationship changed the direction of correlations which resulted in an opposite effect to the general trend observed throughout 1995 to 1999.

Hence, while the hedged option was found to be more volatile and likely to produce huge maitenance costs, periods 1 and 7 indicated that huge savings could be achieved as well. There was no guarantee of cost-effective benefits on the standby fund. Depending on the nature of the correlations in each period, either one or the other option could be cost-effective.

6. INTERPRETATION OF RESULTS

6.1 Proposition 1

The results of the correlations of the global polymers with brent futures contracts showed that for each polymer, the correlations varied from period to period and region to region. This variation could range from very poor values to very high correlations. Hence proposition 1, which asserted that global polymers were highly correlated with the IPE brent futures contracts, was proven not to hold in general. This position was found to present serious difficulty for manufacturers wishing to hedge. They would need to have a high level of forecasting ability as to which region at any given time could present possibilities of reducing input cost risk for the type of polymer required. South African polymers were found to be generally very poorly correlated with oil. It may have been so because of the late entry of South Africa into the global polymer market and also because of the fact that local polymers were manufactured mainly from coal and not oil. Hence South African manufacurers can consider hedging only when they import polymer.

6.2 Proposition 2

The South African polymer correlartions with global polymers where found to be very low except for the region of North West Europe, where the level of correlation was moderately high (that is, 0.60 to 0.64). These correlations, although not very high, were found to be better than the SA polymer correlations with oil. Hence South African manufacturers, by buying local polymers, were increasingly getting exposed to input cost instabilities that followed global polymer trends, while not having the opportunity of cross-hedging with brent futures contracts.

6.3 **Proposition 3**

This study had set a threshold correlation value of $r = 0.80$ to identify polymers that could be cross-hedged with brent futures contracts. Although several polymers exceeded this requirement, the polymer with the highest correlation of $r = 0.87$ failed to produce satisfactory results. This finding indicated that for a cross-hedge to work, significantly higher levels of correlation need to be achieved. This implied that at an r value of 0.87, or an r^2 value of 0.76, which is the main criterion for doing the cross-hedge, an effective hedge could not be achieved. Hence a different hedge instrument to brent futures was seen as an alternative to the management of polymer price risk.

6.3 **Proposition 4**

It was further found that the manufacturer would be exposed to an additional risk from the margin account fluctuations. Manufacturers, ideally, want to deal with internal variables that are under their direct control and influence. External risk exposure should be eliminated and not added to the business. Hence proposition 4 is not satisfied by the cross-hedging of polymers with brent futures contracts.

6.4 **Proposition 5**

It was concluded that there are no guarantees that an unhedged option would always be more cost effective for the manufacturer. Results showed that in one period the standby option costs were lower compared to cross-hedging. In other periods, however, better savings were achieved in the cross-hedge option. There was no definite evidence that the trend will always be that the standby option costs be less than the cross-hedge option costs. The implication of this to the manufacturer was that a better hedging instrument would be required.

For the time that the manufacturer remained unhedged, the risk exposure would continue. Therefore, the manufacturer or converter of polymer still needed a solution to the management of the input cost fluctuation.

7. **CONCLUSION**

7.1 Findings of the Study

The study showed that polymer price risk experienced by manufacturers as an input cost to their businesses could not be reduced by cross-hedging with the IPE brent futures contracts. Although correlations of *r* greater than the threshold of 0.8 were achieved, these were not high enough to get an effective hedge.

The study highlighted the dilemma polymer-based manufacturers experience if there are no suitable hedging instruments available. To remain unhedged exposed the manufacturer to risk. To cross-hedge worsened the current risk and introduced an additional risk arising from the maintenance of the futures exchange margin account.

This study showed that a risk management programme of this kind would have been better and reliable if a direct hedge as opposed to a cross-hedge could be found. Polymers, as well as other commodities, need to have a hedging instrument whose underlying is the same as the commodity itself. For a cross-hedge to be considered, very high correlations would have to be considered.

7.2 Recommendations for Future Research

This report considered a hedge based on futures contracts from formal futures exchanges only like the IPE. Hence, only a cross-hedge was available for the polymer industry as there existed no directly related futures contract based on polymers. The hedge effectiveness, which happened to be poor because of cross-hedging, may as a result convince manufacturers that hedging is risky. An alternative approach could be to consider the South African polymer index and simulate a hedge for the South African polymers. The South African plastic index should by definition have very high correlations with the individual South African polymers. The justification for investigating this possibility is that the major polymer suppliers in South Africa can create Over-The-Counter (OTC) contracts with individual manufacturers (polymer converters). The major polymer suppliers can then transfer this risk, which they have effectively absorbed from manufacturers, through to banks. It is the specialty of banks to trade with such risks. Manufacturers, who do not want risk exposure, will pay a premium for this, but it will create stability and predictability for them on input prices coming from major suppliers. The model of Koch Chemicals in the USA, mentioned under section 2.8 of this report, can be an example to study. Figures APP 6(a) and APP 6(b) show the close correlation between the South African plastic index and two of the local polymers.

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APPENDICES LIST

APP 1: Example of World Polymer Price Trends since 1989 to 1999

APP 2: Annual Polymer Consumption in South Africa

APP 3: Example of other Hypothesis Test results for other polymers

APP 4: Description of Excel Calculations for: Hypothesis Testing; Correlations; Hedge Effectiveness; Margin Account cash Flows and Standby Fund Analysis

APP 5: Demonstration of the Correctness of the Model

APP 6: South African Plastics Index and Examples of South Individual Polymer Indices

APP 7: List Excel and Word Files

<u>APP1</u> Example of World Polymer Price Trends since 1989 to 1999

Figures APP 1(a) and APP 1(b) overleaf show the polymer prices of global polymers and the IPE brent futures prices. The data of figure APP 1(a) shows data of HDPE, LDPE an PP from the Bloomberg Data, 1995 to 1999.
Figure APP 1(b) covers data for HDPE NW E from 1989 to 1999.

<u>APP2</u> Annual Polymer Consumption in South Africa

This graph demonstrates the relative consumption levels of polymer in South Africa.

APP3 Examples of Hypothesis Tests for Polymers

All polymers and brent futures studied in this report were checked for sample size validity, to ensure that the sample results could be generalised to the parent populations. Some of the polymer sample Null Hypothesis testing calculations are shown in the tables attached overleaf. The other calculations can be seen in the attached relevant excel files.

<u>APP4</u> Description of Excel Calculations for: Hypothesis Testing; Correlations; Hedge Effectiveness; Margin Account Cash Flows and Standby Fund Analysis

All calculations of hypothesis testing for correlations, correlation between each polymer and the brent futures contracts, the hedge effectiveness, margin cash flows and the standby fund analysis were calculated in Excel. The spreadsheets for these were saved in the attached compact disk.

The calculations were done as follows:

APP.4.1 *<u>Hypothesis Testing and Correlations of Global Polymers</u>*

The correlations and hypothesis testing calculations were done in two categories of data, viz: data ranging from 1989 to 1999 and data ranging from 1995 to 1999. The standard correlation calculation of Excel, which were verified with the standard formula from Hanke and Reitsch (1994), were used to calculate the the polymer correlations. The Hypothesis Test calculations were done through manual formula entries in the spreadsheets. Each category included the following:

Categorisation of Global Polymer Correlations & Hypothesis Testing

Sub-Category	Category 1 (1989 – 1999)	Category 2 (1995 – 1999)
HDPE	• All HDPE calculations are saved in one file • Calculations for each grade of HDPE per region are on a separate worksheet • Each of these worksheets includes a correlation calculation per futures contract as well as hypothesis test result • A collective graph showing all the correlation results on a separate worksheet • A collective Table showing the same correlation results • Raw brent Futures Contract data on a separate worksheet	Same data as HDPE of 1989 to 1999.
LDPE	Same data as above for LDPE	LDPE has same data as HDPE of 1989 to 1999.
PP	Same data for PP as in HDPE above	PP has same data as HDPE of 1989 to 1999.

Hence there are 6 Excel files on Global Polymer Correlations and Hypothesis Testing.

APP4.2 *Shifted Correlations*

There were only three sets of Bloomberg data ranging from 1995 to 1999. These included HDPE, LDPE and PP. The shifted correlations were calculated in the same way as the above correlations.

The basic difference was that the polymer data in each polymer case was shifted by a week each time relative to the brent futures data and a correlation calculated. So for HDPE data was shifted by 1 week, 2 weeks, etc. and a correlation calculated every time. The calculations for the three polymers are done in one attached Excel file titled the “Shifted Polymer Correlations. The file structure is as follows:

- a worksheet of the raw brent futures and polymer data from 1995 to 1999;
- a single worksheet of calculated correlations per week-shift for all the polymers;
- three worksheets – each for HDPE, LDPE and PP, showing the a plotted graph of correlations shifted per week; and
- additional worksheets t-tests for the polymer correlations.

There was only one Excel file for the shifted correlations.

APP4.3 *Correlations of SA Polymers with Oil Price*

This Excel file calculated the correlations of South African polymer prices with the Oil Price Indices. The file structure was as follows:

- a worksheet on South African polymer prices (Rand-based) as well as the oil price index US$-based. These were 3-monthgly figures ranging from 1990 to 1999;

- a rand-dollar exchange rate on a separate worksheet;
- a worksheet on SA polymer indices converted to US$-basis and Oil price indices which are US$-based;
- A worksheet on calculated correlation results of SA polymer (US$) and Oil price indices;
- a worksheet of correlation results;
- a chart on a worksheet for SA polymers (rand-based), US$-Rand exchange rate and oil price indices; and
- a chart of SA polymers (US $ - based) with Oil price indices on a worksheet.

APP4.4 *Correlations of SA Polymer with Global Polymers*

This Excel file calculated the correlations of South African polymers with Global polymers. The file structure was as follows:

- a worksheet on South African polymer price indices, which are Rand based, as well the rand/dollar exchange rate. These were 3-monthly figures on HDPE, LDPE and PP. The data ranges from 1990 to 1999. A conversion of the SA polymer index from Rand to Dollar base is simultaneously done;
- a worksheet on Global polymer prices in US Dollars. These are weekly figures for all the HDPE for HDPE, LDPE and PP in the three different regions of SEE Asia, NW E and the US Gulf. The data ranges from 1989 to 1999;

- a worksheet that combines these two sets of data such that matching by data or time, based on 3-monthly data is achieved;
- a worksheet that extracts only the sets of data that match in time between SA and Gobal data;
- correlations are calculated and results shown on a separate worksheet; and
- final worksheet shows a graph of the SA polymer correlations with different polymers per global regions.

APP4.5 *Hedge Effectiveness*

A separate file was created for the hedge effectiveness calculation.It consisted of:

a) a worksheet on the raw brent futures data;

b) a worksheet on the raw polymer price per ton;

c) data analysis worksheet. This was the most important worksheet from which the hedge was calculated:

  c.1) the brent futures and polymer prices were matched by date

  c.2) the data was separated horizontally into 6-monthly (26 weekly) hedge periods;

  c.3) the data was also separated into columns where the following were calculated:

    c.3.1) delta's of the futures prices

    c.3.2 delta's of the spot prices

c.3.3 correlations of the delta’s of futures and spot prices. Each correlation value is calculated from previous 26 weeks of delta’s

c.3.4 standard deviations of the delta’s of the spot prices

c.3.5 standard deviations of the delta’s of the futures prices

c.3.6 calculation of the minimum variance ratio (h*) based on c.3.3 to c.3.5

c.3.7 calculation of the ideal number of futures contracts (N_{fc}) to be purchased

c.3.8 the total spot price = spot price/ton * 5000ton/week

c.3.9 the final results columns (5 Columns). These included:

- the calculated effective hedge price per week;
- the total spot price per week; and
- the fixed price Aareement per hedge period. It was assumed that the opening spot price would be the agreed price for raw material with the manufacturer’s customer. In other words, the hedge must guarantee that any raw material price fluctuation relative to the opening price will be effectively cancelled by the hedge.

Note: All the figures were calculated after the first 26 weeks. This was so because the correlations of the delta’s could only be calculated from the previous 26 weeks of data.

d) the effective hedge price graph and the Spot price graph were plotted on the same worksheet. This allowed a visual or qualitative comparison of the effective hedge and spot prices; and

e) the volatility comparison (quantitative comparison) was further done by means of calculating the standard deviations of the effective hedge and spot prices per hedge period. This was done on a separate worksheet. The standard deviations were plotted separately on a worksheet.

f) <u>Margin Account Cash Flow</u>

The margin account cash flow was determined by calculating the week to week brent futures prices changes. This cash flow was compared to the polymer spot price at the week of concern. This was actually a paper cash flow, which implied that the manufacturer did not see the cash flows, except that adjustments were made in the margin account on a weekly basis. However, as shortfalls would occur, the manufacturer would be called to top up the account. Two charts were plotted: one for the actual price fluctuation from the previous to the current week against the polymer spot price of the week and the other for the brent futures prices as a percentage of the polymer spot price.

APP5 Demonstration of the Correctness of the Model

The purpose of the research was to establish whether world polymer prices could be hedged with brent futures contracts. For results arising from this study to be reliable, it was important to ensure that the constructed model simulated the hedge correctly and accurately. The model was constructed on the basic principles of hedging taken from Hull (1997) – see section 4.5.2.

In order to test the validity of this model it was decided to use it in a hedge scenario where the hedge results could be theoretically predicted. Any deviation from these predictable results was to be interpreted as proof of the invalidity of the model.

The model was tested by hedging oil spot prices with oil brent futures prices. It was artificially assumed that the brent futures prices were exactly equal to the oil spot prices per barrel. In practice there is always a small or insignificant difference between the two – in fact correlations between the two usually yield values in the region of 97 to 99%. This scenario was chosen because:

- there was no difference between the commodity (oil) and the underlying of the hedge instrument, which is oil, and
- the prices movements of the two matched exactly. In theory this constituted a basis for a perfect hedge. If prices were not assumed to be exactly the same, then the slight mismatch on the weekly prices of the two would have made it

difficult to predict the hedge results exactly. Hence it would not have been easy to verify the validity of the model.

From the theory of hedging (Hull, 1997), a perfect hedge would transform the unstable volatile spot price of the commodity (oil in this case) to a stable, flat or constant effective hedge price throughout the hedge period. This effective hedge price would be equal to the opening spot price at the beginning of the hedge period. Therefore, if a hedge was created at the beginning of the hedge period, any rise or drop in the spot price of the oil price was cancelled perfectly by a respective drop or rise in the futures contracts. The equation remains:

$$P_{eff} = (Q_p*P_{p2}) - [(P_{fb2} - P_{fb1}) * N_{fc} * B_c] = (Q_p*P_{p1})$$

where all variables are as previously defined.

The model was run with oil spot prices and brent futures prices ranging from 1989 to 1999. The hedge periods were set at 6 months as in the case of the polymer hedge tests. In each six month period the effective hedge price was found to be constant throughout and equal to the opening spot price. Figures APP5(a) and APP5(b) demonstrated the compliance of the model result to the expected theoretical hedge price.

Hence the model was accepted as correct and valid for testing the suitability of cross-hedging world polymer prices with brent futures contracts.

APP6 South African Plastics Index and Examples of South African Individual Polymer Indices

The first and second graphs under appendix APP6 show the Plastics Price Index of South, which is an index of all spot polymer prices in South Africa, and the price indices of HDPE (High Density Polyethylene) and PS (Polystyrene). The first graph is for HDPE and the second for PS. The third and fourth graphs show the South African polymer price indices against the oil index and the rand-dollar exchange rate.

A closer look at the first two graphs show that the price movement of each polymer is very similar to the movement of the general plastics index. This provides a possibility for creating a locally based hedge linked to the SA Plastics Index. If all the peaks and valleys of the individual polymers correspond to the peaks and valleys of the combined index, then the correlations will be very, by definition, high between the two, thus laying the basis for cross-hedging.

The third and fourth graphs show the impact of the rand-dollar exchange rate on the relationship of SA polymers to global oil prices.

<u>APP7</u> List of Excel and Word Files

App7.1 *Excel Files*

a) <u>*Correlations*</u>

- HDPE Correlations : 1980's to 1999

  The file contains all high HDPE types (film, injection and blow moulding) for the 3 global regions and brent futures contracts for 1-month, 2-month, 3-month, 4-month, 5-month and 6-month. The results include hypothesis testing of the validity of results and correlation results.

- HDPE Correlations : 1995 to 1999

  Same contents as above

- LDPE Correlations : 1980's to 1999

  Same contents as above

- LDPE Correlations : 1995 to 1999

  Same contents as above

- PP Correlations : 1980's to 1999

  Same contents as above

- PP Correlations : 1995 to 1999

  Same contents as above

- SA Polymer Correlations

  Has South African correlation results based on South African polymer indices, Oil price index based on US dollar and US$/Rand Exchange Rate.

- SA Polymer Correlations with Global Polymers
- Shifted Correlations. It has all three polymer prices (HDPE,LDPE and PP) brent futures based on Bloomberg data. Data is shifted relative to oil correlations determined.

b) *Hedge Effectiveness*

One file on the hedging of HDPE Injection grade, US Gulf:

Several results are looked into, including: the hedge effectiveness (qualitative evaluation from graphs), standard deviations (quantitative evaluation of the effectiveness from graphs) and margin account margin analysis.

- Oil Hedge

  This file was created just to test whether the hedge model used for the polymer above worked correctly.

c) *Standby Fund Analysis*

This includes one file for HDPE Injection grade, US Gulf.

App7.2 ***Word File***

This includes the main research report