PRICE VOLATILITY EFFECTS ON TRADING RETURNS IN AGRICULTURAL COMMODITY DERIVATIVES IN SOUTH AFRICA

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Masters of Management in Finance and Investment
at the Wits Business School at the University of the
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May 2013

Thesis submitted in fulfilment of the requirements for the degree of

Masters of Management in Finance and Investment

in the

FACULTY OF COMMERCE LAW AND MANAGEMENT

WITS BUSINESS SCHOOL

at the

UNIVERSITY OF THE WITWATERSRAND

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DECLARATION

I, Chrisbanard Motengwe declare that the research work reported in this dissertation is my own, except where otherwise indicated and acknowledged. It is submitted for the degree of Masters of Management in Finance and Investment at the University of the Witwatersrand, Johannesburg. This thesis has not, either in whole or in part, been submitted for a degree or diploma to any other universities.

Signature of candidate: Date:

Acknowledgements

I give thanks firstly to God the Almighty for giving me the strength to complete this project. Special thanks then goes to my family for the support, understanding, time and assistance provided to me over the years. To Chiedza, Lucy, Charles, Kito and Luke, you have been there for me every single step of my life. My heartfelt gratitude goes to Senwes Limited for their contribution to education in South Africa through their Bursary Programme. Likewise, I want to express special thanks to Gerard Van Zyl and Pieter Esterhuysen of Senwes Limited for their visionary leadership and professional support to my career development initiatives. Dr. Blessing Mudavanhu deserves special mention for his commitment to higher education and for providing extraordinary supervision and guidance for this project to reach completion.

Abstract

Recent unexpected variability in the earnings of agribusinesses in South Africa has led stakeholders to ask as to why projected financial performance tended to be so different from the actual results achieved. This paper aims to make an empirical contribution to the discussion on the effects of soft commodity price volatility on the returns of entities whose major business involves derivatives trading in agricultural commodity products. Firstly, mathematical models for commodity price volatility are determined for the major agricultural commodities on the South African Futures Exchange (SAFEX) using the autoregressive conditional heteroskedasticity (ARCH) and the generalised autoregressive conditional heteroskedasticity (GARCH) type of approaches. Secondly, the study then seeks to ascertain whether there are causality links between the commodity price volatility and the returns or earnings realised by selected agribusinesses over time. The paper then discusses some trading strategies that are applicable given that commodity price volatility can be forecasted using the statistical models identified under the study.

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Acronyms

ACF	Autocorrelation Function
ADL	Augmented Dickey Fuller
APARCH	Asymmetric Power Autoregressive Conditional Heteroskedasticity
ARCH	Autoregressive Conditional Heteroskedasticity
ARIMA	Autoregressive Integrated Moving Average
CBOT	Chicago Board of Trade
CDDCs	Commodity Dependent Developing Countries
CFTC	Commodity Futures Trading Commission
CME	Chicago Mercantile Exchange
DAFF	Department of Agriculture, Forestry and Fisheries
DCE	China Dalian Commodity Exchange
CPI	Consumer Price Index
EAAE	European Association for Agricultural Economists
EGARCH	Exponential Generalized Autoregressive Heteroskedasticity
EU	European Union
ERS	Elliot, Rothenberg and Stock
EWMA	Exponentially Weighted Moving Average
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistics
FAIR	Federal Agricultural Improvement and Reform Act
FGLS	Feasible Generalized Least Square
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
GLS	Generalized Least Squares
IACF	Inverse Autocorrelation Function
ICMA	International Capital Market Association
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IIF	Institute of International Finance
IMF	International Monetary Fund
ITC	International Trade Centre
JSE	Johannesburg Stock Exchange Limited
LDCs	Least Developed Countries
LIFFE	London International Financial Futures and Options Exchange
LM	Lagrange Multiplier
MAD	Mean Absolute Deviation
NAMC	National Agricultural Marketing Council
NWK	Noordwes Kooperasie Limited
NYBOT	New York Board of Trade
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
PWC	PriceWaterhouseCoopers Limited
SAFCOM	South African Futures Exchange Clearing Company
SAFEX	South African Futures Exchange
SAGIS	South African Grain Information Service
SAVI	South African Volatility Index
TWK	Transvaal Wes Kooperasie
UNCTAD	United Nations Conference on Trade and Development
UN HLTF	United Nations High-Level Task Force
VAR	Vector Autoregressive
WB	World Bank
WFP	World Food Programme

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Definition of Terms

The definitions below are adopted from the Chicago Mercantile Exchange website (2012).

arbitrage

The simultaneous purchase of cash, futures, or options in one market against the sale of cash, futures or options in a different market in order to profit from a price disparity (Chicago Mercantile Exchange, 2012).

ask price

Also called the "offer." Indicates a willingness to sell a futures or options on futures contract at a given price (Chicago Mercantile Exchange, 2012).

backwardation

Market situation in which futures prices are lower in succeeding delivery months. Also known as an inverted market. This is the opposite of contango.

basis

The difference between the spot or cash price and the futures price of the same or a related commodity. Basis is usually computed to the near future, and may represent different time periods, product forms, qualities and locations. The local cash market price minus the price of the nearby futures contract is equal to the basis.

basis risk

The uncertainty as to whether the cash-futures spread will widen or narrow between the time a hedge position is implemented and liquidated.

bid price

An offer to buy a specific quantity of a commodity at a stated price or the price that the market participants are willing to pay.

bid/ask spread

The price difference between the bid and offer price.

cash commodity

The actual physical commodity or financial instrument as distinguished from the futures contract that is based on the physical commodity or financial instrument. Also referred to as "spot."

cash market

The cash market is a place where people buy and sell the actual commodities. This includes the grain elevator, bank and the farm-gate, among others. Spot usually refers to a cash market price for a physical commodity that is available for immediate delivery. A forward contract is a cash contract in which a seller agrees to deliver a specific cash commodity to a buyer sometime in the future. Forward contracts, in contrast to futures contracts, are privately negotiated and are not standardized.

cash price

Current market price of the actual or physical commodity. Also called the spot price.

contango market

A market situation in which prices are higher in the succeeding delivery months than in the nearest delivery month. Opposite of backwardation.

derivative

A financial instrument whose value is based upon other financial instruments, such as a stock index, interest rates or commodity indexes.

differentials

Price differences between classes, grades, and delivery locations of various stocks of the same commodity.

futures

Standardized contracts for the purchase and sale of financial instruments or physical commodities for future delivery on a regulated commodity futures exchange.

hedge

The purchase or sale of a futures contract as a temporary substitute for a cash market transaction to be made at a later date. Usually involves simultaneous, opposite positions in the cash market and futures market.

hedging

(1) Taking a position in a futures market opposite to a position held in the cash market to minimize the risk of financial loss from an adverse price change. (2) A purchase or sale of futures as a temporary substitute for a cash transaction which will occur later.

spot

The actual physical commodity as distinguished from the futures contract that is based on the physical commodity. Also referred to as “cash commodity.”

spot market

The market in which cash transactions for the physical commodity occurs -- (cattle, currencies, stocks, etc.) are bought and sold for cash and delivered immediately.

spot month

The contract month of a futures contract which is also the current calendar month.

spot price

The price at which a physical commodity for immediate delivery is selling at a given time and place. The cash price.

spread

The price difference between two contracts. Holding a long and a short position in two or more related futures or options on futures contracts, with the objective of profiting from a change in the price relationship.

volatility

A measurement of the change in price over a given time period.

1 INTRODUCTION

The excessive fluctuation in the financial performance of the role players within the soft commodity trading sector has presented substantial challenges when drawing up annual corporate budgets and business plans. The implications of varying company earnings are critical when investment is being mobilised to expand the sector. In general, the increased risks associated with the above not only cause problems for commodity futures market participants but result in the inefficient resource allocation for producers, merchandisers and speculators, with the potential to limit access to the staple foods consumed by the lower income groups in the country. It should be pointed out that the agribusinesses referred to in this paper are the largest single group providing market access to the local farmers. This therefore means that, central to agricultural sustainability in South Africa, is the need for financial viability of these off-takers of farm produce around the country.

This study focusses on the volatility of the financial performance of agribusinesses taking into account the linkages and interdependencies amongst the various role players along the agricultural value chains. On the other hand, commodity price volatility has implications for risk management, asset pricing, asset allocation and food security especially for consumers with low incomes.

1.1 Purpose of the Study

The purpose of this research is to establish a relationship between volatilities in the prices of the major agricultural commodities traded on the South African Futures Exchange (SAFEX) and the trading returns or earnings realised by the soft commodity trading community in South Africa. The autoregressive conditional heteroskedasticity (ARCH) and the generalised autoregressive conditional heteroskedasticity (GARCH) type approaches will be used to measure and forecast price volatility. The study will assist in identifying different levels of price volatility and the corresponding possible returns or profits realisable by trading members of SAFEX. Following the establishment of soft commodity price volatilities and the corresponding mathematical model or approaches, forecasting of volatilities should pave way for suitable trading strategies to be developed by the soft commodity trading fraternity.

1.2 Context of the Study

Trading of maize futures was introduced in May 1995 (JSE Commodity Derivatives Market module, 2010). Wheat futures were introduced in 1997 while sunflower contracts were introduced on SAFEX in 1999. Soybeans contracts emerged in 2002. As the staple food for the majority of South Africans, maize is the most important grain crop in South Africa. Major grains and oilseeds production trends in South Africa over the years are as shown in the table below.

Crop	Crop Production Trend (Tonnes)				
	2007	2008	2009	2010	2011
Maize	7,125,000	12,700,000	11,740,800	12,815,000	10,998,050
Wheat	1,843,900	2,130,000	1,919,800	1,430,000	1,905,280
Sunflower	300,000	872,000	843,530	490,000	780,470
Soybeans	205,000	282,000	509,295	566,000	699,250

Table 1: Selected Soft Commodity Production Trends in South Africa[1]

Local maize and soybeans production has been enjoying a fairly steady increase over the years. The highest maize production levels over the period under study amounted to 12,815,000 tonnes. Domestic wheat and sunflower production levels have been steady over the years with average annual production levels being 1,845,796 tonnes and 657,200 tonnes respectively. Soybeans production has been increasing steadily over the years.

The following table provides a comparison of production and consumption of selected soft commodities in the year 2010.

Commodity	Production (Tonnes)	Commercial Consumption (Tonnes)
Maize	10,998,050	10,296,000
Wheat	1,905,280	3,005,000
Sunflower	780,470	864,000
Soybeans	699,250	429,900

Table 2: Demand and Supply of Soft Commodities in 2011[2]

South Africa has generally been a self-sufficient country with respect to the production of maize and soybeans in recent years. The country presently has limited soybeans processing facilities and has to export surplus production while importing processed products derived from soybeans which include soya-meal, soya-cake and soya-oil. On the other hand, South Africa has to make up for its shortfalls in the supply of wheat and sunflower through the importation of wheat and crude sunflower oil respectively.

[1] Source: South African Grain Information Services
[2] Source: Department of Agriculture, Forestry and Fisheries (DAFF)

Agricultural co-operatives first emerged in South Africa in 1902 (D'Haese and Bostyn, 2001). The Anglo-Boer War had devastated most farming enterprises and capital for reconstruction was generally unavailable. Farmers then started co-operatives with the help of government. In 1912 legislation was introduced for the establishment of the Land Bank in order to assist in the development of agriculture. The year 1922 saw the promulgation of the Co-operatives Act No. 28 which provided guidelines for the establishment, registration and management of co-operatives. Government influenced co-operatives through control boards (D'Haese and Bostyn, 2001).

When the futures market was introduced in 1995, most of the agricultural co-operatives were transformed into registered agricultural companies. Basically, the silo industry serves as a link between supplier or producer of soft commodities and the processor of the commodities. The JSE (2012) acknowledges that the silo industry is quite concentrated owing to the fact that approximately 70 % of all the JSE-approved grain silos are owned by some three role players. Role players in the grain silo industry, most of who used to be co-operatives, are as depicted below.

Company Name	**Town (Head Office)**
Afgri Limited	Bethal
Senwes Limited	Klerksdorp
GWK Limited	Douglas
NTK Limpopo Agric Limited	Modimolle
NWK Limited	Lichtenburg
Oos Vrystaat Kaap Bedryf Limited	Ladybrand
MGK Bedryfsmaatskappy Limited	Brits
Suidwes Landbou Limited	Leeudoringstad
TWK Landbou Limited	Piet Retief
Vrystaat Kooperasie Limited	Reitz
Die Humansdorpsie Kooperasie Limited	Humansdorp
Kaap Agri Bedryf Limited	Malmesbury
Moorreesburgse Koringboere Limited	Moorreesburg
Overburg Agri Limited	Caledon
Sentraal-Suid Kooperasie Limited	Swellendam
Tuinroete Agri Limited	Mossel Bay
Villiersdorp Kooperasie Limited	Villiersdorp

Table 3: Role Players in the Grain Silo Industry in South Africa[3]

[3] Source: Grain Silo Industry

There are 17 key players in the grain silo industry in South Africa with the biggest in terms of market capitalisation being Afgri Limited. Afgri Limited has its silo complexes located largely in the Mpumalanga, Gauteng and eastern Limpopo provinces. Senwes Limited, the second largest owner of grain silos in South Africa has its storage infrastructure in the Free State and the eastern North West provinces.

The diagram below depicts the trends in net profit before tax and turnover in respect of agribusinesses over the last three years.

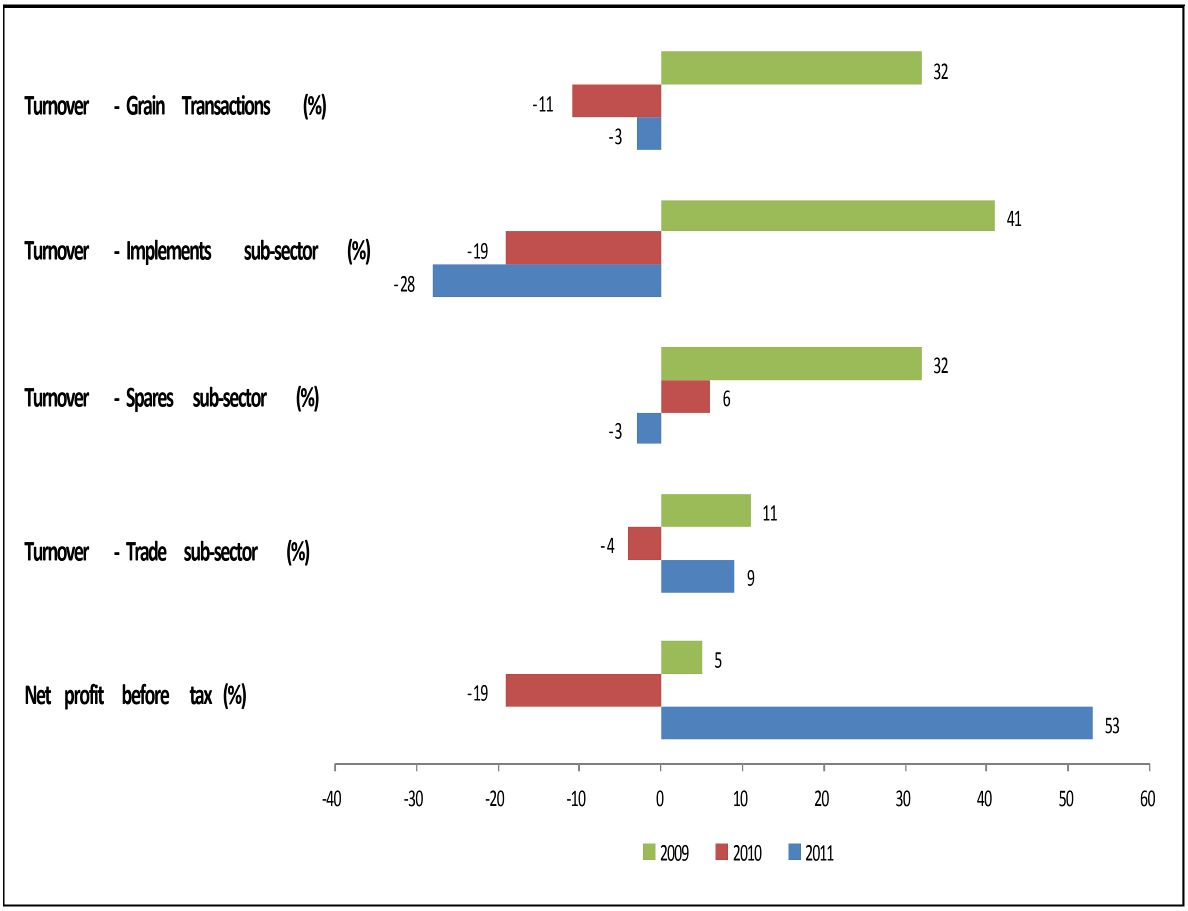


Figure 1: Year-on-year Trends for Agribusinesses (in % terms)[4]

Please note that most of the agribusinesses within the grain silo industry in South Africa are each structured to have the following divisions or sub-sectors:

- Grain transactions sub-sector or division
- Implements or mechanisation sub-sector

[4] Source: PWC Agribusinesses Benchmarking Survey 2011

- Spares sub-sector
- Trade or retail sub-sector

It is imperative to point out that the major focus area under this study is the grain transactions sub-sector. This subsector ordinarily provides grain storage services using some grain elevators and is involved in grain trading operations both in the spot and futures markets of South Africa.

The above graph shows that unstable profitability was experienced by the soft commodities sector over the last few years. Specifically, the grain transactions divisions of the major agribusinesses in South Africa declined in turnover by 11 % in 2010 and then by 3 % in 2011. The other major observation from the above graph relates to the unevenness in the performance levels of most of the sub-sectors within the industry over the years. Performance fluctuations make it very difficult for these entities to plan their activities.

The Chicago Mercantile Exchange (2012) has defined price volatility as a measurement of price change over time. According to the South African Futures Exchange website (2012), volatility measures risk in financial markets. It can estimate a range of price movements in a given time frame.

Gorton and Rouwenhorst (2004) acknowledged that commodity futures have a feature unique to this asset class, that is, some power at diversifying the systematic component of risk. This part of risk is not supposed to be diversifiable. On the other hand, Weiser (2003) reports that commodity futures returns vary with the stage of the business cycle. Commodity futures perform well in the early stages of recessions, a time when equity stocks generally disappoint. In later stages of recessions, commodity returns decline while this is generally a good time for equities (Weiser, 2003). These findings concur with those of Brooks and Pokopczuk (2011) who conclude that commodities can be a useful diversifier of equity volatility as well as equity returns.

1.3 Problem Statement

The National Agricultural Marketing Council (2009) plotted a graph on volatility of Chicago Board of Trade (CBOT) yellow maize prices converted to Rand terms, and corresponding SAFEX yellow maize prices. It was pointed out that based on that graph; the SAFEX price was more volatile than the Rand–denominated CBOT price 61 % of the time. Further, price volatility tends to be higher in South Africa in periods of low commodity stock levels.

This study seeks to determine volatility of prices of major grains and oilseeds in South Africa inclusive of maize, wheat, sunflower and soybeans in order to ascertain the effects of such volatility on the profitability of agribusinesses. There has been significant fluctuation in the returns achieved by agribusinesses as shown in Figure 1 above and the study seeks to find out whether commodity price volatility had an influence on this situation.

The first problem relates to the limited ability by agribusinesses to forecast commodity price volatility ahead of any given marketing year. If this could be done, agribusinesses could then plan their finances more effectively, enabling them to manage their activities across any given year. The second problem is the limited availability of tools and information to use for developing successful trading strategies in any given marketing year. The strategies should enable stability in the profitability of these agribusinesses.

The other problem has to do with the cash grain market which is known to have limited transparency (Roberts, 2009). In the cash market therefore, maize millers and other grain users do not post grain bids publicly, or post prices they have paid. These users of maize feel that to do so would reveal their grain requirements and positions to their competitors (Roberts, 2009). The competitors would then use this information to their advantage and increase their bids in a given area when in need of grain. The study seeks to find out whether there is significant price volatility caused by this and similar such activities.

1.4 Significance of the Study

The study fills a gap in that varying soft commodity price volatility levels require grain traders to use different marketing and hedging strategies (Jordaan, Grove, Jooste and Alemu, 2007). Price volatility over the years after the establishment of SAFEX is therefore going to be determined under the study.

The study will provide guidance to soft commodity agribusinesses by recommending a methodology for determining levels of price volatility ahead of a marketing season. This is particularly important for grain traders when they are crafting trading strategies in line with their set goals. The adverse effect of price volatility across the value chain needs to be reduced especially for the farming community to ensure sustained productivity. At the same time, the opportunities associated with price movements should be identified by the grain trading community to guide trading strategies.

Figure 1 above depicts unstable and even declining profitability levels achieved by soft commodity agribusinesses over the years. Fluctuating company profits make it difficult for bankers and market analysts to award favourable business ratings to the entities involved. These ratings are essential when companies are raising funds for their operations in the local or international money and capital markets. At the same time, unfavourable ratings could potentially threaten investment in the agro-based sector with a possible adverse impact on agricultural production in the country. A possible decline in local crop production could increase the need for food commodity imports thereby increasing the chances of imported inflation. The national balance of payments position might also be adversely affected by such a situation.

This study is therefore important to the extent that it may contribute towards the stabilisation of earnings within the soft commodity agribusiness sector. The possible increased and stable earnings by the grain trading entities will then be ploughed back into the agricultural sector through the trade and retail divisions of these agribusinesses. Please note that most of the grain silo owners in the country have adopted an integrated business model as alluded to in Section 1.2 above.

1.5 Background Literature

The primary objective of a commodity derivatives market is price risk management and not physical delivery of the underlying commodity (Johannesburg Stock Exchange (JSE) Commodity Derivatives Market module, 2010). Buying or selling futures contracts that establish a price now for a future purchase or sale enables individuals and businesses to have some form of insurance protection against adverse price changes (JSE Commodity Derivatives Market module, 2010). This “insurance” amounts to the process of hedging. Derivatives therefore allow investors to unbundle and transfer financial risk (Adelegan, 2009). The South African Futures Exchange (SAFEX) was formed together with the SAFEX Clearing Company Limited (SAFCOM) in September 1988 (Vink and Kirsten, 2002). Agricultural commodities futures trading commenced in South Africa in 1995 after the deregulation of the agricultural market. It was the passing of the Marketing of Agricultural Products Act of 1996 which paved the way for the disbanding of the agricultural marketing boards and the adoption of a new marketing order.

Moledina, Roe and Shane (2004) established that crop producers can distinguish regular features in the price process into predictable and unpredictable elements. Thus predictable and seasonal components of the price process should not be considered as part of price volatility (Moledina, Roe and Shane, 2004). Jordaan, Grove, Jooste and Alemu (2007) concluded from a study they conducted that SAFEX prices show strong seasonality. The stochastic or unpredictable components of the price process are therefore the appropriate measure of volatility according to Moledina, Roe and Shane (2004). Jordaan, Grove, Jooste and Alemu (2007) suggest the use of the Autoregressive Conditional Heteroskedasticity (ARCH) or the Generalised Autoregressive Conditional Heteroskedasticity (GARCH) type approaches for determining soft commodities price volatility. These methodologies meet the requirements of Moledina, Roe and Shane (2004) as well as those of Just and Pope (2002).

1.6 Questions of the Study

The study seeks to establish some suitable methods that can be used to forecast agricultural commodity price volatility levels ahead of a given marketing season. The major problem within the soft commodity trading sub-sector in South Africa is to do with persistent fluctuation in returns earned by entities operating in the sector. It would appear there may be limited tools and instruments to enable the smoothening out of performance to be comparable for example to trends in inflation, population or disposable incomes.

Establishment of the most appropriate mathematical models will assist in forecasting price volatility levels. The accurate measurement of the stochastic component in the prices of agricultural derivatives may contribute to the decision-maker being able to select the best crops to trade in ahead of the other crops (Jordaan, Grove, Jooste and Alemu, 2007).

This study will ask the question whether there is a relationship between the fluctuating earnings of grain trading entities and the price volatility on the agricultural derivatives market in South Africa. Further, are there adequate tools and information to use for developing successful trading strategies in any given marketing year? Is it possible for the soft commodity trading strategies to enable stability in the profitability of these agribusinesses?

1.7 Methodology

The empirical study uses daily maize, wheat, soybeans and sunflower futures prices obtained from the South African Futures Exchange (SAFEX) over the period January 2000 to August 2012 to compute monthly commodity futures price volatility. On the other hand, share price data for the agribusinesses under study is obtained both from the Johannesburg Stock Exchange (JSE) and from the companies themselves, where the firms are not listed on the JSE.

The procedure used to determine whether futures price volatility influences share price returns for the agribusinesses is the Granger Causality methodology. Statistical procedures for testing for stationarity, order of integration and cointegration are performed in an effort to define and to understand the data generating process ahead of conducting the Granger Causality procedure. The research therefore asks if the pattern of past price volatility of maize, wheat, sunflower and soybeans is able to explain past patterns of share prices of selected soft commodity trading entities.

1.8 Assumptions

It is generally assumed that grain price volatility has adverse effects on the activities of farmers and grain users like millers. This is the reason why these role players ordinarily have to hedge to limit the impact of an adverse market. Price movements also create exploitable opportunities for various trading strategies to be used to realise significant trading returns. This is the case only when a given trading entity's view of the market is correct. There are also strategies that benefit from any type of movement, whether positive or negative, for example the straddle or strangle.

It is also thought that low crop production years result in higher commodity price volatility than high crop production years. When there is a deficit, commodity prices move towards import parity while in a case of surpluses, prices tend to move towards export parity.

The study will focus mainly on agribusinesses that operate between the "farm-gate and the mill-door". These entities are either role players in the grain silo industry and own grain elevators or similar infrastructure or are registered members of SAFEX's agricultural commodity derivatives market, or both. The grains and oilseeds under study include maize, wheat, sunflower and soybeans. The study will focus on the South African grain market from the mid 1990's to date.

1.9 Thesis Outline

The remainder of the research document is organised as outlined in this section. Chapter two contains literature review relating to the agricultural derivatives market in South Africa. Chapter three comprises literature review on soft commodity price volatility and related trading strategies, highlighting recent empirical analysis on factors affecting price variability in agricultural commodity markets. The detailed description of the methodology used under this study is provided in Chapter four. Chapter five provides the results of the empirical analysis. Finally, chapter six highlights the implications of this research, the conclusions and recommendations as well as suggested future research in this area.

2 SOUTH AFRICAN AGRICULTURAL MARKETS

The performance of agribusinesses in South Africa in recent years has been unstable from one year to the next. PriceWaterhouseCoopers (2012) pointed out that silo income was subject to great pressure on account of greater competition and the faster flow of maize due to the increase in exports. The National Agricultural Marketing Council (2009) has also alluded to the complaints that have been received in the past from various stakeholders to the effect that tremendous fluctuations and volatility were being experienced on agricultural commodity markets.

Rossouw (2007) maintained that commodity futures' trading in a wide variety of commodities and financial instruments occurs worldwide in numerous futures exchanges. Modern futures trading emerged in the 1800's out of the development of commerce in Chicago (USA) and grain trading in the US Midwestern frontier (Rossouw, 2007). Chicago is located in close proximity to the USA Great Lakes, the fertile farmlands of the well-known American Corn Belt as well as the major transport routes, factors which led to the development of grain terminals in this location (Chicago Mercantile Exchange, 2012). Having been first established in 1988, SAFEX traded for the first time in agricultural derivatives in 1995 (Vink and Kirsten, 2002). Trading in commodity futures however still remains a highly specialised area and an activity in which a limited number of people possess sufficient knowledge to participate in (Rossouw, 2007).

2.1 Definition of Topic and Background Discussion

The major thrust of this study entails the quantification of the true stochastic components in the prices of the major agricultural derivatives in South Africa. The effect of this volatility on the returns or earnings within the soft commodity sector is then determined. This chapter looks at the demand and supply of soft commodities in South Africa and the importance of these two variables within the context of the price volatility of agricultural commodities. Factors influencing price volatility within the agricultural commodities derivatives market will be identified under this study. A comprehensive description of the agricultural commodity markets is presented in this chapter to provide a solid base to discuss price volatility issues in the following chapter.

Rossouw (2007) defines soft commodities as agriculturally produced commodities. This paper has its major focus on the major soft commodities produced and traded in South Africa, which are namely, maize grain, wheat, sunflower and soybeans. This chapter first provides a value chain analysis for the major crops in South Africa.

2.2 Value Chain Analysis

The Independent Consulting Group (2003) provides the following as a simple typical maize marketing chain that shows the relationships of the various role players.

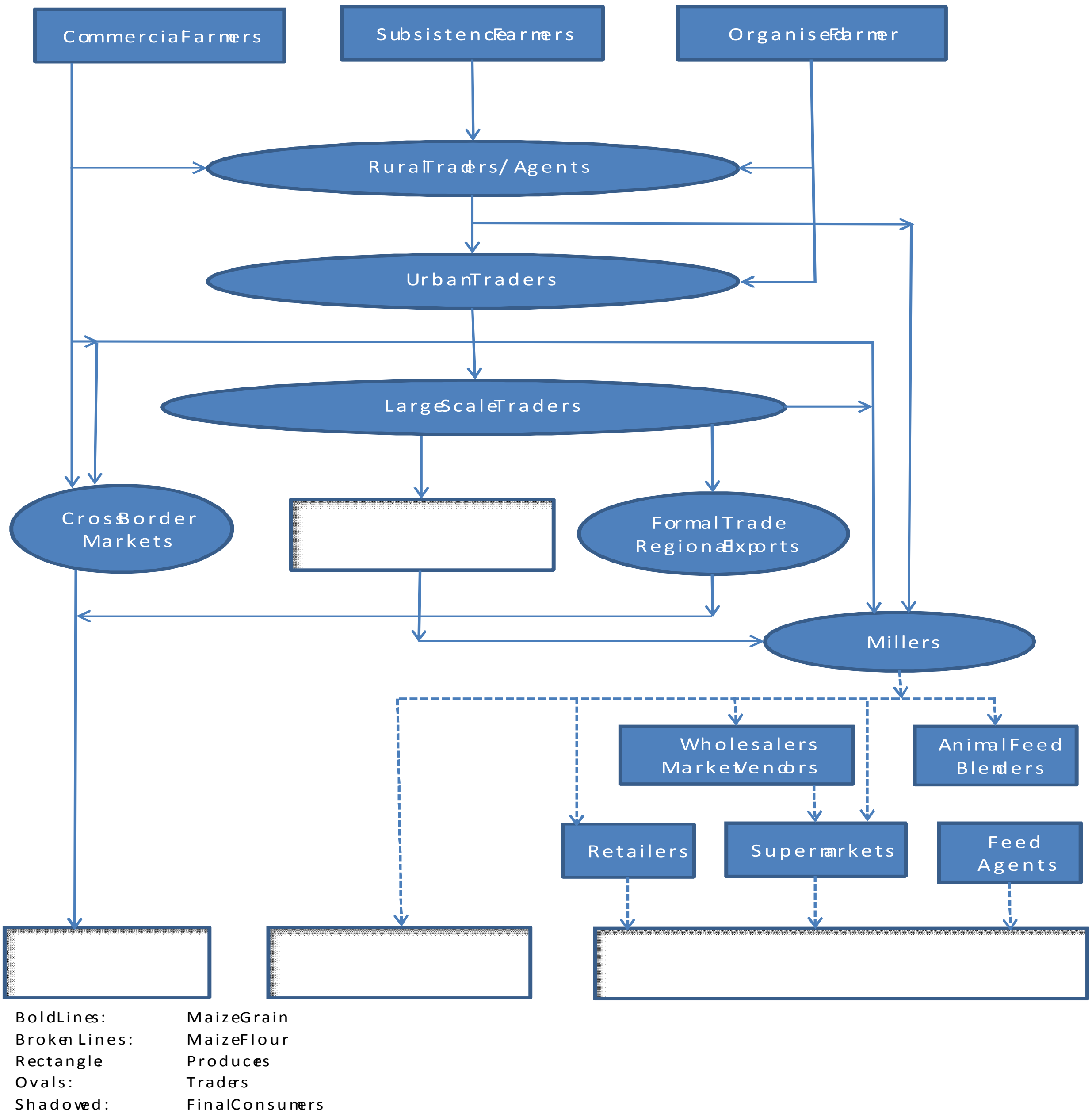
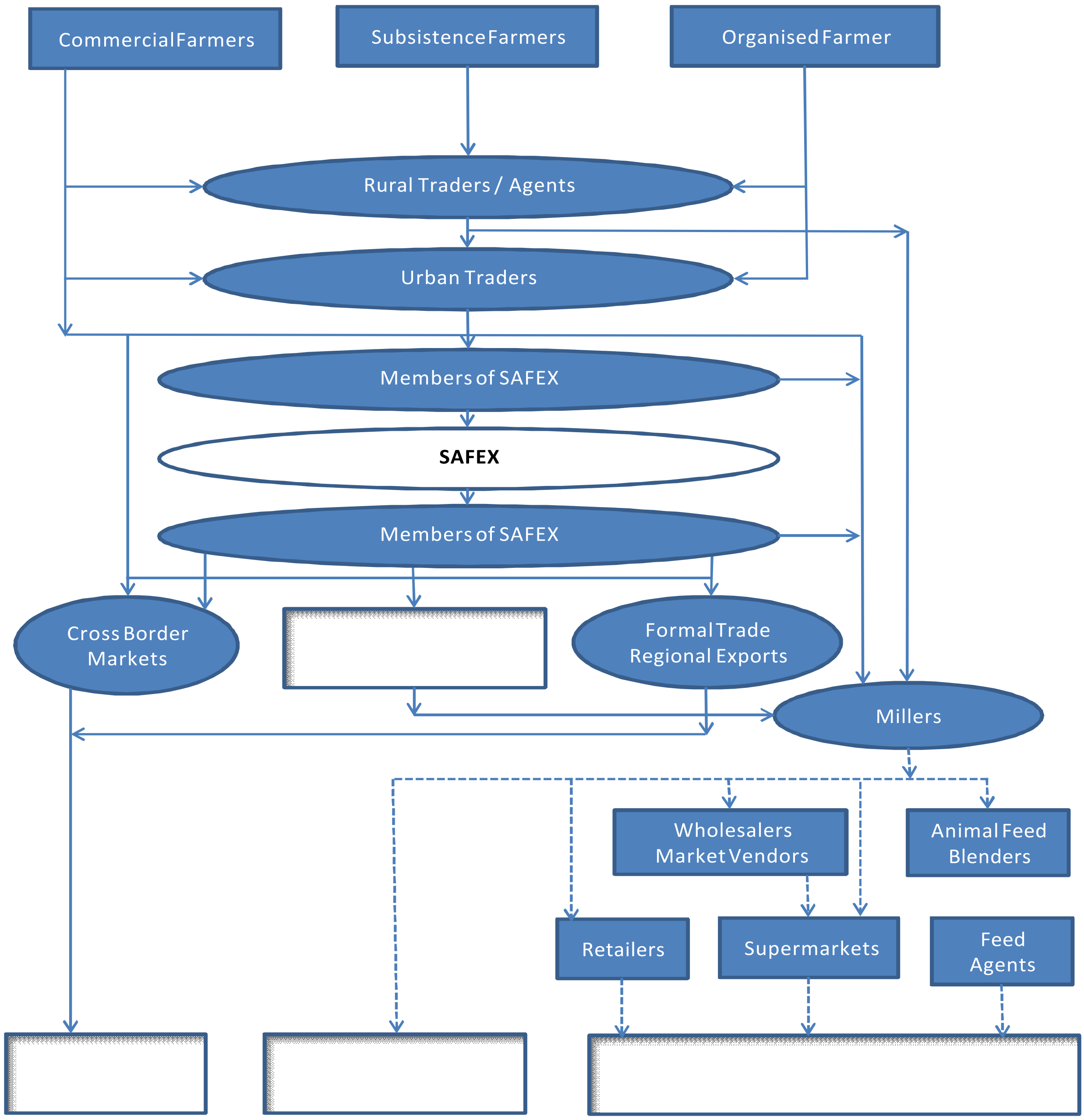


Figure 2: A Typical Maize Marketing Chain before Inception of SAFEX[5]

[5] Source: Independent Consulting Group (2003)

The following diagram depicts the typical grain value chain after the introduction of SAFEX



Bold Lines:	Maize Grain
Broken Lines:	Maize Flour
Rectangle:	Producers
Ovals:	Traders
Shadowed:	Final Consumers

Figure 3: South African Marketing Value Chain for Grains and Oilseeds[6]

[6] Source: Modified from the Independent Consulting Group (2003) Diagram

2.3 Historical Background to Agro-based Markets in South Africa

In accordance with the Agricultural Marketing Act of 1968, the South African maize market was highly regulated by the Maize Board over the period 1968 to 1997 (Shim, 2006). Shim (2006) also acknowledged that the Maize Board promoted a 'single channel fixed-price system', which controlled both the marketing channels and the prices of maize. The price announced around April every year would be effective across the whole country throughout the entire marketing season with all producers obliged to sell their surplus maize only to the Maize Board (Shim, 2006). A levy collected on sales of maize within the domestic market was used to fund the Maize Board's administrative costs and support other grain marketing expenses like subsidies provided on maize exports (Shim, 2006).

2.4 Establishment of the South African Futures Exchange

SAFEX grew out of an informal market that was started in South Africa in 1988 concurrently with the establishment of SAFEX Clearing Company Limited (SAFCOM) (Shim, 2006). Gravelet-Blonding (2008) documents that 84 trading seats were taken up by interested entities at a price of R50,000.00 each, thereby forming start-up capital of R4.2 million. Shim (2006) observed that at inception, SAFEX was only offering a platform for trading in financial derivatives such as equity indices, long bonds and money market futures. Agricultural derivatives were only introduced on SAFEX in 1995 with beef and potato being the first two agricultural contracts (Shim, 2006). These contracts were delisted shortly afterwards owing to limited interest in them (Shim, 2006). White and yellow maize contracts were introduced in 1996 and shortly thereafter these contracts achieved enormous success (SAFEX, 2012).

The SAFEX silo receipt has enhanced efficient trading of agricultural commodities to such a degree that many financial institutions have been accepting it as collateral (Shim, 2006). Gravelet-Blonding (2008) posits that SAFEX has added value to soft commodity trading in South Africa in the following ways:

- Price risk management
- Price transparency
- Price integrity
- Secure settlement (delivery and payment)

May 2001 saw members of SAFEX agreeing to a buyout of SAFEX by the Johannesburg Stock Exchange (JSE) (Rossouw, 2007). Gravelet-Blonding (2008) observed that SAFEX became part of the JSE in August 2001 leading to the establishment of the agricultural derivatives division of

3 PRICE VOLATILITY AND TRADING STRATEGIES

Potential exaggeration of price fluctuations manifested through possible price overshooting could increase trading risk on the agricultural commodity derivatives market (Vink and Kirsten, 2002). Jordaan, Grove, Jooste and Alemu (2007) acknowledged that price variability is an important component of profit variability for agribusinesses and hence the need to quantify price variability of agricultural commodities.

This section of the literature review provides some background on the theory surrounding soft commodity price volatility and possible trading strategies that can be used within the derivatives markets. It further explains some key terms used within the commodity markets. Some background to the main problem and the sub-problems under the study is also provided. Findings of similar studies are explored within the literature review section.

Jordaan, Grove, Jooste and Alemu (2007) used the GARCH approach to determine conditional standard deviation and to distinguish between predictable and unpredictable elements in price levels of maize and sunflower. In the case of wheat and soybeans, the volatility in prices was found to be constant. In this case, Jordaan, Grove, Jooste and Alemu (2007) used the standard error of the Autoregressive Integrated Moving Average (ARIMA) process as the measure of volatility in the prices of these crops. This study seeks to apply these approaches in respect of the period from the commencement of SAFEX trading in South Africa up to year 2011.

3.1 Background to Discussion

Lustig (2012) observed that world food prices increased by 130 percent over the period January 2002 to June 2008. Out of these commodities, the major grains and oilseeds showed even more pronounced increases over the same period as depicted below:

- Maize world price increase - 190 percent
- Wheat world price increase - 162 percent
- Rice world price increase - 318 percent
- Soybeans world price increase - 246 percent

However, from July 2008, food commodity prices began to fall (Lustig, 2012). The performance of global agriculture over the last 25 years has been viewed as a success story with output growing at an average of two percent per year (Lustig, 2012). Munier and Briand (2012) assert that the revolution in finance happened as it was realised that asset prices show large volatility that does not reflect anything about fundamentals. The authors suggest that macroeconomics may not have kept up with this revolution possibly to the great detriment of contemporary macroeconomics. Hernandez (2012) documented that the monthly average price volatility (expressed on an annual basis) for soybeans, corn and wheat on the CME reached record levels of 51, 41 and 73 percent respectively in 2008. Calvo-Gonzalez, Shankar and Trezzi (2010) studied the long-run price volatility of 45 commodities in respect of a period spanning over two centuries and found three most significant breaks in volatility common to most commodities. These most significant breaks in volatility are the two world wars and the collapse of the Bretton-Woods system (Calvo-Gonzalez, Shankar and Trezzi, 2010).

3.2 Defining Volatility

Geyser and Cutts (2007) points out that volatility is closely related to uncertainty, risk, variability, fluctuation or oscillation. Uncertainty describes a situation where several possible outcomes are associated with an event, but assigning probabilities to the outcomes is not possible (Geyser and Cutts, 2007). On the other hand, risk permits the assignment of probabilities to the different outcomes, according to Geyser and Cutts (2007). Geyser and Cutts (2007) posit that volatility is a reflection of risk in that it provides a measure of the possible variation or movement in a particular economic variable or some function of that variable, and growth rate is given as an example. Gilbert and Morgan (2011) define volatility as the quantitative measure of the directionless extent of the variability of the price of a given asset.

Munier and Briand (2012) affirm that volatility refers to the variations in a given measure in respect of a commodity over a pre-specified period of time in a given area. Piot-Lepetit and M'barek (2011) provide two measures of volatility, historical volatility and implicit volatility. Hence, *historical volatility* is based on observed (realised) movements of price over a historical period, representing past price movements and reflecting the resolution of supply and demand factors. On the other hand, Piot-Lepetit and M'barek (2011) define *implicit volatility* as the market's view on how volatile an asset will be in the future, representing the market's expectation of how much the price of a commodity is likely to move and tends to be more responsive to current market conditions.

Huchet-Bourdon (2011) defines volatility as the variation of commodity price changes around their mean value. A variable's volatility is defined by Hull (2010) as the standard deviation of the return provided by the variable per unit of time with such return expressed using continuous compounding.

3.3 Measures of Volatility

Munier and Briand (2012) provide the most basic measures of volatility as being variations in absolute prices $P_t - P_{t-1}$ or percentage variations of prices per unit of time given by

$$\frac{(P_t - P_{t-1})}{P_{t-1}}$$

One can then empirically compute volatility as given by Munier and Briand (2012) in the following manner:

$$R_t = \frac{P_t}{P_{t-1}}$$

In the case of a whole statistical series, Munier and Briand (2012) provide two measurements as being the most popular, *standard deviation*, denoted by the following relation:

$$\sigma = \sqrt{\frac{\sum (R_t - R_{t-1})^2}{n}}$$

and *mean absolute deviation, for short MAD,* denoted by

$$M_t = \frac{\sum |R_t - R_{t-1}|}{n}$$

where n is the total number of observations. If the mean is not zero, these figures are usually normed by the value of the mean, giving us possible measures of volatility as

$$\frac{\sigma}{\mu}$$

or

$$\frac{M_t}{\mu}$$

Munier and Briand (2012) state that it is important to compute for each monthly or daily observation, the *absolute value of the percentage time variation of prices using* σ *as a yardstick for every month or day t* with the expression:

$$V_t = \frac{|R_t|}{\sigma}$$

The above expression allows for comparison of volatility for two series provided the series have the same periodicity of observations.

Hoffman (2011) uses the absolute daily percentage change as the measure of volatility as is shown below:

$$P = \left| \ln\left(\frac{F_t}{F_{t-1}}\right) \right| \times 100$$

where P is the absolute daily percentage change, F_t is the nearby futures price for day t and F_{t-1} is the nearby futures price for day $t-1$.

The diagram below depicts a typical graph depicting volatility of white maize on SAFEX.

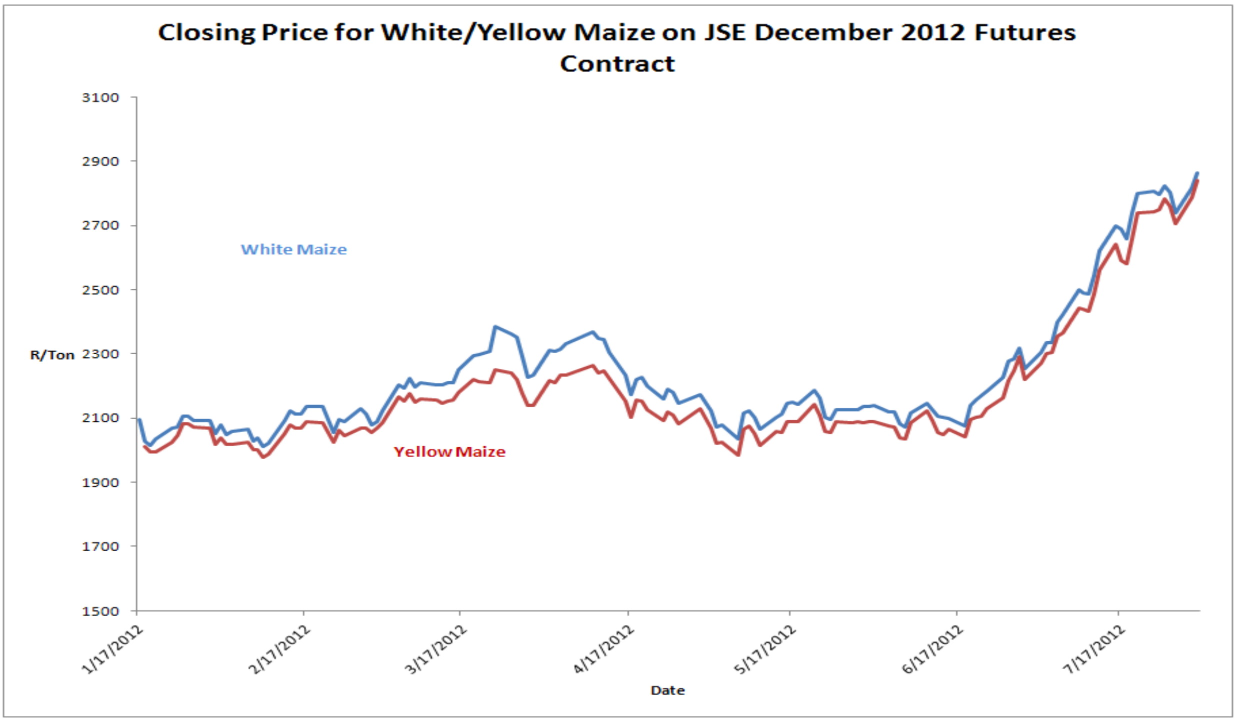


Figure 7: Price Trend for White Maize on SAFEX[16]

3.4 Volatility in Prospect and Retrospect

The presence of volatility trends in agricultural commodity prices affects production and investment decisions (Antypas, Koundouri and Kourogenis, 2011). In the case of farmers, for example, positive volatility trends result in the sky-rocketing of the cost of hedging using options

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[16] Source: SAFEX (2012)

(Antypas, Koundouri and Kourogenis, 2011). Munier and Briand (2012) point out that price volatility of the most basic agricultural commodities has been documented for a very long time. The diagram below depicts the volatility of relative price differentials (the other face of returns) on the FAO's annual food price index. The changes in relative price differentials are expressed in terms of standard deviations. The conclusion has been that there has been a sharp increase in price volatility on final consumption markets (Munier and Briand, 2012).

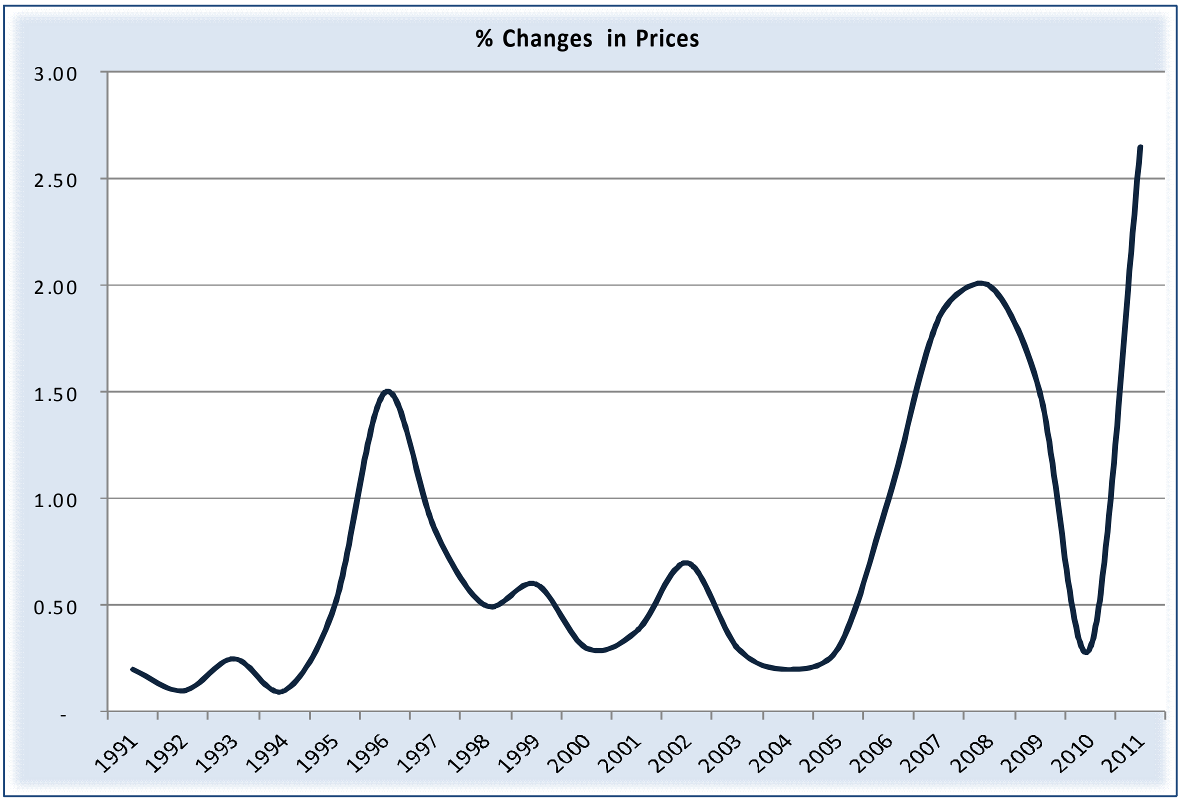

Figure 8: Annual % Changes in Prices of Cereals in Standard Deviations[17]

Munier and Briand (2012) show that commodity price volatility for the cereals has been increasing over the years. Given that there has been a general increase in prices over time, this means that peaks have outweighed lows among spikes.

Piot-Lepetit and M'barek (2011) point out that long-run commodity demand is largely driven by population and income dynamics. However, demographic changes generally occur fairly slowly and so do per capita income growth or decline. As a result, short-term price movements are rarely driven by either of these phenomena (Piot-Lepetit and M'barek, 2011). According to these

[17] Source: FAOSTAT, Food and Agricultural Organisation, 2011

authors however, currency exchange rate fluctuations between trading nations can occur more suddenly and can have significant effects on prices and international trade.

Gilbert and Morgan (2011) reported that agricultural commodity prices were very volatile over the period 2006 to 2010, prompting a lot of interest among economists as to the likely course of volatility over the long term. Rapsomanikis and Mugera (2011) state that between January 2007 and June 2008, the FAO food price index rose by 63 %. Over the same period, international prices of traditional staple foods such as maize and rice increased by 74 % and 166 % respectively. Maize and rice prices also recorded a 30-year high in June 2008 (Rapsomanikis and Mugera, 2011). In a report presented to the G20 grouping by FAO et al. (2011) however, it was put forward that there is no evidence that volatility in international agricultural commodity prices is increasing, with this finding applying to both nominal and real prices.

3.5 What Causes Commodity Price Volatility?

Hull (2010) acknowledged that many traders usually have no problem in accepting that volatility is to a large extent caused by trading itself. Munier (2012) and Xiong (2012) provide a number of factors that are attributable to the fact that commodity prices have apparently become more volatile than ever. The factors are the following:

- The political factor
- Natural risk factor
- Demand structural change factor
- The farming inputs prices factor
- The inventory policy explanation factor
- The bio-fuels factor
- The money supply factor
- Global financialization factor

Gilbert and Morgan (2011) pointed out that the reason why agricultural prices vary is that production and consumption are also variable. There is often a distinction between predictable and unpredictable variability, the latter being characterised by shocks (Gilbert and Morgan, 2011). Shocks to production and consumption transmit into price variability. Hernandez (2012) identifies factors such as integration of energy and agricultural markets, macroeconomic conditions and financial speculation as key drivers of commodity price volatility. Yang, Balyeat and Leatham (2005) made findings from their investigations which were consistent with the destabilising effect of futures trading on agricultural commodity markets. They therefore argue that this may be the explanation why the criticisms of futures markets have traditionally been more virulent for agricultural commodities, as opposed to the other financial asset classes (Yang, Balyeat and Leatham, 2005).

3.5.1 *The Political Factor*

Munier (2012) observed that major commodity producing countries were traditionally either involved in the exportation (dumping) of surplus production on the world market or banned exports when production was short (or when internal prices were too high). However, this trend is contrary to what is being observed on agricultural markets since early 2000 (Munier, 2012). The surpluses of the preceding 30 years have disappeared and been turned into shortages. The ban of exports of Russian wheat in 2010 resulted in wheat prices skyrocketing immediately after the announcement of the policy (Munier, 2012).

3.5.2 *Natural Risk Factor*

Natural events and unexpected supply-side climatic or natural exogenous shocks have been considered as a cause of volatility especially in the face of very small demand and supply short-term elasticities (Munier, 2012). However, a longer period of appraisal of Australia's grain production changes shows that these changes have negligible correlation with the global grain production changes. Tothova (2011) posits that weather-related events impact production variability and thus impact market fundamentals.

3.5.3 *The Demand Structural Change Factor*

Changing diets, increased demand for meat in most emerging economies have all seen an increasing trend in the demand for food (Munier, 2012). China and India have been increasing their consumption of meat significantly in recent years. Maize grain constitutes the largest ingredient in the manufacture of stock feeds. However, Munier (2012) contends that this factor when considered alone is quite inconclusive in explaining high volatility.

3.5.4 *The Farming Inputs Prices Factor*

Munier (2012) alludes to the fact that farming input costs have an effect on agricultural commodity prices, with key inputs costs being inclusive of the price of oil, seeds and fertiliser prices. One observation on the Chicago wheat market has been that the oil price peaks seem to follow the wheat price peaks and a direct causal explanation seems then unconvincing (Munier, 2012).

3.5.5 *The Inventory Policy Explanation Factor*

Munier (2012) says the inventory policy explanation factor entails the reduction of agricultural commodity inventories as a result of government policies. It is also however pointed out by Munier (2012) that inventories of agricultural commodities across the world are known with an error which is probably over 20%.

3.5.6 *The Bio-Fuels Factor*

Bio-fuels have probably influenced the trend of agricultural commodity prices, according to Munier (2012). Munier (2012) however is reluctant to accept that bio-fuels can be invoked to explain the volatility of commodity prices. Tothova (2011) points out that before the advent of bio-fuels, linkages between energy and agricultural markets were one-way as oil and energy were inputs to agricultural production. Tothova (2011) goes on to point out that research that has been conducted to date shows evidence of volatility spill-over among crude oil, maize and wheat markets after autumn 2006 and explained it by tightened interdependence between these markets. The interdependence was said to be induced by ethanol production.

3.5.7 *The Money Supply Factor*

Munier (2012) suggests that the monetary policy of the USA, to the extent that it affects exchange rates, could have an indirect effect on possible soft commodity price volatility. The easing of monetary conditions in Europe and the USA since the early 1980's probably had an impact on the increase of prices of agricultural commodities, although the correlation is expected to be fairly low (Munier, 2012).

3.5.8 *Global Financialization Factor*

Antypas, Koundouri and Kourogenis (2011) observed that consensus generally exists in the financial industry to the effect that the volatility of commodity prices has been increasing under the growing influence of financial derivatives in commodity markets. Speculative activity has been mentioned as a good candidate to explain at least part of world price volatility in agricultural commodities (Munier, 2012). While it is believed that speculation may be associated with the concept of quantitative easing and the slackening of financial markets regulation, speculation as a concept, has been studied very little (Munier, 2012). Piot-Lepetit and M'barek (2011) assert that in the short term, market shocks arise out of financial factors inclusive of speculation and hedging on commodity futures, options and other derivatives markets. The resulting price behaviour depicting the flow of randomly appearing information can also be related to financial shocks such as in interest and exchange rates (Piot-Lepetit and M'barek, 2011). The authors point out that demand created by speculators may have the effect of driving prices higher at times when stocks of these commodities are low.

Tothova (2011) points out that volatility can attract significant speculative activity and in the process destabilise markets. Where there is a thin market, speculative trades may create false trends and drive up prices for consumers (Tothova, 2011). The view of Gilbert and Morgan (2011) is that speculation will tend to be stabilising (that is, volatility reducing) because destabilising speculation will be unprofitable and will therefore not persist. The worry is that the extrapolative-based actions of speculators may result in self-fulfilling beliefs. This therefore means that randomly induced price rises, where they are identified as a nascent trend, may generate further buying, reinforcing the initial movement in the process (Gilbert and Morgan, 2011).

3.6 Implications of Increased Volatility

Tothova (2011) maintains that in the absence of risk management tools, grain producers and processors are exposed to unpredictability and uncertainty associated with changing prices. On the other hand, volatility of agricultural inputs prices (oil, fertiliser and seed, among others) also affects agricultural production and decision-making. Tothova (2012) also further points out that higher price volatility further means higher cost of managing risks. These risk management costs are inclusive of margins on futures contracts and higher premiums for crop revenue insurance. Piot-Lepetit and M'barek (2011) also allude to the link between increased volatility and inflation. This is also due to the fact that higher costs of risk mitigation would eventually translate into higher consumer prices.

Importing rich nations are concerned about food price volatility in terms of the impact it might have on consumer price inflation (Gilbert and Morgan, 2011).

3.7 Seasonality of Agricultural Commodities

According to Piot-Lepetit and M'barek (2011), the biological nature of crop production plays an important role in agricultural product price behaviour. Producers make decisions based to some extent on their expectations of future yields, prices for both outputs and inputs and partly on relevant government policies that impact on given commodities (Piot-Lepetit and M'barek, 2011). These authors state that seasonal effects describe the cyclical fluctuations related to the year calendar. A trend describes the long-term movement in the mean of the series. Richter and

Sørensen (2002) acknowledge that soft commodities exhibit seasonality patterns in both their spot price levels and their volatility.

3.8 Commodity Stock Levels and Price Volatility

Hull (2012) observes that the key statistic called the *stocks-to-use* ratio has an impact on price volatility of a given soft commodity. This ratio is defined as the year-end inventory to the year's usage of the commodity and is typically between 20 % and 40 % in the USA, in the case of maize and wheat. Tothova (2011) asserts that volatility peaks seem to coexist with decreased commodity stock levels. According to Gilbert and Morgan (2011), when commodity stock levels are low, relatively small shocks in production or consumption volumes can have large price impacts, and the converse is true. Hernandez (2012) posits that global rapid economic growth has created additional demand for commodities, which lowered stocks-to-use ratios for wheat, soybeans and maize on average to 18, 23 and 26 percent respectively between 2001 and 2010. This led to a significant increase in agricultural commodity prices (Hernandez, 2012).

3.9 Derived Nature of Agricultural Product Prices

Piot-Lepetit and M'barek (2011) affirm that the demand for agricultural products originates from consumers and industrialists who are the end-users of the commodities. Cereals and other feedstuffs are important inputs into the livestock industry. Feed demand for cereals and protein meals is sensitive to relative feed grain prices (Piot-Lepetit and M'barek, 2011).

3.10 Price-Inelastic Demand and Supply

Piot-Lepetit and M'barek (2011) show that demand and supply of farm products are relatively price inelastic. This means that the quantities demanded and supplied change proportionally less than prices. On the other hand, this means that even small changes in supply can result in large price movements. Unexpected market news can also produce potentially large swings in farm prices and incomes (Piot-Lepetit and M'barek, 2011). At the same time, short-term supply response to a price rise can be very limited during periods of low stock holdings. In the long-run expanded acreage and more intensive cultivation practices could work to increase supplies. Piot-Lepetit and M'barek (2011) further point out that when prices fall, producers might be inclined to withhold their commodity from the market. The cost of storage however and the time it takes for prices to rebound and the producer's current cash-flow situation determine whether storage is a viable alternative. Piot-Lepetit and M'barek (2011) state that inelastic demand and supply responsiveness characterises most agricultural products. They further point out that the speed and efficiency with which various price adjustments occur depend largely on the market structure within which commodities are traded.

Piot-Lepetit and M'barek (2011) list the following as being the common attributes of market structure:

- The number of buyers and sellers in the market and hence the level of competitiveness
- The commodity's homogeneity in terms of type, variety, quality and end-use characteristics (greater product differentiation is generally associated with greater price differences)
- The number of close substitutes
- The commodity's storability
- The transparency of price formation (greater transparency, less manipulation)
- The ease of commodity transfer between buyers and sellers and among markets (greater mobility limits spatial price differences).
- Artificial restrictions on the market processes, for example government policies or market collusion from a major participant.

Hernandez (2012) found that economic relationships that explain commodity demand and supply are derived from the economic theory of consumer demand and production. At the same time, inventory relationships are derived from partial adjustment to equilibrium theory while price relationships emanate from the competitive and non-competitive nature of markets (Hernandez, 2012).

3.11 Commodity Currencies

"Commodity currencies" is a term which refers to the few floating currencies that co-move with the world prices of primary commodity products. The countries from which these floating currencies are from have heavy dependency on commodity production. Three such countries are Australia, Canada and New Zealand (Chen, Rogoff and Rossi, 2010). These countries have well-developed asset markets and a sufficiently long history of market-based floating exchange rates, according to Chen, Rogoff and Rossi (2010). These economies have also been stable and devoid of major crises or hyper-inflationary episodes over the last couple of decades unlike Brazil, Thailand and other major commodity exporters. Chen, Rogoff and Rossi (2010) point out that fluctuation of global commodity prices serves as an easily observable and exogenous terms-of-trade shock to these countries. These shocks in turn affect the currency and equity market values in these countries owing to their heavy production and export dependency. The fact that world commodity prices are a robust and reliable fundamental in explaining the movement of these countries exchange rates is why they are branded “commodity currencies” (Chen, Rogoff and Rossi, 2010).

3.12 Volatility on Futures Markets

The Chicago Mercantile Exchange (2012) offers already calculated measures of volatility. Different agricultural commodities depict different price and volatility patterns. In the case of wheat on the CME over the period January 1980 to January 2010, the volatility of the commodity has gradually increased over time, according to Piot-Lepetit and M’barek (2011). The highest volatility level reached over this period was 73 % around May, 2008. The graph below depicts the US wheat price historical volatility, futures open interest and monthly volumes transacted on the CME futures platform over the period January 1985 to January 2010.

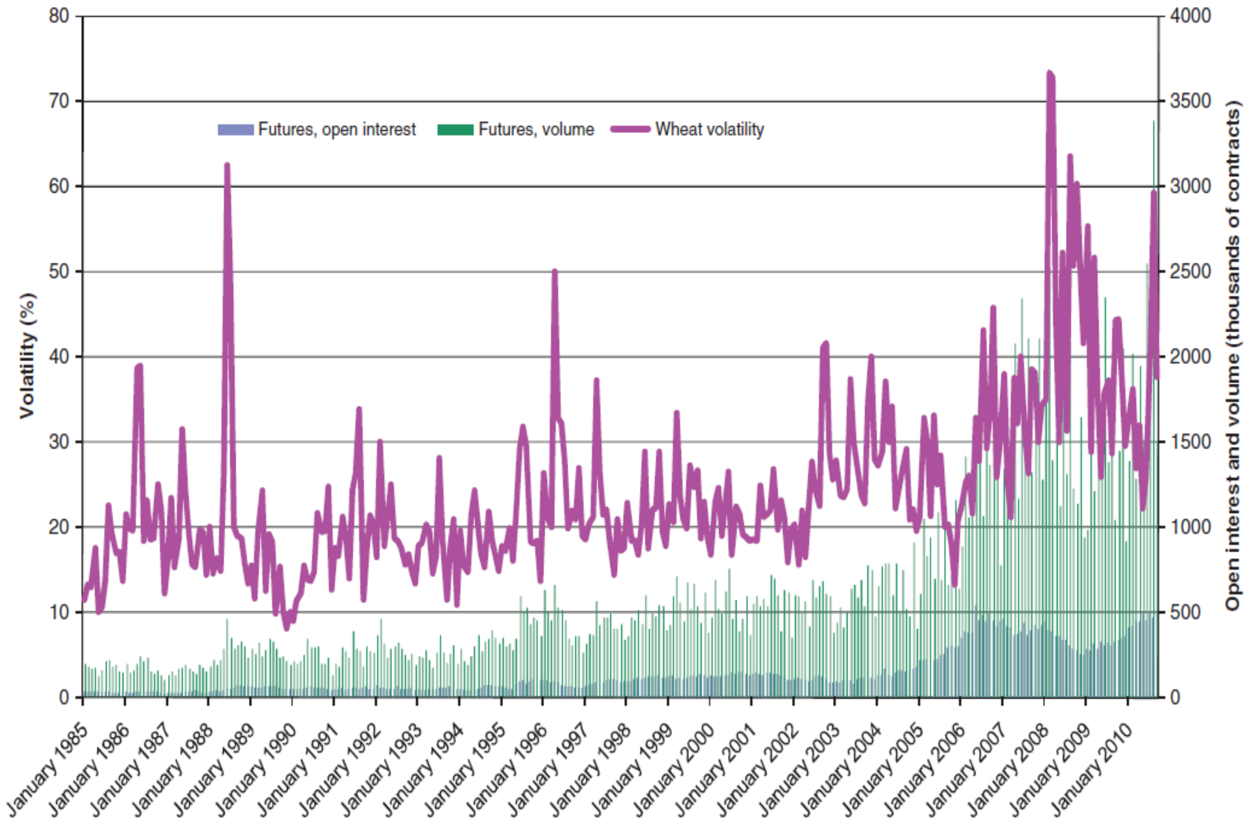

Figure 9: US Wheat Historical Volatility, Futures Open Interest, Monthly Volume[18]

[18] Source: CME Group

The South African Futures Exchange (2012) has a measure called the South African Volatility Index (SAVI) which calculates the volatility of white maize on that exchange. The diagram below depicts the SAVI historical trend.

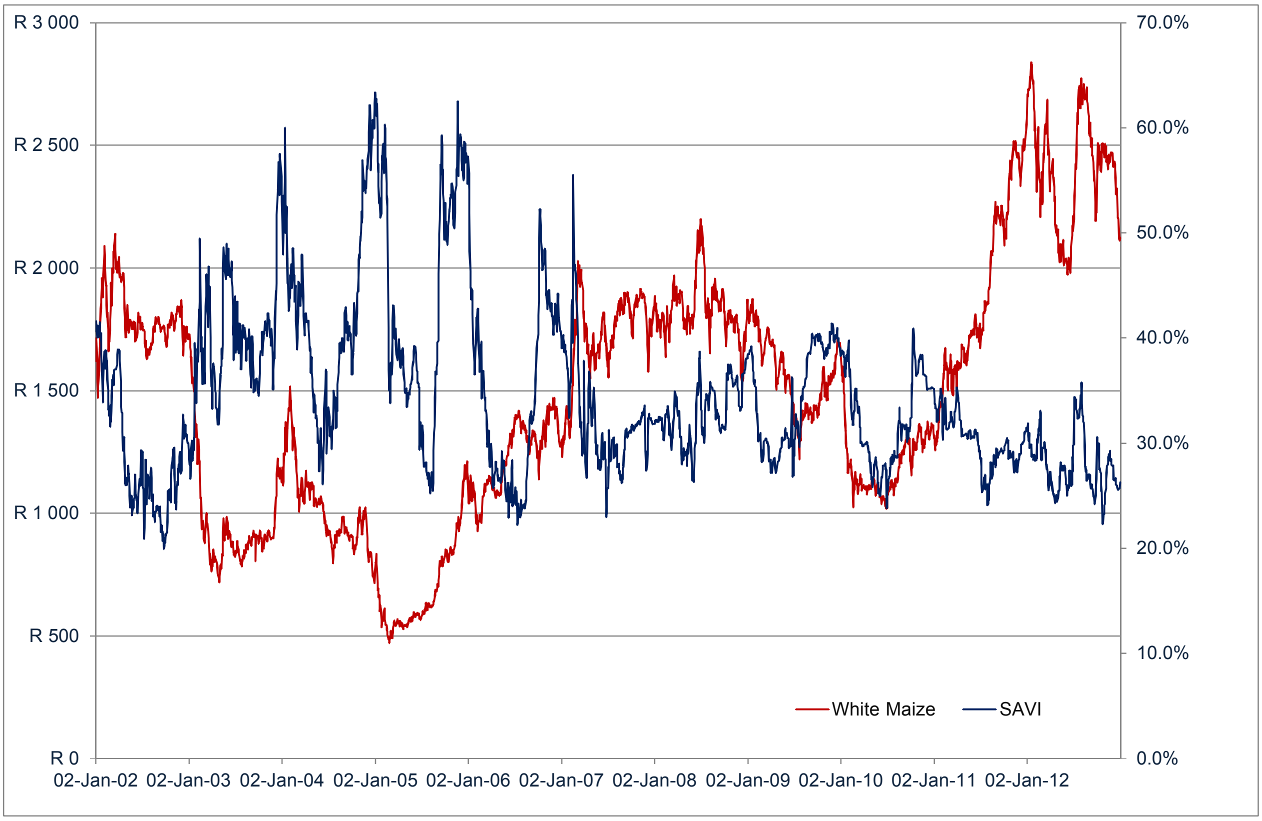

Figure 10: South African Volatility Index[19]

3.13 Modelling Commodity Price Volatility

Just (2001) recognised three families of models which could cope with some of the challenges of commodity modelling, namely game theory, chaos theory and fuzzy measures. He further points out however that none of the models is perfect. Piot-Lepetit and M'barek (2011) assert that in modelling price volatility, we should discriminate what is usual and normal from what is irregular and abnormal. Gilbert and Morgan (2011) showed that complex price models have been developed in recent years that include the following:

- Autoregressive moving average (ARMA) model
- Autoregressive conditional heteroskedasticity (ARCH) model

[19] Source: SAFEX (2012)

- Generalised autoregressive conditional heteroskedasticity (GARCH) model
- Exponential generalised autoregressive conditional heteroskedasticity (EGARCH) model
- Asymmetric power autoregressive conditional heteroskedasticity (APARCH) model

3.13.1 *Autoregressive Moving Average Model*

Piot-Lepetit and M’barek (2011) give the general form of the ARMA(p,q) model of autoregressive order p and moving average order q as follows:

$$\sigma_{\sigma} = \sigma + \mathop{\sigma}\limits_{\sigma\sigma\,\sigma}^{\sigma} \varphi_{i} x_{\sigma\sigma\,\sigma} + \sigma_{\sigma} + \mathop{\sigma}\limits_{\sigma\sigma\,\sigma}^{\sigma} \theta_{j} \sigma_{\sigma\sigma\,\sigma}$$

where σ_{σ} is the dependent variable, $\sigma_{\sigma\sigma\,\sigma}$ for *i = 1,...........,p* are lagged dependent variables; σ_{σ} is the error term and assumed to be white noise; $\sigma_{\sigma\sigma\,\sigma}$, *j = 1,..........,q* are lagged error terms; t denotes the time period and σ the mean. The autoregressive coefficients σ_{σ} and σ_{σ} are parameters to be estimated. Piot-Lepetit and M’barek (2011) provide the assumption that this is a Gaussian process with mean zero and a constant variance σ^2.

3.13.2 *Exponentially Weighted Moving Average Model*

Hull (2010) provides the formula for the EWMA model as:

$$\sigma_{\sigma}^{\sigma} = \sigma\sigma_{\sigma\sigma\,\sigma}^{\sigma} + (1-\sigma)\sigma_{\sigma\sigma\,\sigma}^{\sigma}$$

where σ is a constant between zero and one. In this case, $\sigma_{\sigma\sigma\,\sigma}$ is the lag of the volatility and u_{n-1} is calculated as

$$\sigma_{\sigma} = \frac{\sigma_{\sigma} - \sigma_{\sigma\sigma\,\sigma}}{\sigma_{\sigma\sigma\,\sigma}}$$

S_i is the market variable under study, for example, the maize price on day *i*.

3.13.3 *Autoregressive Conditional Heteroskedasticity Model*

A data series may be described as having time-varying volatility using an ARCH model allowing the variance of error terms to change over time (Piot-Lepetit and M’barek, 2011). The σ_{σ} terms of the ARMA in the equation above are defined as an autoregressive conditional heteroskedastic process where all σ_{σ} are of the form:

$$\sigma_{\sigma} = \sigma_{\sigma}\sigma^{\sigma}$$

initial debit) and is realised at B at expiration (CME, 2012). This loss is less than for the equivalent long straddle (CME, 2012).

3.18 Conclusion of Literature Review

The ARCH/GARCH approach is used by Moledina, Roe and Shane (2004) as well as Jordaan, Grove, Jooste and Alemu (2007) to determine the volatility in the prices of agricultural derivatives in South Africa. This study seeks to extend the study period to 2012 and avail the results for forecasting purposes. The study is to compare the results and conclusions of relevant earlier studies that used comparable models to those proposed in the present study's research methodology chapter.

4 RESEARCH METHODOLOGY

This section will comprise the research methodology, the research design and a description of the nature of the mathematical models that will be used under the study. The research instruments and the theory guiding the data analysis are also explained.

4.1 Research methodology and Paradigm

In estimating the true stochastic components in the prices of agricultural derivatives, the effects of known components (such as the trend and seasonal effect) are eliminated (Jordaan, Grove, Jooste and Alemu, 2007). Historical daily SAFEX price data on agricultural derivatives will be used in this study. This data is to be obtained from the JSE and SAFEX. This paper will therefore make use of quantitative methodologies underpinned by econometric and mathematical modelling.

4.2 Research Design

The methodological approach under this study will encompass the use of case studies and mathematical modelling. The univariate GARCH (1,1) model is presented as shown below.

$$\sigma_{\sigma}^{\sigma} = \sigma + \sigma\sigma_{\sigma\sigma\sigma}^{\sigma} + \sigma\sigma_{\sigma\sigma\sigma}^{\sigma}$$

where the parameters σ, σ and σ are constants with $\sigma = \sigma\sigma_{\sigma}$. The variable σ is given by $1 - \sigma - \sigma$. V_L is the long-term variance. In this case, $\sigma_{\sigma\sigma\sigma}$ is the lag of the volatility and u_{n-1} is calculated as

$$\sigma_{\sigma} = \frac{\sigma_{\sigma} - \sigma_{\sigma\sigma\sigma}}{\sigma_{\sigma\sigma\sigma}}$$

S_i is the market variable under study, for example, the maize futures price on day *i*. The more general GARCH (p,q) is presented as:

$$\sigma_{\sigma}^{\sigma} = \sigma + \overset{\sigma}{\underset{\sigma\sigma\sigma}{\sigma}} \sigma_{\sigma}\sigma_{\sigma\sigma\sigma}^{\sigma} + \overset{\sigma}{\underset{\sigma\sigma\sigma}{\sigma}} \beta j\, \sigma_{\sigma\sigma\sigma}^{\sigma}$$

where the parameters σ, σ and σ are constants with $\sigma = \sigma\sigma_{\sigma}$. V_L is the long-term variance. The variable σ is given by $1 - \sigma - \sigma$. The term $\sigma_{\sigma\sigma\sigma}$ is the lag of the volatility and σ_{t-i} is calculated as

$$\sigma_{\sigma} = \frac{\sigma_{\sigma} - \sigma_{\sigma\sigma\sigma}}{\sigma_{\sigma\sigma\sigma}}$$

S_i is the market variable under study, for example, the wheat futures price on day *i*.

4.3 Population and sample

4.3.1 *Population*

The population under this study includes role players within the grain silo industry that are also registered members of SAFEX. The share price movements of the selected entities from this group is analysed to determine whether they are dependent on the price volatility of maize, wheat, sunflower and soybeans as provided by the GARCH (p,q) model. Table 12 below provides the data definitions of all the variables that are used under the study.

4.3.2 *Sample and sampling method*

A sample will be drawn from the largest top 20 agribusinesses in South Africa (according to market capitalisation) involved in soft commodity handling, trading and agro-processing. Convenience sampling will be appropriate given the anticipated challenges in gathering the share price data from some of the entities targeted under the study.

The following table depicts the expected profile of the professionals with whom potential discussions will be conducted to assist in gathering the share prices referred to above and in the qualitative interpretation of the results of the mathematical modelling.

Description of Professional by Type, within the Grains and Oilseeds sub-sector	
1	Grain commodity general management
2	Grain silo managers
3	Grain brokers
4	Grain international commodity dealers
6	SAFEX traders
7	Procurement professions
8	SAFEX employers
9	Grain logistics professionals
10	Grain marketing management
11	Grain business development professionals

Table 10: Profile of Key Professionals in the Industry

4.4 The research instrument

The key research instrument to be used under the study is the mathematical model(s) to be developed which will be used to accomplish the research objectives. The key attributes and shortcomings of this research instrument will be provided within the course of the research project.

4.5 Procedure for data collection

Agricultural derivatives historical price data will be gathered from SAFEX. Share prices of the chosen agribusinesses will be obtained from the JSE and from each of the respective companies' websites. The Price-Waterhouse Coopers reports on the grain handling and trading sector will also be used in determining financial and economic performance of the role players as a collective. Soft commodities demand and supply statistics will be secured from the National Agricultural Marketing Council (NAMC), the South African Grain Information Services (SAGIS), Agri-SA, Senwes Limited databases and Grain SA.

4.6 Modelling Volatility

The GARCH(p,q) model is used under the study. Most models utilized when studying volatility focus on integration, cointegration and error correction (Hernandez, 2012). Granger causality is one of the major tests used to determine the impact a variable has on price volatility, or what effect price volatility has on a variable. The family of GARCH models is usually the preferred choice when it comes to dealing with financial time series (Zhao, Zhang and Zou, 2012). Yang, Haigh and Leatham (2001) extended the use of the GARCH framework to test the hypothesis on agricultural price volatility changes associated with the introduction of new agricultural marketing-related legislation in the USA. The FAIR Act was promulgated in the USA in 1996.

4.7 Volatility in Agricultural Commodities

The empirical study under this research project uses daily commodity futures prices on SAFEX. The commodities under study are maize, wheat, sunflower and soybeans and the prices used cover the period January 1998 to August 2012. The time-varying pattern of price volatility of agricultural commodities can be described well by a GARCH process (Yang, Haigh and Leatham, 2001 and Calvo-Gonzalez, Shankar and Trezzi, 2010). In addition, Calvo-Gonzalez, Shankar and Trezzi (2010) point out that the GARCH process permits for the inclusion of additional structural determinants in the model that can help to tell how volatility is changing and what drives it. At the same time, price volatility as well as price forecasts can be determined

4.13 Limitations of the study

Data on returns or earnings by grain traders is normally available on an annual or bi-annual basis while information on grain prices is available daily from SAFEX. This makes it more difficult to create a clear relationship between these variables. There also exists a lot of confidentiality exercised by SAFEX trading entities, especially those that are not listed on the Johannesburg Stock Exchange. It was therefore decided that daily share price changes for the firms under study be used in place of returns or earnings of these firms.

4.14 Data analysis and interpretation

The next section will provide the results obtained under the study and give an overview of the data analysis and interpretation of the use of the methods applied in this process. Included in the next chapter will be a brief description of the output of the econometric modelling and analysis under the study, descriptive statistics and content analysis.

5 RESULTS OF THE EMPIRICAL ANALYSIS

This section presents the results of the empirical analysis conducted under the project in accordance with the methodology presented above. In order to streamline the results and make them easier to read, data for commodity prices for white maize, yellow maize and sunflower only was used, while the company share price series for Tiger Brands Limited and Afgri Limited was used to carry out the Granger Causality analysis.

5.1 Descriptive Statistics of the Data

5.1.1 *Agricultural Commodity Price Trend Descriptive Statistics*

The following table depicts the descriptive statistics for the commodity price time series that was used for the study.

Commodity	N	(Rands/Ton)			StandardDeviation
		Minimum	Maximum	Mean	
White Maize	2 245	471	2 140	981	371
Yellow Maize	2 245	483	1 783	931	291
Wheat	1 055	1 233	2 047	1 543	172
Sunflower	804	1 534	3 080	2 093	308
Soybeans	426	1 090	2 350	1 690	292
ValidN (listwise)	426				

Table 13: Agricultural Commodity Price Trend Descriptive Statistics

The mean white maize price over the period under study is R981.00 per tonne while that of yellow maize is R931.00 per tonne. Out of all the commodities under study, sunflower has the highest mean price over the entire price time series length which stands at R2,093.00 per tonne. Also ignoring that the time series of the different commodities are not of the same length in time, white maize registered the highest standard deviation levels at R371.00.

5.1.2 *Tiger Brands Share Price Descriptive Statistics*

Company	N	Cents			Standard Deviation
		Minimum	Maximum	Mean	
Tiger Brands Limited	3 210	5 000	32 700	13 487	6 287

Table 14: Tiger Brands Share Price Descriptive Statistics

Tiger Brands Limited has a mean share price of 13,487 cents and standard deviation of 6,287 cents over the period under study. The minimum share price is 5,000 cents while the maximum share price is 32,700 cents.

5.1.3

Company	N	Cents			Standard Deviation
		Minimum	Maximum	Mean	
Afgri Limited	2 613	304	784	588	90

Table 15: Afgri Limited Share Price Descriptive Statistics

Afgri Limited has a mean share price of 588 cents and a standard deviation of 90 cents over the period under study.

5.1.4

This section presents the trend for the time series for the commodity price and company share price series the under study. The following graph depicts the trend for the white maize price series over the period under study. Maize prices rose tremendously around the period 2001/2002 when a regional drought was experienced within virtually the entire SADC area whilst prices dropped significantly following the global economic recession around the year 2008. In the last few years, white maize prices have been increasing substantially on account of the following reasons:

- The rapid global population increase
- Increased demand from China and India
- Droughts experienced in the USA
- Droughts and unexpected fires experienced in Russia
- Floods, droughts and other adverse weather conditions experienced in Africa, Asia and other parts of the world.

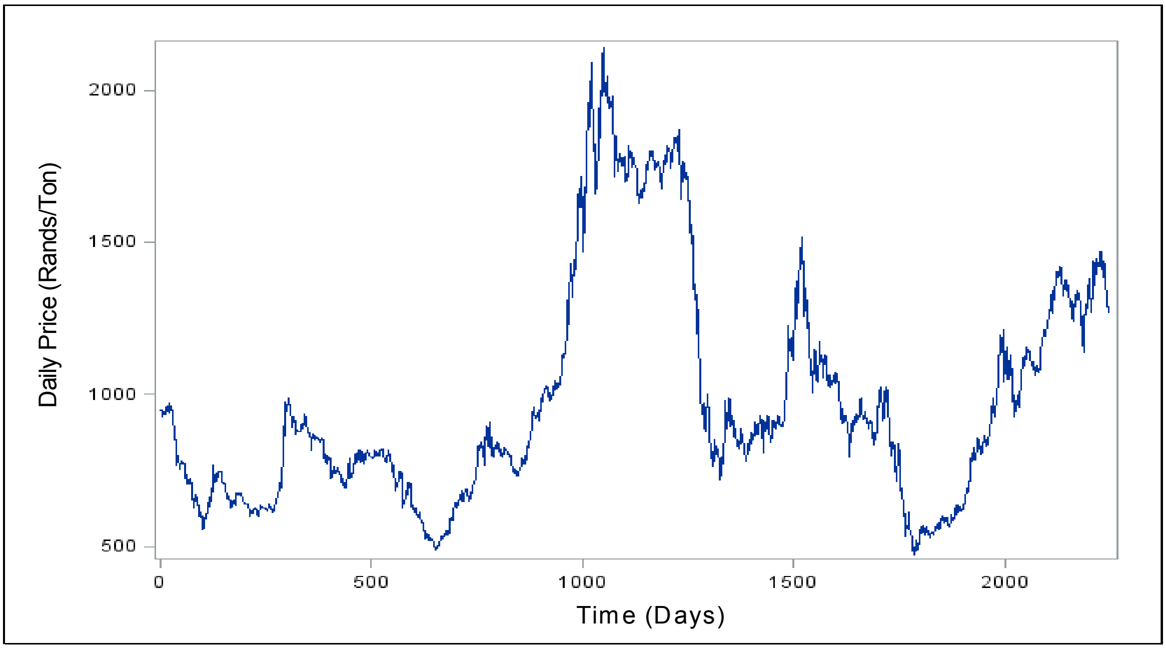

Figure 20: White Maize Price from 5 January 1998 to 29 December 2012

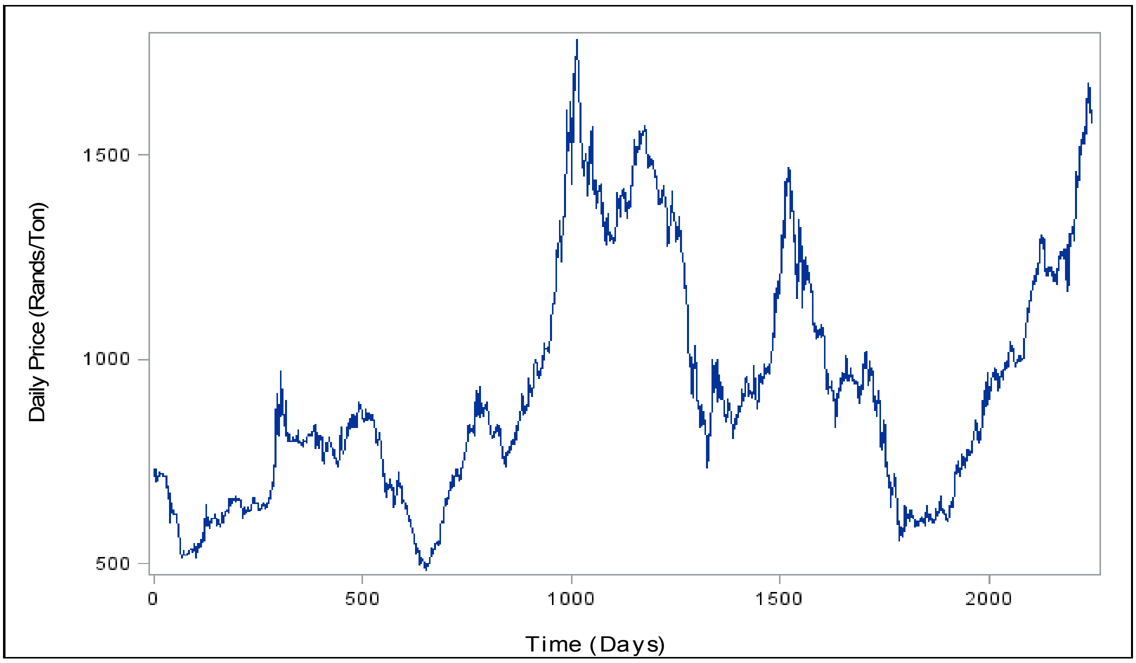

Figure 21: Yellow Maize Price from 5 January 1998 to 29 December 2012

The graph above depicts the yellow maize daily price trend over the period under study. The trend for yellow maize has a fairly similar pattern to that of white maize. It is important to note that the price trend for maize is substantially different to that of wheat given that wheat is a winter crop while maize is a summer crop. The graph below depicts the daily price trend for wheat over the years.

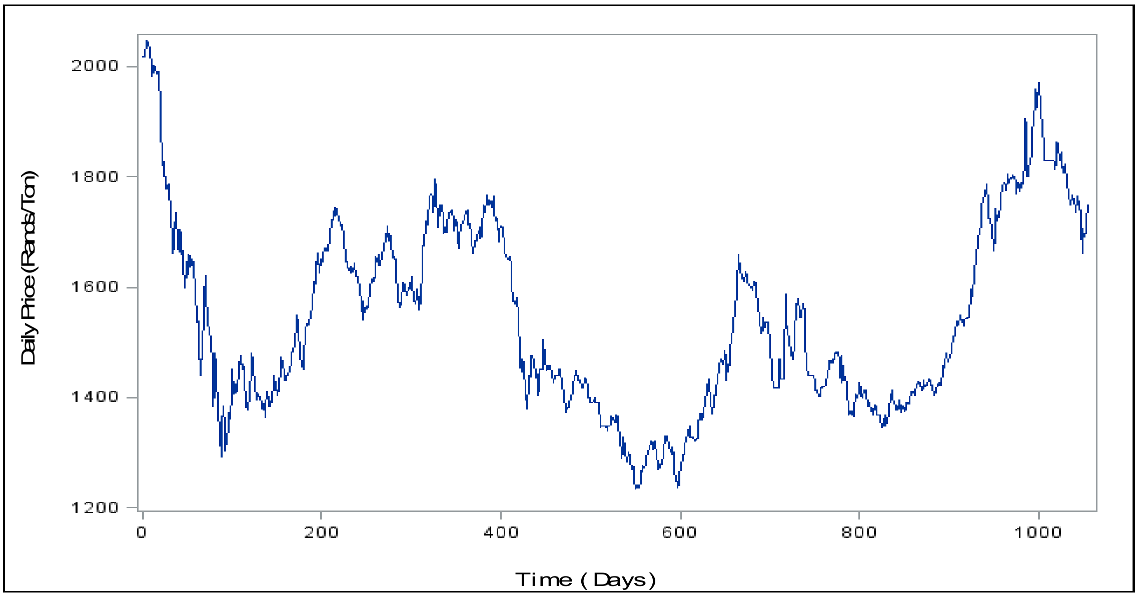

Figure 22: Wheat Daily Price Trend from 1 January 2003 to 29 December 2012

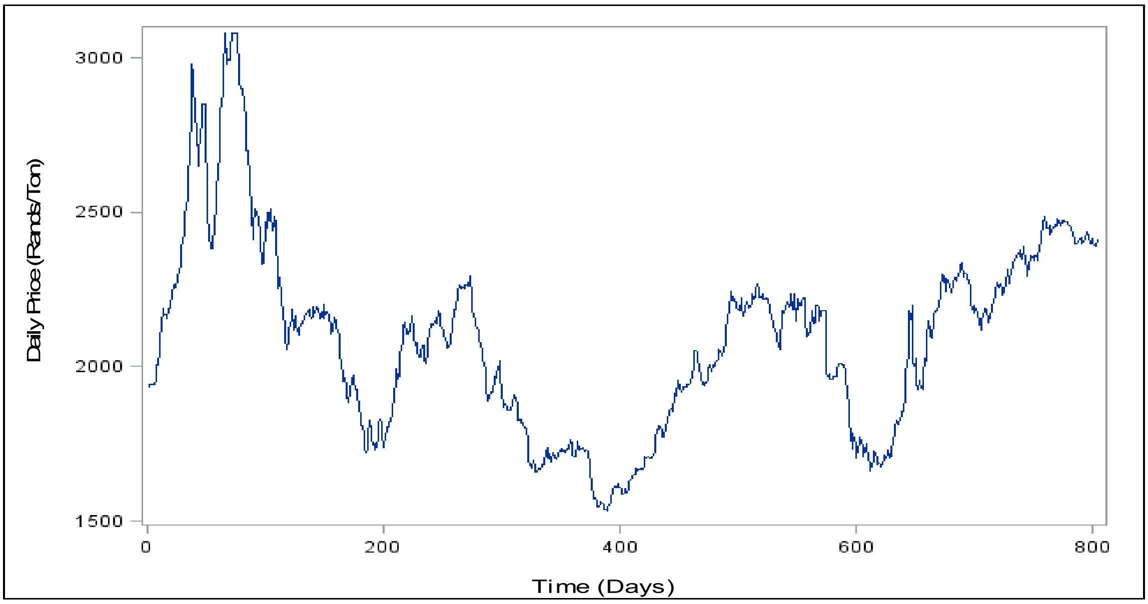

Figure 23: Sunflower Daily Price Trend from 14 October 2003 to 29 December 2012

The sunflower daily price trend somewhat depicts a different trend from the other commodities. The prices of sunflower reached their highest at the beginning of the price series only to decline towards the middle of the price series. The prices rose gradually from there right up to the end of the period depicted by the graph.

The case of company share price series presents a somewhat different picture. The daily share price for Tiger Brands Limited depicts a fairly increasing trend as shown below.

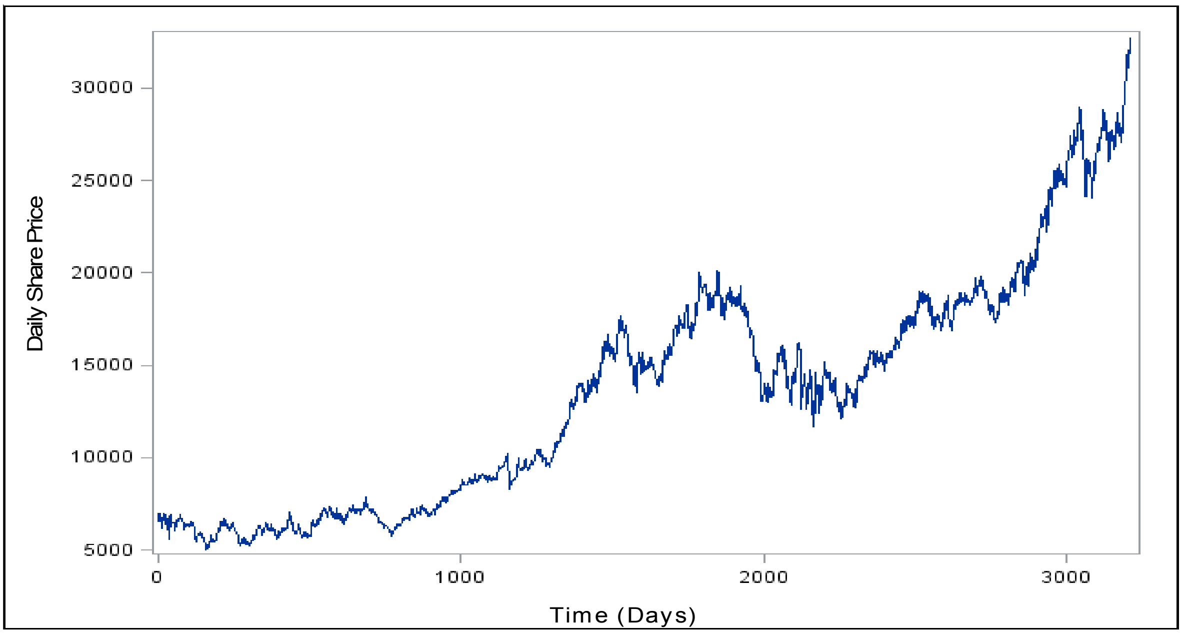

Figure 24: Tiger Brands Daily Share Price from 28 February 2000 to 31 December 2012

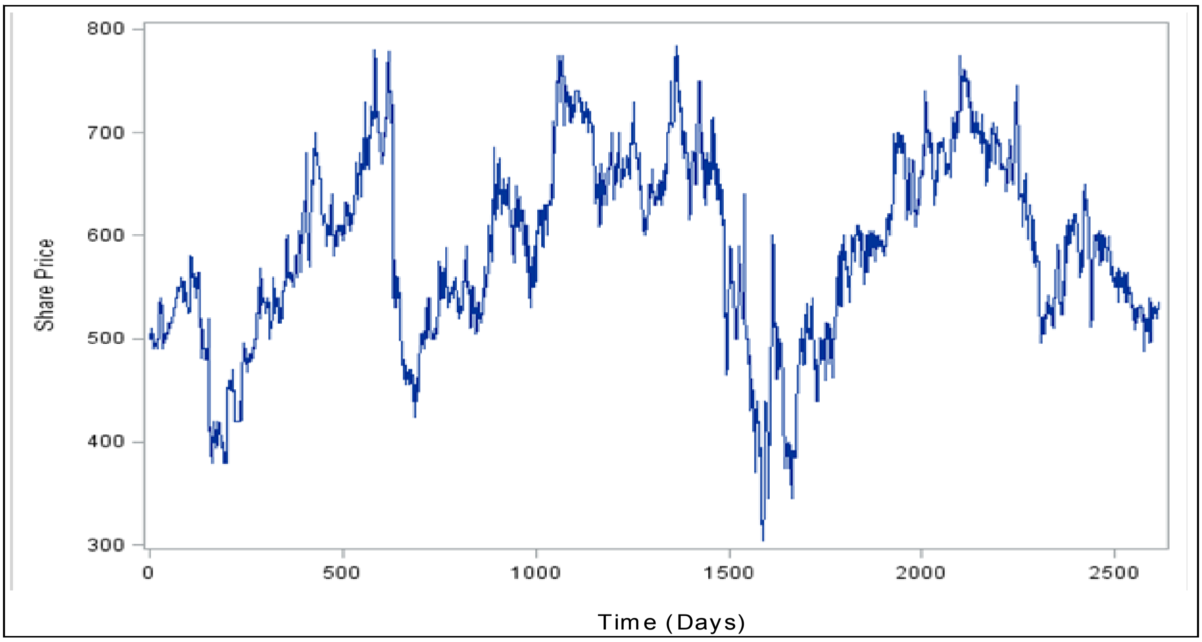

Figure 25: Afgri Limited Daily Share Price from 22 July 2000 to 31 December 2012

The share price of Afgri Limited shows a somewhat more random rising and falling pattern within a range of between 300 cents and 800 cents. The share price of Afgri Limited dropped substantially around the time of the global recession.

5.2 The Data Generating Process

Ahead of running the ARCH and GARCH processes, tests are conducted in order to determine the seasonal component, then whether there is unit root. In this case, since daily prices were used for the series under study rather than monthly series, seasonality may not be such a major impediment to the analysis. If seasonality is present in the price series, then the X11 procedure would have to be used to eliminate the effects of the seasonality. Once the seasonal component is analysed, the tests for unit root is performed based on the Dickey-Fuller methodology. The null hypothesis is usually stated as saying the process is non-stationary. This means the process has unit root. Should this be the case, differencing of the respective series is conducted in order to make the process stationary.

5.3 The Seasonal Component

In order to examine the seasonal component of the price series for the agricultural commodities, the study employed the Autocorrelation Function (ACF) and the Inverse Autocorrelation Function (IACF). Plots of the autocorrelation function were used to confirm whether seasonality could be concluded for the daily commodity price series and the daily share price series for Tiger Brands Limited and Afgri Limited. The correlograms generated are depicted in Appendix I. In the case where there is strong seasonality in the series, spikes in the correlograms would be expected say after every 2, 4, 6, 8 or 12 observations. The results are therefore not showing strong seasonality in the daily data that was used. It should however be noted that seasonality would be expected to occur in the monthly data in the case of the prices of the agricultural commodities. There is therefore no need to adjust for seasonality where daily data has been used in the analysis.

5.4 Stationarity of the Commodity Price Time Series

The Dickey-Fuller test is used to determine unit root or stationarity. The test statistic generated by the Augmented Dickey-Fuller test is interpreted as follows:

- If the statistic generated is 2 or close to 2, then the series is stationary
- If the statistic is closer to zero or closer to 4, then the series is not stationary

The table below depicts the p-values generated by the test in the case of the price series for the agricultural commodities under study.

Commodity	Lag Order	P Value	Stationary or not Stationary
White Maize	0	0.7921	Not Stationary
Yellow Maize	0	0.8952	Not Stationary
Wheat	0	0.3435	Not Stationary
Soyabeans	0	0.9046	Not Stationary
Sunflower	0	0.798	Not Stationary

Table 16: Results of the Unit Root Tests at Zero Lag Order

The time series for each of the commodity prices is not stationary at lag order zero, and hence there is need to conduct some appropriate differencing. Alternatively some suitable transformation of the data is required, for example, log transformation.

5.5 Presenting the ARCH and GARCH Process

5.5.1 *White Maize*

The following table shows the summary output after running the ARCH and GARCH process for the white maize time series.

GARCH Estimates			
SSE	253.29649	**Observations**	2245
MSE	0.11283	**Uncond Var**	0.1106061
Log Likelihood	1131.5678	**Total R-Square**	0.0647
SBC	-2185.9709	**AIC**	-2243.1355
MAE	0.2428844	**AICC**	-2243.0371
MAPE	3.4929664	**HQC**	-2222.2684
		Normality Test	81.1835
		Pr > ChiSq	<.0001

Table 17: White Maize Price Modelling Statistical Output

Where the p-value is less than 0.05, the series has the ARCH effect at 95 % confidence level. The next step is to determine the level of the ARCH and GARCH effects and the level of lags involved. The table below shows the parameter estimates for the ARCH and GARCH process for white maize. In this case the p-value is less than 0.05 and hence the coefficients are significant in the case of the intercept term, the deterministic trend term, the ARCH(0) and the ARCH(1) at 95 % confidence level. The ARCH(7) is significant at 90 % confidence level.

Parameter Estimates					
Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	6.5804	0.002213	2973.03	<.0001
Time	1	0.000154	1.85E-06	83.43	<.0001
ARCH0	1	0.000262	0.0000363	7.22	<.0001
ARCH1	1	0.9137	0.0945	9.67	<.0001
ARCH2	1	0	0	.	.
ARCH3	1	0.0178	0.0391	0.46	0.6485
ARCH4	1	0	0	.	.
ARCH5	1	0.0308	0.0342	0.9	0.3688
ARCH6	1	0	0	.	.
ARCH7	1	0.0353	0.0189	1.87	0.062

Table 18: Parameter Estimates for the ARCH and GARCH Process for White Maize

The graph below depicts the ARCH(7) fit at 95 % confidence level for the log-transformed series of the white maize price trend. A generally rising trend of the fit can be observed.

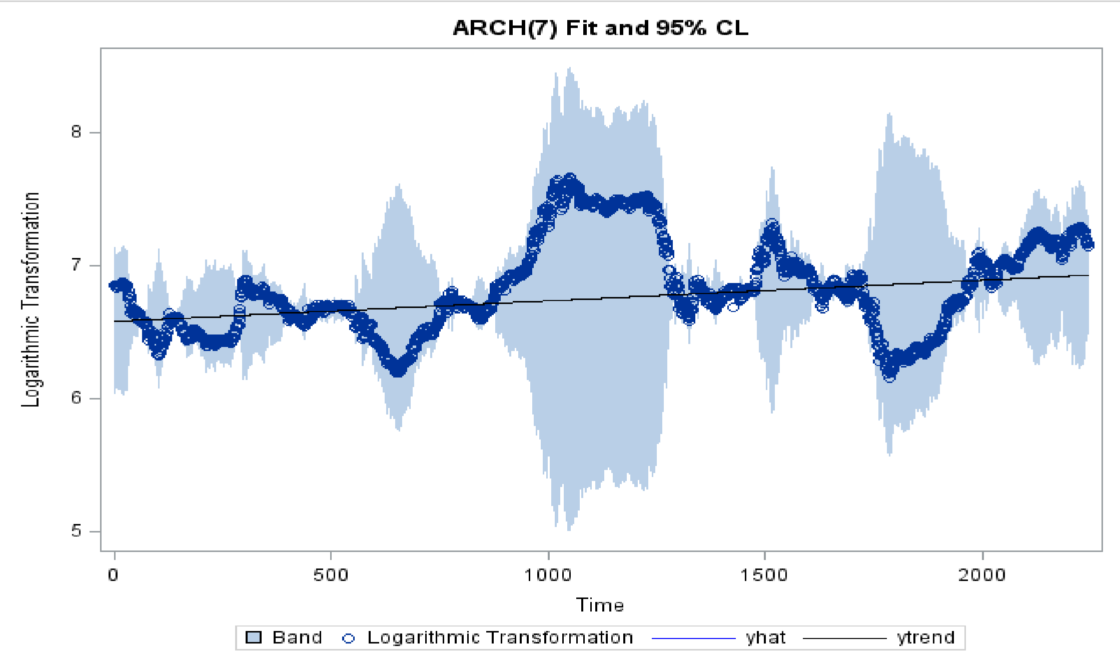

Figure 26: White Maize Price ARCH (7) Fit

5.5.2 *Yellow Maize*

The table below depicts the summary output obtained after running the ARCH and GARCH process for yellow maize. Since the value of the total R-square is fairly small, the fit is also correspondingly not very strong.

GARCH Estimates			
SSE	170.993367	**Observations**	2245
MSE	0.07617	**Uncond Var**	.
Log Likelihood	1380.92081	**Total R-Square**	0.1704
SBC	-2692.3935	**AIC**	-2743.8416
MAE	0.21275144	**AICC**	-2743.7611
MAPE	3.12180792	**HQC**	-2725.0612
		NormalityTest	178.099
		Pr > ChiSq	<.0001

Table 19: Yellow Maize Modelling Statistical Output

The parameter estimates for the ARCH and GARCH process for the yellow maize price time series are shown in the table below. The p-values corresponding to the intercept, the deterministic term, the ARCH(0), the ARCH(1), the ARCH(2) and the ARCH(6) are smaller than 0.05 and hence these parameters are to be included in the model at 95 % confidence level.

Parameter Estimates					
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**
Intercept	1	6.6304	0.001846	3591.1	<.0001
Time	1	0.00013	1.26E-06	105.52	<.0001
ARCH0	1	0.00012	0.000017	6.82	<.0001
ARCH1	1	0.8822	0.0992	8.89	<.0001
ARCH2	1	0.1081	0.0436	2.48	0.0132
ARCH3	1	0	0	.	.
ARCH4	1	0	0	.	.
ARCH5	1	0	0	.	.
ARCH6	1	0.0368	0.0188	1.96	0.0498

Table 20: Parameter Estimates for the ARCH and GARCH Process for Yellow Maize

As in the case of white maize, the yellow maize ARCH(6) fit at 95 % confidence level provides a graph which has a generally rising trend over time.

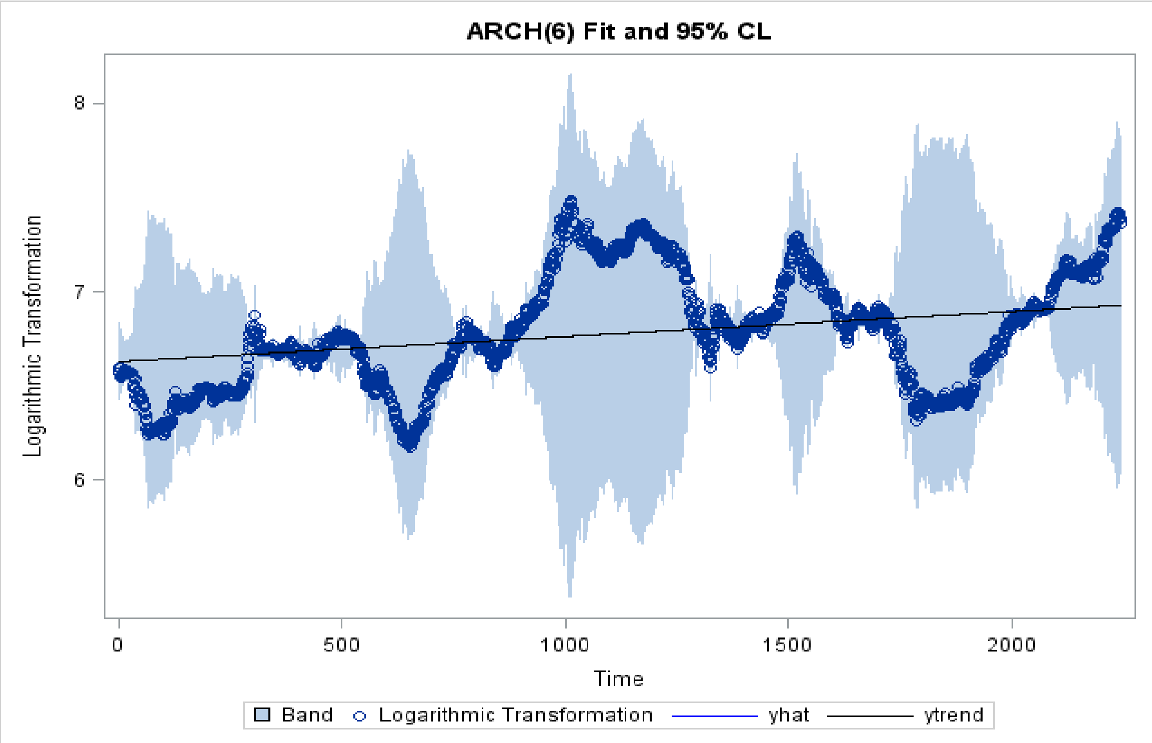

Figure 27: ARCH(6) Fit for Yellow Maize

5.5.3 *Wheat*

The wheat price series statistical output generated after running the ARCH and GARCH process is depicted in the table below.

GARCH Estimate			
SSE	17.3774927	**Observations**	1055
MSE	0.01647	**Uncond Var**	.
Log Likelihood	1384.42314	**Total R-Square**	.
SBC	-2706.1946	**AIC**	-2750.8463
MAE	0.09850696	**AICC**	-2750.674
MAPE	1.32967612	**HQC**	-2733.9197
		NormalityTest	68.5182
		Pr > ChiSq	<.0001

Table 21: Wheat Modelling Statistical Output

The following table provides the parameter estimates for the wheat price series modelling and shows that the ARCH(6) should be included in the fit at 95 % confidence level.

Parameter Estimates					
Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	7.2848	0.001747	4170.19	<.0001
Time	1	-0.00003	2.65E06	-11.33	<.0001
ARCH0	1	0.0000363	0.0000107	3.39	0.0007
ARCH1	1	0.9493	0.1047	9.07	<.0001
ARCH2	1	0	0	.	.
ARCH3	1	0	0	.	.
ARCH4	1	0	0	.	.
ARCH5	1	0.0375	0.034	1.1	0.2697
ARCH6	1	0.0642	0.0315	2.03	0.0419

Table 22: Parameter Estimates for the ARCH and GARCH Process for Wheat

The ARCH(6) fit for the wheat price series provides a graph that can be described as fluctuating randomly but generally depicting a flat or horizontal trend range over time.

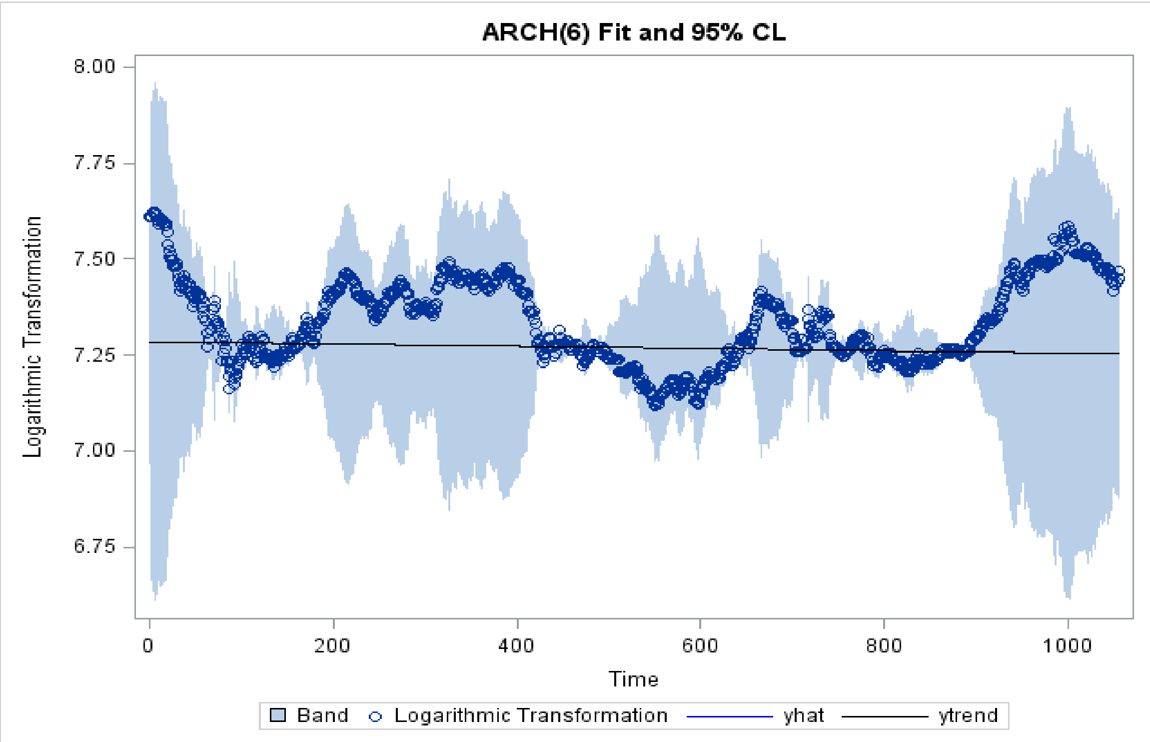

Figure 28: ARCH(6) Fit for the Wheat Price Series

5.5.4 *Sunflower*

The sunflower prices series statistical output is depicted in the following table. The parameter estimates for the ARCH and GARCH process show that the intercept, the deterministic term, the

ARCH(0) and the ARCH(1) should be included in the mathematical model for the sunflower time series.

GARCH Estimates			
SSE	20.1957938	**Observations**	804
MSE	0.02512	**Uncond Var**	.
Log Likelihood	924.292954	**Total R-Square**	.
SBC	-1821.8275	**AIC**	-1840.5859
MAE	0.11964254	**AICC**	-1840.5358
MAPE	1.5767704	**HQC**	-1833.3815
		Normality Test	48.7761
		Pr > ChiSq	<.0001

Table 23: Sunflower Modelling Statistical Output

All the p-values shown in the table below are also below 0.05.

Parameter Estimates					
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx**
					Pr > |t|
Intercept	1	7.6343	0.002895	2636.96	<.0001
Time	1	0.00013	5.51E-06	23.65	<.0001
ARCH0	1	0.000132	0.0000214	6.19	<.0001
ARCH1	1	1.0157	0.1267	8.02	<.0001

Table 24: Parameter Estimates for ARCH and GARCH Process for Sunflower

A graph was plotted for the log-transformed series for the ARCH(1) fit derived from the sunflower time series. The graph is shown below. The graph fluctuates fairly randomly up and down over time. The trend is gradually rising showing that sunflower prices have not effectively changed much over the years. One of the major reasons for this situation is the increased plantings in soybeans in the country over time, a commodity which can be used as a substitute oilseed in place of sunflower.

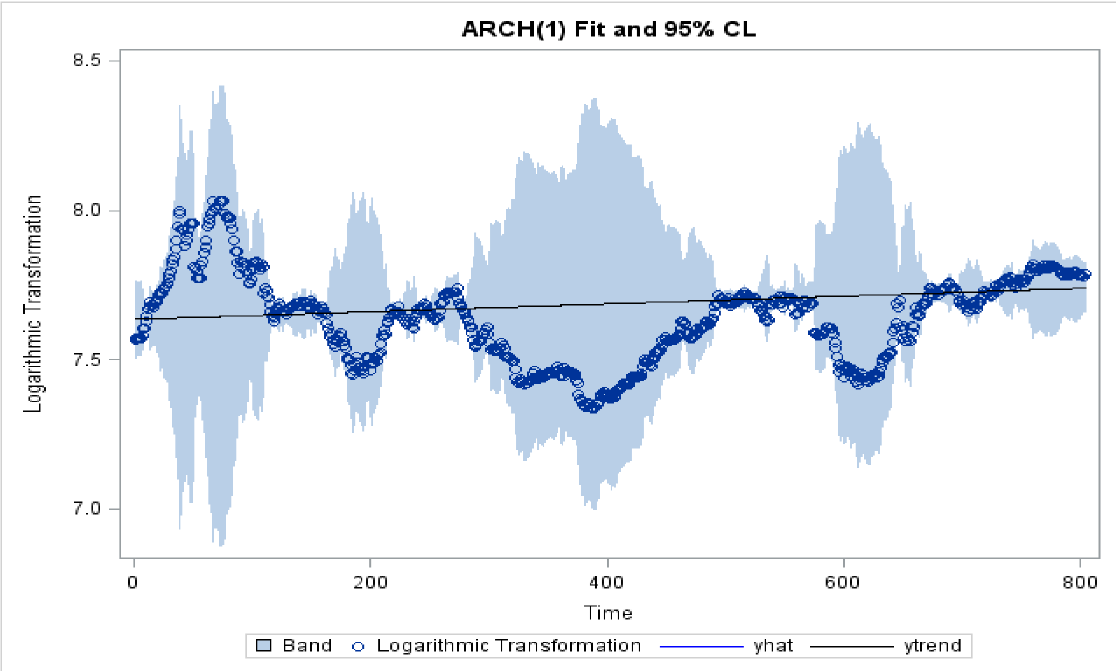

Figure 29: ARCH(1) Fit for the Sunflower Price Series

5.6 Testing for Causality

Granger Causality analysis was carried out to determine whether white maize price volatility had an effect on the share price returns for Tiger Brands Limited and Afgri Limited. Given that maize is by far the largest crop produced in South Africa, it was decided that the tests be conducted between the share prices of the above companies and the white maize price series only. It should also be noted that the price series for white maize is similar to that of yellow maize. The dependent and independent variables relating to the causality analysis are therefore as follows:

- Tiger Brands Limited daily share price returns (dependent variable)
- Afgri Limited daily share price returns (dependent variable)
- White maize daily futures price (independent variable)

The interpretation of the results is such that when the p-value is less than 0.05, one may conclude that the independent variables Granger-cause the dependent variables. The p-values and the decision framework in respect of the analysis are as depicted below.

Dependent Variable	Independent Variable	P Value	Critical Value	Decision
Tiger Brands Share Price Return	White Maize Price	0.2226	0.05	No Causality
Afgri Limited Share Price Return	White Maize Price	0.1317	0.05	No Causality

Table 25: Results of the Granger Causality Tests

According to the analysis carried out herein, there is no causality between the white maize price levels and the share price returns for Tiger Brands Limited and Afgri Limited.

6 CONCLUSIONS AND RECOMMENDATIONS

The study recognises the increased fluctuation in the financial performance of agribusinesses in South Africa and attempts to determine whether agricultural commodity derivatives price volatility has a significant contribution to this situation. The share price series for the largest agro-processing entity in the country, Tiger Brands Limited, shows a rapidly rising trend. To the contrary, the share price series for Afgri Limited, one of the largest grain handling and trading entities in South Africa, shows a randomly fluctuating pattern within the range of 300 cents to 800 cents per share. Agricultural commodity prices generally depict a rising trend over time. This research examines the influence of soft commodity price volatility on the share prices of selected agribusinesses, and to accomplish this, the Granger Causality methodology was utilised.

6.1 Summary

The results of this research suggest that there is not sufficient statistical evidence to conclude that South African maize price volatility explains the share price returns of the major agribusinesses in the country. There are therefore presumably other factors that have a more significant bearing on the share price pattern of the role players in agribusiness in South Africa. It is imperative at this juncture to also note that agricultural derivative prices are determined on SAFEX as the sum total of all the forces of supply and demand experienced on this platform.

On the other hand this study shows that the price volatility of agricultural commodities in South Africa follows largely an ARCH process with the lags ranging from one up to about 7 lags. Preliminary analysis of the lags confirmed the existence of the ARCH effect as depicted further in the appendices. In general, prices of the major agricultural commodities have been going up against the background of increased demand and more severe limitations in the availability of additional land to cultivate under crops, especially the crops with the largest amount of demand around the world.

Among the factors that affect the price volatility of agricultural commodities are energy and fuel costs, the exchange rate, the macroeconomic environment, international commodity prices, socio-political factors and the natural risk factors. Available literature also points out that macroeconomic conditions have allowed developing countries such as China to consume more commodities. Expansion of consumption in such emerging markets has affected the price patterns of various soft commodities constituting the staple diets within the global system. A previous study by Hernandez (2012) however failed to conclude that imports of soybeans into China influenced monthly soybeans futures price volatility on the Chicago Board of Trade over the period 1999 to August 2006. It should however be noted that as from the fourth quarter of 2006, China significantly increased imports of soft commodities from various import sources around the world. On the other hand, previous literature regarding the influence of financial speculation on the price volatility of soft commodities has largely resulted in conflicting conclusions.

6.2 Implications and Conclusions

A common issue among agribusinesses is that the financial performance of these entities may no longer be consistent with the fundamental factors affecting their operations. The results of this study may possibly eliminate one of the possible factors that may have had a bearing on the bottom line performance of the key entities in the agricultural sector in South Africa. Focus can then be redirected to the other possible factors that might explain the fluctuating performance of some entities in the sector. As pointed out earlier, this rather random financial performance could pose some challenges in planning key operations along the grains and oilseeds value chains in South Africa. The net effect of such a situation can actually result in additional price volatility on the commodity derivatives market and this could have severe implications for producers, traders and consumers.

Increased fluctuations in the performance of agribusinesses will firstly impact on their ability to participate in the provision of market access to the farming community around the country. At the same time, since the agribusinesses are the biggest grouping providing crop inputs finance to the farming community, their possible poor performance can impact on the ability to avail this critical financing at the time that it is required by the farmers. The agribusinesses may also possibly fail to provide critical and well-maintained grain handling infrastructure which they control and which assists in minimising post-harvest losses in the South African agricultural sector. Were these losses not to be kept in check, food security in the country could be under threat and the possible increased imports to make up for local deficits could result in the worsening of the country's balance of payments position. On the other hand, the worsening of the food security situation in the country could result in increased social unrest and hence possible socio-political instability in the country.

6.3 Recommendations

The purpose of this paper was to contribute in aiding managerial decision-making within agribusinesses, and hence it is imperative for the generality of role players in the sector to effectively make use of the trading strategies as outlined in Section 3 of this document. The fluctuation in commodity prices has generated considerable interest across the agricultural commodity value chains because of its effects on the real economy and thus on economic growth, food security and investment decision-making. At the policy level, it is proposed that excessive speculation on the futures markets be kept in check and its effects be reduced through ensuring the availability of timely market information as well as through ensuring transparency on the commodity derivatives market. International trade should be kept open and barriers to trade should be removed. The agricultural sector in South Africa should be opened up to more effective participation by diverse groups across the various regions of the country. More research and development is required to allow for the balancing of supply and demand for agricultural commodities to enable stabilisation of agricultural commodity prices. Investment in training and development should be increased through the establishment of additional institutions of higher learning with a particular focus on the agribusiness sector. It is also prudent to encourage the expansion of agricultural foreign direct investment in order to increase the overall contribution of the agricultural sector to the national gross domestic product. In the same vain, additional local investment needs to be channelled into the agribusiness sector to increase the capital levels of the role players and to help in stabilising their operations in light of the detrimental effects of the global economic downturn.

6.4 Areas for Suggested Future Research

The results generated herein could form the basis for further research in the study of agricultural derivatives commodity price volatility and its effects within the economy of South Africa. It is envisaged that commodity price volatility will be forecasted more effectively using the ARCH and GARCH or similar approaches ahead of forecasting the possible effects of such volatility on the financial performance of the key role players along the value chain. Other factors that might affect the bottom line of agribusinesses could also be investigated to get a clearer picture on the effect of each factor. The study conducted herein used daily agricultural commodity prices for selected crops and daily share prices for the identified companies in the sector. The research could be done using monthly average commodity prices and monthly average share prices in which case seasonality could be expected to be a major factor. Appropriate adjustments could then be done ahead of determining whether the results of the Granger Causality obtained would be similar to those obtained in this study.

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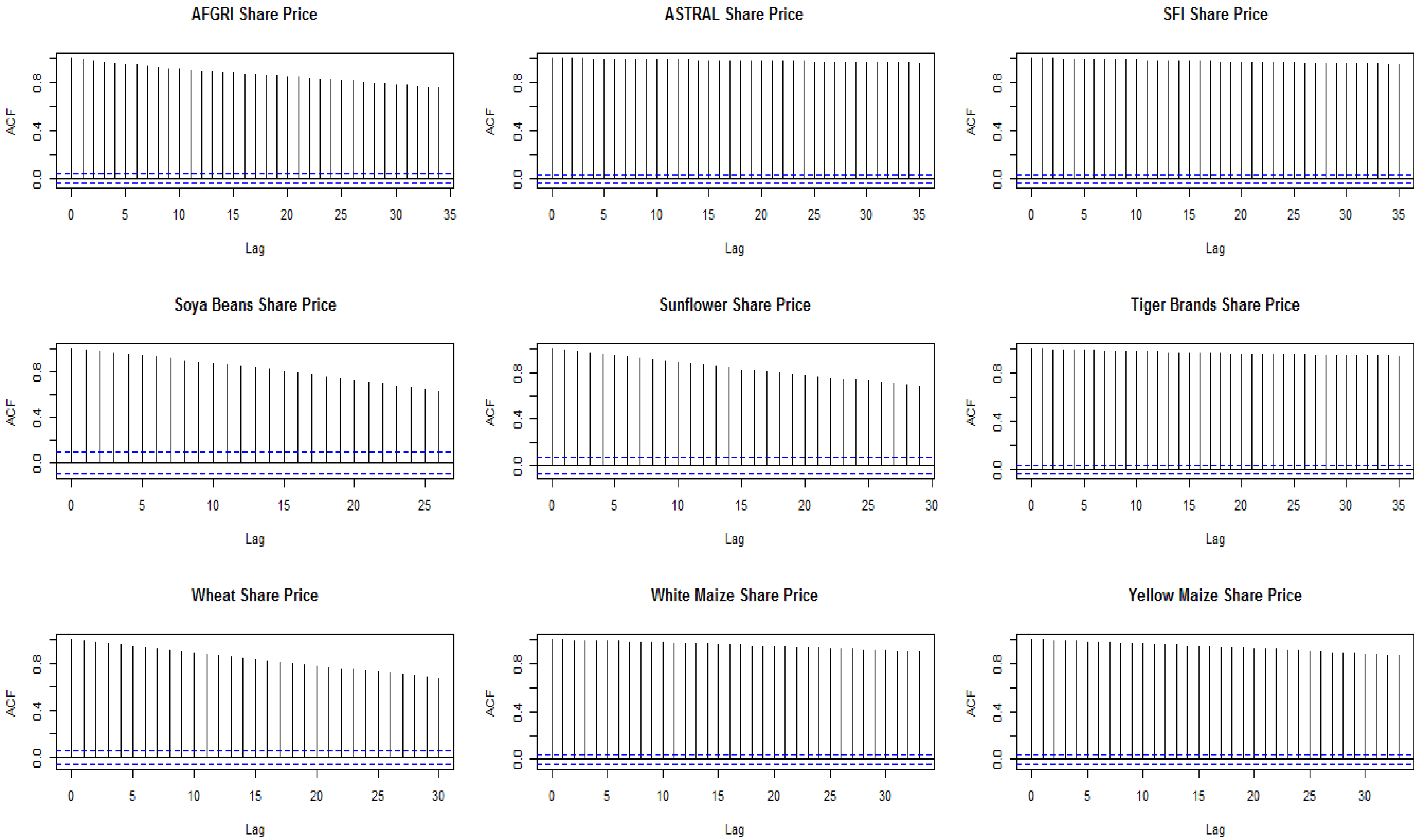
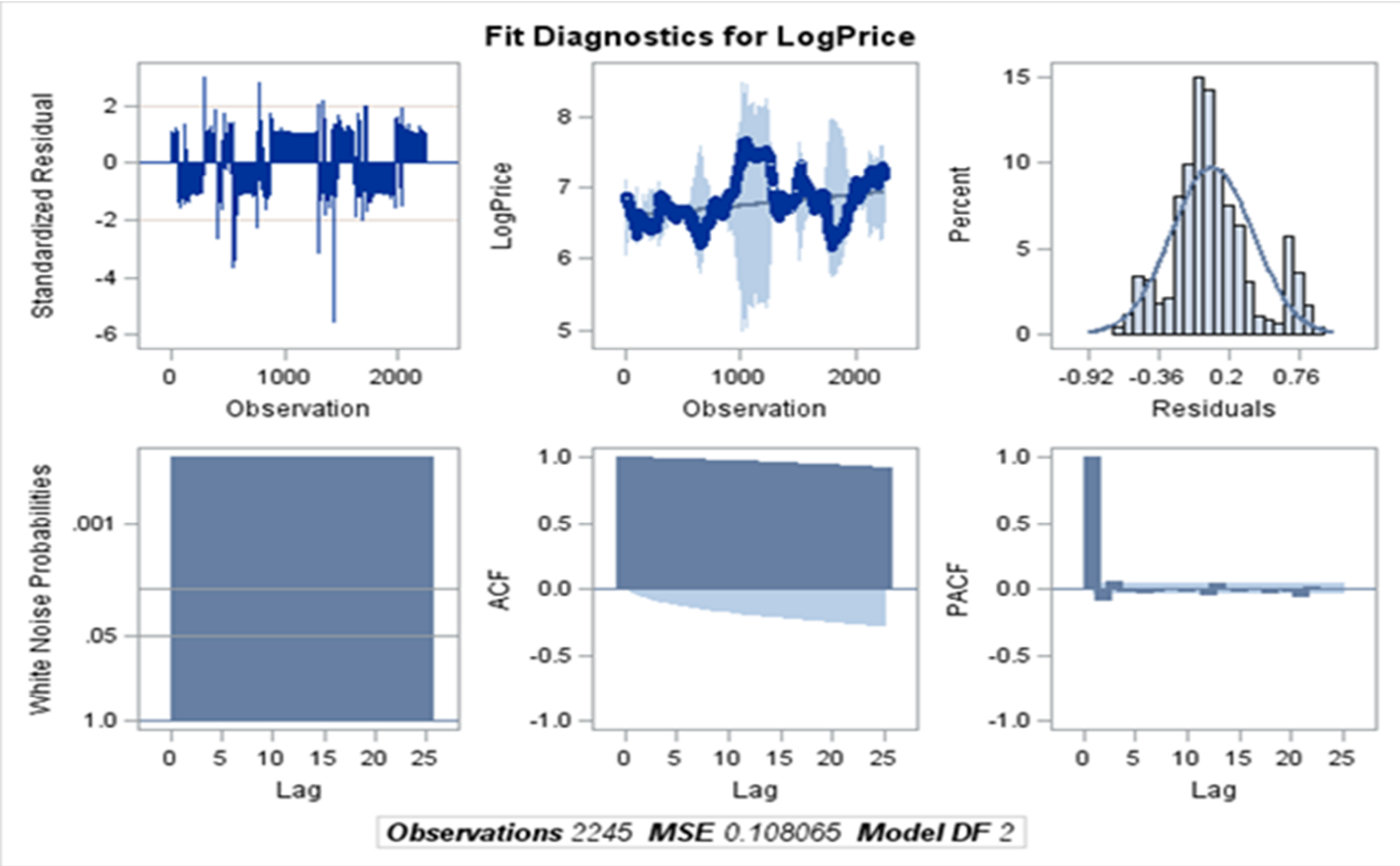
APPENDICES

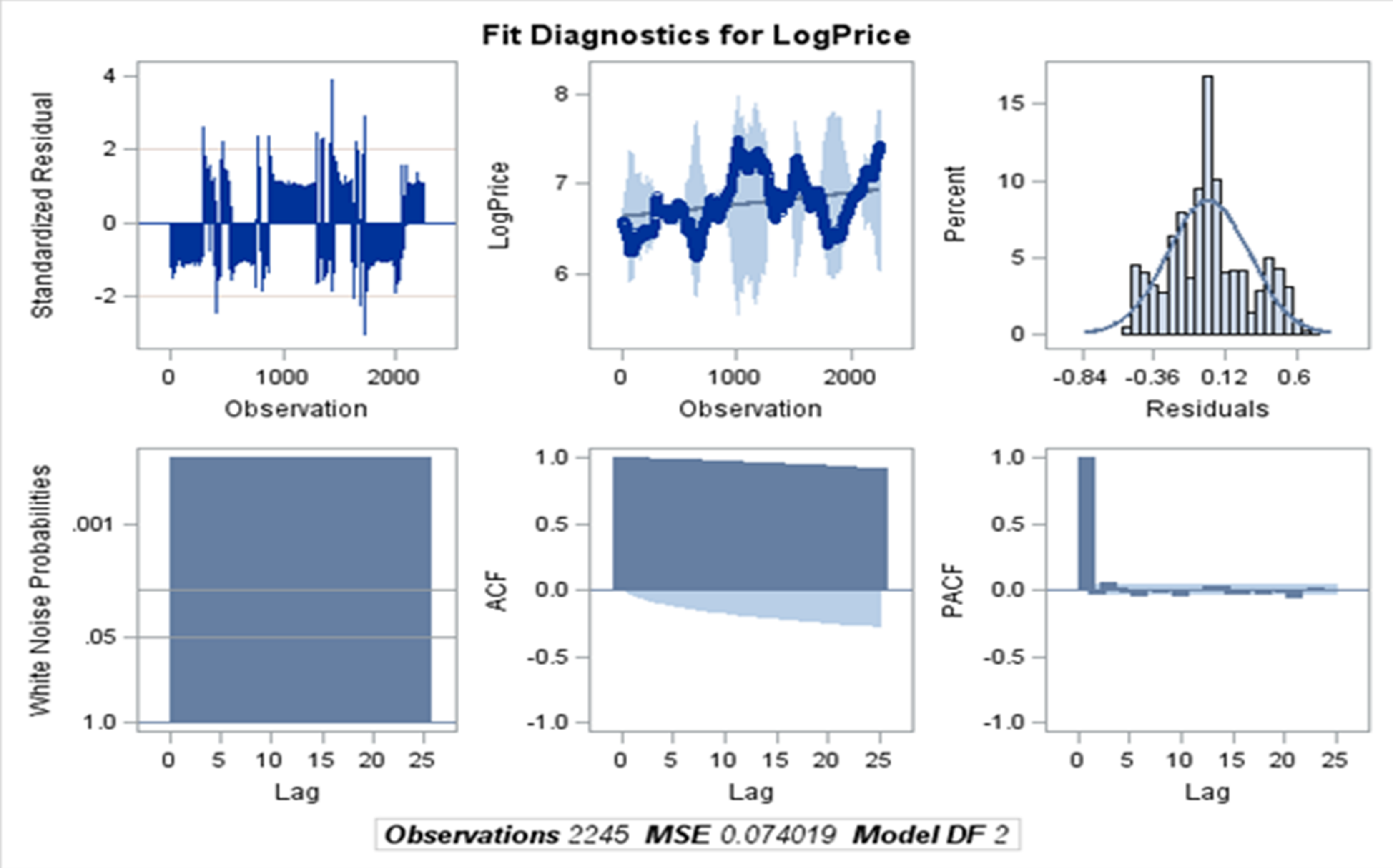
Appendix I: Correlograms Depicting Possible Seasonality



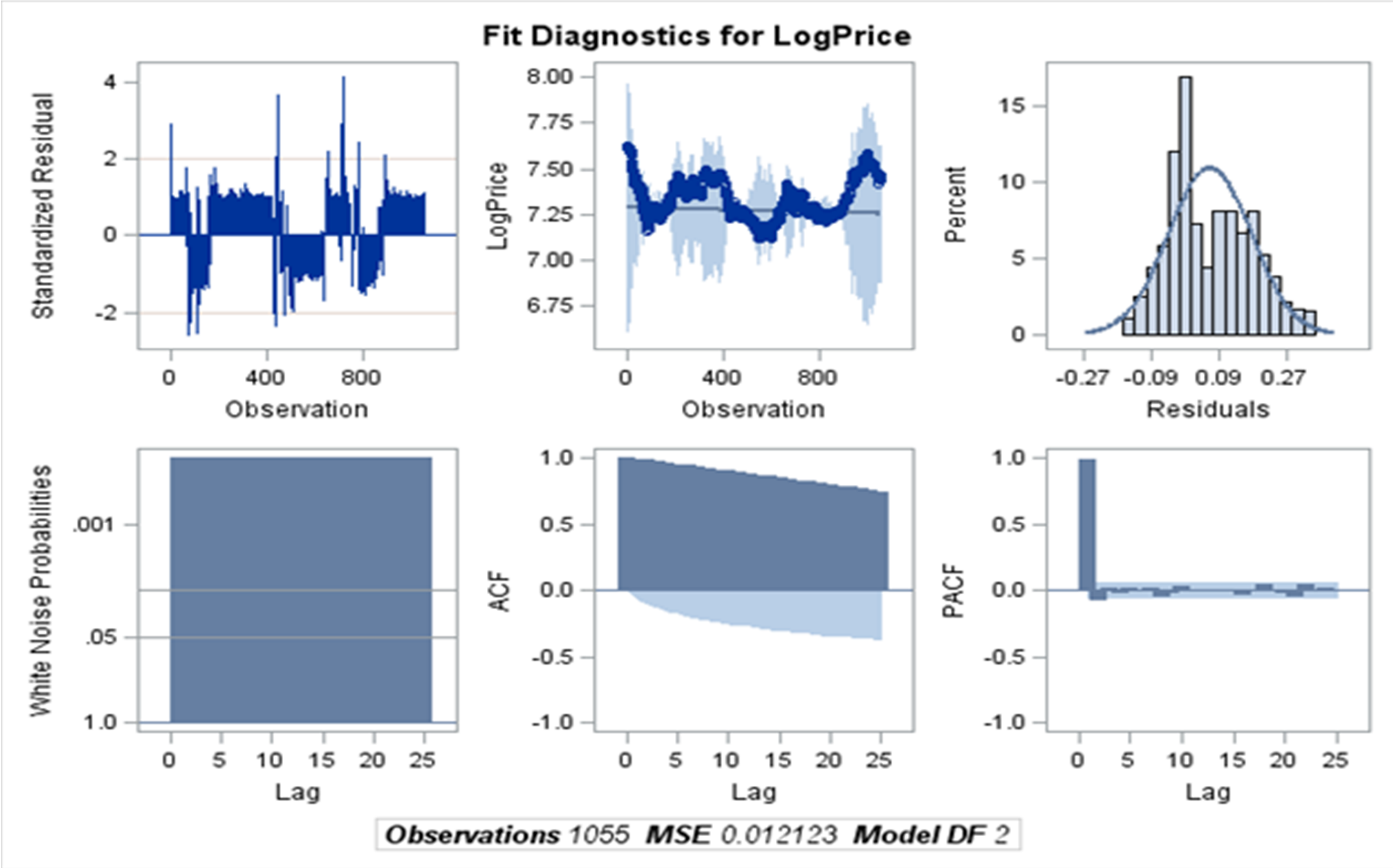
Appendix II: Fit Diagnostics for the Log-Price for White Maize



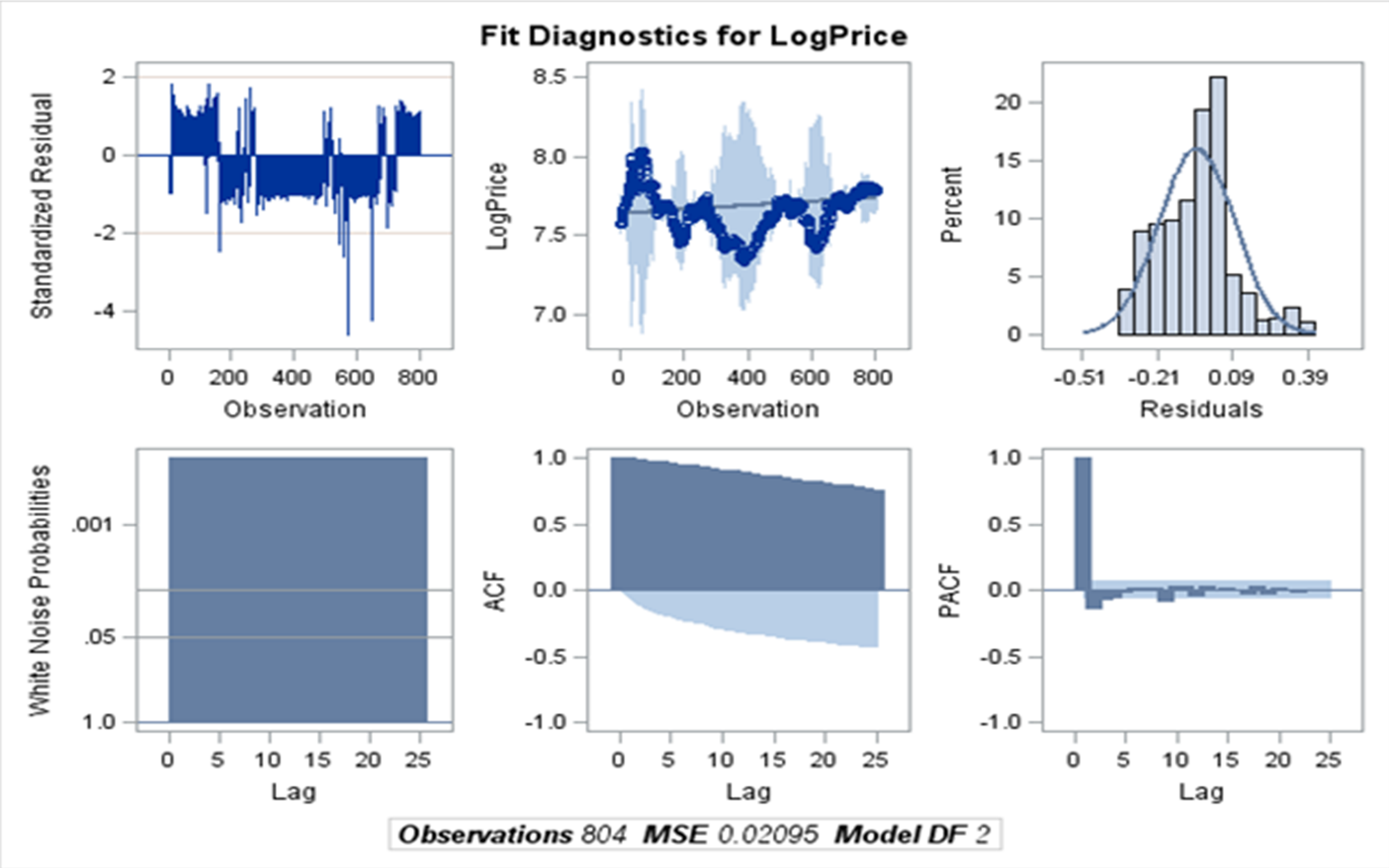
Appendix III: Fit Diagnostics for the Log-Price for Yellow Maize



Appendix IV: Fit Diagnostics for Log-Price for Wheat Price Series



Appendix V: Fit Diagnostics for Log-Price for Sunflower Price Series



Appendix VI: Tests for ARCH Disturbances for White Maize, Yellow Maize, Wheat and Sunflower Prices

Tests for ARCH Disturbances Based on OLS Residuals for White Maize

Order	Q	Pr > Q	LM	Pr > LM
1	2232.2896	<.0001	2229.6246	<.0001
2	4445.8536	<.0001	2229.8986	<.0001
3	6641.636	<.0001	2229.9285	<.0001
4	8819.8655	<.0001	2229.9294	<.0001
5	10980.1584	<.0001	2229.932	<.0001
6	13121.4829	<.0001	2229.9542	<.0001
7	15242.9676	<.0001	2229.9639	<.0001
8	17343.3587	<.0001	2229.9963	<.0001
9	19423.9364	<.0001	2230.0276	<.0001
10	21483.0105	<.0001	2230.1191	<.0001
11	23520.6446	<.0001	2230.1247	<.0001
12	25535.071	<.0001	2230.2073	<.0001

Tests for ARCH Disturbances Based on OLS Residuals for Yellow Maize

Order	Q	Pr > Q	LM	Pr > LM
1	2223.2685	<.0001	2221.0418	<.0001
2	4418.899	<.0001	2221.2261	<.0001
3	6589.6952	<.0001	2221.3207	<.0001
4	8737.3114	<.0001	2221.329	<.0001
5	10862.4978	<.0001	2221.334	<.0001
6	12963.7128	<.0001	2221.3663	<.0001
7	15038.5975	<.0001	2221.4313	<.0001
8	17085.4479	<.0001	2221.4615	<.0001
9	19105.9216	<.0001	2221.4839	<.0001
10	21096.8805	<.0001	2221.6926	<.0001
11	23058.1265	<.0001	2221.6927	<.0001
12	24991.1809	<.0001	2221.7038	<.0001

Tests for ARCH Disturbances Based on OLS Residuals for Wheat

Order	Q	Pr > Q	LM	Pr > LM
1	1005.5095	<.0001	994.4194	<.0001
2	1951.5359	<.0001	994.9966	<.0001
3	2844.1258	<.0001	995.0387	<.0001
4	3680.2872	<.0001	995.3768	<.0001
5	4461.2973	<.0001	995.3821	<.0001
6	5185.7797	<.0001	995.5692	<.0001
7	5857.8112	<.0001	995.5709	<.0001
8	6479.8711	<.0001	995.5808	<.0001
9	7055.4078	<.0001	995.5904	<.0001
10	7591.1148	<.0001	995.6738	<.0001
11	8089.2393	<.0001	995.6928	<.0001
12	8549.281	<.0001	995.7919	<.0001

Tests for ARCH Disturbances Based on OLS Residuals for Sunflower

Order	Q	Pr > Q	LM	Pr > LM
1	777.7128	<.0001	775.0947	<.0001
2	1516.7639	<.0001	776.2947	<.0001
3	2212.8372	<.0001	776.4542	<.0001
4	2863.4137	<.0001	776.5524	<.0001
5	3468.7989	<.0001	776.5577	<.0001
6	4033.4553	<.0001	776.6502	<.0001
7	4560.4371	<.0001	776.6503	<.0001
8	5051.4018	<.0001	776.6616	<.0001
9	5503.6988	<.0001	777.0734	<.0001
10	5915.3395	<.0001	777.2352	<.0001
11	6286.4152	<.0001	777.2541	<.0001
12	6617.2633	<.0001	777.2882	<.0001