TESTING THE EFFICIENCY OF THE SOUTH AFRICAN FUTURES MARKET FOR WHITE AND YELLOW MAIZE

By

JONATHAN ANGUS WISEMAN

Submitted in partial fulfilment of the requirements for the degree of

MASTER IN AGRICULTURAL MANAGEMENT

School of Agricultural Sciences and Agribusiness

University of Natal

Pietermaritzburg

1999

I CERTIFY THAT THE WORK REPORTED IN THIS THESIS IS MY ORIGINAL AND UNAIDED WORK EXCEPT WHERE SPECIFIC ACKNOWLEDGEMENT IS MADE

J. A. WISEMAN

ABSTRACT

An efficient futures market should provide a forecast of the future spot price which reflects all publicly available information; ideally, for effective price discovery such forecasts would also be unbiased. The trading of maize futures contracts began in South Africa (SA) in mid-1996 after the power of the Maize Board to set maize producer prices was abolished. Cointegration analysis of the efficiency of SA white and yellow maize futures markets shows that (1) the futures price for white maize was a biased predictor of the spot (cash) price for white maize in 1997, but an unbiased predictor in 1998 (evidence of a market learning process), and (2) the futures price for yellow maize was an unbiased predictor of the spot (cash) price for yellow maize in 1997 and 1998. White maize is predominantly used for human consumption and SA is considered a leader in the world market for white maize. Yellow maize is mostly used for animal consumption and is traded internationally on the Chicago Board of Trade in the United States of America. This makes the domestic futures price for yellow maize more susceptible to international maize marketing conditions than the domestic futures price for white maize. The relatively greater volume of trade in yellow maize would provide more reliable information about crop and market prospects to futures traders.

Local producers of white and yellow maize can, therefore, use price information derived from recently introduced white and yellow maize futures contracts to forecast likely local white and yellow maize cash prices. This information can help them to decide whether, and what portion of their crops, to hedge against price risk using futures trading, and what cash prices to negotiate with millers and traders. Both markets, however, suffer from past spot price information having a significant effect on current spot prices. This violation of efficiency implies that futures market participants can use this information to make abnormal profits. There is a

lack of spot price information in the maize industry, as there is no readily available price recording system that participants can use. The development of such a system would aid users in price discovery and allow for better decision making by participants.

ACKNOWLEDGEMENTS

I would like to thank all those who assisted in this study, especially:

G. F. Ortmann, Professor of Agricultural Economics, University of Natal, for his supervision throughout the study.

Mr M.A.G. Darroch, Senior lecturer in Agricultural Economics, University of Natal, for his guidance and supervision.

I am also particularly indebted to Chris Sturgess at SAFEX whose helpfulness and patience was greatly appreciated.

The financial assistance of the Centre for Science and Development (HSRC South Africa) towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at, are those of the author and are not necessarily to be attributed to the Centre for Science Devlopment.

Lastly, to my family for their support and encouragement.

CONTENTS

LIST OF FIGURES

FIGURE

LIST OF TABLES

INTRODUCTION

Maize is consistently planted on more than 40 percent of South Africa's arable land annually (Directorate: Statistics and Management Information, 1997). It was the second largest contributor (R 4.7 billion), after poultry, to the gross value of agricultural production in South Africa in 1997 (R38.2 billion).

The marketing of maize in South Africa was highly regulated from the early 1930's until the mid 1990's, with maize being marketed through a single-channel system administered by the Maize Board, which also set producer prices. Pressure for agricultural commodity market liberalisation mounted in the 1980's and culminated in the abolition of most agricultural control boards - including the Maize Board - by the Marketing of Agricultural Products Act of 1996 (Mielies/Maize, 1997). Minimal tariff protection against imports, commencing below a specified equivalent US$ price, is the only remaining government price support for South African maize producers. The deregulation of maize marketing has placed the responsibility for the marketing of this important agricultural commodity in the hands of individual producers.

Maize producers face considerable price risk because seasonal production, which is heavily reliant on annual rainfall, can lead to large shifts in the supply of maize which, coupled with the price inelastic nature of the demand for maize, leads to substantial changes in the price of maize. With the inception of commodity futures contract trading on the South African Futures Exchange (SAFEX) in 1996, local maize farmers now have access to a useful tool for managing price risk. The issue of market efficiency in commodity futures trading is important from both a public and a private perspective. An efficient futures market should provide a forecast of the future spot (cash) price of a commodity which reflects all publicly available information. This serves as a medium through which traders can manage risk by fixing price in advance of transactions relating to the physical commodity. From a public policy perspective, this attribute would suggest that futures markets are potentially a useful alternative to more established forms of market intervention, particularly with respect to price stabilisation policies. This is especially relevant in South Africa, given that the Maize Board used to have the power to set maize prices. Futures trading is one of the more widely used mechanisms in the United States of America (USA) and United Kingdom (UK) for managing the effects of price instability resulting from the production, marketing and purchase of a commodity. The key feature of futures contracts in this context is their ability to predict prices at a specified future date both efficiently and in an unbiased fashion. Thus, an empirical analysis of efficiency and unbiasedness is central to any assessment of the value of futures markets.

It is generally believed that futures markets are primary price discovery centres for many commodities and financial instruments, and an effective tool for risk management. Thus, people engaged in these markets are often concerned with how the markets perform and how effective the markets can be relied on for risk management. In price forecasting, speculators are interested in what information can be used to increase market-timing ability, while hedgers would like to know if price forecasting can facilitate their hedging activity in reducing risk or increasing profits (Lu, 1994).

The demise of the producer-price setting role of the Maize Board in late 1996 has created a need for South African maize farmers to give more attention to individually managing price risk. Increasing concerns over less government expenditures for farm programmes, and movements toward trade liberalization, make it likely that the SA government's contribution towards the management of commodity price risk will continue to diminish in future years. An important component in understanding and managing market price risk for maize using futures trading is identifying the relationship between local cash and nationally traded commodity futures market prices. Understanding the extent to which cash prices are cointegrated with national futures prices - that is, whether or not they move apart through time - is critical in "localizing" futures price information (Fortenbery and Zapata, 1993).

The notion of market efficiency is of considerable importance to any investor who wishes to use these markets to hedge against price risk. An efficient market is one where asset prices fully reflect all known information (Bodie, 1995). The well-functioning futures market adjusts almost instantaneously to all new information and, therefore, profitable trading strategies cannot exist in an efficient market. Consequently, agents can engage in efficient markets at lower transaction costs than in markets which require extensive information search (Chowdhury, 1991). To date, there has been no study in South Africa of the efficiency of maize or other agricultural commodity futures markets, probably due to their only recently having been introduced on the South African Futures Exchange (SAFEX). The Agricultural Marketing Division of SAFEX was founded in January 1995 (SAFEX, 1998a), and futures contracts began trading mid-1996. Trading volumes per month for white maize have increased from 193 contracts in March 1996 to 6610 in July 1998, and for yellow maize from 292 contracts in March 1996 to 2785 contracts in July 1998 (SAFEX, 1998a). The aim of this thesis is to present cointegration based tests for efficiency in the SA futures market for white and yellow maize, and to compare the performance of these two futures contracts, for both 1997 and 1998. Following Aulton et al (1997) and Lu (1994), evidence of cointegration supports market efficiency, since it implies that futures prices can provide forecasts of cash prices - in other words, information is being transmitted between futures and spot prices, and price discovery is taking place. The results should indicate whether or not local maize futures contracts are a useful source of price information to local spot markets for maize. Study results extend past SA futures market research which has focused on the requirements for an efficient market (Frank, 1992) and also what products are most likely to be successfully traded (Van der Vyver and Van Zyl, 1988). The analysis is concentrated on the maize producer market in order to give producers and producer market participants more reliable information about cash / futures price relationships. Recommendations for improving these futures markets as sources of information needed by farmers following deregulation of maize marketing in South Africa can then be made.

This study is expected to improve the understanding of how cointegration analysis can be used to understand spot-futures price relationships and futures market performance. Chapter 1 briefly describes futures market mechanisms and functions, introduces SAFEX and local contracts offered, and then discusses the potential for other countries in Southern Africa to use SAFEX. Chapter 2 combines a review of theoretical and empirical literature pertinent to this study. Discussion of the cointegration technique and how it can be used to analyze the spot-futures relationship is included. A chronological listing of several empirical studies, detailing the theoretical background and methodology is given. Chapter 3 covers the data used, and the specified economic and econometric models, along with the statistical tests to be conducted. Chapter 4 and 5 respectively present the results of the analyses of the efficiency of SA white and yellow maize markets. Policy and management implications of the study are considered in the conclusion.

CHAPTER 1: BACKGROUND TO FUTURES MARKETS

According to Falkena et. al. (1991: 5), a futures contract is "an agreement to buy from, or sell to, a futures exchange, a standard quantity and quality of a specified asset (be it a commodity, a financial asset or a notional asset) on a specified date, at a price that is determined at the time of trading the contract. Thus, a futures contract is a financial instrument regardless of whether the underlying asset happens to be coffee, gold, an index or a financial asset."

As the aim of futures trading for hedgers is to stabilize price risk, there is no need for a futures contract if the commodity is not exposed to significant price variations. Any exogenous factor that reduces the need for hedging, such as government stockpiling, impairs futures markets by reducing the need for them. Van der Vyver (1994) states that the vast potential for futures markets lies with those commodities whose supply is erratic, and of which vast inventories must be carried because consumption is fairly stable, and which are only lightly processed prior to consumption. Agriculture's exposure to climatic conditions renders most agricultural enterprises susceptible to large fluctuations in product prices. A futures contract typically decreases transaction costs because of its highly standardized nature, publicly displayed information and the presence of many participants in the market. Appendix 1 presents an example of a futures contract.

Effective risk management has financial consequences. The futures market serves an economic purpose. According to Leuthold (1989) and Berg (1981), futures contracts are useful in production, financing, storage, pricing, distribution and consumption of goods and services. Their direct role is in facilitating risk transfer and forward pricing. These functions in turn play an important role in the allocation of resources by guiding production, inventories, and rational decision making. The market exists because of support from commercial firms and producers that need to manage risks and make decisions. Futures trading activity is closely tied to the commercial patterns of hedging. Firms do not need to participate in the market to benefit from the information which flows from it. Futures markets also facilitate the use or existence of other market coordinating mechanisms, such as cash forward contracts. They are often a cheap source of information and risk transfer. The continued existence of futures markets affects how commercial agents in cash markets organize themselves for decision making, price discovery, risk management, and the collection and interpretation of information.

1.1 Advantages of the Futures Market

Major benefits exist through futures trading. These include:

a) Shifting risks via hedging.

b) Forward prices generated by futures trading allow better coordination of expectations and plans for producers and marketing firms. The result is a better distribution and allocation of resources (Elliot, 1986). Other benefits include:

- Improved co-ordination and planning
- Stabilizing income
- Freeing working capital
- Reduction in procurement costs
- Ensuring contract obligations
- Expanding bank borrowing ability

- Providing flexibility in the timing of sales and purchases

- Promoting stockpiling of commodities in private hands in times of surplus, inducing economical storage of stocks and promoting their release for consumption at appropriate times (Elliot, 1986).

These advantages have a marked influence on the producer and there should be considerable spill-over effects bestowed on the consumer. The similarities between perfect competition and futures markets may be described as follows:

a) There are a large number of traders, widely dispersed, with many different occupations.

b) In the markets ownership is so widely diffused that no single position can have an appreciable influence on price behaviour.

c) Product homogeneity ensures that the specified quality and quantity of maize is delivered, thereby making traders indifferent as to the person he delivers to or from whom he accepts delivery. Impersonal transactions have typically have low trnsaction costs.

d) Freedom of entry and exit in the market are closely approximated due to low capital requirements of entry and the liquidity of the market for exits.

e) Trade must be in public and prices be disseminated world-wide.

f) Futures markets generate a substantial amount of information that would not otherwise exist (Elliot, 1986).

1.2 Price Stability

A futures market naturally has a role when product prices are unstable. It is the private sector's solution to avoid unacceptable high risk due mainly to price swings. The objective of a futures market is not to curb price swings but only to secure a price for a commodity in advance. South Africa opted for government intervention in maize marketing in the 1930's via the Maize Board which was responsible for price fixing. Government intervention and futures markets are two ways of addressing the same problem. An essential requirement of a futures contract is that the commodity is traded in a free market environment, where there should be multiple buyers and sellers who determine a new price continuously or as often as necessary. Van der Vyver (1994) states that a government should not influence the price determination process significantly by means of price fixing, one-channel regulations or similar drastic interventions in the market. Rather, if government is to play a role, it should be in the dissemination of information through pamphlets, publications, etc. so as to improve information flows and hence promote market efficiency. Government also has a role to play in contract enforcement. As yet no case has gone to court regarding futures contract enforcement, therefore no precedent has been set. This has largely been avoided due to the careful screening of market participants before allowing trade on the Exchange. Kofi (1973) states that the performance of futures markets should be studied before domestic stabilization schemes or International Commodity Agreements are proposed and/or constructed for any commodity. This would assist in determining whether intervention in the market is desirable or will enable the design of better stabilization schemes.

1.3 Price Discovery

Futures markets help allocate resources and stabilize prices and incomes by establishing forward contracts. According to Kofi (1973), in most developed countries proposals for stabilizing producer prices have ranged from price support programmes to efficient use of futures markets by farmers or official agencies trading futures contracts on behalf of farmers. However, most stabilizing schemes interfere with the proper functioning of futures markets. Yet, the introduction of futures contracts as an aid in price determination, in addition to cash markets, adds positive dimensions in competition by enlarging the sphere of price-making forces and providing insurance against risks by projecting market commitments months in advance of contract expiration dates (Kofi, 1973). Therefore, it is of great importance that empirical work is done to analyse how well futures markets perform the functions of guidance of inventory and establishment of forward prices and hence indirectly stabilizing prices.

Resources can be used for current production and consumption or they can be invested to produce goods for later consumption. In the case of traditional futures commodities the investment after the harvest is in inventories, and before the harvest is in working capital to produce a crop. In the case of foreign exchange or financial instruments, the investment in inventories is made by the dealer. In the case of livestock the investment is made in building up a herd. Investment in inventories or in capital goods decreases current welfare; but the consumption of goods at a later date increases future welfare (Kofi, 1973).

1.4 The Operation of the Futures Exchange

According to Falkena (1991), the basic functions of a futures exchange include the following:

i) Underlying commodities or financial securities are delivered through a clearing system, and the clearing house guarantees the fulfilment of contracts entered into by clearing members;

ii) actual delivery against futures contracts tends to be rare;

iii) liquidity has to be high for a futures contract or such a contract tends to be discontinued;

iv) trading costs tend to be low; the standardised nature of the futures contract lowers the transaction and information cost;

v) all futures contract prices are publicly disclosed; and

vi) profits and losses on futures contracts have to be settled daily.

Due to leverage, that is, the ability to control large amounts of value with relatively little cash, enormous potential profits with commensurate risk are at the speculator's disposal. Traders are required to put down a deposit that guarantees fulfilment of the contract. The deposit acts as security to cover any initial loss that may result from adverse movements. Security deposits often run lower than five percent of the value of the contract. The customers are protected by a system wherein all transactions are "cleared" (ie. verified and guaranteed) by a clearing house. Trade-confirmation cards are matched by computer to ensure that opposite sides of a contract agree. The exchange establishes limits on the amount that the price of a particular contract can rise or fall on a given day (Elliot, 1986).

1.5 The South African Futures Exchange (SAFEX)

The South African Futures Exchange (SAFEX) was established in 1988 and started trading financial futures contracts in 1990. It is an association of members, consisting of banks, financial institutions and stockbrokers, who through purchasing a seat on SAFEX acquire the right to trade on the futures market on behalf of clients. SAFEX provides the facility, rather like an auction facility, and is funded through recovering its operating costs from its members. Trading activity in the financial market is concentrated in futures contracts on the Johannesburg Stock Exchange (JSE) share indices. These financial futures have achieved a turnover for SAFEX of between two and three times that of the JSE during the past few years. The Agricultural Marketing Division (AMD) of SAFEX was opened in 1995 with the issue of 84 seats to 60 members. These members include commercial and merchant banks, financial brokers and commodity traders. The AMD is a separate division of SAFEX. In February 1996, the AMD took the decision, in consultation with it's members and other interested parties, to launch yellow and white maize futures contracts.

The AMD provides a vital service in the newly deregulated marketing environment in South Africa. The trading of maize futures contracts has continued to grow at a considerable rate indicating the usefulness and the growing awareness of the market. The SAFEX silo receipt plays a pivotal role in the development of the cash market in South Africa, being used as a guarantee of the product to the buyer. According to Gravelet-Blondin (1998), the futures price has a very strong correlation to the spot price in the market. Before the end of 1998 SAFEX was planning to introduce options on maize futures which will add to the volumes traded.

1.5.1 Maize Marketing

The market for maize in South Africa is characterised by price inelastic supply and demand (van Zyl, 1986). The aggregate supply of maize can be considered price inelastic in the short to medium-term because there are few established alternative crops to maize in many regions of South Africa. Maize production is largely a function of climatic conditions rather than price signals and there are relatively long adjustment lags associated with maize production. White and yellow maize can be considered perfect substitutes in production, although white usually commands a higher price than yellow (Frank, 1986).

Demand for maize comprises mainly of human and animal demand. White maize is used for human consumption and yellow maize for animal consumption. Human demand for maize has been shown to be relatively less price elastic than animal demand but both are considered price inelastic as few substitutes are available (van Zyl, 1986). Animal demand has been steadily increasing due to the increased importance of maize as an animal feed, especially for poultry.

In the current freer market situation, the inelastic nature of supply and demand results in volatile maize prices. Surpluses and deficits necessitate exports and imports respectively. South African maize prices may thus vary between the landed import and the net export realization prices in a free market (van der Vyver and van Zyl, 1989). The size of this price difference, and thus the degree of possible local maize price fluctuation, is dependant largely on transport costs to and from the rest of the world (Frank, 1992). Major world maize markets are situated far from South Africa and are themselves characterised by volatile prices, and international transport costs are considerable, owing to the bulk of the commodity. Within South Africa, transport costs are also high, leading to large price differences between localities (Elliot, 1994). In addition, the supply of maize is strongly seasonal, being concentrated in the harvest period of approximately two months whereas demand for maize is spread throughout the year. Seasonal maize price fluctuations thus also occur due to the costs associated with storage. Price risk is considerable as is evident from farmers' risk perceptions reported by Woodburn *et al* (1995) amongst KwaZulu-Natal commercial farmers. This perception of price risk is characteristic of many agricultural producers worldwide (Schroeder and Goodwin, 1994).

Bunting (1997) found that the maize industry is still perceived as being manipulated for the benefit of major role players. According to Grobler (1998), since the dismantling of the Maize

Board, the market for maize in South Africa has been characterised as a poor price discovery mechanism which lacks transparency, accessibility and reliable market information. Producers face the situation of increased price risk. There exists a need for the creation of a viable regional spot market for maize so that information can be readily accessible to all users. Generally, as in the UK and USA, the creation of a spot market usually pre-empts the creation of the futures market but in South Africa the futures market has pre-empted the spot market. Access to information could be aided by the creation of a public advertising board where buyers and sellers can market their bids and offers in any locality . The advertising procedure should be led by maize users at various localities and in this way local prices would be determined by local supply and demand within the broader spectrum of national and international supply and demand (Grobler, 1998). There is a need for total transparency and no manipulation so that market information can flow freely. The accurate calculation of crop estimates is essential to the price formation process. Monthly updates of stored maize and maize demand is important to allow the market to adjust to this information. The private sector could take up the role of providing these services. Government could also have a role in providing information to the market thus increasing the amount of publicly available information.

Producers have a variety of ways to market their maize. These include forward contracting, processing, sales on the spot market, sales on the futures market, sales to co-operatives and storage on farms and co-operative silos.

Direct farmers' use of futures hedging has traditionally been low, even in countries like the USA, where established, well-developed futures markets have long existed (Goodwin and Schroeder, 1994). In a survey of Indiana maize and soybean farmers, Shapiro and Brorsen (1988) found that only 11.5 percent of their total hectarage was directly hedged on the futures market. Futures hedging is more commonly used by maize buyers and larger intermediaries such as cooperatives and traders. The price stability benefits they achieve can be passed on to farmers by way of back-to-back contracts with farmers. Intermediaries may guarantee spot (cash) and forward contract prices to farmers by taking an appropriate futures position on SAFEX.

Bown (1998), in a postal survey of commercial maize farmers in South Africa, found that though there was a general positive perception of SAFEX, the high percentage of undecided answers indicated there is a general lack of understanding amongst producers as to how the tools available from SAFEX can effectively be used to manage price risk. Scope therefore exists for more educational programmes targeting farmers, aimed at explaining the concepts behind agricultural commodity futures contracts. Bown (1998) reported that the mean percentage of crop that is hedged or sold on the derivatives market increased from 1.1 percent in the 1997/98 marketing season to 5.2 percent in the 1998/99 season and an anticipated 8.6 percent in the 1999/2000 season. Clearly, there is an increasing use of SAFEX by farmers to hedge their maize crop.

Bown (1998) also found that elevators (silo operators including cooperatives) have historically been, and seem set to remain, the largest intermediaries in the maize market, marketing roughly 50 percent of the value of the maize crop in the study area. The share of total maize marketed by the large traders increased from 7.1 percent in 1997/98 to 8.4 percent in 1998/99 and a projected 8.9 percent in 1999/2000. The percentage of farmers dealing with large traders also rose from 17 percent in 1997/98 to 20 percent in 1998/99. Large international grain traders are currently expanding their local operations and setting up regional offices in South Africa (Bown, 1998).

The Agricultural Marketing Exchange (AGMEX) system of on-line spot marketing came into existence in 1995, but has since ceased to operate. Dickson (1998) identified some of the problems as being the fact that the system was not interactive, ie. revision of bids and offers was complicated. Trading also continued for 24 hours a day and this may have discouraged buyers. Bunting (1998) interviewed participants and found that buyers felt they should have been consulted before the system was introduced. Often sellers merely used the market to discover values and withdrew their lots once found, leading buyers to waste time and confidence in the system (this indicates the desire for a cash price publishing system). The system was perceived to be misused and manipulated as sellers had bid on their own stocks. There are many advantages to electronic trading, some being the decrease in transaction costs and market access is eased, prices are transparent and competition is enhanced. This is borne out by the fact that the AGMEX system is successfully used in other countries.

SAFEX only reflects the price of maize delivered to Randfontein. Grobler (1998) believes that there is a lack of accessibility to the market and this is particularly true for remote producers. During the single-channel marketing era, all players had full access to the market via the Board. Now it is up to the buyers and sellers to find one another and according to Grobler (1988), this is done in the following ways:

a) Elevator owners are contracted to store quantities of maize for large consumers and traders. In turn, producers are contracted to supply these elevators and therefore large, nearby producers are contracted so as to contain transactions costs, and not distant producers. Contract size is important so that transaction costs per unit traded are kept low.

b) Large consumers buy directly from producers on spot and forward contracts. Such contracts are often inaccessible to small farmers.

c) Advantage gained from information can be used to make excess profits by traders. SAFEX is used as a physical market rather than a mechanism for price risk management.

Grobler (1998), supported by Bunting (1997), claims the Chicago Board of Trade (CBOT) has virtually no relevance for inland producers, consumers and traders as inland prices can and do show large fluctuations due to changes in South Africa's domestic supply and demand. The limits within which prices can vary in any locality at any given point in time is set by the import and export parity prices of maize in that local industry at that time. The difference between these two prices will increase the further one moves inland. The levels of the price floor and ceiling in the domestic market are in this way largely set by international supply and demand factors. Within these parameters, the actual local price levels will be determined by the expectations and perceptions of local supply and demand. For example, if domestic supply is perceived to be above domestic demand, prices will trade toward export parity levels. Due to the size of the gap between export and import parity levels, domestic prices can move far and fast as local supply and demand expectations change.

Market participants analyse supply and demand information, the most important being the amount of maize in elevators at the end of the marketing year, ie on April 30. This is the quantity of maize available to supply requirements until the next harvest and to cushion setbacks in the development of the new crop. One of the more commonly watched numbers that gives the market quick information on current supply and demand is the stock-to-use ratio (STU). When high, prices are less sensitive to anything that might threaten the crop, and vice versa (CBOT, 1998c). In order to get good numbers on stocks, imports, exports and consumption on a monthly basis, the South African Grain Information Service (SAGIS) company was created in August 1997. However, it only reports on actuals (statistics) and does no forecasting. The National Crop Estimating Committee is responsible for production estimates. Estimates are reported monthly, however there is a general belief that the parties involved do not yet realize the importance of their figures (Grobler, 1998). Some of the large participants spend time and money on market intelligence, giving them a competitive edge. Grobler (1998) proposes that government should publish data on stocks monthly, giving everyone the chance to recalculate their carry-out estimates.

1.5.2 The Reasons for Failure of Futures Contracts

Failure of futures contracts is relatively common in futures markets around the world. This is due to a variety of reasons that do not satisfy the aim of a futures contract of price risk insurance. What follows is a description of the beef and potato markets in South Africa and why these futures contracts failed.

1.5.2.1 Beef Marketing

"The establishment of futures trading will have to overcome reluctance, and sometimes the resistance, of those who hold power and naturally prefer keeping it instead of supporting a competitive market" (van der Vyver, 1994: 55). This is pertinent to the proposed study, since the intention originally was to study the efficiency of the beef and maize futures markets, however discussions with SAFEX indicated that although the South African beef futures market began well, it has been halted as interest has waned. This has been attributed to a number of factors.

After deregulation, the market required a price indicator that was unbiased. One option to market beef for producers was through SAFEX, and this began well. The other option was use of AGMEX, an electronic cash market trading system bought and administered by Vleissentraal. This led to the perception that the AGMEX option was being manipulated and confidence was lost in this system. There have been allegations in the beef industry of large buyers colluding to buy at a low price and then sharing out their purchases between them. Beef is vertically and horizontally concentrated (Dickson, 1998).

A hint of the present problem is provided by Lubbe et al. (1992: 300) who state that "the magnitude of the present concentration and vertical integration in the red meat industry poses problems in the market reform process and may result in increased monopolisation if deregulation is not done wisely". Lubbe (1991) shows that the concentration in the marketing structure of the red meat industry is controlled by three organisations. Excessive horizontal as well as vertical concentration exist and were created, promoted and maintained by the previous red meat scheme. He concluded that simply removing the controlling body (Meat Board) will not remove the monopolistic controlling bodies.

Further reason for failure of the beef futures contract is acknowledged by SAFEX as possibly being that the physical delivery contract may have been too complicated and delivery was restricted to a 50 kilometre radius of City Deep abattoir in Gauteng. This makes it difficult for those who want to deliver on the contract. No delivery would then involve calculation to discount the prices away from City Deep. Peck et al. (1992) show that both timing and location affected market performance on the Chicago Board of Trade. Hedging effectiveness was shown to differ significantly depending on how the analysis accounted for both timing and location options. SAFEX are in the process of updating their index (NABI, see Appendix 1) to allow for a more representative index. At the moment the beef contract is suspended, however SAFEX feel that since the demise of the Meat Board there is definitely a need for an accurate price formation market.

1.5.2.2 Potato Marketing

The local potato futures market has also seen the volume traded fall to virtually nothing. SAFEX (1998b) felt there was a well established forward market in place and that they had extensively marketed the potato contract; buyers felt that the price insurance they have through the forward contract was sufficient. The producers of french fries and crisps felt they used their forward contracts effectively to insure themselves against price hikes. Retail stores have indicated that price insurance is not necessary as price differences are simply passed onto the customers. SAFEX (1998b) feel the potato contract is simple and cash settled, delivery of the physical commodity is not necessary, and as soon as people realize the additional benefits the contract is expected to improve.

Production of potatoes, which are particularly susceptible to drought and disease, can result in a situation where the farmer gets a low cash price because of poor quality, and in addition, he must buy back his futures position when prices have risen due to the lack of supply of the desired quality of potato. The farmer therefore loses money in both markets and most likely will not use the market again.

The above experiences explain why traders decided to focus on yellow and white maize contracts, which has resulted in the increased volume of trade in those areas. Once these contracts are well enough established, SAFEX will reintroduce other commodities. Volume of trade is an important determinant of the success and efficiency of a commodity futures market. Appendix 4 presents the cumulative maize futures volumes and it is evidence that the number of contracts is increasing at a rapid rate.

Ennew et al. (1992) examined the influences on decisions to trade on the London Futures Exchange, which experienced a decline in use in the late 1980's. Many causes were proposed, including inefficiency, concern about the level of speculation, and the farmers' suspicion of the market which was compounded by a number of disaster stories about the consequences of trading on the Exchange. Despite the obvious arbitrage opportunities, London was regularly out of line with continental markets. From 1986-87 volumes began to fall from previous high levels, creating thinness in the market. Surveys found the main reasons why growers and merchants ceased to use the market were the absence of a link to the spot market, information was not moving between markets and prices were not reflecting supply and demand, and the degree of instability and the risks associated with delivery. Reasons why non-users chose not to enter the market were uncertainty regarding the benefits of use and the absence of sufficient information. Ennew (1992) concludes that the problem is simply poor information and poor levels of understanding, combined with negative views about the processes of trading that have led existing users to exit and potential users not to enter. This indicates that a proactive stance (education drive) by the London Potato Futures Market (LPFM) is needed to market itself better and attract users.

1.6 Possible use of SAFEX by Southern African Countries

In 1994, South Africa became a member of the Southern African Development Community (SADC) which has trade agreements between its 14 member countries. The intention of SADC is to become a free trade area, but as yet only a few countries have ratified the agreement (Gay, 1998). There is no direct difference between hedging on the Chicago Board of Trade (CBOT) and on SAFEX, however with SAFEX the Southern African countries have the knowledge of local supply and demand, weather conditions, political situation, crop expectations, etc. and are far closer to the market. Being closer, they need not take into account basis calculations to the Gulf or to the port where the crop is unloaded, for example Durban. South Africans need not consider currency fluctuations when calculating their prices at which to hedge. Discussions have been held by SAFEX with representatives of Zimbabwe, Botswana, Zambia and recently private individuals in the north of Mozambique on how to use SAFEX as a hedging mechanism. These countries can safely hedge their crops on SAFEX to give better price insurance. Physical delivery does, however, create a problem and in most cases positions are closed out unless parties are interested in acquiring the commodity. Therefore, SAFEX offers an alternative to price insurance - sourcing maize to export to the respective country. No obstacles are in place for any Southern African country, firm or individual to trade on SAFEX, and a good infrastructure is provided for any country to use. International participation is welcomed, the only requirement being a resident South African bank account (SAFEX, 1998b).

The need for increased trade with less restrictions is recognized and is evident from the fact that as of 1 January 1998, a bilateral agreement was signed with Zimbabwe whereby no tarrif is implemented until a quota of 5000 tons has been reached. Thereafter, a tarrif of R25.50/ton for maize and five percent of the value of the shipment for processed maize, ie. maize meal, is implemented. This agreement is reciprocal in nature (Department of Agriculture, 1998). If the SADC free trade agreement is signed, this would remove barriers between countries which would decrease transaction costs of trade between countries and allow for increased trade. The objectives of the South African Customs Union (SACU), whose members are South Africa, Botswana, Lesotho, Namibia and Swaziland, are to maintain free trade between member countries. As far as the trade of maize in Southern Africa is concerned, only Zimbabwe and South Africa have the potential to export maize.

CHAPTER 2: LITERATURE REVIEW

The concept of efficient markets is discussed in this chapter with relevance to futures markets and price discovery. The concept of cointegration is introduced and its link with testing for the efficiency in a futures market is established. Factors relating to disequilibrium in a futures market are discussed as an indication of where the market goes wrong.

2.1 Price Discovery in Futures and Spot (cash) Markets

The potential for deliverability of commodities in the futures market is expected to prevent prices from becoming too divergent because of arbitrage. This implies that futures and cash prices should be related (Kofi 1973). Additionally, the cash market tends to derive much of its price information from the futures market. A lead-lag relationship between cash and futures prices is expected, as price information is transferred from the futures to the cash market, with the cash market responding to changes in the futures market. When continuous inventories are carried, the daily price spread movements on all futures delivery months are affected "smoothly", interacting with inventory adjustments and contributing to pricing efficiency.

Kofi (1973) considered the effects of continuous and discontinuous inventories. He found that a viable futures market not only provides a constellation of prices which reflects available information on supply and demand, but also facilitates the carrying of inventories through hedging. This reduces the variance of prices for the seasonally produced continuous inventory commodity. Furthermore, he states that all things being equal, the allocative and forward pricing function of futures markets will be more reliable for continuous than for discontinuous inventory markets. He found that the wheat market, a continuous inventory market, outperforms the potato market, a discontinuous market that has relatively more pronounced uncertainties about conditions of supply and demand.

Well functioning futures markets are about the closest in relation to a perfectly competitive market that occur. Just and Rausser (1981) report that evidence is not overwhelmingly in favour of either futures markets or econometric models being more accurate in their forecasts of future spot prices. Decomposition of the forecast error suggests that the futures market was generally more accurate in terms of bias, while econometric models were more accurate in terms of variance. Goss et al. (1992: 25) support these results and found that for the USA oats market during 1972-1981 the futures price clearly outperformed the econometric model as a predictor of the cash price.

Garbade and Silber (1982) showed that the futures markets for wheat and corn in the USA play a crucial role in the price discovery process. On the other hand, the pricing of oats and copper was split approximately evenly between the cash and futures markets. The lesser importance of the futures market for oats emphasizes the importance of liquidity and size to the price discovery role of futures markets. Corn and wheat futures markets were large and very liquid, but there was significantly less trading and liquidity in oats futures. Their study emphasizes collection of research data at the same time of day from the different markets. If the cash price is collected later in the day than the futures price then these biases imply that the cash market will appear more important for price discovery than is the fact. Conversely, if a futures price is collected later in the day than a cash price, the futures market will appear more important for price discovery than is the case.

Previous research by Brorsen et al. (1984), dealing with price discovery in Southwest USA cotton markets, report unidirectional determination of the cash price by the futures price, implying cotton prices are discovered in the futures market. The futures market has more participants and lower transaction costs; therefore, it should be a more efficient mechanism for price determination. Leuthold et. al. (1992) also found that prices for hogs in the USA were discovered in the futures market. The futures market tended to dominate cash market pricing activity, but futures market information is transmitted and incorporated rapidly by cash markets. Kenyon et al. (1993), using corn and soybean data from 1952 to 1991, found that decreased yield predictability in corn and soybean yields may be a key factor in declining forward pricing performance of futures prices.

2.2 Cointegration - Concept, Estimation and Tests

The concept of cointegration between multiple nonstationary time series was originally introduced by Granger (1981). The empirical econometric techniques for estimating and testing the cointegrating relationship were proposed by Engle and Granger (1987).

Regression analysis based on time series data implicitly assumes that the underlying time series are stationary. The classical t and F tests are based on this assumption, however if series are nonstationary, the distribution of the t and F tests change and regression of one time series on another time series often give nonsensical or spurious results.

Many economic time series exhibit nonstationarity in levels and stationarity in first differences. This kind of process is said to be integrated of order 1, denoted by I(1). The linear combinations of two nonstationary I(1) processes are normally nonstationary as well. However, if a linear combination of two I(1) processes is stationary, then the two processes are cointegrated (Lu, 1994).

Cointegration implies that two cointegrated I(1) processes (say Fp and Sp) have a tendency to drift away individually, but they move closely together through time so that a certain linear combination of them fluctuates around it's constant mean value - a property of stationary time series. For economic time series, this can be interpreted as showing an equilibrium relationship between them. Thus, a cointegration relationship is closely related to an economic equilibrium (Townsend, 1998). "If the two price series cannot drift apart in the long run, the forces determining the delivery date spot price (S_{t+1}) are reflected in the current futures price (F_t). Thus the current futures price can provide forecasts of the future spot price. Evidence of cointegration between non-stationary spot and futures prices is, therefore, supportive of market efficiency" (Aulton et al., 1997: 410). Once cointegration is established between spot and futures prices, this information can be used by analysts to predict future relationships between the two price series. If the price series are cointegrated, information is being transmitted between futures and spot prices and price discovery is taking place. By definition, the spot and futures series are cointegrated if the residuals (u_t) from the time series regression of spot on futures are stationary. However, if the residual series is autocorrelated rather than being white noise, past price information as well as the current futures price can be used to predict the subsequent spot price and this constitutes a violation of efficiency.

Therefore u_t measures the extent to which the system is out of equilibrium, and can thus be termed equilibrium error. Cointegration thus implies that since Sp_t and Fp_t (the spot and futures price series) are both I(1), the equilibriating error will be I(0) and u_t will rarely drift far from zero. In other words, equilibrium will occasionally occur, at least to a close approximation, whereas if Sp_t and Fp_t are not cointegrated ($u_t \sim I(1)$), the equilibrium error will wander widely, suggesting the absence of equilibrium. Dickey and Rossana (1994) and Mills (1993) provide an easily readable explanation of cointegration and point out that if individual time series are integrated, say of order one, it is still possible that certain linear combinations of these time series will be integrated I(0). Such systems are then said to be cointegrated.

The term unit root refers to the root of the polynomial in the lag operator eg. $LY_t = Y_{t-1}$. Engle and Granger (1987) employed Dickey-Fuller (DF) and augmented Dickey-Fuller (ADF) unit root tests to test for stationarity of variables. Testing whether the first differenced series is stationary should yield the same results. The empirical critical values of the unit root tests are tabulated in Engle and Granger (1987). Rejection of the unit root hypothesis means the hypothesis of cointegration among the I(1) series is accepted. In this case the regression on the levels of the two variables is meaningful and the traditional t and F tests are applicable.

According to Lu (1994), there are two problems associated with this two-step procedure. The first one is which component of the I(1) series should be chosen as the dependent variable in the cointegrating regression. Asymptotically, this problem should be irrelevant if consistency is of concern only, although it may affect the test performance in the finite sample case. Secondly, the short run dynamics of the I(1) series are ignored in the estimating process. Note that if cointegration exists, the residuals in the cointegrating regression model will drive the changes in the I(1) processes under investigation. Thus, the residuals are typically correlated with the regressors. Asymptotically, this does not matter. However, ignoring this correlation and short run dynamics generally results in finite sample bias and inefficiency. Lu (1994) suggests adding k leads and lags of the first differences of the regressors in the cointegrating regression to remove the correlation and short run dynamics effect, where k depends on the sample size.

2.3 Cointegration Analysis in Spot and Futures Markets

Conventional regression analysis is generally inappropriate for testing time series relationships because the data are typically non-stationary and usually I(1) (Chowdhury, 1991). As a result, Elam and Dixon (1988) state that the standard F test of the hypothesis a=0 and b=1 is no longer appropriate (a is the constant or intercept term and b is the estimated coefficient of the explanatory variable). Using Monte Carlo experiments, they show how the F-test tends to bias toward incorrectly rejecting market efficiency.

A cointegration-based approach addresses the issue of non-stationarity. Cointegration between two variables implies that they never drift far apart. The market efficiency hypothesis, on the other hand, requires that the current futures price and the spot price of a commodity are "close together". If these two prices are not cointegrated, they will tend to deviate apart without bound, which is contrary to the market efficiency hypothesis (Chowdhury, 1991). Thus, the existence of cointegration between two price series (for the same commodity) is evidence of a long run relationship between them and, consequently, cointegration is a necessary condition for efficiency (Chowdhury, 1991; Fortenbury and Zapata, 1993; Lai and Lai, 1991).

"Recent developments in cointegration analysis by Johansen (1988, 1990) provide a new technique for testing market efficiency. The procedure uses a maximum likelihood method and allows one to formally conduct likelihood ratio tests of the parameters of the equilibrium relationship between nonstationary variables. In contrast to the Engle-Granger single equation procedure, this model is based on a vector auto-regressive model that allows for possible interactions in the determination of spot prices and forward or futures prices" (Lai and Lai, 1991: 568). This method is, however, beyond the scope of this study and the Engle-Granger procedure will is used.

Bessler and Covey (1991) used applied cointegration tests to daily data for USA slaughter cattle cash and futures prices. The results offered mixed support for a cointegration type relationship between cash and nearby futures, and no support between cash and distant contract futures. This supports Leuthold's (1979) findings that a relationship between cash and futures prices is stronger for nearby contracts than for distant contracts. They also identified the cash market as being inefficient, since cash prices could be forecast more accurately using futures prices in an error correction forecasting model than forecasting cash prices with a univariate autoregression model.

Schroeder and Goodwin (1991) used cointegration to examine the longer- run stability of live hog futures and cash markets in the USA. Price discovery generally originated in the futures market with an average of 65 percent of new information being passed from the futures to the cash market. Little short run feedback was generally present from the cash market to the futures market. However, especially during large price movements, the cash market dominated.

Crowder and Hamed (1993) use Johansen's (1989) cointegration technique to test the efficiency of the oil futures market. The futures price was an unbiased predictor of the corresponding future cash price. There was no evidence of a risk premium or that past forecast errors are useful in predicting the future spot price. This supports the simple efficiency hypothesis that the expected return to futures speculation in the oil futures market should be zero.

Fortenbury and Zapata (1993) used daily data to investigate the extent to which cointegration between markets is consistent over time. Four of the five markets tested showed significant cointegration and, in general, cash markets reflected new information within five days of futures markets. Previous studies have tended to conclude that lag structures imply market inefficiency. However, while a delayed response is a necessary condition, it may not be sufficient. As noted by Garcia et al. (1988) and Rauser (1981), the sufficiency condition for market inefficiency rests on an evaluation of the benefits and costs of acquiring new information.

Wang and Yau (1994) used cointegration on intraday data of index futures and cash prices. The two markets were strongly linked on some of the days but on other days the two markets were independent of each other, and index arbitrage was not active then. The volume of index arbitrage activities appeared to be too low to cause a substantial discount on the index futures.

Hudson et al. (1996) used a cointegration test of Southwest USA cotton futures and producer markets and error correction (causality) models to determine the nature of lead-lag relationships when these price series were cointegrated. Again the futures market led the cash market. However, the results were not as strong as those reported by Brorsen et al. (1984). It seemed that the reliability of the futures price as a source of price information to Southwest USA cotton producers was questionable. This was attributed to quality uncertainty in the producer market. Producers uncertain about the quality of their cotton before harvesting and grading may tend not to hedge (using contracts having a base quality which they may diverge from), but rather use local electronic spot market information specific to sales for their region.

Aulton et al. (1997) tested for cointegration in the United Kingdom (UK) wheat, pigmeat and potato futures markets during 1980-1993. Results suggest efficiency and unbiasedness in relation to wheat, some inefficiencies in relation to pigmeat and some inefficiencies and bias in relation to potatoes. For both potatoes and pigmeat the futures price did not incorporate all the information used by the market in forming a prediction of the subsequent spot price. The results are intuitively correct given that inefficiency is likely to be more common in thin markets (the relative volumes of trade being lower in potatoes and pigmeat). Wheat was the most strongly traded of the three, and thus expected to display the least amount of bias.

According to Tomek (1997), a forecast from a correctly specified econometric model should not be able to improve on the market's price estimate. If an econometric model outperforms the market, three interpretations are possible:

a) Both appear to be incorrect, reflecting sampling error.

b) One or the other is wrong. If the market outperforms the model, the latter is incorrectly specified, and if the model outperforms the market, the market is inefficient.

c) The market is weak-form efficient, not strong-form efficient. Strong-form efficiency implies that all information, including insider information, is reflected in stock prices.

Tomek (1997) suggests that futures prices can be viewed as forecasts of maturity month prices, and that it is difficult for time series econometric models to improve on these forecasts. Accurate forecasts are difficult to make, particularly when the forecast is for a distant time. Prices are influenced by a complex array of forces and the information available can change dramatically over time. Precision seems to decline rapidly for forecasts made three or four months in advance. Therefore, though a futures price is an unbiased forecast, a large variance of forecast error should not be surprising. In addition, markets with continuous inventories, such as maize, have more information available at planting time than do markets with discontinuous inventories. Finally, data are probably not adequate to discriminate among competing hypotheses about market performance.

2.4 The Concept of Efficient Markets

Leuthold et al. (1989) consider an efficient market to be one which fully reflects available information so that there is no opportunity for agents to profit from publicly available information. Empirical tests of market efficiency can be classified as weak, semi-strong and strong:

1) Weak-form efficiency tests examine whether current prices fully reflect the information contained in historical prices.
2) Semi-strong tests assert that prices fully reflect not only historical information but also publicly available information.
3) The strong-form of the market efficiency hypothesis asserts that prices fully reflect historical price information, as well as public and private information.

Early studies of market efficiency were based on a search for a random walk of market prices as the test for weak-form efficiency. However, these studies are seen as restrictive. The other approach is to assess the forecasting performance of futures markets by regressing the spot price at maturity on a previous futures price. If the intercept coefficient is zero and the slope is one, i.e. the futures price is an unbiased predictor, then the market is regarded as efficient. This test does not directly establish market efficiency, and Garcia et al. (1988) argue that biasedness may occur because of uncertainty and lack of information, but not necessarily from market inefficiency.

To test the semi-strong form efficiency, an econometric price forecasting model using available public information is usually employed to compare the forecast error of the model with that of the futures price. The comparison of relative forecasting abilities is usually based on statistical criteria, such as mean squared error. If the futures price has less forecasting power, then it implies some public information is not fully reflected in the futures price and this information can be used to improve the forecasting accuracy (Garcia, 1988).

These tests are limited as they cannot be used to prove markets are inefficient. They only indicate potential market inefficiency because they cannot test market efficiency as they are not sufficient to show that an agent can earn abnormal profits in the market (Lu, 1994). To search for market inefficiency, it is widely accepted to examine if using some forecasting model can result in abnormal profits (Garcia et al.1988; Leuthold et al. 1989).

According to Pasour (1981), under real world conditions of uncertainty and costly information, the concept of efficiency loses much of its precision as it is evaluative and is defined by the goals and knowledge of the decision maker. In reality, knowledge is imperfect, markets are in disequilibrium, and some people are unable to carry out their plans. Consequently, under real world conditions there is always a state of partial ignorance on the part of the decision-maker concerning market opportunities (Pasour, 1981). Almost every current decision concerning how to invest is influenced by the views held about the future. The utility-maximising entrepreneur will only seek additional information if the costs thereof are less than the benefits.

Leuthold et al. (1989) state that finding a bias in the data is not necessarily inconsistent with market efficiency. Unbiasedness is not a property required for prices to reflect fully all available information. Biased prices may exist because of a risk premium, the cost of information, risk aversion, irrational participants, imperfect capital markets, and alternative transaction and information costs. Thus, the test for efficiency is not necessarily that of a bias or not, but rather that prices contain all information from an existing source.

2.4.1 Causes of Disequilibrium

According to Boyd and Brorsen (1991), if risk-adjusted returns are positive and statistically different from zero, they imply weak-form inefficiency and short-run disequilibrium. Disequilibrium is also attributed to inaccurate or untimely information flows, information arriving in uneven doses, transaction costs, taxes, interest rates, inflation and risk premia. A number of studies show the link between futures trading volume and price variation (Boyd and Brorsen, 1991).

Berg (1981) considers conditions for pure competition, as a whole, can be substantially met by futures markets. The pricing process in commodities with active futures can be considered more efficient relative to those in other commodities for this reason. When the working of the arbitrage mechanism is considered, the presumption of futures market efficiency is further clarified. Under perfectly competitive conditions in futures markets, prices are able to move in response to changing conditions. So long as price is able to move, arbitrageurs are able to maintain price alignments between time periods. These alignments are correct when supply and demand conditions, storage costs, and storage returns are reflected in futures prices. If the basis (the difference between the spot and the futures prices) cannot be attributed to these component parts, it cannot accurately reflect storage market equilibrium and the market is said to be inefficient.

2.4.2 Information and Efficient Markets

When doing comparative efficiency studies, the costs and benefits of additional information must be considered. In the event of costly information, though traders act rationally, futures prices will not be unbiased estimates of the spot price. From this perspective, an informationally efficient market is incompatible with costly information (Leuthold and Peterson, 1983). A key question is the speed with which each market (cash and futures) receives and evaluates information in registering a market-clearing price. Thus, it is important to traders to establish the market which is the most informationally efficient. This market will lead the other markets as information flows from it. In a perfectly integrated system, all markets assimilate information at the same time, and prices adjust simultaneously. In cash livestock markets, spatial temporal transaction costs exist. Transportation costs between cash markets and the cost of buying and holding livestock from one period to the next are large. Such costs impede the active arbitrage between cash and futures, and suggest that futures markets, which are more liquid, may process information more rapidly (Leuthold et al., 1992).

2.4.3 Liquidity and Efficient Markets

A liquid market is one where traders can move in and out of the market with ease. This means that a buyer always finds a seller and a seller always finds a buyer. Liquidity feeds on itself. If the market is liquid then traders will enter the market more freely because they know that they can close out their positions with ease. More traders make the market more liquid. Frank (1992) identifies this as one of the main problems facing a fledgeling futures exchange. Pennings and Meulenberg (1997) note that new futures markets are thin, meaning that the size of the transaction of an individual hedger may have a significant effect on the price and may therefore result in substantial transaction costs. These transaction costs are the premiums that hedgers are forced to pay, or the discounts they are forced to accept, in order to close out futures positions. In a deep market, given a constant equilibrium price, relatively large market orders result in a smaller divergence of transaction prices from the underlying equilibrium price than in a thin market.

Van der Vyver (1994) states that the volume of business on a futures market depends primarily on the amount of hedging business that it attracts. Van der Vyver and Van Zyl (1989) show that the value of the volume of transactions traded on the CBOT is approximately four times the value of the USA's maize harvest. This is not necessarily the minimum number of transactions / turnover necessary for the successful operation of the futures market, but it indicates what is meant by liquidity.

According to Cornell (1981), uncertainty introduces two motives for futures trading. The transfer of risk is done if individuals risk preferences are different. Secondly, as long as information is not transferred efficiently then this will lead to differing beliefs and therefore trading. Both motives account for the volume of trading at any point in time. This leads to the idea that an increase in uncertainty should lead to an increase in belief trading and hedging. The most important implication from his study is for the design of new futures contracts. Cornell (1981) maintains that established markets have a degree of monopoly power because they can promise liquidity. A new contract can succeed only if there are no similar contracts and whether the underlying commodity is sufficiently uncertain to sustain futures trading.

2.4.4 The Basis Concept

The basis, or difference between futures and cash prices, reflects for most storable commodities transportation costs and availability, storage, and insurance costs. According to the CBOT (1998b) some of the fundamental factors that affect the basis include:

- carryover amount
- foreign and domestic demand
- crop forecasts
- transportation costs
- government policies
- storage and availability
- seasonality
- weather
- government reports

In a competitive industry in an uncertain world, a trading firm maximising storage returns supplies storage facilities, loading and unloading charges, interest and insurance. These outlays increase as the quantity of stocks held by the firm increases.

The difference in price between two futures contracts reflects the expected storage costs between the two associated delivery periods. Any one basis gets smaller as the futures contract approaches the maturity date, meaning that cash and futures prices move together. It is this long term relationship between futures prices and cash prices that is tested using the cointegration technique. The stronger the relationship, the better is the futures price an indication of the spot price, and the more efficient is the futures market.

The theory of carrying charges explains the observed relationship between storable agricultural cash and futures prices. For storable commodities, the cash and futures prices within any crop year differ by the cost of carrying the commodity over time, holding location and quality constant. According to Leuthold and Petersen (1983), the basis represents storage, interest, and insurance costs and is called the cost of carry.

Storage costs do not change noticeably from day to day. Thus, in the short run cash and futures prices maintain their relative positions, and the basis remains fairly constant. This stability is what makes the market so useful to firms. Over the long run, however, cash prices rise relative to futures prices, or the basis gradually gets smaller as the futures contract nears maturity. The remaining storage costs become less over time. This gives the basis a seasonal pattern. Theoretically, the basis should be zero during delivery month except for marketing costs. If the prices are not equal then arbitrageurs have the opportunity to make profit from the discrepancy as long as this is greater than the transaction costs. Minor differences are common, and the size of the spot premium or discount relative to futures depends on costs and risks of arbitrage between the two markets.

In summary, cash and futures prices for storable commodities should be intimately related. This is true whether the cash price is at a premium or a discount to the futures price. Both prices respond similarly to changing economic conditions and the bases and spreads reflect logical economic factors. And, regardless of their relationship before contract maturity, spot and futures prices ought to be nearly the same during the delivery period at a par delivery point.

CHAPTER 3: RESEARCH METHODOLOGY

This chapter deals with the data that will be used in the study, the proposed empirical model and the statistical method to be used. Statistical methodology includes tests for stationarity, cointegration and error correction mechanisms.

3.1 Data

Data were collected directly from SAFEX as closing daily spot and futures prices over the period August 1996 to July 1998. Trades on SAFEX are between 09:00 and 12:00, and SAFEX takes the final futures price at its discretion between 11:55 and 12:00. If, however, there is a higher bid or lower offer then that will be the close of market price to indicate in what direction the market is heading the following morning.

The spot price reported by SAFEX is a weekly update calculated as an average figure. Every Monday approximately five of the main futures market players, including co-operatives and traders, are contacted to give their prices for the week. An average of these figures is taken by SAFEX to get an estimated spot price for Randfontein delivery. Recently this average has begun to be updated daily. A far more accurate and representative spot price indicator is being set up by SAFEX since the market has begun to put so much emphasis on published spot prices. This is an estimated spot price which is not completely accurate. This was the most reliable source of daily price information available, as other sources like millers and individual traders had incomplete data sets and there is no established price reporting system available in South Africa (SAFEX, 1998b). As a result of the weekly update of the spot price, an artificial degree of heteroscedasticity is created in the residuals. Some of the diagnostic statistics that are proposed in the thesis must, therefore, be treated with caution.

In dealing with crop commodities which experience a one-time supply shock each year and exhibit futures price structures which essentially allocate the crop through the current crop year, the long-run would be that crop year. This is the horizon over which most marketing and storage decisions are made and the period over which futures markets allocate supply. This is the rationale for selecting the year contract. The July contract is the most appropriate year contract as it represents the start of harvesting, and farmers, millers and traders would need to decide what action to take with maize orders from this time on for the year ahead. As a result, this is a fairly well traded month on SAFEX in terms of contract volumes.

Three-month period contracts are also analysed, as the relationship between the two price series will likely become stronger as the contract nears maturity date because more information is available to participants about items like crop size and expected carryover amounts.

3.2 Statistical Methodology

The theory of cointegration is established on the premise that time series are non-stationary. Thus, before proceeding to test for cointegration between spot (Sp) and futures prices (Fp), it is essential to determine if the Sp and Fp price series are non-stationary.

3.2.1 Tests of Stationarity

3.2.1.1 The Correlogram

Following Gujurati (1995), the sample autocorrelation correlogram function, pk, can be computed to test for stationarity. To compute this, the sample covariance is first computed at lag k, $\hat{y}_k$, and the sample variance, $\hat{y}_0$, which are defined as

$$\hat{y}_k = \Sigma (Y_t - \check{Y}) (Y_{t+k} - \check{Y}) / n \tag{3.1}$$

$$\hat{y}_0 = \Sigma (Y_t - \check{Y})^2 / n \tag{3.2}$$

where n is the sample size, and $\check{Y}$ is the sample mean (of the spot and/or futures price series). Therefore the sample autocorrelation function at lag k ($\hat{g}_k$) is

$$\hat{g}_k = \hat{y}_k / \hat{y}_0 \tag{3.3}$$

A plot of $\hat{g}_k$ against k is known as the sample correlogram. Visual inspection of the sample correlogram gives some indication as to the stationarity of the time series. The statistical significance of any $\hat{g}_k$ can be judged by its standard error. If a time series is purely random then it exhibits 'white noise', the sample autocorrelation coefficients are approximately normally distributed with zero mean and variance 1/n, where n is the sample size. Confidence intervals for this can be calculated and if an estimated $\hat{g}_k$ falls inside the interval the hypothesis that the true $\hat{g}_k$ is zero is not rejected (Gujurati, 1995). To test the joint hypothesis that all the $\hat{g}$

autocorrelation coefficients are simultaneously equal to zero, the Ljung - Box (LB) statistic is used, where

$$LB = n(n+2)\sum \text{ sub } k=1, \text{ sup } m, (\hat{g}_k^2 / n- k) \sim X^2_m \tag{3.4}$$

The LB statistic follows the Chi-square distribution with m degrees of freedom (df). If the computed LB exceeds the critical LB value from the Chi-square tables at the chosen level of significance, the null hypothesis that all $\hat{g}_k$ are zero can be rejected; at least some of them must be non-zero.

Many price series, especially in highly speculative markets, are found to be nonstationary in levels and stationary in the first difference, ie. have unit roots. A more formal and simpler, and most widely used test for unit roots was developed by Fuller (1976) and Dickey-Fuller (1979).

3.2.1.2 The Unit Root Test

The existence of a unit root in a price series indicates non-stationarity, and implies that conventional regression statistics are inappropriate (see section 2). Test statistics can be based on the OLS estimation of suitably specified "augmented Dickey-Fuller" (ADF) regression equations for both time series. Equations (3.5) and (3.6) below show these equations for the Sp series (similar equations substituting Fp for Sp would be estimated for the Fp series):

This concept is introduced by considering the equation

$$Sp_t = Sp_{t-1} + u_t \tag{3.5}$$

where u_t is the stochastic error term that is termed white noise as it follows the classical assumptions of zero mean, constant variance and is non-autocorrelated. If this regression is estimated and the coefficient of Sp_{t-1} is found to be equal to one, the time series has a unit root or exhibits a random walk. The same test is done for the futures price series.

The Dickey-Fuller test is computed in exactly the same way as the ordinary t statistic. Since this type of Dickey-Fuller test does not follow the Student's t- distribution, even asymptotically, it is usually referred to as the tau statistic. The empirical distributions are tabulated in Fuller (1976) and Dickey and Fuller (1981). Equation (3.5) can also be expressed in a different manner:

$$\begin{aligned} \Delta Sp_t &= (p-1)Sp_{t-1} + u_t \\ &= \partial Sp_{t-1} + u_t \end{aligned} \tag{3.6}$$

where $\partial = (p-1)$ and where delta is the first difference operator. If ∂ is in fact zero, (3.6) is written as

$$\Delta Sp_t = (Sp_t - Sp_{t-1}) = u_t \tag{3.7}$$

This means that the first differences of a random walk time series (= u_t) are a stationary time series because by assumption u_t is purely random. If a time series that is differenced once is stationary, the original series is integrated of order one, denoted by I(1).

For theoretical and practical reasons, the Dickey-Fuller test is applied to regressions run in the following forms:

a) $\Delta Sp_t = \partial Sp_{t-1} + u_t$ (3.8)

b) $\Delta Sp_t = c + \partial Sp_{t-1} + u_t$ (3.9)

c) $\Delta Sp_t = c + \partial Sp_{t-1} + ht + e_t$ (3.10)

where t is the time or trend variable, c is a constant and h the coefficient of t, and e_t is the error term. In each case the null hypothesis is that $\partial = 0$, that is there is a unit root and

$\Delta Sp_t = c + \partial Sp_{t-1} + ht + \partial\sum$sub i=1, sup m, $\Delta Sp_{t-i} + e_t$ (3.11) (3.11)

if the error term is expected to be autocorrelated. Superscript m is the number of lags, in this case 1, subscript i=1. Here the augmented Dickey-Fuller test applies which has the same asymptotic distribution as the DF statistic, so the same critical values can be used.

To test the significance of the estimated ∂ coefficients, the Dickey-Fuller unit root test computes the tau statistic for each estimated coefficient, in exactly the same way as the Student's t statistic is calculated (estimated coefficient divided by estimated standard error). The estimated tau statistic, however, does not follow the Student's t distribution, even asymptotically, so its statistical significance must be assessed by comparing it with critical tau values derived for tau distributions tabulated in Fuller (1976) and Dickey and Fuller (1981). The unit root hypothesis can be rejected if the estimated tau statistic is smaller in absolute terms than the appropriate critical value.

As each pair of price series (spot and futures are from the same contract month) is the basic case for cointegration tests, if either spot or futures is found to be stationary, the pair will be rejected from further analysis. This is consistent with Lu (1994: 32)

3.3 Market Efficiency, Cointegration and Bias

The Efficient Market Hypothesis (EMH) postulates that an asset price reflects all known information (Aulton, 1997). For empirical tests it is common to distinguish between weak, semi-strong and strong-form efficiency, with the distinction based on the definition of information. Tests for weak-form efficiency rely on information embodied in past prices, while tests for semi-strong form efficiency would typically use all publicly available information, both prices and other relevant information (Garcia et al., 1988). Tests for strong-form efficiency would be based on all information including insider information. Testing for weak-form efficiency is the most common approach, and will be applied in this study. A futures market is efficient relative to an information set such that only new unanticipated information leads to a price change (Chowdhury, 1991:577).

Testing for cointegration between the spot and futures prices can be effected by using Engle and Granger's (1987) two-step procedure. The cointegrating regression model is specified as

$$Sp_t = a + b_0 \, Fp_t + u_t \qquad (3.12)$$

where Sp and Fp are the spot and futures prices at t respectively, a, b_0 are parameters, and u_t is the residual (error) term that is assumed to be a stationary process. This specification does not take into account the property of the spot-futures (basis) convergence. The parallel movement of spot and futures is implicitly assumed in the specifications. The model may be improved by including a term for the basis convergence:

$$Sp_t = Fp_t e^{-r(T-t)} \tag{3.13}$$

where Sp and Fp are defined as before, r is the continuously compounded rate of cost of carry and assumed to be constant, and T is the date of maturity. However, the basic model from (3.12) will be used in this study to be consistent with Aulton (1997).

Traditional efficiency tests regress the spot price series (Sp) on the futures price series (Fp), and test whether the intercept term a =0 and the slope coefficient b_0 =1 in equation (3.12). If a and b_0 are, respectively, not significantly different from 0 and 1, the futures price is regarded as being an unbiased predictor of the spot price (Chowdhury, 1991). However, testing only that b_0=1 is not a sufficient test for pricing efficiency. Financial price series are generally found to be non-stationary and contain a unit root, making the standard t- and F-tests of the hypotheses a=0 and b_0 =1 inappropriate as they tend to bias toward rejecting market efficiency (Elam and Dixon, 1988:368; Lai and Lai, 1991). A time series is stationary if its mean and variance are constant over time and the value of covariance between two time periods depends only on the distance or lag between the two time periods and not on the actual time at which the covariance was computed (Gujurati, 1995). A further explanation for the rejection of the simple efficiency hypothesis is the existence of a risk premium. Such a risk premium can account for the existence of non-zero returns in the futures market. This does not imply markets are inefficient, but rather that investors require compensation for the risk they undertake (Crowder and Hamed, 1993:933).

A cointegration-based approach addresses the issue of non-stationarity. Specifically, if two non-stationary series are cointegrated, then there exists some linear combination of the two which is stationary and this ensures that in the long-run the two series cannot drift too far apart. Thus, the existence of cointegration between two price series for maize is evidence of a long-run relationship between them and consequently cointegration is a necessary condition for efficiency (Chowdhury, 1991; Fortenbery and Zapata, 1993; Lai and Lai, 1991; Lu, 1994).

A time series is integrated of order d, denoted I(d), if the series can achieve stationarity after differencing d times. An I(0) series is thus, by definition, stationary; whereas a I(1) series contains a unit root and is non-stationary. When the spot price and the futures price are both I(1), the linear combination $u_t = Sp_t - a - b_0Fp_t$ is generally also I(1). However, if there exists a and b_0 such that u_t is stationary or I(0), then Sp and Fp are said to be cointegrated (Engle and Granger, 1987). The standard test for cointegration between Sp and Fp thus entails estimating the residuals series, $\hat{u}_t$, from equation (3.12) as

$$\hat{u}_t = Sp_t - \hat{a} - b_0Fp_t \qquad (3.14)$$

and then testing whether or not this series is stationary according to equation (3.15):

$$\Delta\hat{u}_t = q\hat{u}_{t-1} \qquad (3.15)$$

Since the estimated u is based on the estimated cointegrating parameter b_0, the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) critical significance values are not quite appropriate (Gujurati, 1995). Engle and Granger have calculated these values. Therefore, the DF and ADF tests in the present context are known as the Engle-Granger (EG) and augmented Engle-Granger (AEG) tests, the null hypothesis being that there is a unit root. If the estimated tau value (tau is used as the t value is inappropriate in non-stationary time series data) exceeds the critical value, the conclusion would be that the estimated u_t is stationary, ie. it does not have a unit root and therefore Sp and Fp, despite being individually non-stationary, do not drift apart over the long-run, and are said to be cointegrated (Gujurati, 1995).

A limitation of this Engle-Granger procedure is that no strong statistical inference can be drawn with respect to the parameters a and b_0 which are of main interest here. Although the coefficient estimator can be shown to be consistent, the estimated standard errors may be misleading for hypothesis testing. Recent developments in cointegration analysis by Johansen (1988, 1990) provide a new technique for testing market efficiency. He uses a maximum likelihood method which allows for the formal testing of the parameters of the equilibrium relationship between non-stationary variables (Lai and Lai, 1991).

If the two price series cannot drift apart in the long-run, the forces determining the delivery date spot price (Sp) are reflected in the present futures price (Fp). Thus, the futures price can provide forecasts of the future spot price. Evidence of cointegration between non-stationary spot and futures prices, therefore, supports the presence of market efficiency and implies that information is being transmitted between futures and spot prices and price discovery is taking place. By definition, the spot and futures series are cointegrated if the residuals from the time series regression of spot and futures are stationary. Evidence of cointegration establishes a necessary condition of efficiency. Once this has been established, further analysis can be conducted to establish additional conditions of efficiency. If the residual series is autocorrelated rather than being white noise, past price information as well as the futures price can be used to predict the subsequent spot price and this constitutes a violation of efficiency (Aulton, 1997:410).

Thus, weak-form market efficiency requires that past spot and futures prices do not provide additional and useful information to agents in forming expectations about the future spot price. This embodies the notion that the futures market instantaneously and fully reflects all available information and that agents are efficient information processors. Furthermore, if agents are risk neutral, efficiency also implies that the futures price provides an unbiased predictor of the subsequent spot price. Tests for efficiency and unbiasedness are described in the next section.

3.4 Testing for Efficiency and Bias

3.4.1 Efficiency

Testing the hypothesized relationship in equation (3.12) for efficiency comprises three steps, namely (i) test whether the price series are individually non-stationary, (ii) test for cointegration; and (iii) if the null hypothesis of no cointegration is rejected, then proceed to test for the parameter values consistent with efficiency. The first step involves assessing whether or not the two price series Sp and Fp individually have a unit root. The second step requires a test of the null hypothesis that there is no cointegration between Sp and Fp. If two series are cointegrated then there is a linear combination of the two that is stationary.

Testing for cointegration, therefore, entails estimating the long-run relationship and testing the residuals from equation (3.12) for non-stationarity. The estimated parameters of the long-run regression are consistent but have a non-standard distribution (Gujurati, 1995). If the null hypothesis of no cointegration is rejected, the second stage of testing for efficiency entails a test of the joint null hypothesis that $B_1 = \partial = 0$ in equation (3.16), which ensures that the lagged futures price and the lagged spot prices do not contain additional information that could be used to forecast Sp, thus giving traders information with which to make abnormal profits. Since these coefficients can be rewritten as coefficients on stationary variables, the standard distributions apply to the parameter estimators of B_1 and ∂ obtained via OLS on (3.16) (Aulton, 1997:413):

$$Sp_t = a + b_0Fp_t + B_1Fp_{t-1} + \partial Sp_{t-1} + u_t \quad (3.16)$$

If the null hypothesis of no cointegration is rejected (ie. there is a long-run relationship between the two series) and the null hypothesis that the lagged spot and futures prices do not influence the spot price is not rejected (lagged prices do not contain any relevant information), then it is appropriate to test for biasedness, namely that b_0=1. There is no direct way to carry out this test if Fp and Sp are I (1) series; however, the restriction b_0=1 can be imposed and the residual series $u_t = Sp_t - Fp_t - a$ tested for stationarity. If the residuals are stationary then there is evidence to support the hypothesis that b_0=1 and the market is unbiased.

Following Aulton (1997:423), the rationale for this approach is that the cointegrating parameter is unique if cointegration exists between two I(1) series (Granger, 1991), so that if the hypothesis of unbiasedness is incorrect when the two series are cointegrated, the residual series obtained by imposing unbiasedness will be non-stationary. In other words, if unbiasedness holds, then the spot and futures series are cointegrated with a unit parameter. Conversely, if the unbiasedness hypothesis does not hold, the spot and futures prices will diverge without bound.

3.5 Cointegration and Error Correction Mechanism

The error term can be treated as the equilibrium error. The error correction mechanism (ECM) corrects for disequilibrium and can be used to connect the short run to the long run. Details are found in Engle and Granger (1987). Consider the equation:

$$\Delta Sp_t = a + b_2\Delta\ Fp_t + b_3\hat{u}_{t-1} + et \qquad (3.17)$$

where Δ as usual denotes first differences; $\hat{u}_{t-1}$ is the one-period lagged value of the residual from the cointegrating regression, the empirical estimate of the equilibrium error term; and e is the error term with the usual properties (Gujurati, 1995).

Regression (3.17) relates the change in Sp to the change in Fp and the equilibrating error in the previous period. In this regression, change in Fp captures the short run disturbances in Fp, whereas the error correction term u_{t-1} captures the adjustment toward the long run equilibrium. If b_3 is statistically significant, it reveals what proportion of the disequilibrium in Sp in one period is corrected in the next (Gujurati, 1995: 729).

Kremers et al. (1993) state that contrasting results for cointegration are common when using the Dickey-Fuller statistic and the error correction term. A plausible explanation for this centres on an implicit common factor restriction imposed when using the Dickey-Fuller statistic to test for cointegration. "If that restriction is invalid, the Dickey-Fuller test remains consistent, but loses power relative to cointegration tests that do not impose a common factor restriction, such as those based upon the estimated error correction coefficient" (Kremers et al.,1993: 325). They find that the error correction based test is preferable because it uses available information more efficiently than the Dickey-Fuller test.

A caution sounded by Hall (cited by Gujurati, 1995: 730) is worth remembering:
" While the concept of cointegration is clearly an important theoretical underpinning of the error correction model there are still a number of problems surrounding it's practical application; the critical values and small sample performance of many of the tests are unknown for a wide range of models; informed inspection of the correlogram may still be an important tool." Chapters 4 and 5 present the results of the white and yellow maize contracts for 1997 and 1998.

CHAPTER 4 : WHITE MAIZE RESULTS

It is important to establish whether the individual series of futures and spot prices for white maize are stationary or not. An informal test is to use the sample correlogram. Appendix 2 shows the sample correlograms for each price series. The shape of the correlogram is of importance and the three-month 1998 spot price graph is a typical shape of a non-stationary time series. A stationary time series typically drops off faster toward the zero line than a non-stationary series. However, as this method is subject to interpretation, the more formal method of unit root testing is used.

The Adjusted Dickey-Fuller (ADF) tau statistics for both the spot price, Sp, and the futures price, Fp, series for the 1997 white maize contracts are shown in Table 4.1, where the prefix 3 indicates the three months prior to delivery contract, using the results from equation (3.11).

Table 4.1. Unit root test statistics for white maize contract for July 1997.

Series	tau statistic	DW*	Series	tau statistic	DW*
Fp	-4.696	1.730	3-Fp	-1.852	2.170
Sp	-0.492	2.059	3-Sp	-1.631	2.094

Note: Fp = futures price series
Sp = spot price series
*DW is the Durbin Watson statistic
3-Fp = three-month Fp series
3-Sp = three-month Sp series

The Fp series for the annual July 1997 contracts is stationary as the tau statistic exceeds the critical value, whereas the Sp series is non-stationary. Therefore, the daily analysis cannot continue as the two different series cannot be compared. The three-month contract series both exhibit non-stationary series and so the analysis can continue with them.

Tau test statistics for both Sp and Fp series for the 1998 white maize contracts are shown in Table 4.2 (the prefix 3 again indicates the three-months prior to delivery contract). Results indicate that for the July 1998 contract both the spot and futures price series are non-stationary for the annual and three-month contracts, as the estimated tau statistic is less in absolute terms than the critical Dickey-Fuller value (2.58).

Table 4.2. Unit root test statistics for white maize contract for July 1998.

Series	tau statistic	DW	Series	tau statistic	DW
Fp	-1.088	1.371	3-Fp	-1.031	1.791
Sp	-1.336	1.955	3-Sp	-1.703	2.251

Note: Critical Dickey-Fuller value = 2.58
DW is the Durbin-Watson statistic

The next step in the procedure is to test for cointegrating (long-run) relationships (necessary condition for efficiency) between the price series which are non-stationary.

4.1 Testing for Cointegration in the White Maize Contract

Cointegrating regressions estimated by equation (3.12) for the non-stationary price series identified by unit root tests described in section 3.2.1.2 are presented in Table 4.3.

Table 4.3. Cointegrating regression estimates, white maize contracts.

Contract	a	B_0	CRDW	R^2
98	287	0.545	0.474	0.74
3-98	280	0.557	0.511	0.86
3-97	-0.2	1.058	0.047	0.27

Note: 98 = year-long contract
3-98 = three-month 1998 contract
3-97 = three-month 1997 contract

The sharp drop in R^2 for the 1997 contract shows that the 1997 futures price explains relatively less of the variation in the 1997 spot price than the 1998 futures price explains of the variation in the 1998 spot price. The 1997 spot price could depend more on past spot prices. Figures 4.1, 4.2 and 4.3 show the futures price series plotted against the spot price series for the three-month 1997, three-month 1998 and 1998 contracts respectively. It is clear from the graphs that the two series are more closely related in the three-month 1998 contract, where cointegration exists, than in the three-month 1997, where no cointegration exists.

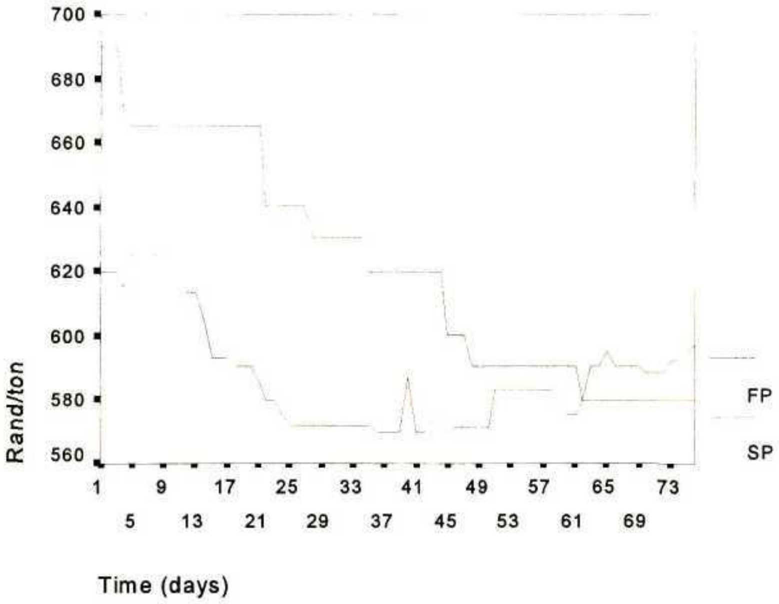


Figure 4.1 Fp vs Sp, white maize, three-month 1997

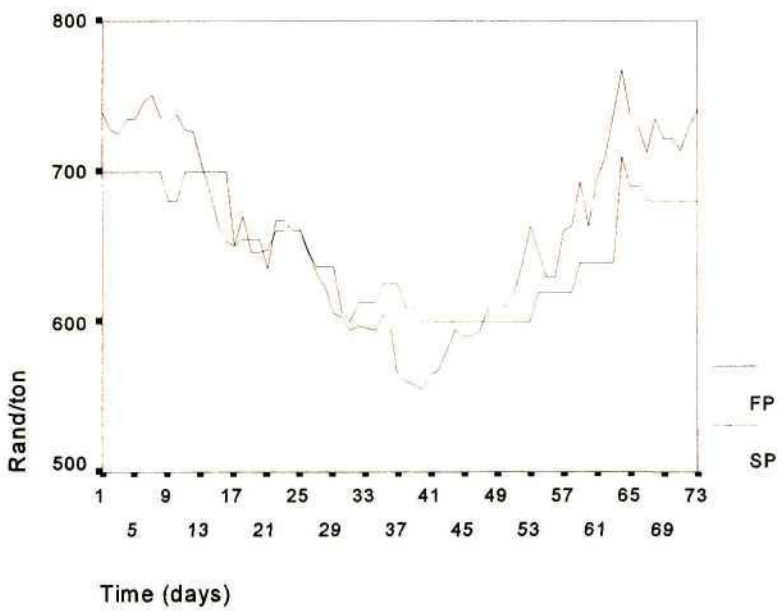


Figure 4.2 Fp vs Sp, white maize, three-month 1998

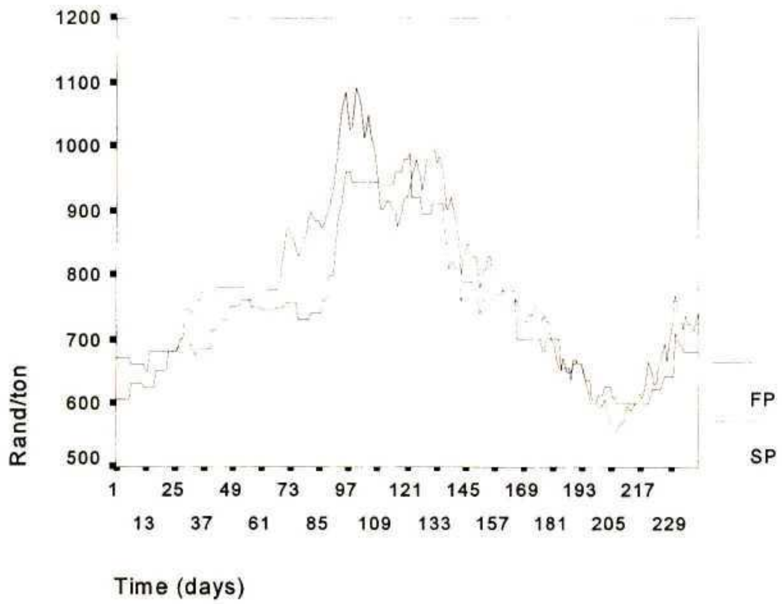


Figure 4.3 Fp vs Sp, white maize, 1998

A quick method for testing whether the two time series are cointegrated is the Cointegrating Regression Durbin-Watson (CRDW) test whose critical values were first provided by Sargan and Bhargava (Gujurati, 1995). The Durbin-Watson (DW) statistic obtained from the cointegrating regression is used, but now the null hypothesis is that the DW statistic = 0 rather than the standard DW=2. Thus, if the computed value is smaller than the critical CRDW value, the null hypothesis of cointegration is rejected at the 1 percent level of probability. The critical CRDW values are about 0.51 at the 1 percent level, 0.39 at the 5 percent level and 0.32 at the 10 percent level of probability. The results shown in Table 4.3 thus show cointegration between the annual and the three-month 1998 price series, but reject cointegration for the 1997 price series. The slope coefficient estimators, which are consistent if the relevant series are cointegrated, but which may be subject to finite sample bias, are not that close to unity and therefore indicate bias (Aulton, 1997:416).The estimated intercepts are far from zero. The biasedness hypothesis is formally tested for each regression in the next section.

Table 4.4 shows the results from the Engle-Granger tests for stationarity of the residuals as estimated from equation (3.14) for both of the 1998 contracts and the 1997 three-month contract. The coefficient values are the estimates of the parameter q defined in equation 3.15.

Table 4.4. Tests for stationarity of residuals series estimated from cointegrating regression equations, 1997 and 1998 white maize contracts

Contract	Tau statistics	DW
98	-2.660*	1.820
3-98	-3.081*	2.011
3-97	-0.498^{NS}	1.938

Note: * statistically significant at the 1 percent level of probability

NS denotes not statistically significant

Tau values tested against the AEG critical value of 2.58

The null hypothesis of a unit root is rejected for both of the 1998 contracts, indicating that the residual series is stationary - strong evidence that a long-run relationship exists between the futures and spot prices (ie. they are cointegrated). The regression coefficients for these cointegrating regressions are, therefore, consistent estimators of the long-run relationship between spot and futures prices. In comparison, the 1997 contract shows no cointegration. The change in cointegration status from 1997 to 1998 may indicate that there has been an improvement in the information transmission performance of the futures market since 1997. As expected, the three- month 1998 contract shows a stronger relationship than the year-long contract does, as more information has become available. The DW statistics reveal no serial correlation in the residuals of any of the contracts.

Having established the necessary condition for efficiency in the 1998 contracts, it is now possible to apply the second stage of testing to consider whether the current futures price actually embodies all publically available information for predicting a future spot price. The F - values presented in Table 4.5 test the joint null hypothesis that $B_1 = \partial = 0$ in equation 3.16 and were computed using equation 4.1.

Table 4.5 Second stage test of efficiency, white maize contracts

Contract	F Value of joint hypothesis
98	1368**
3-98	68**
3-97	1353**

Note: ** significant at the 1 percent level of probability

Using the joint null hypothesis

$$F = ((R^2_{ur} - R^2_{r}) / m) / (1-R^2_{ur}) / n-k \qquad (4.1)$$

(where k is the number of parameters, R^2 is the coefficienct of determination, m is the number of omitted variables in the restrained equation, subscript ur represents the unrestrained equation

(3.16) and subscript r represents the restrained equation (3.12)) all the F values are highly significant ($F_{2,236}$ =4.61; $F_{2,40}$ = 5.18), suggesting that past price information has a very important effect on the current spot price. This could be evidence that the market is not wholly efficient and that lagged spot and futures prices do contain useful information in the forecasting of future spot prices. Further evaluation of efficiency can be made by examining the residuals from equation (3.12) to determine whether or not they are white noise.

The Jaque-Berra statistic (SPSS, 1975) is used for testing the residuals for normality. This is calculated as

$$JB = N\,(S^2/6 + K^2/24) \tag{4.2}$$

where N = number of observations, S is the skewness and K is the kurtosis in the sample. The JB statistics (with estimated probablility of normality in parentheses) for the annual 1998, three-month 1998 and three-month 1997 contracts were 14.953 (0.0), 2.86 (0.25) and 6.57 (0.04), respectively, implying that possibly only the estimated residuals of the three-month 1998 contract are normaly distributed. White's general heteroskedasticity test (Gujurati, 1995) showed further that the residuals are not white noise. The presence of heteroskedasticity most probably reflects the way in which the spot price data used in the analysis were recorded. The spot price on Monday, when the estimated spot price is calculated, is closest to the actual value. Then, as the week continues the published/reported spot price is held the same whereas the futures price will diverge away from the spot price. Therefore, every week the residuals from the regression of spot on futures price will diverge and then converge repeatedly. For this reason, these results should be viewed with caution.

4.2 Testing for Bias in the White Maize Contract

The results reported thus far provide evidence about the efficiency of the selected futures markets, but they do not show whether the cointegrating relationships are unbiased. However, when a series is I(1) this cannot be tested directly and an indirect method must be used. This test imposes the condition for an unbiased relationship ($b_0 = 1$)on the variables and tests the resulting residuals for stationarity. If the relationship between the price series is unbiased, the residuals ($\hat{a} + \hat{u}_t$)from the relationship will be stationary (Aulton, 1997) and are tested for stationarity using equation (4.4). The tau values estimated for the two 1998 contracts and the three-month 1997 contract are reported in Table 4.6.

$$Sp_t - b_0 Fp_t = (a + u_t) = \hat{e}_t \qquad (4.3)$$

$$\Delta \hat{e}_t = q\hat{e}_{t-1} \qquad (4.4)$$

Table 4.6 Testing for bias, white maize contracts

Contract	tau value	Biased
98	-2.206**	NO
3-98	-1.818*	NO
3-97	-1.541	YES

Note: **significant at the 5 percent level of probabililty

* significant at the 10 percent level of probability

Both of the 1998 contracts are unbiased in the prediction of the spot price, though only at the five percent or ten percent significance levels of probability. The three-month 1997 contract indicates a biased prediction of the spot price. These results again suggest that there could have been a degree of market adjustment toward improved efficiency of the local white maize futures market as market players gained more experience and liquidity improved from 1997 to 1998.

4.3 The Error Correction Mechanism

The results from estimating equation (3.17) are given in Table 4.7. These results show that short-run changes in Fp have significant positive effects on Sp for all the contracts. About six percent of the disequilibrium between the actual and the long-run (equilibrium) value of Sp is eliminated or corrected for each period of the 1998 annual contract. For the three-month 1998 contract, some 35.9 percent of the Sp is corrected for each period. This indicates that as the contract nears maturity, there is increased trading and activity on the contract. The slow correction of the short-run to the long-run is probably due to the method used to report the estimated spot prices. For this reason, it is expected that these results probably underestimate the actual value of the adjustment per period.

Table 4.7 Error correction model results, 1997 and 1998 white maize contracts

Contract	Coefficient of lagged residual in the ECM
98	-0.06**
3-98	-0.359**
3-97	-0.038**

Note: ** Significant at the 1 percent level of probability

4.4 Conclusion

In order for a futures market to play a role in price risk management it must be efficient and preferably unbiased. The study results suggest that in the 1998 contracts there is a long-run relationship between the spot price and futures price for white maize, whereas there is no evidence of a long-run relationship between the two price series for the 1997 contract. The 1998 contracts provide an unbiased prediction of the spot price though, predictably, the 1997 contract gives a biased prediction. However, both the 1997 and the 1998 contracts show evidence of inefficiency in that past prices, especially past spot prices, provide information that can be used to predict future spot prices. White maize futures prices, therefore, do not seem to incorporate all of the information needed to predict a future spot price. Therefore, since the inception of white maize futures contracts, agents in the market appear to have been able to profit from information embodied in past prices.

The three-month contracts for both 1997 and 1998, being closer to the contract delivery date and thus reflecting more recent information, are relatively more efficient than year-long contracts, but also suffer from past spot prices influencing the present spot price. Over the time period tested in this analysis, the futures market for white maize in South Africa exhibits some weak-form inefficiency; however, a process of adjustment toward efficiency is observed between the 1997 and 1998 contracts. This evidence, albeit limited, suggests that local producers of white maize can use SAFEX futures contracts to manage maize price risk, at least for a portion of their expected annual maize crop.

CHAPTER 5. YELLOW MAIZE RESULTS

The individual price series must first be tested for stationarity. The correlograms of all the price series for yellow maize are shown in Appendix 3. The three-month 1997 spot price series is a good indication of a non-stationary time series, whereas the annual futures price series is a stationary time series. As this is an informal test, the more formal unit root test for stationarity of price series is presented is covered in the next section.

5.1 Unit Root Tests for Stationarity of Price Series

The existence of a unit root in a price series indicates non-stationarity, and implies that conventional regression statistics are inappropriate (see Chapter 2). Test statistics can be based on the OLS estimation of suitably specified "augmented Dickey-Fuller" (ADF) regression equations for both time series (see Gujarati, 1995, for details of methodology). Table 5.1 shows the results of the Dickey-Fuller unit root test on the individual time series for yellow maize.

Table 5.1. Unit root test statistics of yellow maize contracts for July 1997

Series	tau statistic	DW	Series	tau statistic	DW
Fp	-4.350	2.498	3-Fp	-1.568	1.795
Sp	-0.166	1.965	3-Sp	-1.095	2.190

Notes: Fp = Futures price series
Sp = Spot price series
3-Fp = three-month Futures price series
3-Sp = three-month Spot price series

Appropriate ADF regressions showed that the Fp series for the annual July 1997 contracts is stationary as the absolute calculated tau statistic exceeds the critical value, whereas the Sp series is non-stationary. Therefore, the daily analysis cannot continue as the two different series cannot be compared. The three-month contract series were both non-stationary and so the analysis can continue with them. Table 5.2 shows the results of the unit root tests for the 1998 yellow maize price series.

Table 5.2 Unit root test statistics of yellow maize contracts for July 1998

Series	tau statistic	DW	Series	tau statistic	DW
Fp	-1.439	2.203	3-98	-1.467	1.984
Sp	-1.377	1.908	3-98	-1.433	1.925

Note: DW = the Durbin-Watson statistic

For the July 1998 contract, both the spot and futures price series are non-stationary for the annual and three-month contracts as the calculated value is less than the critical value of 2.58. The next step in the procedure is to test for cointegrating (long-run) relationships (necessary condition for efficiency) between the price series which are non-stationary.

5.2 Testing for Cointegration

Cointegrating equation regressions estimated by equation (3.12) for the non-stationary price series identified by unit root tests described in section 3.2.1.2 are presented in Table 5.3.

Table 5.3 Cointegrating regression estimates for yellow maize contracts

Contract	a	B_0	CRDW*	R^2
98	147	0.673	0.120	0.66
3-98	162	0.656	0.391	0.57
3-97	1048	2.949	0.245	0.78

Note: * CRDW is the Cointegrating Regression Durbin-Watson value

The Cointegrating Regression Durbin-Watson (CRDW) test suggests cointegration only between the three-month 1998 prices series. The slope coefficient estimators (b_0), which are consistent if the relevant series are cointegrated, but which may be subject to finite sample bias, are not that close to unity and therefore indicate bias (Aulton, 1997:416).The estimated intercepts (a) are far from zero. The hypothesis is formally tested for each regression in the next section. Table 5.4 shows the results from the Engle-Granger tests for stationarity of the residuals as estimated from equation (3.14) for both of the 1998 contracts and the 1997 three-month contract. The coefficient values are estimates of the parameter q as defined in equation 3.15.

The null hypothesis of a unit root is rejected for both of the 1998 contracts and the 1997 contract, indicating that all of the estimated residual series are stationary - strong evidence that a long-run relationship exists between the futures and spot prices (ie. they are all cointegrated). The regression coefficients for these cointegrating regressions are, therefore, consistent estimators of the long-run relationship between spot and futures prices.

Table 5.4 Tests for stationarity of residuals series estimated from cointegrating regression equations, 1997 and 1998 yellow maize contracts

Contract	Tau statistic	DW
98	-2.858**	2.26
3-98	-2.789**	1.75
3-97	-2.046*	1.936

Note: ** statistically significant at the 1 percent level of probability
* statistically significant at the 5 percent level of probability
DW = Durbin-Watson statistic

The DW statistics reveal no serial correlation in the residuals of any of the contracts. Figures 5.1, 5.2 and 5.3 present the relationship between the spot and the futures price series for yellow maize for the three-month 1997, three-month 1998 and the 1998 contracts. Cointegration exists in all of these contracts and this is evident from the graphs where the two series follow each other relatively closely.

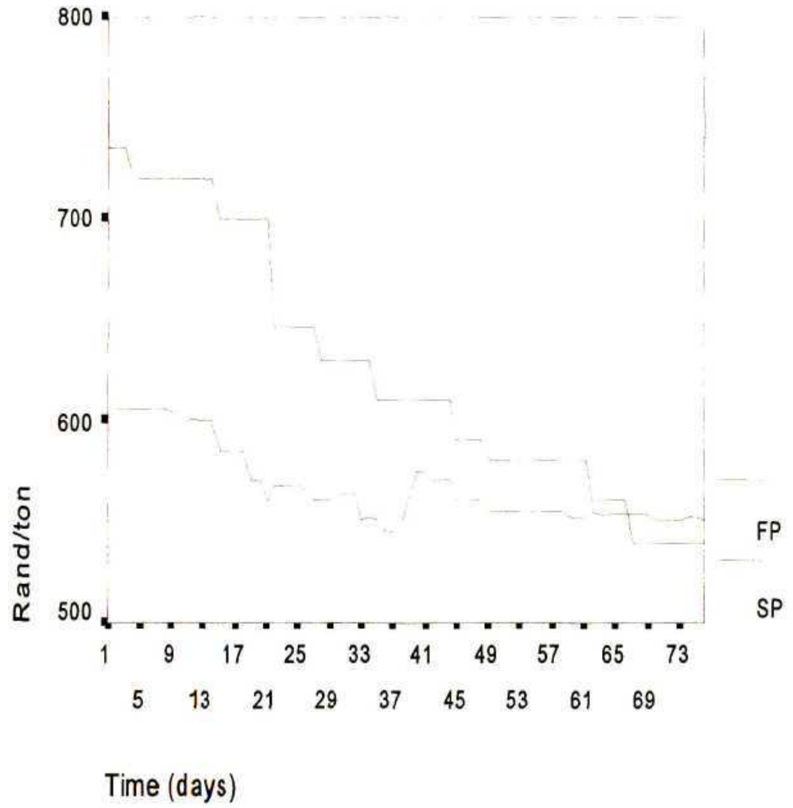


Figure 5.1 Fp vs Sp, yellow maize, three-month, 1997

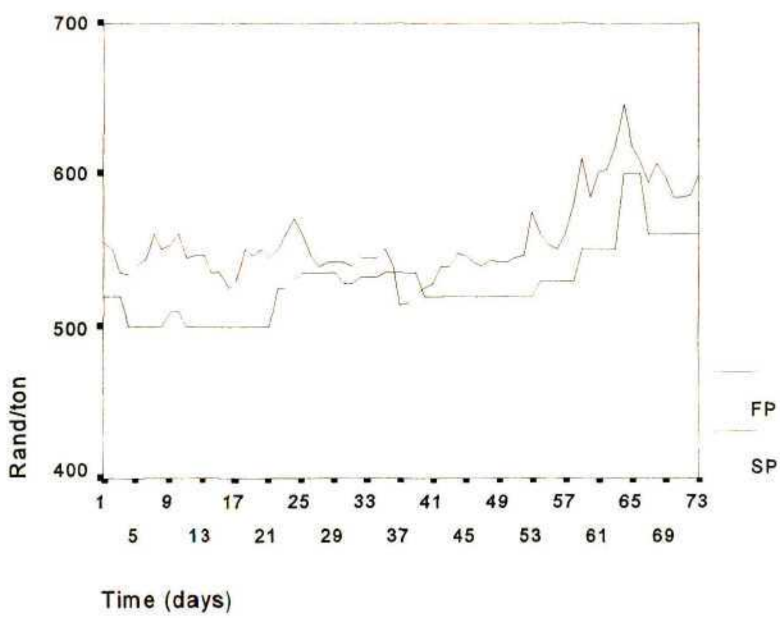


Figure 5.2 Fp vs Sp, yellow maize, three-month, 1998

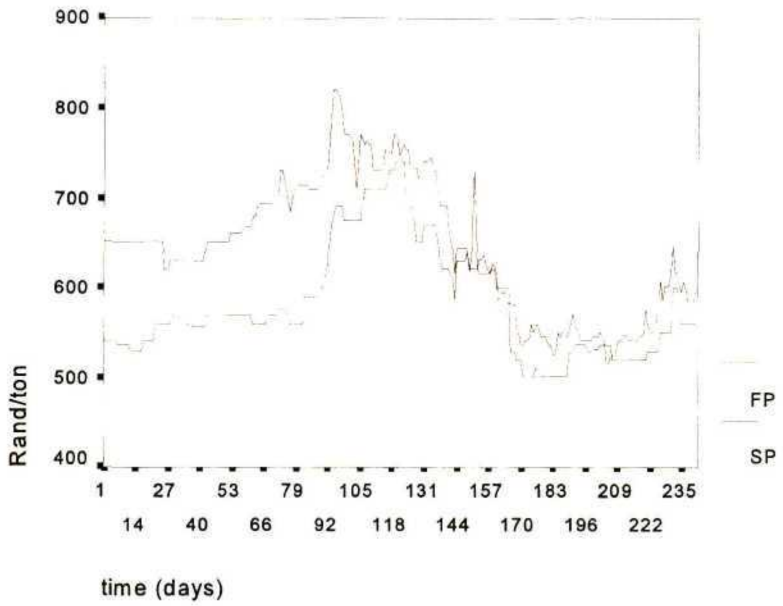


Figure 5.3 Fp vs Sp, yellow maize, 1998

Having established the necessary condition for efficiency in all the contracts, the second stage of testing is to consider whether the current futures price actually embodies all publicly available information for predicting a future spot price. The F- values presented in Table 5.5 test the joint null hypothesis that $B_1 = \partial = 0$ in equation (3.16) and were computed using equation (4.1).

Table 5.5 Second stage test of efficiency for yellow maize contracts

Contract	F Value of the joint hypothesis
98	1411**
3-98	101**
3-97	475**

Note: ** significant at the 1 percent level of probability

Using equation (4.1) all the F values are highly significant ($F_{2,236}$ =4.61; $F_{2,40}$ = 5.18), suggesting that past price information has a major effect on the current spot price. This could be evidence that the market is not wholly efficient and that lagged spot and futures prices do contain useful information in the forecasting of future spot prices. Further evaluation of efficiency can be made by examining the residuals to determine whether or not they are white noise.

The Jaque-Berra statistic (JB), equation (4.2), is used for testing the residuals for normality (SPSS, 1975). The JB statistics (with estimated probability of normality in parentheses) for the annual 1998, three-month 1998 and three-month 1997 contracts were 5.66 (0.075), 1.06 (0.630) and 9.54 (0.008), respectively, implying that only the three-month 1998 contract estimated residuals are normally distributed. White's general heteroskedasticity test (Gujurati, 1995) showed further that the residuals are not white noise. The heteroskedasticity most probably reflects the way that the spot price data used in the analysis were recorded. The spot price on Monday, when the estimated spot price is calculated, is closest to the actual value. Then, as the week continues the reported spot price is held the same whereas the futures price will diverge away from the spot price. Therefore, every week the residuals from the regression of spot on futures price will diverge and then converge repeatedly.

5.3 Testing for Bias

The results given in sections 5.1 and 5.2 provide evidence about the efficiency of the selected futures markets, but they do not show whether the cointegrating relationships are unbiased. However, when a series is I(1) this cannot be tested directly and an indirect method must be used. This test imposes the condition for an unbiased relationship on the variables, and tests the resulting residuals for stationarity. If the relationship between the price series is unbiased, the residuals from the relationship will be stationary (Aulton, 1997). Using equations (4.3) and (4.4), the tau values estimated for the two 1998 contracts and the three-month 1997 contract are reported in Table 5.6.

Table 5.6 Testing for bias in yellow maize contracts

Contract	tau value	Biased
98	-1.874*	NO
3-98	-1.464	YES
3-97	-2.064**	NO

Note: **significant at the 1 percent level of probability

* significant at the 5 percent level of probability

Both the annual 1998 and three-month 1997 futures contract price series are unbiased predictors of the spot price series, at the five percent and one percent significance levels respectively. The fact that price is a perception of supply and demand, may explain bias in the three-month 1998 contract. The Rand was falling at an unprecedented rate prior to, and after, the maturity of the July contract. This uncertainty may indeed cause incorrect price perceptions and result in biased perceptions of the value of the future cash price.

5.4 The Error Correction Mechanism

The results of estimating equation (3.17) for each contract are given in Table 5.7. These results show that short-run changes in Fp have significant positive effects on Sp for all the contracts. About six percent of the disequilibrium between the actual and the long-run, or equilibrium, value of Sp is eliminated or corrected for each period of the 1998 annual contract. For the three-month 1998 contract, some 22 percent of the Sp is corrected for each period. This indicates that as the contract nears maturity, there is increased trading and activity on the contract. The slow correction of the short-run to the long-run is probably due to the method used to report the estimated spot prices. For this reason it is expected that these results probably underestimate the actual value of the adjustment per period.

Table 5.7: Error correction model results, 1997 and 1998 yellow maize contracts

Contract	Coefficient of lagged residual in the ECM
98	-0.064**
3-98	-0.224**
3-97	-0.087**

Note: ** Significant at the 1 percent level of probabililty

5.5 Conclusion

Results suggest that for both the 1997 and 1998 contracts there is a long-run relationship between the spot price and futures price for yellow maize. The annual 1998 and three-month 1997 futures contract prices series were unbiased predictors of the corresponding spot price series. Local producers of yellow maize can use nationally quoted SAFEX yellow maize futures contract prices to predict the likely direction and level of "local" spot prices. This can help them to make better decisions regarding whether or not to use futures trading - at least for a portion of their expected annual maize crop - to hedge against maize price risk, when to liquidate hedge positions, and in price discovery negotiations with feedlotters, millers and other yellow maize traders. However, both the 1997 and the 1998 contracts show evidence of inefficiency in that past prices, especially past spot prices, provide information that can be used to predict future spot prices. Yellow maize futures prices, therefore, do not seem to incorporate all the information needed to predict a future spot price. Agents in the SA yellow maize futures market thus appear to have been able to profit from information embodied in past prices during 1997 and 1998.

The three-month contracts for both 1997 and 1998, though being closer to the contract delivery date and thus reflecting more recent information, show no better results than the year-long contract, and also suffer from past spot prices influencing the present spot price. Similar relationships between futures and spot prices for white maize in South Africa were identified. The major difference was the finding of a long-run relationship for yellow maize in the 1997 contract whereas no long-run relationship was found for the white maize 1997 contract.

South Africa is regarded as a leader in the world market for white maize (SAFEX, 1998), whereas for yellow maize which is traded on the CBOT, South Africa is a price taker. Therefore, the import/export parity cap is very much in existence for yellow maize. In addition, yellow maize is seen as having a more stable price than white maize so SAFEX would be able to track these adjustments more accurately, lending itself to the finding that cointegration exists in the 1997 yellow maize contract. Yellow maize is predominantly used for animal feeds and white maize is mainly used for human consumption. Yellow maize consumers are more price sensitive than white maize consumers because their margins are generally smaller (Elliot, 1998). All arguments support the finding that the yellow maize contract for 1997 shows evidence of a long-run relationship between spot and futures prices whereas the white maize 1997 contract does not, even though white maize contracts trade at higher contract volumes in South Africa.

The finding that the three-month 1998 yellow maize contract gave a biased prediction of the spot price, against expectations, might be attributed to the fact that the value of the Rand was falling substantially at the time. This led to uncertainty in the market and overestimation of the spot price. This problem may well be smoothed out in the year-long run contract by the number of observations. The problem would not affect the white maize contract as it did the yellow maize contract because, as stated, white maize is not traded internationally as much as yellow maize and is not, therefore, affected by changing exchange rates as is yellow maize.

CONCLUSIONS

Commodity futures markets can be a useful tool for price risk management if they are efficient (futures prices reflect all known information) and futures prices are unbiased predictors of future spot (cash) prices. Given that there is no published research on the efficiency of South African futures markets for white and yellow maize which were established in mid-1996, this study has examined the performance of annual and three-month July white and yellow maize contracts over the last two years using cointegration analysis.

Theory reviewed indicates that there should be a relationship between the spot and futures price series for white and yellow maize if these futures markets are efficient. Cointegration analysis establishes whether or not there is a long-run economic relationship between the two price series for each type of maize product. If spot prices are cointegrated with national futures prices, then the two price series do not markedly move apart through time and thus have a long-run relationship. This is a necessary condition for market efficiency.

For the white maize futures market, results indicate that a process of adjustment or learning by market participants has taken place between 1997 and 1998. There is no evidence of cointegration in the 1997 price series data, whereas spot and futures prices were cointegrated in the 1998 contract. Price discovery was taking place and information was being transmitted between the two markets in 1998, but not in 1997. The transfer of data between the futures and the spot markets was relatively slow, as indicated by the error correction mechanism (35.9 percent was the highest) though this is probably understated because spot prices used in this study were updated weekly and not daily.

The spot and futures price series for yellow maize show evidence of cointegration in 1997 and 1998. This is probably due to yellow maize being traded internationally and therefore having a relatively greater volume of trade and hence more information available about crop and market prospects compared to white maize. White maize prices are led mostly by domestic supply which, when it changes, leads to a change in the price of white maize, resulting in an increased fluctuation of prices. Yellow maize prices follow the more stable world price series more closely than white maize (local farmers are price takers), therefore there is more likely to be a long-run relationship between the domestic yellow maize futures and spot prices.

Evidence of cointegration implies that local maize farmers can use price information derived from recently introduced white and yellow maize futures contracts to forecast local white and yellow maize cash prices. This can help them to decide whether, and what portion, of their crop to hedge against price risk by using futures contracts, and they can use the information in discovering maize prices when negotiating with millers and other traders. Both markets, however, suffer from past spot price information having a significant effect on current spot prices. This violation of efficiency implies that traders and farmers can use this information to make abnormal profits. The availability of reliable price information, and the education of potential users of SAFEX is of paramount importance to the successful implementation of futures trading. Continued marketing and education seminars need to be conducted to increase awareness of the advantages of using this price risk management method. The SAFEX white and yellow maize contracts are currently viable as local maize farmers and traders need to manage variable maize prices resulting from variable annual rainfall which markedly affects local yields.

The data used in the analysis were not ideal as the reported spot price series were based on the weekly estimates of the five major players in the local maize market. Consultation with industry players, however, indicates that this estimate was the best available data source. This identifies a market price reporting opportunity, as more reliable white and yellow maize spot price reporting series need to be developed, probably on a regional and daily basis. At present, market players use the SAFEX yellow maize futures price as a basis for estimating a spot price, by discounting transport costs to the specific region. This is a relatively simple method, though it is flawed by varying supply in different locations. An improved price information service to farmers and other users may help participants to improve forecasts of future spot prices. This will depend upon the costs of acquiring additional information relative to the benefits. Government may have a role to play in improving maize price reporting information, and a reliable legal system is obviously needed to enforce contracts. As yet, no trader in breach of contract has been taken to court and therefore no precedent has been set, due largely to measures taken internally by SAFEX. The results given in this study provide support for continuing education efforts to educate potential users as to the possible benefits of trading on SAFEX to manage white and yellow maize price risk.

SAFEX can be used as a source of trading for high quality maize (grades of maize are set). The lowering of existing tariff structures between countries, if the free trade agreement of all SADC members were to be ratified, would facilitate increased trade between South Africa and the other Southern African countries and encourage increased use of SAFEX. This increased volume would improve the liquidity of contracts on SAFEX.

Further research on South African futures markets could investigate whether cointegration between spot and futures prices leads to improved hedging effectiveness and whether cointegration can improve price forecasting. An improved model that takes into account basis convergence may further enhance the models developed in this study.

SUMMARY

With the abolition of the Maize Board and the deregulation of maize marketing in South Africa since 1996, farmers now have to market their own product in an environment of uncertain weather conditions and prices. Futures contract trading on SAFEX provides a useful tool to manage price risk. An efficient futures market is one in which pertinent fundamental information is rapidly incorporated into the equilibrium price. A futures market displays forward pricing efficiency if it correctly reflects fundamental storage market information and, hence, optimally allocates inventories over time. Futures markets perform important functions of price discovery and price stability. The issue of market efficiency in commodity futures is important from both a public and a private perspective. An efficient futures market should provide a forecast of the future spot (cash) price of a commodity which reflects all publicly available information. This serves as a medium through which traders can manage risk by fixing price in advance of transactions relating to the physical commodity. From a public policy perspective this attribute would suggest that futures markets are potentially a useful alternative to more established forms of market intervention particularly with respect to price stabilisation policies. The key feature of futures contracts in this context is their ability to predict prices at a specified future date both efficiently and in an unbiased fashion. Thus, an empirical analysis of efficiency and unbiasedness is central to any assessment of the value of futures markets.

The specific aim of this study, therefore, was to test the efficiency of the South African futures markets for both yellow and white maize. The analysis was concentrated on the maize producer market in order to give producers and producer market participants more reliable information about cash / futures price relationships. Review of past research suggests that the cointegration

technique is best suited for the research method as it can account for non-stationarity in the price series. Previous studies have given varying results, but cointegration is found relatively consistently in futures and cash price time series, and there persists a lead-lag relationship from the futures to the cash market. Efficiency of futures markets seems to be correlated with the degree of market liquidity.

Following Aulton et al. (1997), cointegration tests of the relationship between futures and producer market prices, and error correction (causality) models, were conducted to determine the nature of lead-lag relationships when local maize futures and spot price series are cointegrated. The data used were the daily spot and futures prices that are published by SAFEX in 1997 and 1998. The null hypothesis tested was that the spot and futures markets are not cointegrated.

Cointegration was found in the 1998 white maize contracts, but not in the 1997 white maize contacts. This is evidence of a learning process by market participants adjusting to using new methods for managing maize price risk. For yellow maize, there was evidence of cointegration in the three-month 1997 contract and in the 1998 contracts. This reflects the fact that yellow maize is traded internationally to a much greater extent than white maize. Yellow maize differs in that it is more susceptible to world market price fluctuations and exchange rates. There was a violation of efficiency for both the yellow and white maize contracts in that past spot prices provided information that could be used to predict current spot prices, thus offering traders the opportunity of making abnormal profits.

Reliable local information on maize spot prices is lacking. Although SAFEX data provide a good estimation of the future spot price, calculated from data provided by market participants, there is no existing price information system that reports on regional spot prices. The development of such a spot price reporting system would enable price information to be more easily disseminated to market participants. Study results suggest that South African maize farmers can use futures trading to successfully hedge a portion of their crop against price risk. Futures prices on SAFEX also provide information that can be used to forecast local spot prices and hence serve as a basis for negotiating prices with millers and other traders.

REFERENCES

AULTON, A. J., ENNEW, C. T. and RAYNER, A. J. (1997). Efficiency Tests of Futures Markets for UK Agricultural Commodities. *Journal of Agricultural Economics*, 48: 408-424.

BERG, D. A. (1981). The Efficiency of the Wheat Futures Market. North Dakota State University. *M.S.* thesis. University Microfilms International.

BESSLER, D. A. and COVEY, T. (1991). Cointegration: Some Results on U.S. Cattle Prices. *Journal of Futures Markets*, 11: 461-474.

BLANK, S. C. (1989). Research on Futures Markets: Issues, Approaches, and Empirical Findings. *Western Journal of Agricultural Economics*, 14: 126-139.

BODIE, Z., KANE, A. and MARCUS, A.J. (1995). Essentials of Investments. Second Edition. The Irwin Series in Finance, Yale University, USA.

BOWN, A (1998). Commercial Farmers' Choices Amongst Maize Marketing Alternatives in the Northwest Province, Mpumalanga and Free State. Unpublished Seminar, Department of Agricultural Economics, University of Natal, Pietermaritzburg.

BOYD, M. S. and BRORSEN, B. W. (1991). Factors Related to Futures Market Disequilibrium. *Canadian Journal of Agricultural Economics*, 39: 769-778.

BRORSEN, B. W., BAILEY, D and RICHARDSON, J. W. (1984). Investigation of Price Discovery and Efficiency for Cash and Futures Cotton prices. *Western Journal of Agricultural Economics*, 9: 170-176.

BUNTING, C. (1997). The viability of electronic marketing of grains in Southern Africa. Unpublished report, Department of Range and Forestry Resources, University of Natal, Pietermaritzburg.

CBOT. (1998a). Agricultural futures for the beginner. *General information series* , No. 1.

CBOT. (1998b). Improving margins using basis. *Grain Merchandiser Series*, No. 2.

CBOT. (1998c). Understanding Ag Fundamentals. *General information series* , No. 4.

CHOWDHURY, A. R. (1991). Futures Market Efficiency. *Journal of Futures Markets*, 11: 577-589.

CORNELL, B. (1981). The Relationship between Volume and Price Variability in Futures Markets. *Journal of Futures Markets*, 1: 303-316.

CROWDER, W. J. and HAMED, A. (1993). A Cointegration Test for Market Efficiency. *Journal of Futures Markets*, 13: 933-941.

DICKEY, D. A. and ROSSANNA, R. J. (1996). Cointegrated Time Series: A Guide to

Estimation and Hypothesis Testing. *Oxford Bulletin of Economics and Statistics, 58*: 325-342.

DICKEY, D.A. and FULLER, W.A. (1981). Likelihood Ratio Statistics for Autoregressive Time Series Model Specification. *Econometrica*, 49: 1057-1072.

DICKSON, I. 1998. Personal communication. Agri-Marketing Exchange (Pty) Ltd (AGMEX), Pretoria.

ELAM, E. and DIXON, B. L. (1988). Examining the Validity of a Test of Futures Market Efficiency. *Journal of Futures Markets*, 8: 365-372.

ELLIOT, M.B. (1998). Elliot Grains, Pretoria, Personal Communication.

ELLIOT, M.B. (1986). An Economic Analysis of an Opinion Survey of South African Beef Farmers. Unpublished Msc Agric Thesis, Department of Agricultural Economics, University of Natal, Pietermaritzburg.

ELLIOT, M. B. (1994). Developments in South African Maize Marketing. University Lecture delivered at the University of Natal, Pietermaritzburg, 17 August 1994.

ENGLE, R.F. and GRANGER, C. W. J. (1987). Cointegration and Error Correction: Representation, Estimation, and Testing. *Econometrica*, 55: 251-276.

ENNEW, C. T., MORGAN, C. W. and RAYNER, A. J. (1992). Objective and Subjective

Influences on the Decision to Trade on the London Potato Futures Market. *Journal of Agricultural Economics*, 43: 160-173.

FALKENA, H. B., KOK, W. J., LUUS, C. W. and RAINE, G. (1991). *The Futures Market*. Southern Book Publishers, Johannesburg.

FORTENBERY, T. R. and ZAPATA, H. O. (1993). An Examination of Cointegration Relations between Futures and Local Grain Markets. *Journal of Futures Markets*, 13: 921-932.

FRANK, D. (1992). Agricultural Commodity Futures Markets in South Africa. *Agrekon*, 31: 313-320.

FULLER, W.A. (1976). *Introduction to Statistical Time Series*. John Wiley and Sons, New York.

GAY, S. (1998). Agricultural bilateral trade agreements between South Africa and the European Union: Implications for the South African orange industry. Unpublished Seminar. Department of Agricultural Economics, University of Natal, Pietermaritzburg.

GARBADE, K. D. and SILBER, W. L. (1982). Price Movements and Price Discovery in Futures and Cash Markets. *The Review of Economics and Statistics*, 64: 289-297.

GARCIA, P., LEUTHOLD, R. M., FORTENBERY, T. R. and SARASSORO, G. F. (1988). Pricing Efficiency in the Live Cattle Futures Market: Further Interpretation and Measurement. *American Journal of Agricultural Economics*, 70:162-169.

GOODWIN, B.K. and SCHROEDER, TC. (1994). Human Capital, Producer Education and the Adoption of Forward-Pricing Methods. *American Journal of Agricultural Economics*, 76: 936-947.

GOSS, B. A. and STEIN, J. L. (1992). Price Discovery and Price Determination. Supplement to the Economic Record: Special Issue on Futures Markets: 1-9

GOSS, B. A., GULAY AVSAR, S. and CHAN, Siang-Choo. (1992). Rational Expectations and Price Determination in the US Oats Market: Supplement to the Economic Record. Special Issue on Futures Markets: 16-25.

GRAVELET-BLONDIN, R. (1998). Personal Communication, South African Futures Exchange (SAFEX), Houghton, Johannesburg.

GROBLER, J.E. 1998. The Changing Market for Maize in South Africa. *Address given at the Grain Organisation of South Africa (GOSA) symposium,* April 17, 1998.

GUJURATI, D. (1995). *Basic Econometrics.* Third Edition. McGraw-Hill International Editions, New York.

HUDSON, D., ELAM, E., ETHRIDGE, D. and BROWN, J. (1996). Price Information in Producer Markets: An Evaluation of Futures and Spot Cotton Price Relationships in the Southwest Region Using Cointegration. *Agribusiness*, 12: 363-369.

JOHANSEN, S. (1988). Statistical Analysis of Cointegration Vectors. *Journal of Economic Dynamics and Control*, 12: 231-254.

JUST, R.E. and RAUSSER, G.C. (1981). Commodity Price Forecasting with Large Scale Econometric Models and the Futures Market. *American Journal of Agricultural Economics*, 63: 197-208.

KENYON, D., JONES, E. and McGUIRK, A. (1993). Forecasting Performance of Corn and Soybean Harvest Futures Contracts. *American Journal of Agricultural Economics, 75*: 399-407.

KOFI, T.A. (1973). A Framework for Comparing the Efficiency of Futures Markets. *American Journal of Agricultural Economics,* 54: 584-593.

KOONTZ, S. R., HUDSON, M. A. and HUGHES, M. W. (1990). Rational Price Formation in the Live Cattle Futures Market. *Current Farm Economics*, 63: 30-42.

KREMERS, J. J. M., ERICSSON, N. R. and DOLADO, J. J. (1993). The Power of Cointegration Tests. *Oxford Bulletin of Economics and Statistics*, 55: 325- 343.

LAI, K. S. and LAI, M. (1991). A Cointegration Test for Market Efficiency. *Journal of Futures Markets*, 11: 567-575.

LEUTHOLD, R. M., GARCIA, P., CHAHERLI, N. (1992). *Information, Pricing, and the Efficiency in Cash and Futures Markets: The Case of Hogs.* The Economic Record:

Supplemental Edition on Futures Markets. Burwood Co., Victoria. 27-33.

LEUTHOLD, R. M. and PETERSON, P. E. (1983). The Cash Futures Price Spread for Live Hogs. *North Central Journal of Agricultural Economics,* 5: 25-29.

LEUTHOLD, R. M., JUNKUS and CORDIER, M. (1989). *The Theory and Practice of Futures Markets*. Lexington, United Kingdom.

LU, R. (1994). Cointegration Relations between Spot and Futures Prices for Selected Commodities: Implications for Hedging and Forecasting. Unpublished PhD thesis, University of Illinois at Urbana-Champaign, USA.

LUBBE, W. F. (1991). Normalising Competition in Agricultural Marketing- The Case for Red Meat in South Africa. *Agrekon*, 30: 253-258.

LUBBE, W. F. and GROENEWALD, J. A. (1992). Market Reform in the Red Meat Industry. *Agrekon*, 31: 294-301.

MACKINNON, J.G. (1991). Critical Values of Cointegration Tests in ENGLE, R.F. and GRANGER, C.W.J. (eds). *Long Run Economic Relationships: Readings in Cointegration.* Chapter 3, Oxford University Press, New York.

MILLS, T. C. (1993). *The Econometric Modelling of Financial Time Series*. Cambridge University Press. United Kingdom.

MIELIES/MAIZE. (1997). Information as the Key to Price Determination. July 1997:5.

NAIK, G. and LEUTHOLD, R. M. (1991). A Note on the Factors Affecting Corn Basis Relationships. *Southern Journal of Agricultural Economics*, 23: 147-153.

NATIONAL DEPARTMENT OF AGRICULTURE, (1998). Personal Communication. Pretoria.

NIE, N.H., HULL, C.H., JENKINS, J.G., STEINBRENNER, K. And BENT, D.H. (1975). *Statistical Package for the Social Sciences (SPSS)*. Second Edition. New York, McGraw-Hill International Editions.

PASOUR, E. C. (1981). A Further Note on the Measurement of Efficiency and the Economies of Farm Size. *Journal of Agricultural Economics, 32*: 135-147.

PECK, A. E. and WILLIAMS, J.C. (1992). *Deliveries on Commodity Futures Contracts*. Supplement to the Economic Record: Special Edition on Futures Markets. Burwood, Victoria. 63-74.

PENNINGS, J. M. E. and MEULENBERG, M. T. G. (1997). The Hedging Performance in New Agricultural Futures Markets: A Note. *Agribusiness,* 13: 295-300.

SAFEX. (1998a). The home page of the South African Futures Exchange. Http//www.safex.co.za.

SAFEX. (1998b). Personal Communication with R. Gravelet-Blondin and C.Sturgess.

SCHROEDER, T. C. and GOODWIN, B. K. (1991). Price Discovery and Cointegration for Live Hogs. *Journal of Futures Markets*, 11: 685-696.

SHELDON, I. M. (1987). Testing for Weak Form Efficiency in New Agricultural Futures Markets: Some UK Evidence. *Journal of Agricultural Economics*, 38: 51-64.

SHAPIRO, B.I. and BRORSEN, B.W. (1998). Factors Affecting Farmers' Hedging Decisions. *North Central Journal of Agricultural Economics*, 10: 145-153.

THOMPSON, S. R., EALES, J. S. and HAUSER, R. J. (1990). An Empirical Analysis of Cash and Futures Grain Price Relationships in the North Central Region. *North Central Journal of Agricultural Economics*, 12: 241-254.

TOMEK, W. G. (1997). Commodity Futures Prices as Forecasts. *Review of Agricultural Economics*, 19: 23-44.

TOWNSEND, R.F. (1998). Econometric Methodology II: Strengthening Time Series Analysis. *Agrekon*, 37: 83-98.

VAN DER VYVER, A. and VAN ZYL, J. (1989). A Futures Market for Maize in South Africa. *Agrekon*, 28: 77-84.

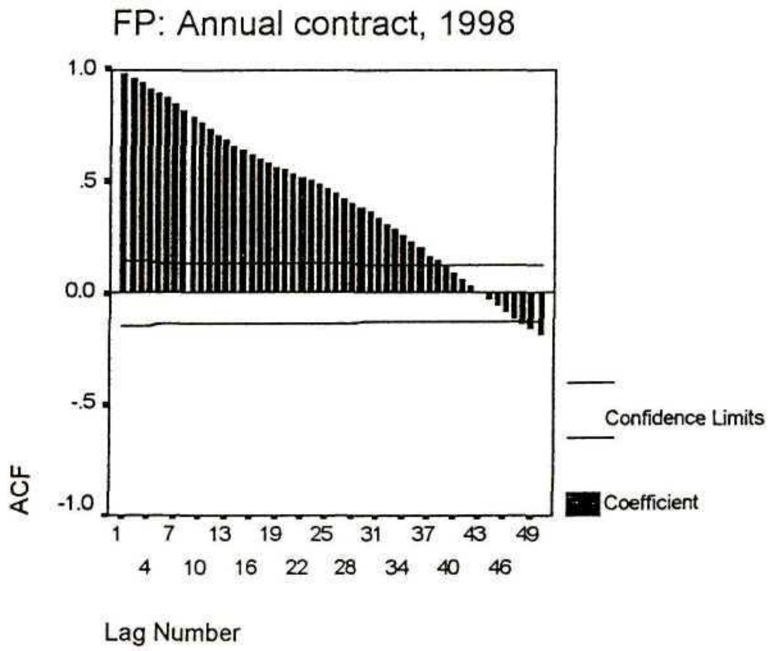
VAN DER VYVER, A. (1994). Viewpoint: Futures Contracts for Agricultural Commodities- Is the Time Ripe For South Africa? *Agrekon*, 33: 50-56.

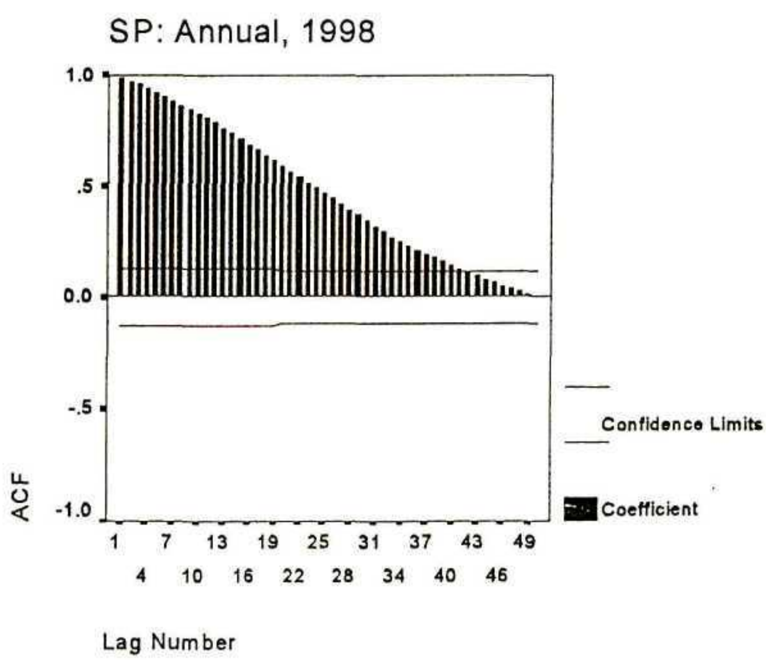
VAN ZYL, J. (1986). A Statistical Analysis of the Demand for Maize in South Africa, *Agrekon*, 25 (3): 45-51.

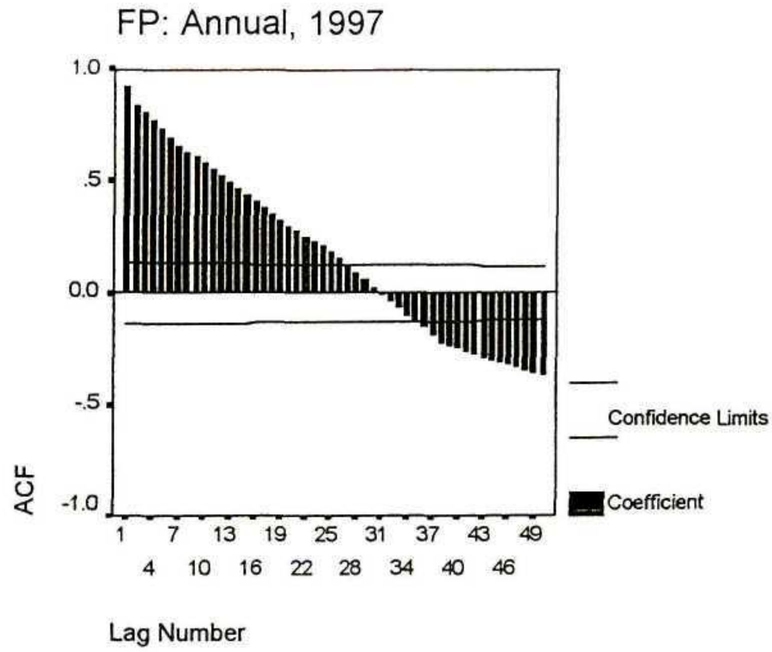
WANG, G. H. K. and YAU, J. (1994). A Time Series Approach to Testing For Market Linkage: Unit Root and Cointegration Tests. *Journal of Futures Markets*, 14: 457-474.

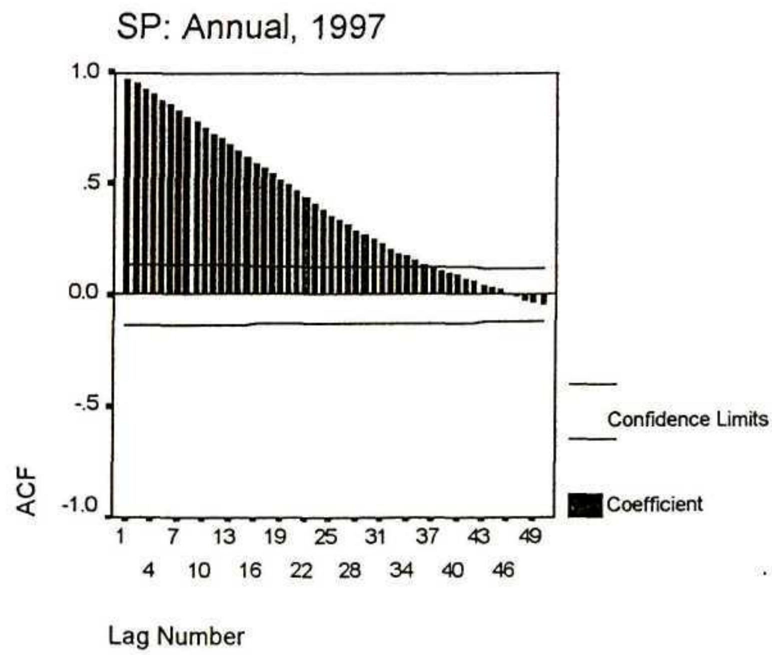
WOODBURN, M.R., ORTMANN, G.F. and LEVIN, J.B. (1995). Sources and Management of Risk: Evidence from Commercial Farmers in KwaZulu-Natal. *South African Journal of Economic and Management Sciences*, 17: 46-63.

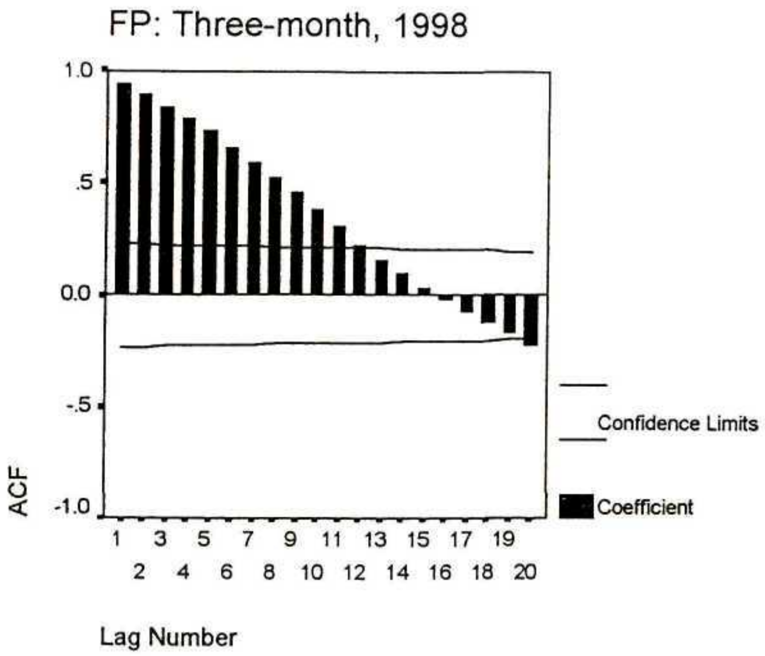
APPENDIX 2: CORRELOGRAMS OF INDIVIDUAL WHITE MAIZE PRICE SERIES

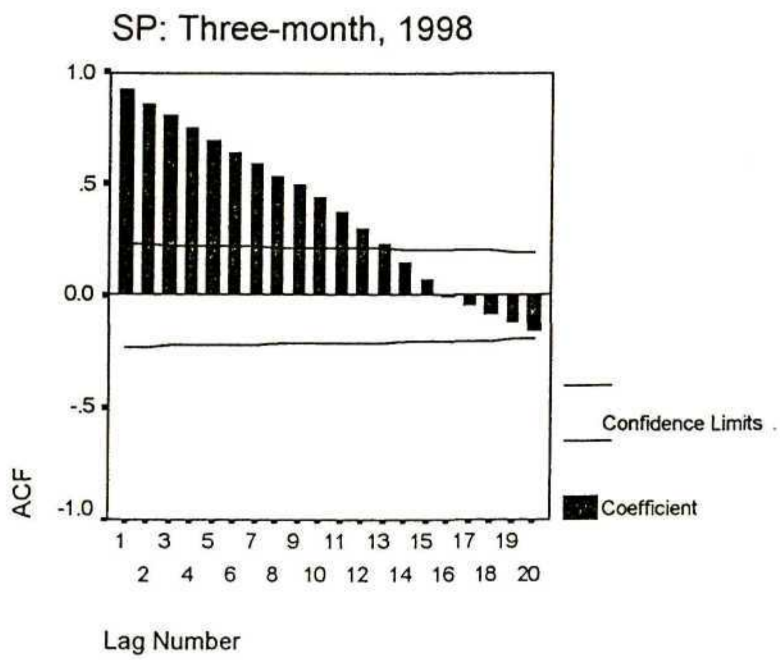




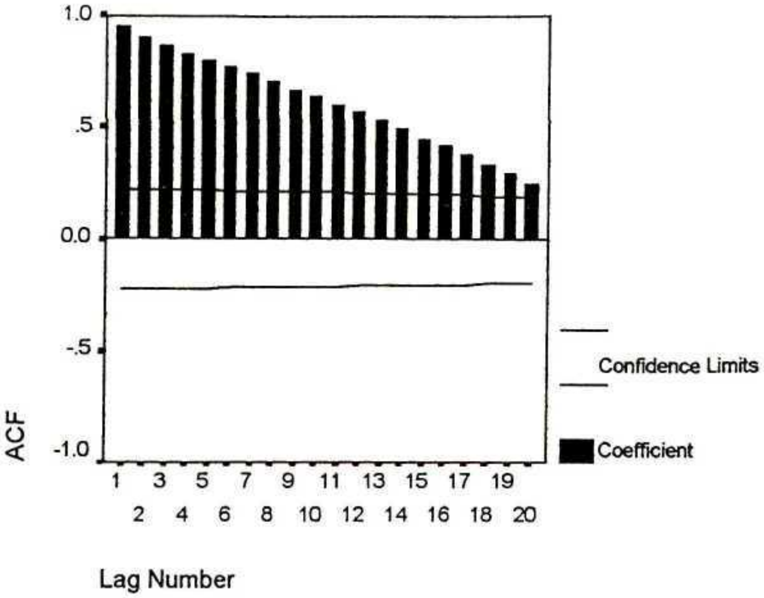

FP: Annual, 1997
1.0
.5
0.0
-.5
-1.0
ACF
1 7 13 19 25 31 37 43 49
4 10 16 22 28 34 40 46
Lag Number
Confidence Limits
Coefficient


SP: Annual, 1997
1.0
.5
0.0
-.5
-1.0
ACF
1 7 13 19 25 31 37 43 49
4 10 16 22 28 34 40 46
Lag Number
Confidence Limits
Coefficient

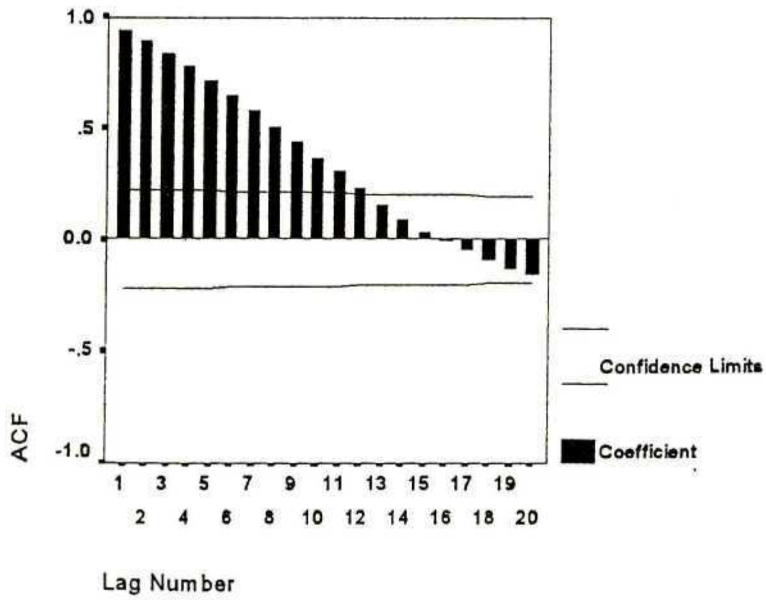

FP: Three-month, 1998
1.0
.5
0.0
-.5
-1.0
ACF
1 3 5 7 9 11 13 15 17 19
2 4 6 8 10 12 14 16 18 20
Lag Number
Confidence Limits
Coefficient


SP: Three-month, 1998
1.0
.5
0.0
-.5
-1.0
ACF
1 3 5 7 9 11 13 15 17 19
2 4 6 8 10 12 14 16 18 20
Lag Number
Confidence Limits
Coefficient

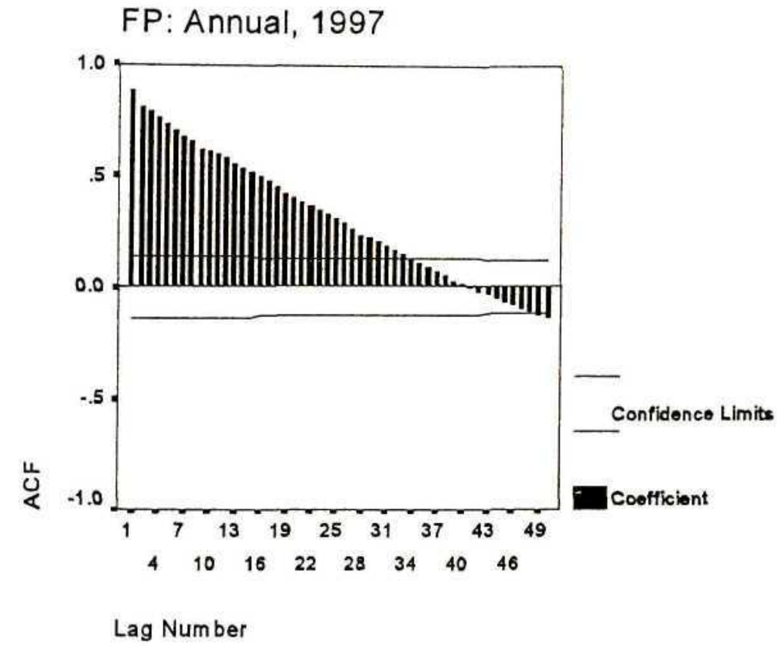
SP: Three-month, 1997

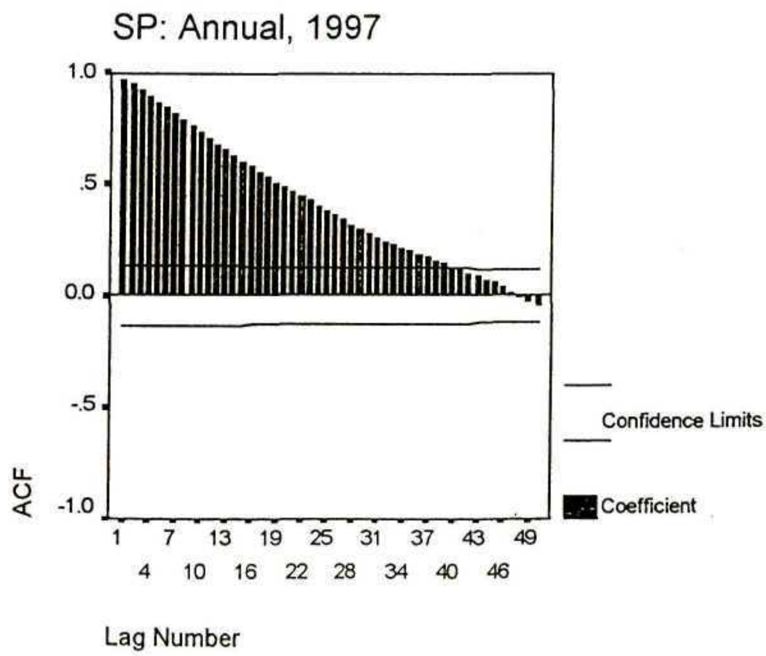


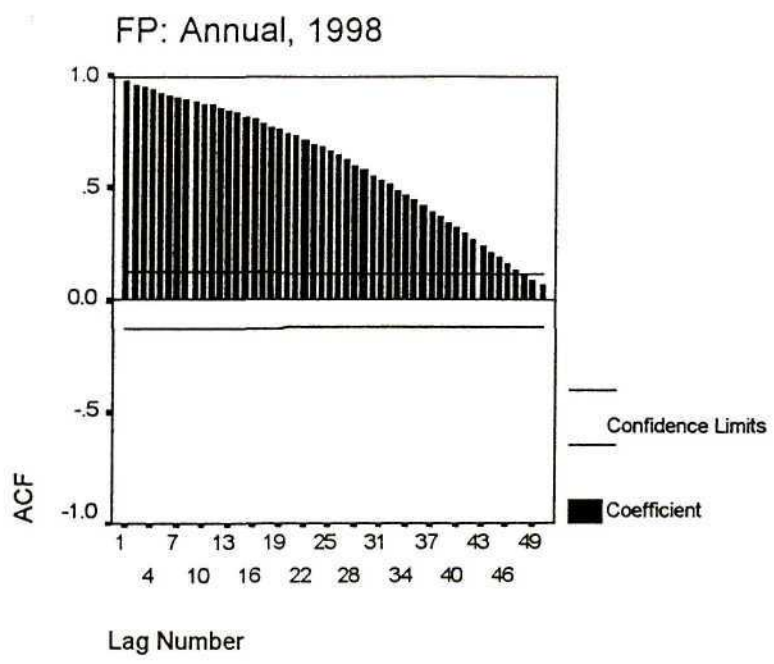
FP: Three-month, 1997

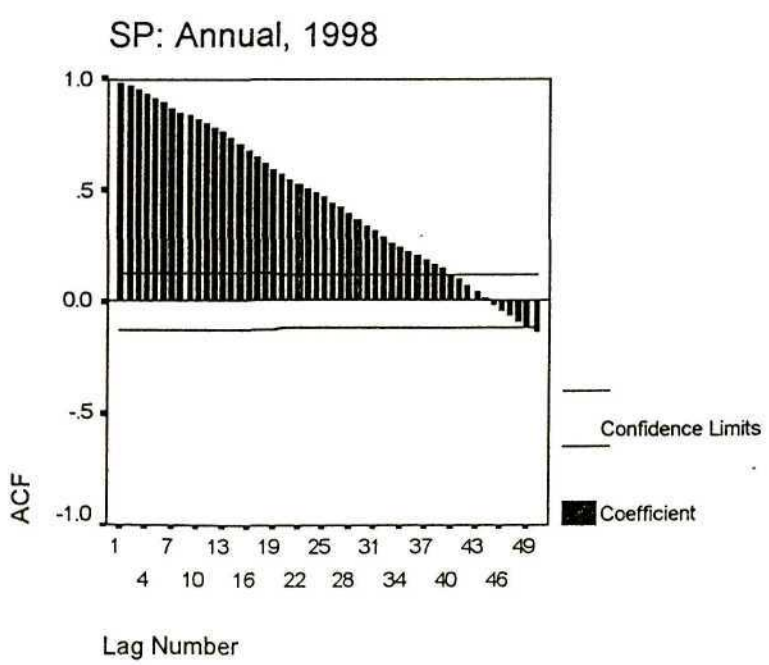


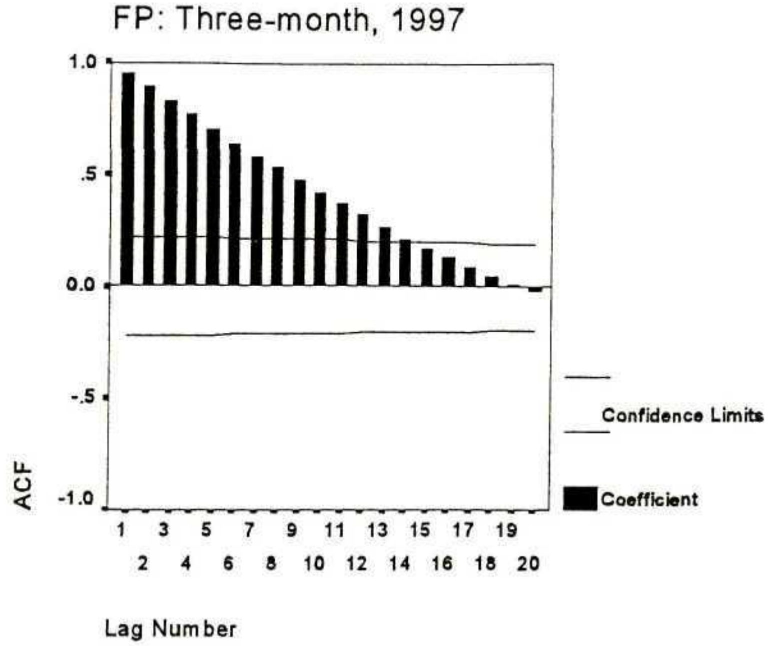
APPENDIX 3: CORRELOGRAMS OF INDIVIDUAL YELLOW MAIZE PRICE SERIES



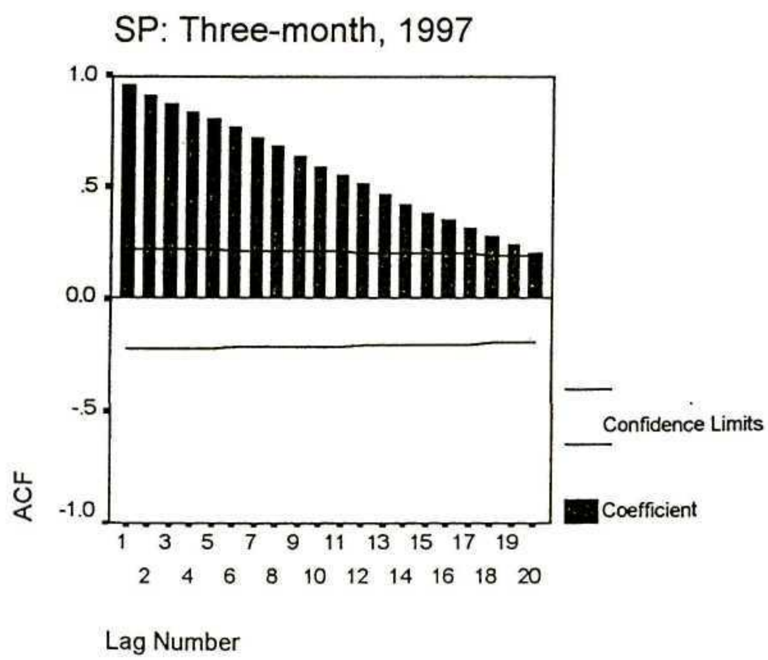



FP: Annual, 1998
1.0
.5
0.0
-.5
-1.0
ACF
1
7
13
19
25
31
37
43
49
4
10
16
22
28
34
40
46
Lag Number
Confidence Limits
Coefficient

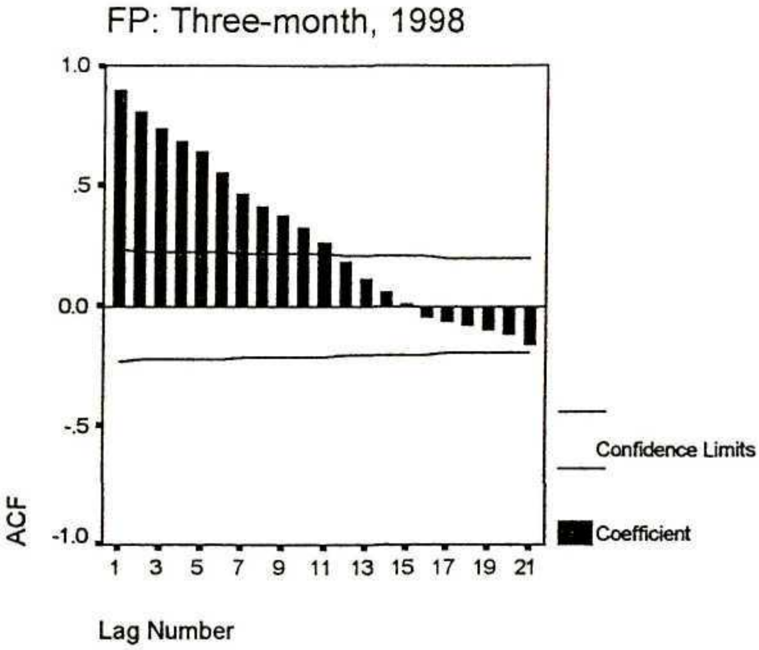

SP: Annual, 1998
1.0
.5
0.0
-.5
-1.0
ACF
1
7
13
19
25
31
37
43
49
4
10
16
22
28
34
40
46
Lag Number
Confidence Limits
Coefficient

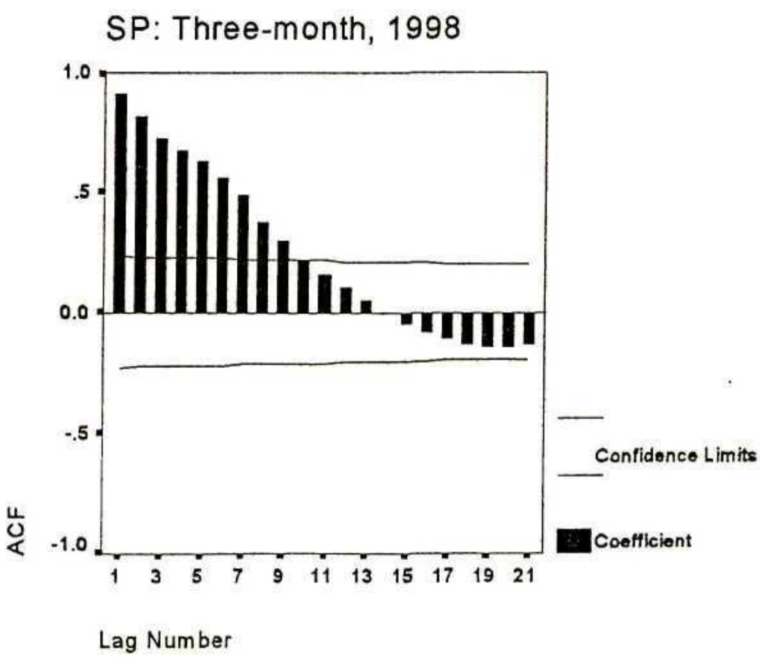


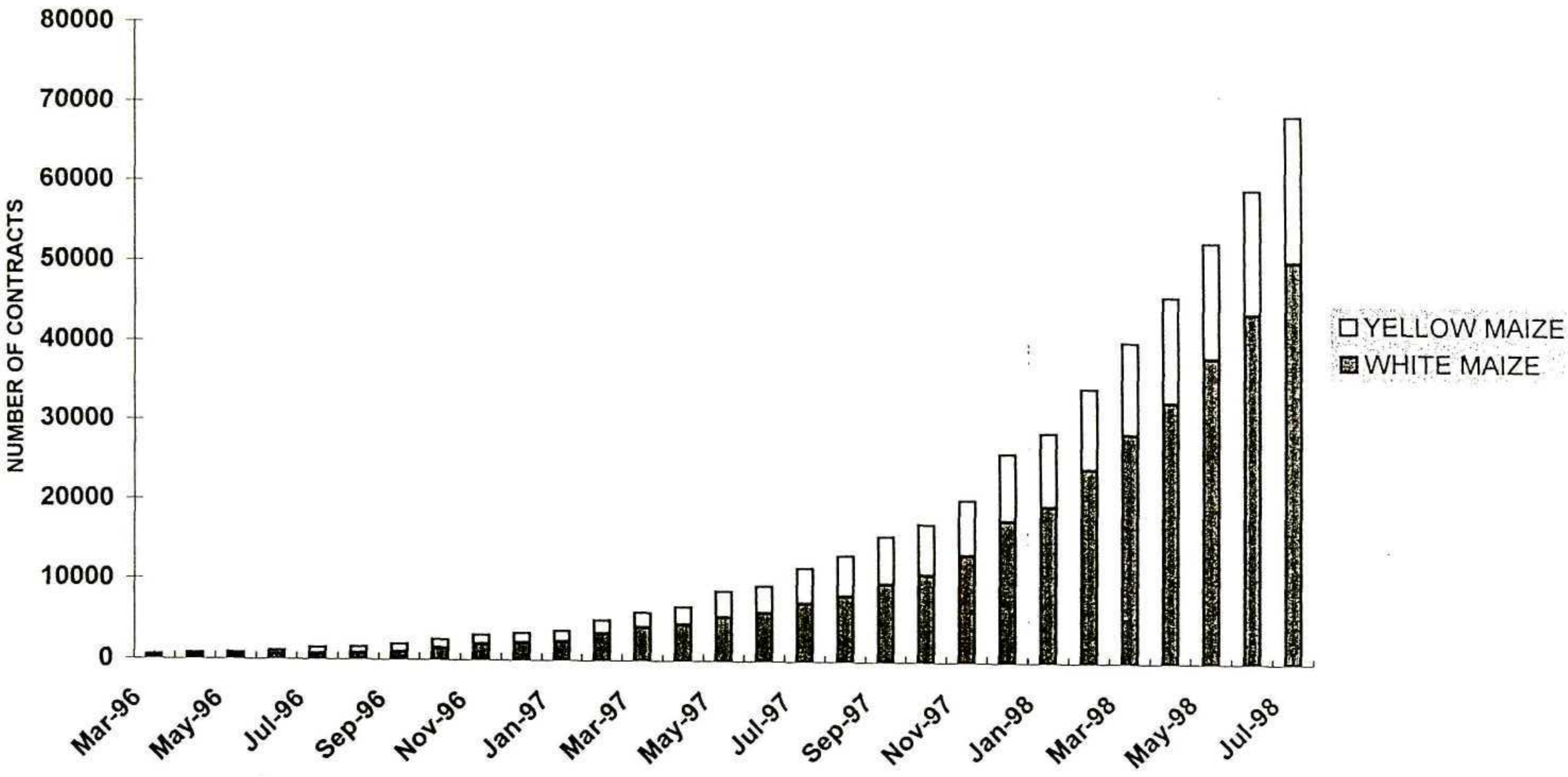
FP: Three-month, 1997
1.0
.5
0.0
-.5
-1.0
ACF
1 3 5 7 9 11 13 15 17 19
2 4 6 8 10 12 14 16 18 20
Lag Number
Confidence Limits
Coefficient



SP: Three-month, 1997
1.0
.5
0.0
-.5
-1.0
ACF
1 3 5 7 9 11 13 15 17 19
2 4 6 8 10 12 14 16 18 20
Lag Number
Confidence Limits
Coefficient


FP: Three-month, 1998
1.0
.5
0.0
-.5
-1.0
ACF
1
3
5
7
9
11
13
15
17
19
21
Lag Number
Confidence Limits
Coefficient


SP: Three-month, 1998
1.0
.5
0.0
-.5
-1.0
ACF
1
3
5
7
9
11
13
15
17
19
21
Lag Number
Confidence Limits
Coefficient



Appendix 4: SAFEX Cumulative Maize Futures Volumes

FUTURES CONTRACT	BEEF	BEEF	POTATOES	WHITE MAIZE	YELLOW MAIZE	WHEAT
ATS code	NABI	BEEF	SPUD	WMAZ	YMAZ	WEAT
Trading Hours	09:00 to 12:00	09:00 to 12:00	09:00 to 12:00	09:00 to 12:00	09:00 to 12:00	09:00 to 12:00
Underlying Commodity	National Average Beef Index (NABI)	Chilled beef carcasses grade A2/A3	National Average Potato Price Index (NAPPI)	White maize of African origin grade WM1	Yellow maize of African origin grade YM1	Bread Milling Wheat meeting protein, specific weight, moisture and falling number criteria with fall back positions for protein and specific weight
Contract Size	2000 x NABI	2000kg	100 x NAPPI	100 metric tons	100 metric tons	100 metric tons
Expiry Dates & Times	12h00 on last Friday of four near consecutive calendar months.	12h00 on second last Friday of four near consecutive calendar months. Physical delivery on Monday to Friday of following week	12h00 on last Friday of four near consecutive calendar months	12h00 on eighth last business day of May, July, September, December and March. Physical deliveries from first business day to last business day of expiry month.	12h00 on eighth last business day of May, July, September, December and March. Physical deliveries from first business day to last business day of expiry month.	12h00 on eighth last business day of May, July, September, December and March. Physical deliveries from first business day to last business day of expiry month.
Settlement method	Cash settled	Physical delivery in approved cold stores within a 50 km radius of City Deep	Cash settled	Physical delivery of Safex silo receipts giving title to maize in bulk storage at approved silos at an agreed storage rate.	Physical delivery of Safex silo receipts giving title to maize in bulk storage at approved silos at an agreed storage rate.	Physical delivery of Safex silo receipts giving title to wheat in bulk storage at approved silos at an agreed storage rate.
Quotations	Rands/kg	Rands/kg	Rands/10kg pocket	Rands/ton	Rands/ton	Rands/ton
Minimum Price Movement	One cent per kg	One cent per kg	One cent per pocket	Twenty cents per ton	Twenty cents per ton	Twenty cents per ton
Initial Margin	R2500 / contract R750 / contract for calendar spreads	R2500 / contract R750 / contract for calendar spreads	R200 / contract No reduction for calendar spreads	R7000/contract up to first notice day. R10 000/contract up to expiry day. R20 000/contract up to last delivery day. R2250/ contract for calender spreads. R4000/contract for white spreads	R6000/contract up to first notice day. R10 000/contract up to expiry day. R20 000/contract up to last delivery day. R1750/ contract for calender spreads. R4000/contract for yellow spreads	R6000/contract up to first notice day. R10 000/contract up to expiry day. R20 000/contract up to last delivery day. R2000/ contract for calendar spreads.
Expiry valuation method	Closing NABI value, being a six-day weighted average of City Deep and Cato Ridge A2/A3 beef prices	Closing futures price as determined by the Clearing House.	Closing NAPPI value, being a five-day weighted average of Johannesburg, Cape Town, Durban and Pretoria prices	Closing futures price as determined by the Clearing House	Closing futures price as determined by the Clearing House	Closing futures price as determined by the Clearing House
Booking Fee charges by SAFEX	R11.40 / contract	R11.40 / contract	R2.28 / contract	R45.60 / contract	R45.60 / contract	R45.60 / contract