

# Investigating the optimization of the white maize spread/price

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## Abstract

The agricultural sector contributes significantly to job creation in South Africa. However, the area under maize production has decreased in the past years whilst the consumption increased. The increase in demand has put pressure on maize farmers to increase their yields per hectare. Furthermore, the continued decrease in land allocated for maize production will ultimately threaten food security and lead to an increase in maize prices. Trading firms sell the March/July white maize spread each year. The money received from selling the March/July white maize spread pays for the interest and storage costs associated with carrying white maize from March to the end of June. The difference between the price at which the spread is sold and the full carrying costs associated with carrying white maize from March to the end of June is paid by the trading firm. Eventually, the lower the price at which the spread is sold, the higher the amount the trading firm must pay to carry white maize from March to the end of June. This study serves as a tool for trading firms to better predict the best price to sell the March/July white maize spread to relieve pressure from their cashflow. It will also ensure that maize meal is affordable to the final consumer at a competitive price because the cost that trading firms incur from getting maize from the farm to the miller will be minimised. The aim of the study was to determine the best price to sell the March/July white maize spread under the prevailing circumstances and conditions at the time. The study followed the positivist paradigm and the quantitative approach. The study design used was longitudinal in nature. The study population was the crop estimates committee reports released from 1999 to date. The sample of the population that was used in this study was the crop estimates committee reports from 2009 to 2020. Purposive sampling was used to determine the sample size, resulting in ten units of analysis being utilised. Each unit of analysis was the final report of the crop estimates committee. Data on supply and demand estimates of white maize was obtained from SAGIS and data on white maize prices was obtained from Thomson Reuters. This study made use of a regression analysis to determine what the price of the March/July white maize spread will be given a certain amount of white maize ending/opening stock, R/\$ exchange rate and the stock to use ratio. The study found that the optimal price of the March/July white maize spread is associated with an opening stock of more than 1 362 000 tons, a R/\$ exchange rate of less than R12.09 and a stock to use ratio of more than 22%. In reality these variables may vary. A model derived from a regression analysis of the March/July 2017 white maize spread was suggested to determine the optimal price of the March/July white maize spread taking all these variables into account.

**Keywords:** Spread, white maize, stock to use, SAFEX, opening stock, exchange rate.

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## **ABBREVIATIONS**

|       |                                                  |
|-------|--------------------------------------------------|
| CEC   | Crop Estimates Committee                         |
| SAFEX | South African Futures Exchange                   |
| JSE   | Johannesburg Stock Exchange                      |
| SAWS  | South African Weather Service                    |
| CME   | Chicago Mercantile Exchange                      |
| VAT   | Value added tax                                  |
| DAFF  | Department of agriculture forestry and fisheries |
| NAMC  | National agricultural marketing council          |
| DWA   | Department of water affairs                      |
| NDA   | National department of agriculture               |
| LSTR  | Logistical smooth transition modelling framework |
| CDM   | Commodity derivative market                      |
| SAGIS | South African grain information service          |

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# **Chapter 1: Introduction**

## **1.1 Chapter overview**

Chapter 1 describes the background, problem statement, rationale and significance of the study, the aim and objectives as well as the research questions, paradigm, method and design. It also explains the demarcation of the study, the population, sample method and sample size, data collection instruments, data coding and analysis and it gives a brief description of the layout of the study.

## **1.2 Background**

The agricultural sector is continuing to be one of the main important contributors to the South African economy. According to Greyling (2015), South Africa's agricultural sector serves as a provider of food, employment, capital, input to the manufacturing sector, buyer of goods and earner of foreign exchange. The deregulation of agricultural markets and the promotion of free trade in the agricultural sector in the 1990's pressurised maize prices. As a result, farmers considerably reduced the amount of area under maize production. Maize is the major input used in the production of several of the main food items consumed. The lack of food security in South Africa will ultimately lead to an increase in food prices and thus in maize prices (Greyling, 2015). The increase in maize prices has been exacerbated by the increase in broiler consumption which has risen, since 1980, from 6 kg per person per year to 36 kg per person per year (Greyling, 2015). In the livestock sector, broiler production is the largest consumer of maize in the form of animal feed (Nkhuoa, 2017). Various factors influence the supply and demand of maize. This causes fluctuations in the amount of maize available each month as well as annually which ultimately impacts on maize prices (Crop Estimates Committee (CEC), 2019).

## **1.3 Problem statement**

The problem that the study seeks to address is selling the March/July white maize spread at the highest price that the spread traded during the period from when the

spread started trading until it expired. Each year, agricultural trading firms sell the March/July white maize spread in order to carry white maize from March to July. The price at which they sell the spread pays for the interest and storage costs associated with carrying the white maize. The difference between the price at which the spread is sold and the total interest and storage costs is paid by the trading firm. The lower the price at which the March/July white maize spread is sold, the higher the money the trading firm must pay for interest and storage costs (Competition Tribunal, 2009).

There are five months that have liquidity on the South African Futures Exchange (SAFEX). These months are March, May, July, September and December. Each SAFEX month has an opening date and an expiry date. Farmers can only sell their white maize on any of the five liquid SAFEX months but only after the specific SAFEX month is open and before it expires (Johannesburg Stock Exchange (JSE), 2013).

Trading firms are continuously moving net short positions from farmers and/or net long positions from millers from the nearby SAFEX month to a further SAFEX month to avoid having a position (long/short) in the spot month. When a trading firm is net long white maize in the spot month, the firm will get delivery of the white maize. In contrast, if a trading firm is net short white maize in the spot month, the firm has until the expiry date of the SAFEX month to move the short positions to another SAFEX month in the future. If it fails to do so, it will have to deliver the white maize (.

The selling of a spread such as the March/July white maize spread, implies that the trading firm is extending its storage of physical white maize in the silo from the 1<sup>st</sup> of March to the end of June. If during the period from March to the end of June the millers do not commit to buying that physical white maize, the trading firm extends their storage of the physical white maize in the silo by selling another spread such as the July/December white maize spread (Competition Tribunal 2009).

Each year when maize is stored in a silo from the 1<sup>st</sup> of March to the 30<sup>th</sup> of June it accumulates interest and storage costs (carrying costs). To pay for these costs, firms must sell the March/July white maize spread. The higher the price at which the spread is sold, the more money is available to pay for the interest and storage costs. The price of the March/July white maize spread fluctuates. The firm has a fixed period to secure

income that will contribute to financing the costs associated with the extension of storage from March to the end of June. As March approaches, the pressure to have zero positions in March increases. At times the bids on the March/July white maize spread may be at 40% of the full carry costs. The firm may be reluctant to offer the spread at those levels because it would imply that the firm would have to pay for the other 60% of carry costs. Hindsight may indicate that selling the spread at only 40% of full carry costs, would have been the best price at the time. After being bid at 40% of full carry costs, the spread may narrow and inverse to trade below zero. This would have a bigger cashflow and profit implication on the firm because selling the spread at R0 means that the firm extended the storage of its white maize that is currently in the silo for another four months (March to the end of June) but will have to pay for 100% of the carry costs. The challenge of selling the March/July white maize spread at a price that covers the interest and storage costs of storing maize from the 1<sup>st</sup> of March to the 30<sup>th</sup> of June is caused by various factors that impact on the volatility of the price of the spread. An accurate measure of the factors that influence the price of a spread as well as a quantification of the impact of those factors on a spread will ultimately enable firms to anticipate a certain high price where they will sell the March/July white maize spread at a price that will pay for most if not all the costs associated with storing maize from the 1<sup>st</sup> of March to the 30<sup>th</sup> of June (Competition Tribunal, 2009).

#### **1.4 Rationale and significance**

The study will benefit the agricultural sector particularly the grain industry. It will enable management in firms involved in the agricultural product market to sell the March/July white maize calendar spread at a price that is high enough to pay for the interest and storage costs associated with storing maize from the 1<sup>st</sup> of March to the 30<sup>th</sup> of June. The income generated from selling the spread at the best price will relieve pressure from the firm's cashflow and contribute to maximising profit. The trading firms will be in the position to sell white maize to millers at a competitive price because they won't have to pass on the carry cost to Millers. Ultimately the final consumer will benefit from relatively lower food prices because Millers will not have the need to pass on costs to the final consumer.

The study will serve as a formal guide for traders in the agricultural product market. It will provide them with a step by step approach to selling the March/July white maize spread at a relatively higher price. Thereby ensuring profit maximisation, competitive prices for millers and affordable food prices for the final consumer. There is currently no documented approach to selling the March/July white maize spread in South Africa. This knowledge is generally passed on in the workplace from senior traders to junior traders.

The study identified several factors that contribute to the fluctuation of the March/July white maize spread. It distinguished between the major and minor elements that cause the spread to open, close and sometimes inverse. Traders will be able to analyse these factors in their workplaces and make decisions on whether to sell based on their analysis. This study improved my understanding of calendar spreads in general.

The best price to sell the March/July white maize spread differs from one year to the next. A competitive price to sell the spread depends on the cost of storing maize for that period. The cost to store maize from 1<sup>st</sup> of March to 30<sup>th</sup> June (full carrying cost) is based on the silo storage costs per day per ton for white maize, the prime interest rate and the SAFEX March white maize price for that specific year.

The full carrying costs were calculated for a period of four months because the stock must be out loaded from the silo by the end of June. If the stock is not out loaded by the end of June, a new calculation will be made that will reflect the cost of storing the maize in the silo from the 1<sup>st</sup> of July to a later month. Another reason for not including the cost to store maize in July in the March/July spread was because the SAFEX July contract expires before the end of July. When the SAFEX July contract expires and the short positions from the white maize in the silo were not moved to a later SAFEX month, the firm will be forced to deliver the white maize through the JSE. The cost to store maize in July will be captured in a different spread such the July/December white maize spread.

## **1.5 Aim and objectives**

### **1.5.1 Aim**

To determine the optimal price to sell the March/July white maize spread under the prevailing circumstances and conditions at the time.

### **1.5.2 Objectives**

- Determine the ending/opening stock associated with the optimal price.
- Explore the exchange rate (R/\$) associated with the optimal price.
- Assess the stock to use associated with the optimal price.

## **1.6 Research questions**

### **1.6.1 Main research question**

- What is the optimal price to sell the March/July white maize spread under the prevailing circumstances and conditions at the time?

### **1.6.2 Sub research questions**

- What is the ending/opening stock associated with the optimal price to sell the March/July white maize spread?
- What is the exchange rate associated with the optimal price to sell the March/July white maize spread?
- What is the stock to use ratio associated with the optimal price to sell the March/July white maize spread?

## **1.7 Research paradigm**

The study followed the positivist paradigm. The positivist paradigm is the most relevant for the study because it follows the quantitative approach. A considerable amount of quantitative research follows the positivist paradigm mainly because positivists have confidence in the empirical hypothesis testing.

## **1.8 Research method**

This study followed a quantitative approach. It analysed numerical figures of various factors through statistical methods to obtain the objectives of the study. Hence the quantitative approach was the most suitable approach for purposes of the study.

## **1.9 Research design**

The study was longitudinal in nature. The July contract opens after the March contract, but the March contract expires before the July contract. The time interval was from when the July contract started trading because then the price difference between March and July was available in the form of a calendar spread. The time interval ended at the end of February because there should not be any short or long positions in March.

## **1.10 Demarcation/delimitation of study**

The study focused on the March white maize prices and on the July white maize prices from 2009 to 2020. The prices were obtained from the department of agriculture. It took the supply and demand of white maize from 2009 to 2020 into consideration. The supply and demand estimates were obtained from the CEC.

## **1.11 Population**

The unit of analysis was the CEC report. The report contains information about various factors which give an indication of the quantity of white maize that will be available on the 30<sup>th</sup> of April and the 1<sup>st</sup> of May. The 30<sup>th</sup> of April is the end of the maize marketing season while the 1<sup>st</sup> of May is the beginning of the new season. Maize that is left on the 30<sup>th</sup> of April is referred to as the ending stock but on the 1<sup>st</sup> of May it is referred to as the beginning stock. The population was the crop estimates committee reports released from 1999 to date. The sample of the population that was used in this study was the CEC reports from 2009 to 2020.

### **1.12 Sample method/technique and sample size**

Purposive sampling was used in the study. According to this strategy the white maize marketing seasons are selected deliberately to provide important information that cannot be obtained from other choices (Maxwell, 1996). The study made use of 10 units of analysis. Each unit of analysis was the final report of the CEC.

### **1.13 Data collection instruments**

The data on the supply and demand estimates of white maize was obtained from the South African Grain Information Service (SAGIS). The SAGIS is a reliable source that has been widely used in South Africa for several years. The data on the prices of the March/July white maize spreads will be obtained from Thomson Reuters. Thomson Reuters provides market information for reputable organizations throughout the world and locally such as Silostrat Investments (Pty) Ltd.

### **1.14 Data collection/fieldwork**

The study made use of secondary data derived from the CEC reports, the South African Weather Service (SAWS) and Thomson Reuters. These sources were the most relevant because they are credible, available to the public and provided the required data for purposes of the study.

### **1.15 Data coding and analysis**

This study made use of historical data on white maize ending/opening stocks and on white maize prices. The white maize ending/opening stocks were determined by subtracting the total white maize demand from the total white maize supply. The white maize prices were derived from Thomson Reuters. The prices of the March/July white maize spreads were readily observed on Thomson Reuters. This study made use of a regression analysis to determine what the price will be given a certain amount of white maize ending/opening stock, R/\$ exchange rate and stock to use ratio.

## **1.16 Layout of the study**

### **Chapter 2: Related work**

The related work section provides and discusses literature that has already been done on the agricultural derivative market. It gives a brief background on the various types of derivatives used in the agricultural product market with a particular focus on spreads. The literature includes an overview of the grain market and the factors that play a role in price determination through their influence on supply and demand and ultimately on price.

### **Chapter 3: Research methodology**

Chapter 3 focuses on the research paradigm, methods and methodology that were used to address the aim and objectives of the study. The chapter provides an approach on how the exchange rate, stock to use and opening stock will be evaluated to achieve the aim and objectives of the study.

### **Chapter 4: Data analysis and discussion of results**

The results consist of the interpretation of the data through inferential statistics. This chapter predicts the monthly March/July white maize spreads from the 2009/10 marketing season to the 2019/20 maize marketing season. It also analyses the extent of the impact of each independent variable on the March/July white maize spread.

### **Chapter 5: Conclusions and recommendations**

Conclusions were made based on the results. The limitations of the study were established particularly with regards to assumptions made on the basis of insufficient availability of data and time constraints. Recommendations were given in areas that were outside the scope of this study.

### **1.17 Chapter summary**

Chapter 1 explained the problem statement, rationale and significance of the study, aim and objectives as well as the research questions, paradigm, method and design. It also described the population of the study, Sample method/technique and sample size, data collection instruments, data collection/fieldwork, data coding and analysis and layout of the study. The following section explores literature on agricultural derivatives.

## **CHAPTER 2: Related Work**

### **2.1 Chapter overview**

The related work section provides and discusses literature that has already been done on the agricultural derivative market. It gives a brief background on the various types of derivatives used in the agricultural product market with a particular focus on spreads. The literature includes an overview of the grain market and the factors that play a role in price determination through their influence on supply and demand and ultimately on price.

### **2.2 Introduction: agricultural derivative market**

The agricultural derivatives market is a formal market that is found on the JSE which allows for price determination, promotes transparency and provides price risk management in the South African grain market. The derivatives clearing structure guarantees that all transactions that are executed are honoured (JSE, 2013). There are two different types of agricultural derivatives traded on the derivatives market, namely futures and options. According to JSE, (2013) “a futures contract is an agreement to buy or sell an asset at a certain time in the future for a certain price.” An options contract is a financial instrument used to protect against unfavourable price movements. There are two types of option contracts, namely a put option and a call option. A put option is mainly used by farmers to protect themselves against a downward movement in commodity prices. Farmers buy put options at a certain premium from option writers in order to fix their prices. If the market price falls the farmer will exercise the option but if the market price rises the farmer will let the option expire. Call options are mainly used by millers to protect themselves against price increases. Like farmers, millers will allow out the money call options to expire and thus lose the premium. However, they will exercise in the money call options (JSE, 2013). In addition to options and futures contracts, spreads are also traded on the derivatives market.

## **2.3 Put options**

A commodity put option contract gives the buyer of the option the right, but not the obligation, to sell a particular futures contract at a predetermined fixed price at any time before or on the expiration date of the option. To obtain this right to sell a particular futures contract, the purchaser of the option pays a premium to the seller of the option. The holder of the option only pays the option premium and brokerage fees. Put option contracts indicate the futures commodity and month, the strike price, and the period for which the option is valid. The seller of the option obtains the premium in exchange for his obligation to take the specific futures contract position if the option holder wants to exercise the right to sell under the option contract. The put option gives the buyer of the option the right to sell (go short), while the seller has the obligation to take the opposite long position (Evans, 2019).

Holders of put options can protect themselves against a decrease in prices for a period of time and still benefit from potential increases in price. The holder pays a premium to protect against a decrease in prices. The farmer has the option to accept or leave the predetermined fixed price. If the price goes up after the holder has bought the option, the holder can sell in the cash market and let the option expire out the money. However, if the price decreases, the holder of the option can exercise the option at the higher predetermined strike price (Evans, 2019).

After the holder has bought an option from the option writer, the holder can let the option contract expire, he may offset it or he can exercise the option contract (Evans, 2019).

### **2.3.1 Expire**

If the cash price is higher than the strike price at the expiration date of the option, the holder of the option will let the option expire out the money. Ultimately, the buyer of the put option will only lose the option premium (Evans, 2019).

### **2.3.2 Offset**

If the option premium increases to a value higher than what the option holder initially paid, the buyer of the option may decide to sell the option. The act of the holder selling the option on the exchange is an offsetting transaction (Evans, 2019).

### **2.3.3 Exercise**

If the strike price is higher than the cash price, the holder of the option exercises the put option on or before the expiration date. Exercising the put option gives the holder of the option a short position on the futures market at the strike price of the options contract and expose him to margin requirements (Evans, 2019).

## **2.4 Call options**

A commodity call option contract gives the buyer of the option the right, but not the obligation, to buy a particular futures contract at a predetermined fixed price at any time before or on the expiration date of the option. To obtain this right to buy a particular futures contract, the purchaser of the option pays a premium to the seller of the option. The holder of the option only pays the option premium and brokerage fees. Call option contracts indicate the futures commodity and month, the strike price, and the period for which the option is valid. The seller of the option obtains the premium in exchange for his obligation to take the specific futures contract position if the option holder wants to exercise the right to buy under the option contract. The call option gives the buyer of the option the right to buy (go long), while the seller has the obligation to make the opposite short position (Evans, 2019).

Holders of call options can protect themselves against an increase in prices for a period of time and still benefit from potential decreases in price. The holder pays a premium to protect against an increase in prices. The farmer has the option to accept or leave the predetermined fixed price. If the price goes down after the holder has bought the option, the holder can buy in the cash market and let the option expire out the money. However, if the price increases, the holder of the option can exercise the option at the lower predetermined strike price (Evans, 2019).

After the holder has bought an option from the option writer, the holder can let the option contract expire, he may offset it or he can exercise the option contract (Evans, 2019).

#### **2.4.1 Expire**

If the cash price is lower than the strike price at the expiration date of the call option, the holder of the option will let the option expire out the money. Ultimately, the buyer of the call option will only lose the option premium (Evans, 2019).

#### **2.4.2 Offset**

If the option premium increases to a value higher than what the option holder initially paid, the buyer of the option may decide to sell the option. The act of the holder selling the option on the exchange is an offsetting transaction (Evans, 2019).

#### **2.4.3 Exercise**

If the strike price is lower than the cash price, the holder of the option exercises the call option on or before the expiration date. Exercising the call option gives the holder of the option a long position on the futures market at the strike price of the options contract and expose him to margin requirements (Evans, 2019).

### **2.5 Vertical spreads**

A vertical spread structure comprises of one long option and one short option of the same type (call or put) with the same underlying asset and expiration date but different strike prices. A vertical spread offers less exposure to risk as well as a payoff that is similar to an outright short option position (Nations, 2014).

One sells a vertical spread if he/she is receiving the money for the spread and buys a vertical spread when paying money for the spread. For instance, one is long a call spread if he/she is long the lower strike call and short the higher strike call. One is

short a call spread if he/she is short the lower strike call and long the higher strike call. One is long a put spread if he/she is long the higher strike put and short the lower strike put. One is short a put spread if he/she is short the higher strike put and long the lower strike put (Nations, 2014).

The lowest possible value of a vertical spread is zero. It cannot be less than zero. The maximum possible value for a vertical spread is the difference between the higher strike price and the lower strike price (Nations, 2014).

### **2.5.1 Moneyness of vertical spreads**

Vertical spreads where one leg is at the money and the other leg is in the money behave like fully in the money vertical spreads. Vertical spreads where one leg is at the money and the other leg is out the money behave like fully out of the money vertical spreads. Vertical spreads with both legs in the money behave like in the money spreads and vertical spreads with both legs out of the money behave like fully out of the money spreads (Nations 2014).

### **2.5.2 Bullish and bearish vertical spreads**

Buying an out of the money call spread is bullish. The call spread will only be profitable if the market prices of the underlying assets increase. Selling an out of the money call spread is profitable if the market price of the underlying assets decreases, remain unchanged or goes up but remains below the strike price where the call spread was sold (Nations, 2014).

Buying an out of the money put spread is bearish. The put spread will only be profitable if the market price of the underlying assets decreases. Selling an out of the money put spread is profitable if the market price of the underlying assets increases, remain unchanged or decrease but remains above the strike price where the put spread was sold (Nations, 2014).

### **2.5.3 Breakeven of vertical spreads**

For a long call vertical spread to breakeven, the market price needs to increase above the lower strike price by the amount that was paid to buy the vertical spread. For a long put vertical to breakeven, the market price needs to drop below the upper strike price by the amount spent to buy the put vertical (Nations, 2014).

### **2.6 Option calendar spreads**

An option calendar spread is put into effect by buying or selling a longer dated put or call option and simultaneously selling or buying a shorter dated put or call option. Buying an option calendar spread implies buying the longer dated option and selling the shorter dated option. Selling an option calendar spread implies selling the longer dated option and buying the shorter dated option (Nations, 2014).

### **2.7 Calendar and commodity spreads**

There are two different types of spreads in the agricultural derivatives market. Calendar spreads and commodity spreads. A commodity spread is the difference in price between two different contracts with the same expiry month. For example, March 2019 white maize yellow maize spread. The March 2019 white maize yellow maize spread is the difference in price between March 2019 white maize contract and the March 2019 yellow maize contract (Chicago Mercantile Exchange (CME), 2019). Calendar spreads are the differences in prices between contracts of the same commodity that have different expiry months (JSE, 2013). For example, March 2019/July 2019 white maize spread. The March 2019/July 2019 white maize spread is the difference in price between the July 2019 white maize price and the March 2019 white maize price (CME, 2019).

Monk *et al.* (2010) identified the crop estimates committee (CEC) report as a factor that contributes to the volatility of the July white maize contract from December to early May. When the CEC reports that the white maize harvest will be higher than the trader's expectation there is a drop in the July white maize price. When the CEC

reports that the white maize harvest will be lower than the trader's expectation, there is an increase in the July white maize price (Monk *et al.* 2010).

## **2.8 Carrying costs**

The calendar spread discounts carrying costs (interest and storage costs) in varying amounts from season to season. Interest refers to the interest rate that the bank charges its clients when they finance their grain. Banks currently charge an interest rate of prime rate minus 2% when they finance a client's grain. Storage costs is the costs that Silo owners charge their clients for storing their grain. For example, Senwes (Pty) Ltd charged their clients R0.91 per ton of maize stored per day, excluding value added tax (VAT), in the 2020/21 maize marketing season. The variation in the extent to which a calendar spread discounts interest and storage costs is caused by the differences in carryover stocks and stock to use from one season to another (Napier, 2016).

## **2.9 Maize production and consumption**

Maize is a staple crop in South Africa. It is mainly produced in Mpumalanga, the Free State and North West. There are two types of maize namely, white maize and yellow maize. White maize is mainly produced in the western parts of South Africa which include the North West and the western Free State. Yellow maize is predominantly produced in the eastern regions of South Africa such as Mpumalanga (Department of Agriculture Forestry and Fisheries (DAFF), 2016:11). The planting time occurs earlier in Mpumalanga than in the North West because Mpumalanga receives earlier rainfall that is enough for them to start planting. There has been a general increase in maize production from the 1997/98 maize marketing season to present. However, in some seasons production is poor and in others it is good. In the 2011/12, 2013/14 and 2016/17 maize marketing season maize production was poor in South Africa particularly due to poor rainfall across the country. In the 2014/15, 2015/16 and 2017/18 maize marketing season maize production high and this was largely attribute to good rainfall (CEC, 2019). Thus, rainfall is a limiting factor of production (DAFF, 2016:11). In South Africa white maize is mainly consumed by human beings and yellow maize is largely consumed by livestock (DAFF, 2017). There has been a

general increase in maize consumption from the 1997/98 maize marketing season to present. The supply and demand of maize impact on the ending stock which is the difference between supply and demand (CEC, 2019).

## **2.10 Ending/opening stock**

The South African maize marketing season starts on the 1<sup>st</sup> of May and ends on the 30<sup>th</sup> of April. The ending stock refers to the maize that is left after a certain period. For instance, the ending stock of a particular maize marketing season refers to the maize that will be left on the 30<sup>th</sup> of April when the total demand is subtracted from the total supply (National Agricultural Marketing Council (NAMC), 2019). It can also refer to the amount of maize available at the end of each month. The ending stock at the end of one month is the opening stock of the next month. Similarly, the ending stock of one maize marketing season is the beginning stock of the next marketing season. The total supply of maize includes the opening stock, producer deliveries, imports and surplus. The total demand consists of the local demand (processed for the local market, withdrawn by producers, released to end consumers and the deficit) and exports (CEC, 2019).

According to Monk *et al.* (2010) low white maize stock at the end of the month have little impact on the expected white maize supply whereas a large white maize stock at the end of the month has greater contribution to the expected white maize supply. Thus, a large stock at the end of the month contributes to increased volatility of white maize futures prices.

## **2.11 Exchange rate**

Monk *et al.* (2010) suggests that if the rand depreciates against the United States (US) dollar there will be a reduction in maize imports because it will be expensive to import maize. The reduction in imports will ultimately render imports to have little impact on the expected supply of white maize in South Africa. This is expected to decrease the volatility of white maize prices. Hence an appreciation of the rand against the US dollar would increase the volatility of the July white maize price.

The impact of the exchange rate would not only be on the July white maize contract but also on all the other months that have liquidity on SAFEX such as March, May, September and December. For purposes of this study the focus will be on the March and July white maize contracts. Despite the exchange rate having an impact on both March and July white maize contracts, the impact will vary in intensity between the two months. As mentioned by Monk *et al.*, (2010), if the rand appreciates against the US dollar there will be an increase in imports. The increased imports will result in a higher supply at the end of each month. However, due to consumption in March, April, May and June, the supply at the end of February will be higher than the supply at the end of June. This entails that the pressure exerted on the March white maize contract will be greater than the pressure exerted on the July white maize contract. Ultimately the March/July white maize spread will become a bigger positive. If the spread was negative, it would become a smaller negative and eventually become zero then become a bigger positive.

## **2.12 Interest rates**

High interest rates encourage farmers to sell their white maize as soon as possible instead of storing it and waiting for a relatively higher selling price. The need to sell is motivated by their obligation to settle their interest and debt requirements. When farmers sell their maize, they are increasing the supply of white maize available in the market which in turn contributes to the volatility of white maize prices (Monk *et al.*, 2010).

The impact of an interest rate hike will be different on the March and July white maize contracts. Maize is harvested close to July in South Africa (Monk *et al.*, 2010). Therefore, by the time farmers harvest their white maize the March white maize contract will have expired in March. The farmer must deliver his white maize during the SAFEX month on which he sold his white maize (JSE, 2019). Hence farmers are more likely to sell their white maize against the July white maize contract if interest rates rise. The aggressive selling of white maize against the July white maize contract will put pressure on the July white maize contract. As a result, the July white maize price will go down more compared to the March white maize price. If the March/July white maize spread was positive, it will move closer to zero and become a negative.

## 2.13 Weather

Irrigated agriculture accounts for 60% of the total water use in South Africa (Department of Water Affairs (DWA), 2013). Thus, the sector is highly dependent on freshwater. In the 2015/16 production season, South Africa experienced a severe drought (National department of Agriculture (NDA), 2016). As a result, production of white maize fell to 4 735 000mt from 7 710 000mt in the 2014/15 production season as indicated in figure one below. Figure 1 shows how white maize production varied from the 2010/11 to 2019/20 production season. The highest level of production was seen in 2017/18 production season where farmers produced 9916000 tons. The average production for the period was seen at 6424696 tons. The lowest level of production was estimated at 3408500 in 2016/17.

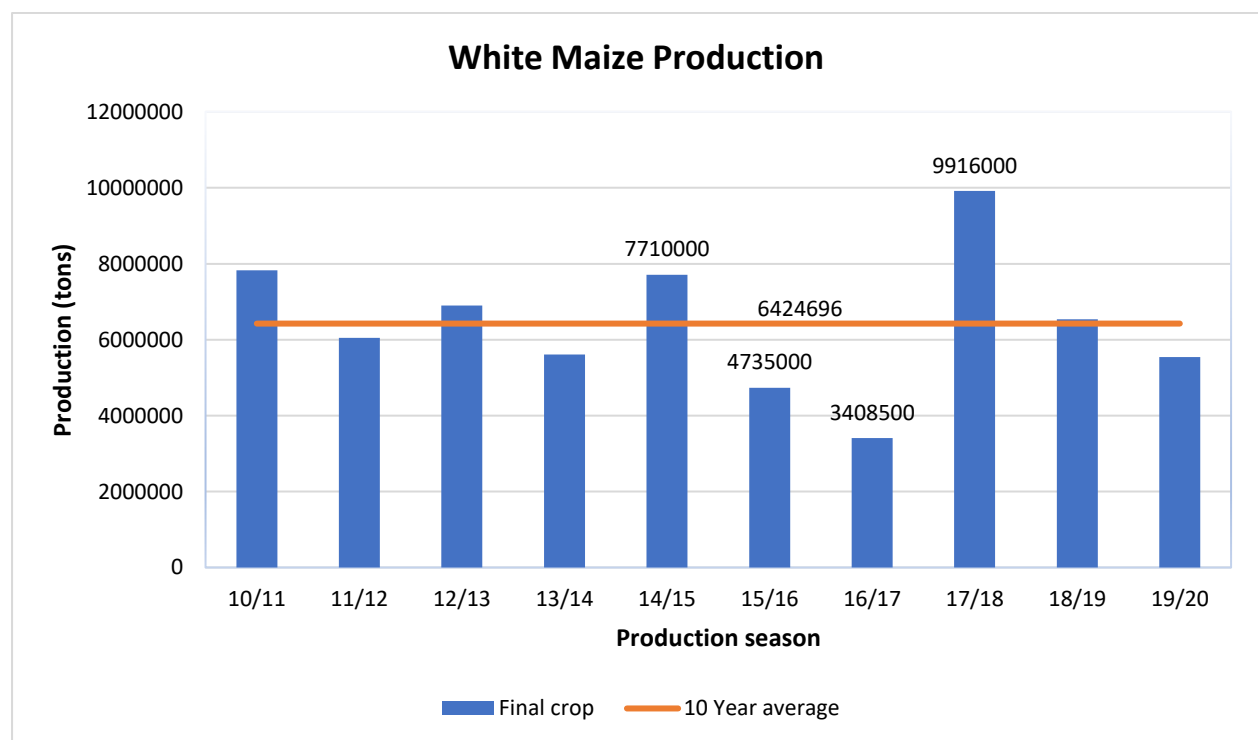


Figure 2.1: White maize production (CEC, 2019)

The highest price seen on the March contract in the 2015/16 Marketing season was R5376 on the 21<sup>st</sup> of January 2016 and the highest price seen on the July contract was R5165 on the 1<sup>st</sup> of March 2016. These prices were relatively high compared to

the prices seen in the 2014/15 marketing season. The high prices were attributed to the lower production that occurred as a result of a lack of rainfall.

As the maize production season approaches, weather becomes an important factor that determines whether farmers are able to plant on time and over the area of land that they intend to produce maize on.

## **2.14 Optimal price**

Optimal means producing the best possible results (Oxford University Press, 2021). Therefore, for the purposes of this study, the optimal price of the March/July white maize spread refers to the best price to sell the March/July white maize spread in a specific maize marketing season given the prevailing market conditions. This means that the prevailing exchange rate, stock to use ratio and/or opening stock will determine the optimal price of the March/July white maize spread. This also means that the optimal price will vary from one year to another and between months because the exchange rate, stock to use and opening stock will also vary from month to month and from one year to another.

## **2.15 Related research**

Seok *et al.*, (2013) discovered that although calendar spreads may approach full carry, they rarely reach full carry. The table below indicates the levels at which the March/July white maize spread traded since 2010 on SAFEX. It is clear from table 1 below that the findings of Soek *et al.* (2013) are true as far as the South African March/July white maize spreads are concerned. In the period from 2010 to 2019, the March/July 2010 white maize spread was closest to full carry when it traded at 94.31%. However, it never reached full carry even in the years that followed.

Table 2.1: March/July white maize prices

| White maize | Low      | High     | Prime interest rate (%) | Storage (JSE)    | March contract price (until to 28/29 Feb) | Full carry cost | % of full carry |
|-------------|----------|----------|-------------------------|------------------|-------------------------------------------|-----------------|-----------------|
| Mar/Jul'10  | -R91     | R94      | 10.5                    | 0.46             | 1532.73                                   | R99.67          | 94.31%          |
| Date        | 20/10'09 | 18/2'10  | 1/3'10                  | 1/5'09 – 30/4'10 |                                           |                 |                 |
| Mar/Jul'11  | R27      | R66      | 9                       | 0.47             | 1312.29                                   | R88.04          | 74.97%          |
| Date        | 5/1'11   | 25/11'11 | 1/3'11                  | 1/5'10 – 30/4'11 |                                           |                 |                 |
| Mar/Jul'12  | -R725    | R9       | 9                       | 0.50             | 2125.22                                   | R110.72         | 8.13%           |
| Date        | 18/1'12  | 1/7'11   | 1/3'12                  | 1/5'11 – 30/4'12 |                                           |                 |                 |
| Mar/Jul'13  | -R500    | -R26     | 8.5                     | 0.54             | 2363.93                                   | R117.24         |                 |
| Date        | 22/3'12  | 28/2'13  | 1/3'13                  | 1/5'12 – 30/4'13 |                                           |                 |                 |
| Mar/Jul'14  | -R1021   | R45      | 9                       | 0.57             | 2482.40                                   | R127.62         | 35.26%          |
| Date        | 31/1'14  | 8/3'13   | 1/3'14                  | 1/5'13 – 30/4'14 |                                           |                 |                 |
| Mar/Jul'15  | -R69     | R86      | 9.25                    | 0.61             | 2036.24                                   | R123.76         | 69.49%          |
| Date        | 15/12'14 | 25/2'15  | 29/1'15                 | 1/5'14 – 30/4'15 |                                           |                 |                 |
| Mar/Jul'16  | -R726    | R49      | 10.25                   | 0.63             | 3420.92                                   | R171.19         | 28.62%          |
| Date        | 29/6'15  | 29/2'16  | 28/1'16                 | 1/5'15 – 30/4'16 |                                           |                 |                 |
| Mar/Jul'17  | -R1650   | -R477    | 10.5                    | 0.68             | 4002.89                                   | R196.69         |                 |
| Date        | 25/2'16  | 4/10'16  | 24/1'17                 | 1/5'16 – 30/4'17 |                                           |                 |                 |
| Mar/Jul'18  | R3       | R122     | 10.25                   | 0.72             | 1977.56                                   | R142.37         | 76.47%          |
| Date        | 23/2'17  | 28/2'18  | 18/1'18                 | 1/5'17 – 30/4'18 |                                           |                 |                 |
| Mar/Jul'19  | R332     | R149     | 10.25                   | 0.76             | 2423.16                                   | R159.54         | 93.39%          |
| Date        | 19/9'18  | 27/2'19  | 17/1'19                 | 1/5'18 – 30/4'19 |                                           |                 |                 |
| Mar/Jul'20  | -R734    | -R14     | 9.75                    | 0.79             | R2917.42                                  | R171.95         |                 |
| Date        | 28/1'20  | 7/11'19  | 16/1/2020               | 1/5'19 – 30/4'20 |                                           |                 |                 |

The value of calendar spreads is only influenced by volatility and the price relationship between 2 contracts with different maturity dates (Soek *et al.*, 2013). Volatility in the market can cause the March white maize price to move further away from or closer to the July white maize contract price. The further away the March white maize contract

price is from the July white maize contract price, the larger the spread. The closer the March white maize contract price is to the July white maize contract price, the smaller the spread.

Napier (2016) evaluated if there was a correlation between nonlinear price behaviour in corn futures markets and the relative level of corn stock to use estimates using a logistical smooth transition modelling framework (LSTR). He further analysed whether LSTR model can provide a profitable corn future spread trading strategy. He found that there is a correlation between the non-linear price movements in the corn futures market and stock to use ratios. The greater the corn reserves are compared to demand, the more positive the spread would widen. In contrast, if the corn reserves are increasingly less compared to demand, the spread would inverse.

According to AgWeb (2014), the old crop (July corn contract on the CME) new crop (December corn contract on the CME) corn spread is an indication of a bear or a bull market. In a normal market condition, the new crop normally has a premium added to the price because there is uncertainty about the size of the crop that will be harvested. The higher the uncertainty about the new crop, the higher the premium. This entails that the old corn crop price will be lower than the new corn crop price. The lower the old crop price is compared to the new crop, the higher the probability of a bear market. In contrast, if there is a shortage of corn in the old season, the old crop price will be higher than the new crop price. This is an indication of a bull market. Old crop and new crop prices normally move in the same direction, but that direction is led by the old crop. In the South African context, in terms of the March July white maize spread, the old crop is the March white maize contract, and the new crop is the July white maize contract.

Whilst it is true that calendar spreads never approach full carry, it is also important to identify factors that could indicate when they have approached their maximum levels. It is also critical to confirm whether in the South African context, there is a correlation between white maize reserves or opening stocks and the March July white maize spread. The capability to anticipate the price of the March July white maize spread will also serve as an indication whether white maize is in a bull or bear market.

Van der Wath (2011) investigated the correlations and causalities that can explain the interaction between the demand, supply and price of maize. After analysing the July/December white spread, he found that the spread will never be higher than the carry cost. Traders can therefore use the carry cost for the March/July white maize spread as the maximum level where the spread can possibly trade. It will also assist traders in determining the best price to sell the March/July white maize spread.

## **2.16 Benefits of spread trading**

Usually, spread trading yields speculators smaller potential losses, but also smaller potential profits, than outright long or short positions established in a single futures contract month. Spread trading reduces a speculators exposure to losses but also to potential profits compared to long or short positions in one futures contract month (Napier, 2016).

## **2.17 Significance of the old crop new crop spread**

According to Napier (2016), the July (old crop) December (new crop) corn futures spread is more attractive to speculators because it has more volatility compared to other corn calendar spreads. As such this study is concerned with the March (old crop) July (new crop) maize futures spreads which is the old crop new crop maize futures spreads in the South African context. Although the volatility in the spread increases risk, it also increases the potential profits that can be generated through the spread.

The volatility of the March July white maize spread is attributed to the fact that the spread is influenced by the stocks to use estimates of white maize in two different marketing seasons. The stock to use ratio of white maize is the ending stock for white maize at the end of a marketing season as a percentage of the total consumption. When the July white maize price is higher than the March white maize price, the spread is trading at a positive value and this encourages grain merchandisers to store the white maize by covering some of the storage costs. However, if the March white maize price is trading higher than the July white maize price the spread is trading at a negative value or at an inverse, and this encourages grain merchandisers to sell the grain because there is no incentive to store the grain. Thus, if the March July white

maize spread is trading at an inverse, it is a signal that there is a high demand for maize now and that the opportunity cost of not selling it now is greater than the value that will be derived from selling it later. In contrast, if the spread is trading positive, it is a signal that the market wants grain handlers to store their maize (Napier, 2016).

The old crop – new crop spreads usually trade at an inverse during planting and harvesting time. The old crop price will be higher than the new crop price because the old crop reserves from last year's harvest will be approaching depletion. The new crop price will be lower than the old crop price because of the expectation of large new crop reserves coming from the harvest (Napier, 2016).

Economic theory puts a limitation on the extent to which a calendar spread can trade positive however, it suggests that the extent to which a calendar spread can inverse is unlimited (Napier, 2016). This entails that the full carrying cost is the highest level at which a spread can trade.

## **2.18 Chapter summary**

The SAFEX is a formal platform that facilitates exchanges between market participants in the agricultural product market. There are various tools available for use by individual investors and market participants such as spreads, options and futures contracts. The ending stock is a measure of production and consumption. The influence of weather on crop production patterns is also seen in the size of the ending or opening stock of white maize. There are various international studies on maize spreads but there are currently no local studies that investigate the factors that impact in the March July white maize spread. The following section describes the methodology that will be used for the study.

## **Chapter 3: Research Methodology**

### **3.1 Chapter overview**

Chapter 3 focuses on the research paradigm, methods and methodology that were used to address the aim and objectives of the study. The chapter provides an approach on how the exchange rate, stock to use and opening stock will be evaluated to achieve the aim and objectives of the study.

### **3.2 Paradigm**

#### **3.2.1 Positivism**

The study followed the positivist paradigm. The positivist paradigm was the most relevant for the study because the study followed the quantitative approach. A considerable amount of quantitative research follows the positivist paradigm mainly because positivists have confidence in the empirical hypothesis testing (Rehman and Alharthi, 2016).

The positivism paradigm assumes that human beings do not intervene in the natural process of phenomena but is based on the belief that there are laws that determine phenomena. It has assumptions about ontology, epistemology, methodology and methods (Rehman and Alharthi, 2016).

- Ontological position

The ontological perspective of positivists is realism. Positivists believe in causality. They believe that for each outcome there is a stimulus. Once the relationship between the stimulus and the outcome can be established, future events can be forecasted (Rehman and Alharthi, 2016).

- Epistemological position

The epistemological perspective of positivists is objectivism. Positivists study phenomena as it occurs without any interference from them and communicate their observations. They assume that there are laws that determine social phenomena and rely on scientific methods to describe these laws and express them through factual statements (Rehman and Alharthi, 2016).

- Methodology position

The methodology of positivists is based on experimentation. When analysing data, the hypothesis about the causality between variables is presented and subjected to statistical analyses to either confirm or reject the hypothesis. Positivist studies make use of numerical data (Rehman and Alharthi, 2016).

- Method position

The numerical data is analysed by means of descriptive or inferential statistical analyses. The positivist paradigm considers good quality research as research that has internal validity, external validity, reliability and objectivity. The research has internal validity if it can prove that only the independent variable had an effect on the dependent variable. It has external validity if the results can be generalised. It has reliability if other researchers can duplicate it and obtain the same results. Lastly, it has objectivity if the researchers do not interfere with their observations of the phenomena (Rehman and Alharthi, 2016).

### **3.3 Research method**

This study followed a quantitative approach. It focused on the monthly opening stock and ending stock of white maize as well as the volumes that farmers harvest in the new season and how both of those aspects influence the March/July white maize calendar spreads. Special attention was also given to historical prices of the March/July white maize spread and the R/\$ exchange rate.

### **3.3.1 Ending stock/opening stock**

It is evident from the reports released by the crop estimates committee since 1999 that the quantity of maize in general and white maize in particular fluctuates each year. The fluctuations in white maize produced in South Africa may be attributed to various factors such as droughts, floods, sufficient rainfall, pests, diseases, farmers switching to other commodities, the reduction in farmers, the introduction of new cultivars and many other factors. Regardless of the cause of the fluctuation, the reality is that supply is not constant. This is exacerbated by the fluctuations in demand. It is common knowledge that price is a function of supply and demand. However, the impact of supply and demand on the price difference between two commodities such as the March/July white maize spread is unclear.

### **3.3.2 Historical maize prices**

It can be seen on the commodity derivative market (CDM) of SAFEX that white maize prices fluctuate daily. It can also be seen how the prices of the March/July white maize spread fluctuate accordingly. Thomson Reuters also releases historical prices of both white maize and the March/July white maize spread which indicate that prices have been fluctuating not only for the period that the study analysed but even before.

### **3.3.3 R/\$ Exchange rate**

The R/\$ exchange rate has weakened over time since 2011 and it fluctuates each day. This is evident from Thomson Reuters. The study investigated whether there is a relationship between the fluctuations in the R/\$ exchange rate and the price of the March/July white maize spread.

## **3.4 Research design**

The study was longitudinal in nature. The July contract opened after the March contract, but the March contract expired before the July contract. The time interval was from when the July contract started trading because then the price difference between March and July was available in the form of a calendar spread. Although the March

contract expired in March, the time interval ended at the end of February because there should be no short or long positions at the beginning of March. There should be no long positions in March because the trading firm would have received physical delivery of white maize. There should be no short positions in March because the trading firm would have been expected to make physical delivery of white maize.

### **3.4.1 Weather**

The study gathered monthly rainfall data for all the provinces in South Africa from 2009 to 2020. After considerable analysis of the data it was found that the data does not provide an accurate measure of the rainfall that occurred on maize production farms across the country. The SAWS estimated that 543.2mm of rainfall occurred in the Free State in 2019. This does not mean that 543.2mm of rainfall occurred on a farm that produced white maize. Some of that rainfall occurred in cities, where there were no white maize farms. To measure the contribution of rainfall on the March/July white maize spread requires rainfall data at farm level. Given the constraints of time and covid-19 restrictions, it was not possible to acquire the data. Nevertheless, even with the data, the results would have been flawed because one would also have to consider groundwater because it also contributes to the freshwater available for the white maize crop. As mentioned in chapter two, rainfall has a direct impact on white maize production which is represented in the study by the opening stock. Therefore, by assessing the impact of the opening stock on the March/July white maize spread, the author is indirectly evaluating the impact of rainfall on the spread.

### **3.4.2 Opening stock**

The study gathered data on the quantity of white maize available at the beginning of each month from March 2009 to February 2020. White maize early deliveries commence in March. Therefore, the white maize opening stock were considered from March for each March/July white maize spread. The opening stocks for each March/July spread were taken until the end of February for each spread because there should be no white maize positions on the 1<sup>st</sup> of March. Therefore, monthly opening stock estimates of white maize from March to February were analysed for each March/July white maize spread.

The monthly opening stocks of white maize from March 2009 to February 2010 were determined for the March/July 2010 white maize spread. The monthly opening stock from March 2010 to February 2011 were used for the March/July 2011 spread. The monthly opening stock from March 2011 to February 2012 were used for the March/July 2012 spread. The monthly opening stock from March 2012 to February 2013 were used for the March/July 2013 spread. The monthly opening stock from March 2013 to February 2014 were used for the March/July 2014 spread. The monthly opening stock from March 2014 to February 2015 were used for the March/July 2015 spread. The monthly opening stock from March 2015 to February 2016 were used for the March/July 2016 spread. The monthly opening stock from March 2016 to February 2017 were used for the March/July 2017 spread. The monthly opening stock from March 2017 to February 2018 were used for the March/July 2018 spread. The monthly opening stock from March 2018 to February 2019 were used for the March/July 2019 spread. The monthly opening stock from March 2019 to February 2020 were used for the March/July 2020 spread.

Ultimately, each monthly opening stock of white maize coincided with the average price of the March/July white maize spread for that specific month. This enabled the author to determine whether there is a relationship between the variation in the monthly opening stock of white maize and the March/July white maize spread. The test for the relationship between the monthly opening stock of white maize and the March/July white maize spread was repeated for each year starting from 2009 with the March/July 2010 white maize spread to 2020 with the March/July 2020 white maize spread.

### **3.4.3 Stock to use ratio**

The stock to use ratio is made up of two components namely, the opening stock and the total local consumption of white maize for the maize marketing season. The opening stock is the monthly opening stock of white maize. The use is the monthly local consumption of white maize. The maize marketing season starts on the 1<sup>st</sup> of May and ends at the end of April the following year. Therefore, the monthly opening stock was considered from May to the end of April the following year for each

March/July white maize spread. However, for the purposes of this study, the opening stock was considered from May to February the following year because this study assumed that all the white maize short positions must have been moved from March to July by the end of February.

The stock to use ratio was determined for each month from May to February the following year. The stock to use in May was the opening stock of white maize in May divided by the sum of the local consumption from May to the end of April. The stock to use of June was the opening stock of white maize in June divided by the sum of the local white maize consumption from June to the end of April. The stock to use of July was the opening stock of white maize in July divided by the local consumption of white maize from July to the end of April. The stock to use in August was the opening stock of white maize in August divided by the sum of the local consumption of white maize from August to the end of April. The stock to use in September was the opening stock of white maize in September divided by the sum of the local consumption of white maize from September to the end of April. The stock to use in October was the opening stock of white maize in October divided by the sum of the local consumption of white maize from October to the end of April. The stock to use in November was the opening stock of white maize in November divided by the sum of the local consumption of white maize from November to the end of April. The stock to use in December was the opening stock of white maize in December divided by the sum of the local consumption of white maize from December to the end of April. The stock to use in January was the opening stock in January divided by the sum of the local consumption of white maize from January to the end of April. The stock to use of white maize in February was the opening stock of white maize in February divided by the sum of the local consumption from February to the end of April. The stock to use in March was the opening stock of white maize in March divided by the sum of the local consumption of white maize from March to the end of April. The stock to use of April was the opening stock of white maize in April divided the local consumption of white maize in April.

Each stock to use ratio was put against the average price of the March/July white spread in the corresponding month. This allowed the author to determine whether there was a relationship between the monthly variation in the stock to use ratio and the March/July white maize spread. The test for a relationship was repeated for each

year starting from 2009 in the case of the March/July 2010 white maize spread to 2020 in the case of the March/July 2020 white maize spread.

#### **3.4.4 R/\$ Exchange rate**

The daily closing values of the R/\$ exchange rate were gathered from March 2009 to February 2020. The daily values were made into monthly averages to obtain a monthly R/\$ exchange rate. Each monthly R/\$ exchange rate was put against the average March/July white maize spread in the corresponding month. This enabled the author to determine whether there was a relationship between the fluctuations in the R/\$ exchange rate and the March/July white maize spread. The test for a relationship was repeated for each year starting from 2009 in the case of the March/July 2010 white maize spread to 2020 in the case of the March/July 2020 white maize spread.

A regression analysis was conducted to determine the extent to which the opening stock, stock to use and exchange rate individually and collectively account for the variation in the March/July white maize spread. This was done for all the spreads namely the March/July 2010 white maize spread to the March/July 2020 white maize spread.

#### **3.5 Delimitation of study**

The study focused on the prices of the March/July white maize spread. The spreads consisted of the March/July 2010 white maize spread to March/July 2020 white maize spread. The prices of each spread were taken from March to February. The study investigated the influence of the opening stock, stock to use and R/\$ exchange rate on the March/July white maize spread. Data on the opening stock, stock to use and R/\$ exchange rate was gathered from March 2009 to February 2020. The opening stock is the monthly opening stock of white maize from March 2009. The stock to use is the monthly opening stock of white maize divided by the local white maize consumption for the maize marketing season. The prices of the March/July white maize spread as well as R/\$ exchange rate were obtained from Thomson Reuters. The opening stock and local consumption of white maize figures were obtained from the crop estimates committee.

## **3.6 Research methodologies/processes**

### **3.6.1 Population**

The unit of analysis was the CEC report. The report contained information about various factors which give an indication of the quantity of white maize that will be available on the 30<sup>th</sup> of April and the 1<sup>st</sup> of May. The 30<sup>th</sup> of April is the end of the maize marketing season while the 1<sup>st</sup> of May is the beginning of the new season. Maize that is left on the 30<sup>th</sup> of April is referred to as the ending stock of the maize marketing season but on the 1<sup>st</sup> of May it is referred to as the beginning stock of the maize marketing season. Nevertheless, opening stocks and ending stocks are also given on a monthly basis within a marketing season.

The CEC reports contain monthly supply and demand estimates of white maize. The variables under supply include opening stock, producer deliveries, imports and surplus. Demand is made up of white maize processed for the local market (human consumption, animal consumption, gristing and biofuel production), withdrawn by producers, released to end consumers, net dispatches, deficit and exports. The report determines the difference between supply and demand and expresses it as the ending stock of white maize.

The CEC reports were first released in the 1997/98 maize marketing season. Since then, there have been released monthly to provide supply and demand estimates of groundnuts, maize, sorghum, soybeans, sunflower, barley, canola, oats and wheat. The CEC releases several reports before it releases its final report. The final report about maize planted in 2019 was released early in 2021. Before then it released reports monthly with a different but more accurate estimate in each subsequent report. The population is the crop estimates committee reports released from the 1997/98 maize marketing season to date. The sample of the population that was used in this study is the crop estimates committee reports from 2009 to 2020.

### **3.6.2 Sample method/technique and sample size**

Purposive sampling was used in the study. According to this strategy the white maize marketing seasons are selected deliberately in order to provide important information that cannot be obtained from other choices (Maxwell, 1996).

The study made use of 10 units of analysis. Each unit of analysis was the final report of the CEC. Under normal conditions, the CEC releases 10 reports each year. The first report is usually released in October. It provides the market with information about farmers intentions to plant. It also provides information on how much area will be allocated to each summer crop such as white maize amongst others. From this estimate, the market can project how big the final crop will be based on their expectations of the yield per hectare which is informed by historical yields per hectare. From January to September, the first, second, third, fourth, fifth, sixth, seventh, eighth and final production estimates are released each month.

Each production forecast contains estimates on the area that farmers planted white maize, the quantity of white maize to be harvested during the harvesting season, the area planted in the previous seasons as well as the crop harvested. The crop estimate usually changes from the first production forecast to the final production forecast report with each production forecast report that is released, the white maize estimate is more accurate than the estimate in the previous report. Until finally, the final crop estimate report is released in September after all the white maize has been harvested. Usually in the first production forecast which is released in January, the total area planted with white maize is known with certainty.

### **3.6.3 Data collection instruments**

The data on the supply and demand estimates of white maize were obtained from [www.sagis.org.za](http://www.sagis.org.za). The South African Grain Information Service (SAGIS) is a reliable source that has been widely used in South Africa for several years. The data on the prices of the March/July white maize spread and the R/\$ exchange rate were obtained from Thomson Reuters. Thomson Reuters provides market information for reputable organizations throughout the world and locally such as Silostrat Investments (Pty) Ltd.

### **3.6.4 Data collection**

The study made use of secondary data derived from the crop estimates committee reports and Thomson Reuters. These sources were the most relevant because of their credibility and availability to the public and provide the required data for purposes of the study.

### **3.7 Data coding and analysis**

This study made use of historical data on white maize ending/opening stocks and on the prices of March/July white maize spreads. The white maize ending stocks were determined by subtracting the white maize demand from the white maize supply. The ending stock is given in the CEC reports together with the opening stock of white maize. The supply of white maize is the sum of the beginning stock, producer deliveries, imports and surplus. The total demand is the sum of the white maize local demand and exports. The March/July white maize prices were derived from Reuters. The prices of the March/July white maize spreads were readily observed on Thomson Reuters. The study made use of a regression analysis using stata to determine what the price will be given a certain amount of white maize ending stock, opening stock, R/\$ exchange rate and stock to use ratio.

### **3.8 Ethical consideration**

All the quantitative data was secondary data freely available on the internet and other databases. As such no respondents were involved and no letter of consent was required. This also eliminated the need for a questionnaire. The study made use of data on the opening stock and ending stocks of white maize as well as the stock to use ratio. This data was derived from CEC reports which are available to the public on the internet. The R/\$ exchange rate and the prices of the March/July white maize spreads were available from various sources but for the purposes of this study they were derived from Thomson Reuters.

The study presented no or minimal risk because it used secondary data and there was no contact with human participants, animals and/or the environment. Data was de-

identified before it was released to the researcher, consent of study subjects were reasonably presumed, outcomes of the analysis did not allow re-identifying participants and the use of the data did not result in any damage or distress.

### **3.9 Chapter summary**

Deriving a model from a regression analysis of the March/July white maize spread allowed for the optimal price of future March/July white maize spreads to be predicted. Substituting the prevailing or expected exchange rate, stock to use and opening stock in the model will enable traders to predict the optimal price of the spread. Those values that are substituted into the model then become the exchange rate, stock to use and opening stock associated with the optimal price. The following section makes use of inferential statistics to test for significance in the relationship between the March/July white maize spread and the exchange rate, stock to use and opening stock collectively and individually. It also predicts the March/July white maize spread from 2010 to 2020 and derives the associated models.

## **Chapter 4: Data Analysis and Discussion of Results**

### **4.1 Chapter overview**

This chapter analyses the monthly March/July white maize spreads from the 2009/10 marketing season to the 2019/20 maize marketing season. It also analyses the extent of the impact of each independent variable on the March/July white maize spread. It does so by estimating the R-squared of each March/July white maize spread and determining the P-values of each independent variable for each March/July white maize spread.

### **4.2 Actual vs predicted spreads**

Tables 4.1 to 4.11 below provides the monthly opening stock levels, average exchange rate and stock to use as well as the monthly average price of the March/July white maize spread. The tables also provide the predicted monthly values of the March/July white maize spread. As mentioned, the optimal price of the March/July white maize spread is the highest price that it trades.

It is evident in Table 4.1 that the optimal price of the March/July 2010 white maize spread varied from March 2009 to February 2010. There is a deviation between the actual and the predicted values of the March/July white maize spread. In some months the actual values of the March/July white maize spread are higher than the predicted values and in other months the predicted values are higher than the actual monthly average prices of the March/July 2010 white maize spread. Even though the actual monthly average prices and the predicted prices of the March/July white maize spread differ, they are both positive from March 2009 to July 2009 and they're both negative from August 2009 to February 2010. According to the predicted values of the March/July 2010 white maize spread, the optimal price of the March/July white maize spread was seen in May 2009 at R34. This was associated with an opening stock of 762 000 tons, an exchange rate of R8.34/\$ and a stock to use of 16%.

Table 4.1: Predicted March/July 2010 white maize spread

|        |               |               |              | March/July 2010 white maize spread |           |
|--------|---------------|---------------|--------------|------------------------------------|-----------|
| Month  | Opening stock | Exchange rate | Stock to use | Monthly Average                    | Predicted |
| Mar-09 | 1 834 000     | 9.90          | 2.29         | 20                                 | 22        |
| Apr-09 | 1 203 000     | 8.92          | 3.37         | 6                                  | 2         |
| May-09 | 762 000       | 8.34          | 0.16         | 2                                  | 34        |
| Jun-09 | 814 000       | 8.02          | 0.19         | 35                                 | 28        |
| Jul-09 | 1 996 000     | 7.93          | 0.51         | 38                                 | 10        |
| Aug-09 | 4 351 000     | 7.90          | 1.23         | -10                                | -9        |
| Sep-09 | 4 805 000     | 7.47          | 1.52         | -17                                | -19       |
| Oct-09 | 4 554 000     | 7.45          | 2.49         | -62                                | -29       |
| Nov-09 | 4 047 000     | 7.47          | 1.69         | -22                                | -19       |
| Dec-09 | 3 607 000     | 7.48          | 1.78         | -26                                | -18       |
| Jan-10 | 3 178 000     | 7.44          | 1.90         | -28                                | -18       |
| Feb-10 | 2 754 000     | 7.66          | 2.06         | 34                                 | -14       |

It is evident in Table 4.2 that the optimal price of the March/July 2011 white maize spread varied from March 2010 to February 2011. There is a deviation between the monthly average actual and the predicted values of the March/July 2011 white maize spread. In some months the actual values of the March/July white maize spread are higher than the predicted values and in other months the predicted values are higher than the actual monthly average prices of the March/July 2011 white maize spread. Even though the actual monthly average prices and the predicted prices of the March/July white maize spread differ, they are both positive from March 2010 to February 2011. According to the predicted values of the March/July 2011 white maize spread, the optimal price of the March/July 2011 white maize spread was seen in May 2010 at R54.56. This was associated with an opening stock of 1 362 000 tons, an exchange rate of R7.64/\$ and a stock to use of 22%.

Table 4.2: Predicted March/July 2011 white maize spread

|        |               |               |              | March/July 2011 white maize spread |           |
|--------|---------------|---------------|--------------|------------------------------------|-----------|
| Month  | Opening stock | Exchange rate | Stock to use | Monthly Average                    | Predicted |
| Mar-10 | 2299000       | 7.3958        | 2.3824       | 43                                 | 47.0526   |
| Apr-10 | 1742000       | 7.3259        | 3.8971       | 41                                 | 42.0491   |
| May-10 | 1362000       | 7.6421        | 0.2200       | 54                                 | 54.5613   |
| Jun-10 | 1453000       | 7.6323        | 0.2550       | 55                                 | 54.4461   |
| Jul-10 | 3654000       | 7.5164        | 0.6969       | 55                                 | 53.1692   |
| Aug-10 | 5935000       | 7.2804        | 1.2482       | 48                                 | 50.0567   |
| Sep-10 | 6235000       | 7.1041        | 1.4633       | 44                                 | 47.9352   |
| Oct-10 | 5827000       | 6.8961        | 1.5547       | 52                                 | 45.7381   |
| Nov-10 | 5307000       | 6.9506        | 1.6605       | 41                                 | 45.8475   |
| Dec-10 | 4745000       | 6.7978        | 1.8028       | 42                                 | 43.9666   |
| Jan-11 | 4206000       | 6.9075        | 1.9709       | 43                                 | 44.3787   |
| Feb-11 | 3653000       | 7.1681        | 2.2633       | 57                                 | 45.7990   |

It is evident in Table 4.3 that the optimal price of the March/July 2012 white maize spread varied from March 2011 to February 2012. There is a deviation between the monthly average actual and the predicted values of the March/July 2012 white maize spread. In some months the actual values of the March/July white maize spread are higher than the predicted values and in other months the predicted values are higher than the actual monthly average prices of the March/July 2012 white maize spread. Even though the actual monthly average prices and the predicted prices of the March/July 2012 white maize spread differ, they are both negative from May 2011 to February 2012 and positive in April 2011 but in March 2011 the March/July 2012 white maize spread trades positive while the predicted March/July 2012 white maize spread indicates an inverse. According to the predicted values of the March/July 2012 white maize spread, the optimal price of the March/July 2012 white maize spread was seen in April 2011 at R62.16. This was associated with an opening stock of 2 334 000 tons, an exchange rate of R6.70/\$ and a stock to use of 459%.

Table 4.3: Predicted March/July 2012 white maize spread

|        |               |               |              | March/July 2012 white maize spread |           |
|--------|---------------|---------------|--------------|------------------------------------|-----------|
| Month  | Opening stock | Exchange rate | Stock to use | Monthly Average                    | Predicted |
| Mar-11 | 3019000       | 6.8983        | 2.7571       | 37                                 | -80.6748  |
| Apr-11 | 2334000       | 6.7008        | 4.5945       | 16                                 | 62.1565   |
| May-11 | 1609000       | 6.8465        | 0.2892       | -16                                | -125.0582 |
| Jun-11 | 1007000       | 6.7750        | 0.2012       | -52                                | -83.9386  |
| Jul-11 | 1587000       | 6.7715        | 0.3547       | -172                               | -97.4523  |
| Aug-11 | 3342000       | 7.0610        | 0.8353       | -317                               | -208.1924 |
| Sep-11 | 4191000       | 7.5741        | 1.2005       | -404                               | -373.5110 |
| Oct-11 | 3891000       | 7.9317        | 1.2974       | -446                               | -484.1439 |
| Nov-11 | 3296000       | 8.1359        | 1.2840       | -478                               | -544.3249 |
| Dec-11 | 2742000       | 8.1847        | 1.2819       | -487                               | -552.2505 |
| Jan-12 | 2239000       | 7.9875        | 1.2700       | -627                               | -478.9095 |
| Feb-12 | 1717000       | 7.6284        | 1.3117       | -368                               | -347.7002 |

It is evident in Table 4.4 that the optimal price of the March/July 2013 white maize spread varied from March 2012 to February 2013. There is a deviation between the monthly average actual and the predicted values of the March/July 2013 white maize spread. In some months the actual values of the March/July 2013 white maize spread are higher than the predicted values and in other months the predicted values are higher than the actual monthly average prices of the March/July 2013 white maize spread. Even though the actual monthly average prices and the predicted prices of the March/July white maize spread differ, they are both negative from March 2012 to February 2014. According to the predicted values of the March/July 2011 white maize spread, the optimal price of the March/July 2013 white maize spread was seen in February 2013 at -R101.49. This was associated with an opening stock of 2 169 000 tons, an exchange rate of R8.86/\$ and a stock to use of 150%.

Table 4.4: Predicted March/July 2013 white maize spread

|        |               |               |              | March/July 2013 white maize spread |           |
|--------|---------------|---------------|--------------|------------------------------------|-----------|
| Month  | Opening stock | Exchange rate | Stock to use | Monthly Average                    | Predicted |
| Mar-12 | 1261000       | 7.5896        | 1.4511       | -452                               | -367.7575 |
| Apr-12 | 798000        | 7.5233        | 1.9655       | -274                               | -327.9207 |
| May-12 | 518000        | 8.1536        | 0.0993       | -168                               | -154.4579 |
| Jun-12 | 1403000       | 8.3753        | 0.2932       | -150                               | -199.0637 |
| Jul-12 | 2999000       | 8.2281        | 0.6784       | -326                               | -309.3996 |
| Aug-12 | 4374000       | 8.2656        | 1.0910       | -374                               | -332.2779 |
| Sep-12 | 4377000       | 8.2515        | 1.2192       | -244                               | -333.7564 |
| Oct-12 | 3944000       | 8.6455        | 1.2387       | -285                               | -222.3738 |
| Nov-12 | 3508000       | 8.7881        | 1.2673       | -173                               | -173.3938 |
| Dec-12 | 3043000       | 8.5772        | 1.3207       | -165                               | -211.1975 |
| Jan-13 | 2603000       | 8.7621        | 1.3758       | -128                               | -146.9075 |
| Feb-13 | 2169000       | 8.8571        | 1.5031       | -141                               | -101.4936 |

It is evident in Table 4.5 that the optimal price of the March/July 2014 white maize spread varied from March 2013 to February 2014. There is a deviation between the monthly average actual and the predicted values of the March/July 2014 white maize spread. In some months the actual values of the March/July 2014 white maize spread are higher than the predicted values and in other months the predicted values are higher than the actual monthly average prices of the March/July 2014 white maize spread. Even though the actual monthly average prices and the predicted prices of the March/July 2014 white maize spread differ, they are both negative from March 2013 to February 2014. According to the predicted values of the March/July 2014 white maize spread, the optimal price of the March/July 2014 white maize spread was seen in March 2013 at -R96.48. This was associated with an opening stock of 1 644 000 tons, an exchange rate of R9.16/\$ and a stock to use of 171%.

Table 4.5: Predicted March/July 2014 white maize spread

|        |               |               |              | March/July 2014 white maize spread |           |
|--------|---------------|---------------|--------------|------------------------------------|-----------|
| Month  | Opening stock | Exchange rate | Stock to use | Monthly Average                    | Predicted |
| Mar-13 | 1644000       | 9.1561        | 1.7054       | -90                                | -96.4824  |
| Apr-13 | 1098000       | 9.0771        | 2.3462       | -196                               | -222.5490 |
| May-13 | 757214        | 9.3396        | 0.1549       | -233                               | -175.4792 |
| Jun-13 | 1429313       | 9.9753        | 0.3224       | -215                               | -330.0425 |
| Jul-13 | 2921701       | 9.8793        | 0.7260       | -184                               | -175.0744 |
| Aug-13 | 3702725       | 10.0572       | 1.0403       | -216                               | -234.9744 |
| Sep-13 | 3492449       | 9.9327        | 1.1055       | -203                               | -200.9726 |
| Oct-13 | 3119195       | 9.8674        | 1.1117       | -297                               | -198.2664 |
| Nov-13 | 2700791       | 10.1784       | 1.1276       | -307                               | -367.1400 |
| Dec-13 | 2259090       | 10.3339       | 1.1388       | -527                               | -475.4828 |
| Jan-14 | 1838486       | 10.8350       | 1.1500       | -668                               | -740.2122 |
| Feb-14 | 1362440       | 10.9221       | 1.1771       | -928                               | -847.3242 |

It is evident in Table 4.6 that the optimal price of the March/July 2015 white maize spread varied from March 2014 to February 2015. There is a deviation between the monthly average actual and the predicted values of the March/July 2015 white maize spread. In some months the actual values of the March/July 2014 white maize spread are higher than the predicted values and in other months the predicted values are higher than the actual monthly average prices of the March/July 2014 white maize spread. According to the predicted values of the March/July 2015 white maize spread, the optimal price of the March/July 2015 white maize spread was seen in July 2014 at R56.37. This was associated with an opening stock of 2 730 010 tons, an exchange rate of R10.66/\$ and a stock to use of 54%.

Table 4.6: Predicted March/July 2015 white maize spread

|        |               |               |              | March/July 2015 white maize spread |           |
|--------|---------------|---------------|--------------|------------------------------------|-----------|
| Month  | Opening stock | Exchange rate | Stock to use | Monthly Average                    | Predicted |
| Mar-14 | 943905        | 10.7144       | 1.2456       | -11                                | 14.6523   |
| Apr-14 | 532157        | 10.5054       | 1.4859       | 12                                 | 3.9555    |
| May-14 | 274318        | 10.3720       | 0.0460       | 42                                 | 44.2292   |
| Jun-14 | 636590        | 10.6746       | 0.1145       | 56                                 | 46.3687   |
| Jul-14 | 2730010       | 10.6571       | 0.5357       | 62                                 | 56.3683   |
| Aug-14 | 4899210       | 10.6543       | 1.0807       | 56                                 | 48.0381   |
| Sep-14 | 4976806       | 10.9820       | 1.2510       | 60                                 | 32.9591   |
| Oct-14 | 4500954       | 11.0565       | 1.3247       | 15                                 | 26.7369   |
| Nov-14 | 3970586       | 11.0907       | 1.4051       | -5                                 | 21.1015   |
| Dec-14 | 3471439       | 11.5044       | 1.5032       | -29                                | 3.4131    |
| Jan-15 | 2961632       | 11.5582       | 1.6446       | 1                                  | -5.3227   |
| Feb-15 | 2483970       | 11.5793       | 1.9135       | 16                                 | -17.5000  |

It is evident in Table 4.7 that the optimal price of the March/July 2016 white maize spread varied from March 2015 to February 2016. There is a deviation between the monthly average actual and the predicted values of the March/July 2016 white maize spread. In some months the actual values of the March/July 2016 white maize spread are higher than the predicted values and in other months the predicted values are higher than the actual monthly average prices of the March/July 2016 white maize spread. Even though the actual monthly average prices and the predicted prices of the March/July 2016 white maize spread differ, they are both negative from March 2015 to February 2016. According to the predicted values of the March/July 2016 white maize spread, the optimal price of the March/July 2016 white maize spread was seen in January 2016 at -R47.69. This was associated with an opening stock of 2 373 622 tons, an exchange rate of R15.76/\$ and a stock to use of 199%.

Table 4.7: Predicted March/July 2016 white maize spread

|        |               |               |              | March/July 2016 white maize spread |           |
|--------|---------------|---------------|--------------|------------------------------------|-----------|
| Month  | Opening stock | Exchange rate | Stock to use | Monthly Average                    | Predicted |
| Mar-15 | 2037531       | 12.0757       | 2.4476       | -442                               | -387.0551 |
| Apr-15 | 1593219       | 11.9842       | 4.3145       | -266                               | -282.1670 |
| May-15 | 1282581       | 11.9663       | 0.2950       | -399                               | -473.5217 |
| Jun-15 | 1730955       | 12.2807       | 0.4345       | -501                               | -459.4452 |
| Jul-15 | 3103388       | 12.4513       | 0.8563       | -608                               | -464.6019 |
| Aug-15 | 3852244       | 12.9123       | 1.1934       | -396                               | -420.9987 |
| Sep-15 | 3677788       | 13.6526       | 1.2942       | -414                               | -344.9897 |
| Oct-15 | 3401411       | 13.4904       | 1.3609       | -284                               | -350.7159 |
| Nov-15 | 3102697       | 14.1412       | 1.4603       | -135                               | -279.6398 |
| Dec-15 | 2747623       | 15.0321       | 1.5770       | -49                                | -183.6477 |
| Jan-16 | 2373622       | 16.3282       | 1.7175       | -168                               | -47.6864  |
| Feb-16 | 2040133       | 15.7605       | 1.9907       | -107                               | -74.5308  |

It is evident in Table 4.8 that the optimal price of the March/July 2017 white maize spread varied from March 2016 to February 2017. There is a deviation between the monthly average actual and the predicted values of the March/July 2017 white maize spread. In some months the actual values of the March/July 2017 white maize spread are higher than the predicted values and in other months the predicted values are higher than the actual monthly average prices of the March/July 2014 white maize spread. Even though the actual monthly average prices and the predicted prices of the March/July 2017 white maize spread differ, they are both negative from March 2016 to February 2017. According to the predicted values of the March/July 2017 white maize spread, the optimal price of the March/July 2017 white maize spread was seen in February 2017 at -R895.40. This was associated with an opening stock of 1 241 705 tons, an exchange rate of R13.17/\$ and a stock to use of 111%.

Table 4.8: Predicted March/July 2017 white maize spread

|        |               |               |              | March/July 2017 white maize spread |            |
|--------|---------------|---------------|--------------|------------------------------------|------------|
| Month  | Opening stock | Exchange rate | Stock to use | Monthly Average                    | Predicted  |
| Mar-16 | 1764659       | 15.3499       | 2.6290       | -1276                              | -1202.4902 |
| Apr-16 | 1519871       | 14.5825       | 4.3748       | -939                               | -977.5311  |
| May-16 | 1307867       | 15.3457       | 0.3004       | -1320                              | -1369.7554 |
| Jun-16 | 1273334       | 15.0267       | 0.3209       | -1276                              | -1308.1534 |
| Jul-16 | 1602371       | 14.3884       | 0.4439       | -1189                              | -1137.8053 |
| Aug-16 | 2197791       | 13.7911       | 0.6761       | -1048                              | -957.0013  |
| Sep-16 | 2510029       | 14.0186       | 0.8668       | -959                               | -972.9354  |
| Oct-16 | 2390684       | 13.9153       | 0.9394       | -745                               | -955.5557  |
| Nov-16 | 2092810       | 13.9408       | 0.9636       | -1041                              | -979.4958  |
| Dec-16 | 1829512       | 13.8435       | 1.0332       | -1030                              | -976.4158  |
| Jan-17 | 1526792       | 13.5604       | 1.0509       | -1019                              | -945.4594  |
| Feb-17 | 1241705       | 13.1735       | 1.1062       | -836                               | -895.4012  |

It is evident in Table 4.9 that the optimal price of the March/July 2018 white maize spread varied from March 2017 to February 2018. There is a deviation between the monthly average actual and the predicted values of the March/July 2018 white maize spread. In some months the actual values of the March/July 2018 white maize spread are higher than the predicted values and in other months the predicted values are higher than the actual monthly average prices of the March/July 2018 white maize spread. Even though the actual monthly average prices and the predicted prices of the March/July 2018 white maize spread differ, they are both positive from March 2017 to February 2018. According to the predicted values of the March/July 2018 white maize spread, the optimal price of the March/July 2018 white maize spread was seen in February 2018 at R105.73. This was associated with an opening stock of 4 205 238 tons, an exchange rate of R11.81/\$ and a stock to use of 246%.

Table 4.9: Predicted March/July 2018 white maize spread

|        |               |               |              | March/July 2018 white maize spread |           |
|--------|---------------|---------------|--------------|------------------------------------|-----------|
| Month  | Opening stock | Exchange rate | Stock to use | Monthly Average                    | Predicted |
| Mar-17 | 984293        | 12.9338       | 1.2399       | 88                                 | 98.4840   |
| Apr-17 | 818973        | 13.4364       | 2.1480       | 97                                 | 93.6490   |
| May-17 | 597837        | 13.2544       | 0.0903       | 106                                | 97.5022   |
| Jun-17 | 1264335       | 12.8913       | 0.2055       | 97                                 | 100.6283  |
| Jul-17 | 4066841       | 13.1355       | 0.7187       | 97                                 | 99.7812   |
| Aug-17 | 6319825       | 13.2238       | 1.2328       | 99                                 | 99.0060   |
| Sep-17 | 6733786       | 13.1635       | 1.4891       | 105                                | 99.0918   |
| Oct-17 | 6294931       | 13.6956       | 1.5820       | 99                                 | 95.4372   |
| Nov-17 | 5802475       | 14.0541       | 1.7044       | 85                                 | 92.8395   |
| Dec-17 | 5247231       | 13.0718       | 1.8750       | 103                                | 98.7854   |
| Jan-18 | 4733269       | 12.1834       | 2.0864       | 102                                | 104.0618  |
| Feb-18 | 4205238       | 11.8141       | 2.4576       | 107                                | 105.7336  |

It is evident in Table 4.10 that the optimal price of the March/July 2019 white maize spread varied from March 2018 to February 2019. There is a deviation between the monthly average actual and the predicted values of the March/July 2019 white maize spread. In some months the actual values of the March/July 2019 white maize spread are higher than the predicted values and in other months the predicted values are higher than the actual monthly average prices of the March/July 2019 white maize spread. Even though the actual monthly average prices and the predicted prices of the March/July 2019 white maize spread differ, they are both positive from March 2018 to February 2019. According to the predicted values of the March/July 2019 white maize spread, the optimal price of the March/July 2019 white maize spread was seen in April 2018 at R99.28. This was associated with an opening stock of 3 070 458 tons, an exchange rate of R12.09/\$ and a stock to use of 533%.

Table 4.10: Predicted March/July 2019 white maize spread

|        |               |               |              | March/July 2019 white maize spread |           |
|--------|---------------|---------------|--------------|------------------------------------|-----------|
| Month  | Opening stock | Exchange rate | Stock to use | Monthly Average                    | Predicted |
| Mar-18 | 3659675       | 11.8263       | 3.1522       | 84                                 | 74.2840   |
| Apr-18 | 3070458       | 12.0935       | 5.3277       | 83                                 | 99.2772   |
| May-18 | 2428653       | 12.5302       | 0.3836       | 76                                 | 74.8418   |
| Jun-18 | 2102259       | 13.3260       | 0.3666       | 73                                 | 87.5624   |
| Jul-18 | 2812074       | 13.3761       | 0.5454       | 79                                 | 79.2292   |
| Aug-18 | 4499219       | 14.0976       | 0.9792       | 76                                 | 73.1322   |
| Sep-18 | 5657929       | 14.7564       | 1.4121       | 54                                 | 74.8250   |
| Oct-18 | 5340870       | 14.5267       | 1.5533       | 80                                 | 75.6392   |
| Nov-18 | 4763505       | 14.0687       | 1.6814       | 79                                 | 76.0972   |
| Dec-18 | 4147825       | 14.2855       | 1.8809       | 85                                 | 84.5472   |
| Jan-19 | 3616735       | 13.8210       | 2.1334       | 93                                 | 86.6601   |
| Feb-19 | 3045014       | 13.8262       | 2.5598       | 120                                | 95.9045   |

It is evident in Table 4.11 that the optimal price of the March/July 2020 white maize spread varied from March 2019 to February 2020. There is a deviation between the monthly average actual and the predicted values of the March/July 2020 white maize spread. In some months the actual values of the March/July 2020 white maize spread are higher than the predicted values and in other months the predicted values are higher than the actual monthly average prices of the March/July 2020 white maize spread. Even though the actual monthly average prices and the predicted prices of the March/July 2014 white maize spread differ, they are both negative from March 2019 to February 2020. According to the predicted values of the March/July 2020 white maize spread, the optimal price of the March/July 2020 white maize spread was seen in July 2019 at -R149.05. This was associated with an opening stock of 2 205 401 tons, an exchange rate of R14.05/\$ and a stock to use of 47%.

Table 4.11: Predicted March/July 2020 white maize spread

|        |               |               |              | March/July 2020 white maize spread |           |
|--------|---------------|---------------|--------------|------------------------------------|-----------|
| Month  | Opening stock | Exchange rate | Stock to use | Monthly Average                    | Predicted |
| Mar-19 | 2596119       | 14.3842       | 3.2833       | -273                               | -207.1736 |
| Apr-19 | 2197123       | 14.1400       | 5.4891       | -120                               | -220.0460 |
| May-19 | 1798998       | 14.4175       | 0.3260       | -94                                | -208.3444 |
| Jun-19 | 1665065       | 14.5684       | 0.3274       | -96                                | -232.6279 |
| Jul-19 | 2205401       | 14.0451       | 0.4716       | -221                               | -149.0550 |
| Aug-19 | 3177855       | 15.1754       | 0.7547       | -202                               | -250.4552 |
| Sep-19 | 4432923       | 14.8481       | 1.1727       | -192                               | -188.1512 |
| Oct-19 | 4238733       | 14.9150       | 1.2614       | -160                               | -200.8978 |
| Nov-19 | 3812448       | 14.7892       | 1.3321       | -63                                | -196.6253 |
| Dec-19 | 3261316       | 14.3827       | 1.3895       | -115                               | -164.2499 |
| Jan-20 | 2772075       | 14.4018       | 1.4466       | -453                               | -181.5369 |
| Feb-20 | 2197669       | 15.0336       | 1.5155       | -486                               | -275.8368 |

### 4.3 Relationship between the March/July white maize spread and the exchange rate, stock to use and opening stock

Table 4.12 to 4.13 below are regression analysis of the March/July white maize spread. The March/July white maize spread is the dependent variable while the exchange rate, stock to use and opening stock are the independent variables.

The R-squared for the March/July 2010 white maize spread indicates that the combined effect of the exchange rate, stock to use and opening stock account for 47.41% of the variation in the March/July 2010 white maize spread. The P value of the combined effect of the independent variables indicates that their effect on the spread is significant. It is evident from Table 4.12 that a R1 increase in the exchange rate increases the March/July white maize spread by R14.50, a 1% increase in the stock to use decreases the March/July white maize spread by R10.52, a 1 ton increase in the opening stock decreases the March/July white maize spread by R14.32. However, the individual effect of each independent variable on the March/July 2010 white maize spread is insignificant.

Table 4.12: March/July 2010

| March/July 2010 spread |          |                       |             |         |
|------------------------|----------|-----------------------|-------------|---------|
| R-squared              | Prob > F | Independent variables | Coefficient | P value |
|                        |          |                       |             |         |
| 0.4741                 | 0.0260   | Exchange Rate         | 14.50       | 0.156   |
|                        |          | Stock to use          | -10.52      | 0.275   |
|                        |          | Opening stock         | -14.32      | 0.205   |
|                        |          | Constant              | 108.55      | 0.610   |

Equation 1 below summarises the impact of the exchange rate, stock to use and opening stock on the March/July white maize spread. The equation is based on a regression run on data for the March/July 2010 white maize spread.

$$\begin{aligned}
 \text{Spread} = & 108.55 + 14.50 \times \text{exchange rate} - 10.52 \times \text{stock to use} \\
 & - 14.32 \times \text{opening stock} \\
 & (\text{equation 1})
 \end{aligned}$$

Where:

Spread (R/ton) = March/July white maize spread

Exchange rate (R/\$) = The value of the United States dollar in terms of the rand

Stock to use = the quantity of white maize available divided by the total local demand for white maize for the remaining maize marketing season

Opening stock (tons) = The quantity of white maize available on the 1<sup>st</sup> day of the month which is also equivalent to the quantity of white maize at the end of the previous month.

The R-squared for the March/July 2011 white maize spread indicates that the combined effect of the exchange rate, stock to use and opening stock account for 45.43% of the variation in the March/July 2011 white maize spread. The P value of the combined effect of the independent variables indicates that their effect on the spread is significant. It is evident from Table 4.13 that a R1 increase in the exchange rate increases the March/July 2011 white maize spread by R9.04, a 1% increase in the stock to use decreases the March/July white maize spread by R2.70, a one ton increase in the opening stock increases the March/July white maize spread by R1.04.

The individual effects of the exchange rate and opening stock on the March/July 2011 white maize spread are insignificant while that of the stock to use is significant.

*Table 4.13: March/July 2011*

| March/July 2011 spread |          |                       |             |         |
|------------------------|----------|-----------------------|-------------|---------|
| R-squared              | Prob > F | Independent variables | Coefficient | P value |
|                        |          |                       |             |         |
| 0.4543                 | 0.0093   | Exchange Rate         | 9.04        | 0.187   |
|                        |          | Stock to use          | -2.70       | 0.068   |
|                        |          | Opening stock         | 1.04        | 0.686   |
|                        |          | Constant              | -28.66      | 0.721   |

Equation 2 below summarises the impact of the exchange rate, stock to use and opening stock on the March/July white maize spread. The equation is based on a regression run on data for the March/July 2011 white maize spread.

$$\begin{aligned}
 \text{Spread} = & -28.66 + 9.04 \times \text{exchange rate} - 2.70 \times \text{stock to use} \\
 & + 1.04 \times \text{opening stock} \\
 & (\text{equation 2})
 \end{aligned}$$

The R-squared for the March/July 2012 white maize spread indicates that the combined effect of the exchange rate, stock to use and opening stock account for 86.16% of the variation in the March/July 2012 white maize spread. The P value of the combined effect of the independent variables indicates that their effect on the spread is significant. It is evident from Table 4.14 that a R1 increase in the exchange rate decreases the March/July 2012 white maize spread by R328.09, a 1% increase in the stock to use increases the March/July white maize spread by R36.21, a one ton increase in the opening stock decreases the March/July white maize spread by R44.43. The individual effects of the stock to use and opening stock on the March/July 2012 white maize spread are insignificant while that of the exchange rate is significant.

Table 4.14: March/July 2012

| March/July 2012 spread |          |                       |             |         |
|------------------------|----------|-----------------------|-------------|---------|
| R-squared              | Prob > F | Independent variables | Coefficient | P value |
|                        |          |                       |             |         |
| 0.8616                 | 0.0002   | Exchange Rate         | -328.39     | 0.002   |
|                        |          | Stock to use          | 36.21       | 0.169   |
|                        |          | Opening stock         | -44.43      | 0.610   |
|                        |          | Constant              | 2747.69     | 0.011   |

Equation 3 summarises the impact of the exchange rate, stock to use and opening stock on the March/July white maize spread. The equation is based on a regression run on data for the March/July 2012 white maize spread.

$$\begin{aligned}
 \text{Spread} = & 2747.69 - 328.39 \times \text{exchange rate} + 36.21 \times \text{stock to use} \\
 & - 44.43 \times \text{opening stock} \\
 & (\text{equation 3})
 \end{aligned}$$

The R-squared for the March/July 2013 white maize spread indicates that the combined effect of the exchange rate, stock to use and opening stock account for 74.30% of the variation in the March/July 2013 white maize spread. The P value of the combined effect of the independent variables indicates that their effect on the spread is significant. It is evident from Table 4.15 that a R1 increase in the exchange rate increases the March/July 2013 white maize spread by R254.15, a 1% increase in the stock to use increases the March/July white maize spread by R17.13, a one ton increase in the opening stock decreases the March/July white maize spread by R104.65. The individual effects of the exchange rate and the opening stock on the March/July 2013 white maize spread are significant while that of the stock to use is insignificant.

Table 4.15: March/July 2013

| March/July 2013 spread |          |                       |             |         |
|------------------------|----------|-----------------------|-------------|---------|
| R-squared              | Prob > F | Independent variables | Coefficient | P value |
|                        |          |                       |             |         |
| 0.7430                 | 0.0132   | Exchange Rate         | 254.15      | 0.002   |
|                        |          | Stock to use          | 17.13       | 0.603   |
|                        |          | Opening stock         | -104.65     | 0.015   |
|                        |          | Constant              | -851.39     | 0.092   |

Equation 4 summarises the impact of the exchange rate, stock to use and opening stock on the March/July white maize spread. The equation is based on a regression run on data for the March/July 2013 white maize spread.

$$\begin{aligned}
 \text{Spread} = & -851.39 + 254.15 \times \text{exchange rate} + 17.13 \times \text{stock to use} \\
 & - 104.65 \times \text{opening stock} \\
 & (\text{equation 4})
 \end{aligned}$$

The R-squared for the March/July 2014 white maize spread indicates that the combined effect of the exchange rate, stock to use and opening stock account for 93.11% of the variation in the March/July 2014 white maize spread. The P value of the combined effect of the independent variables indicates that their effect on the spread is significant. It is evident from Table 4.16 that a R1 increase in the exchange rate decreases the March/July 2014 white maize spread by R434.88, a 1% increase in the stock to use decreases the March/July white maize spread by R111.08, a one ton increase in the opening stock increases the March/July 2014 white maize spread by R221.11. The individual effects of the exchange rate, stock to use and the opening stock on the March/July 2014 white maize spread are significant.

Table 4.16: March/July 2014

| March/July 2014 spread |          |                       |             |         |
|------------------------|----------|-----------------------|-------------|---------|
| R-squared              | Prob > F | Independent variables | Coefficient | P value |
|                        |          |                       |             |         |
| 0.9311                 | 0.0001   | Exchange Rate         | -434.88     | 0.000   |
|                        |          | Stock to use          | -111.08     | 0.027   |
|                        |          | Opening stock         | 221.11      | 0.001   |
|                        |          | Constant              | 910.04      | 0.173   |

Equation 5 below summarises the impact of the exchange rate, stock to use and opening stock on the March/July white maize spread. The equation is based on a regression run on data for the March/July 2014 white maize spread.

$$\begin{aligned}
 \text{Spread} = & 910.04 - 434.88 \times \text{exchange rate} - 111.08 \times \text{stock to use} \\
 & + 221.11 \times \text{opening stock} \\
 & (\text{equation 5})
 \end{aligned}$$

The R-squared for the March/July 2015 white maize spread indicates that the combined effect of the exchange rate, stock to use and opening stock account for 56.64% of the variation in the March/July 2015 white maize spread. The P value of the combined effect of the independent variables indicates that their effect on the spread is significant. It is evident from Table 4.17 that a R1 increase in the exchange rate decreases the March/July 2015 white maize spread by R29.87, a 1% increase in the stock to use decreases the March/July white maize spread by R32.53, a one ton increase in the opening stock increases the March/July 2015 white maize spread by R15.92. The individual effects of the stock to use and the opening stock on the March/July 2015 white maize spread are significant while the contribution of the exchange rate on the March/July 2015 white maize spread is insignificant.

Table 4.17: March/July 2015

| March/July 2015 spread |          |                       |             |         |
|------------------------|----------|-----------------------|-------------|---------|
| R-squared              | Prob > F | Independent variables | Coefficient | P value |
|                        |          |                       |             |         |
| 0.5664                 | 0.0450   | Exchange Rate         | -29.87      | 0.277   |
|                        |          | Stock to use          | -32.53      | 0.025   |
|                        |          | Opening stock         | 15.92       | 0.069   |
|                        |          | Constant              | 156.15      | 0.531   |

Equation 6 below summarises the impact of the exchange rate, stock to use and opening stock on the March/July white maize spread. The equation is based on a regression run on data for the March/July 2015 white maize spread.

$$\begin{aligned}
 \text{Spread} = & 156.15 - 29.87 \times \text{exchange rate} - 32.53 \times \text{stock to use} \\
 & + 15.92 \times \text{opening stock} \\
 & (\text{equation 6})
 \end{aligned}$$

The R-squared for the March/July 2016 white maize spread indicates that the combined effect of the exchange rate, stock to use and opening stock account for 71.17% of the variation in the March/July 2016 white maize spread. The P value of the combined effect of the independent variables indicates that their effect on the spread is significant. It is evident from Table 4.18 that a R1 increase in the exchange rate increases the March/July 2016 white maize spread by R91.18, a 1% increase in the stock to use increases the March/July white maize spread by R51.11, a one ton increase in the opening stock decreases the March/July 2016 white maize spread by R72.41. The individual effects of the exchange rate and the stock to use on the March/July 2016 white maize spread are significant while the contribution of the opening stock on the March/July 2016 white maize spread is insignificant.

Table 4.18: March/July 2016

| March/July 2016 spread |          |                       |             |         |
|------------------------|----------|-----------------------|-------------|---------|
| R-squared              | Prob > F | Independent variables | Coefficient | P value |
|                        |          |                       |             |         |
| 0.7117                 | 0.0155   | Exchange Rate         | 91.18       | 0.005   |
|                        |          | Stock to use          | 51.11       | 0.017   |
|                        |          | Opening stock         | -72.41      | 0.394   |
|                        |          | Constant              | -561.21     | 0.625   |

Equation 7 below summarises the impact of the exchange rate, stock to use and opening stock on the March/July white maize spread. The equation is based on a regression run on data for the March/July 2016 white maize spread.

$$\begin{aligned}
 \text{Spread} = & -561.21 + 91.18 \times \text{exchange rate} + 51.11 \times \text{stock to use} \\
 & - 72.41 \times \text{opening stock} \\
 & (\text{equation 7})
 \end{aligned}$$

The R-squared for the March/July 2017 white maize spread indicates that the combined effect of the exchange rate, stock to use and opening stock account for 77.05% of the variation in the March/July 2017 white maize spread. The P value of the combined effect of the independent variables indicates that their effect on the spread is significant. It is evident from Table 4.19 that a R1 increase in the exchange rate decreases the March/July 2017 white maize spread by R202.40, a 1% increase in the stock to use increases the March/July 2017 white maize spread by R52.79, a one ton increase in the opening stock increases the March/July 2017 white maize spread by R150.81. The individual effects of the exchange rate and the stock to use on the March/July 2017 white maize spread are significant while the contribution of the opening stock on the March/July 2017 white maize spread is insignificant.

Table 4.19: March/July 2017

| March/July 2017 spread |          |                       |             |         |
|------------------------|----------|-----------------------|-------------|---------|
| R-squared              | Prob > F | Independent variables | Coefficient | P value |
|                        |          |                       |             |         |
| 0.7705                 | 0.0005   | Exchange Rate         | -202.40     | 0.000   |
|                        |          | Stock to use          | 52.79       | 0.008   |
|                        |          | Opening stock         | 150.81      | 0.337   |
|                        |          | Constant              | -403.63     | 0.861   |

Equation 8 below summarises the impact of the exchange rate, stock to use and opening stock on the March/July white maize spread. The equation is based on a regression run on data for the March/July 2017 white maize spread.

$$\begin{aligned}
 \text{Spread} = & -403.63 - 202.40 \times \text{exchange rate} + 52.79 \times \text{stock to use} \\
 & + 150.81 \times \text{opening stock} \\
 & (\text{equation 8})
 \end{aligned}$$

The R-squared for the March/July 2018 white maize spread indicates that the combined effect of the exchange rate, stock to use and opening stock account for 30.92% of the variation in the March/July 2018 white maize spread. The P value of the combined effect of the independent variables indicates that their effect on the spread is insignificant. It is evident from Table 4.20 that a R1 increase in the exchange rate decreases the March/July 2018 white maize spread by R6.44, a 1% increase in the stock to use decreases the March/July 2018 white maize spread by R1.50, a one ton increase in the opening stock increases the March/July 2018 white maize spread by R1.28. The individual effects of the opening stock and the stock to use on the March/July 2018 white maize spread are insignificant while the contribution of the exchange rate on the March/July 2018 white maize spread is significant.

Table 4.20: March/July 2018

| March/July 2018 spread |          |                       |             |         |
|------------------------|----------|-----------------------|-------------|---------|
| R-squared              | Prob > F | Independent variables | Coefficient | P value |
|                        |          |                       |             |         |
| 0.3092                 | 0.2147   | Exchange Rate         | -6.44       | 0.063   |
|                        |          | Stock to use          | -1.50       | 0.567   |
|                        |          | Opening stock         | 1.28        | 0.631   |
|                        |          | Constant              | 166         | 0.023   |

Equation 9 below summarises the impact of the exchange rate, stock to use and opening stock on the March/July white maize spread. The equation is based on a regression run on data for the March/July 2018 white maize spread.

$$\text{Spread} = 166 - 6.44 \times \text{exchange rate} - 1.50 \times \text{stock to use} + 1.28 \times \text{opening stock}$$

(equation 9)

The R-squared for the March/July 2019 white maize spread indicates that the combined effect of the exchange rate, stock to use and opening stock account for 34.46% of the variation in the March/July 2019 white maize spread. The P value of the combined effect of the independent variables indicates that their effect on the spread is insignificant. It is evident from Table 4.21 that a R1 increase in the exchange rate increases the March/July 2019 white maize spread by R9.81, a 1% increase in the stock to use increases the March/July 2019 white maize spread by R7.47, a one ton increase in the opening stock decreases the March/July 2019 white maize spread by R34.92. The individual effects of the exchange rate, stock to use and opening stock on the March/July 2019 white maize spread are insignificant.

Table 4.21: March/July 2019

| March/July 2019 spread |          |                       |             |         |
|------------------------|----------|-----------------------|-------------|---------|
| R-squared              | Prob > F | Independent variables | Coefficient | P value |
|                        |          |                       |             |         |
| 0.3446                 | 0.5547   | Exchange Rate         | 9.81        | 0.300   |
|                        |          | Stock to use          | 7.47        | 0.185   |
|                        |          | Opening stock         | -34.92      | 0.242   |
|                        |          | Constant              | 462.54      | 0.185   |

Equation 10 below summarises the impact of the exchange rate, stock to use and opening stock on the March/July white maize spread. The equation is based on a regression run on data for the March/July 2019 white maize spread.

$$\begin{aligned}
 \text{Spread} = & 462.54 + 9.81 \times \text{exchange rate} + 7.47 \times \text{stock to use} \\
 & - 34.92 \times \text{opening stock} \\
 & (\text{equation 10})
 \end{aligned}$$

The R-squared for the March/July 2020 white maize spread indicates that the combined effect of the exchange rate, stock to use and opening stock account for 6.65% of the variation in the March/July 2020 white maize spread. The P value of the combined effect of the independent variables indicates that their effect on the spread is insignificant. It is evident from Table 4.22 that a R1 increase in the exchange rate decreases the March/July 2020 white maize spread by R115.38, a 1% increase in the stock to use decreases the March/July 2020 white maize spread by R11.90, a one ton increase in the opening stock increases the March/July 2020 white maize spread by R88.66. The individual effects of the exchange rate, stock to use and opening stock on the March/July 2020 white maize spread are insignificant.

Table 4.22: March/July 2020

| March/July 2020 spread |          |                       |             |         |
|------------------------|----------|-----------------------|-------------|---------|
| R-squared              | Prob > F | Independent variables | Coefficient | P value |
|                        |          |                       |             |         |
| 0.0665                 | 0.9305   | Exchange Rate         | -115.38     | 0.537   |
|                        |          | Stock to use          | -11.90      | 0.687   |
|                        |          | Opening stock         | 88.66       | 0.620   |
|                        |          | Constant              | 182.14      | 0.920   |

Equation 11 below summarises the impact of the exchange rate, stock to use and opening stock on the March/July white maize spread. The equation is based on a regression run on data for the March/July 2020 white maize spread.

$$\begin{aligned}
 \text{Spread} = & 182.14 - 115.38 \times \text{exchange rate} - 11.90 \times \text{stock to use} \\
 & + 88.66 \times \text{opening stock}
 \end{aligned}$$

(equation 12)

## 4.4 Discussion of findings

### 4.4.1 Opening stock, stock to use and exchange rate associated with the optimal price

The 5 highest predicted prices were seen in March/July 2018 followed by March/July 2019, March/July 2012, March/July 2015 and March/July 2011. The opening stock associated with the optimal predicted price for March/July 2018 was 4 205 238 tons, March/July 2019 was 3 070 458 tons, March/July 2012 was 2 334 000 tons, March/July 2015 was 2 730 010 tons and March/July 2011 was 1 362 000 tons. Therefore, an opening stock of more than 1 362 000 tons is associated with the optimal price to sell the March/July white maize spread. The stock to use associated with the optimal predicted price for March/July 2018 was 246%, March/July 2019 was 533%, March/July 2012 was 459%, March/July 2015 was 54% and March/July 2011 was 22%. Therefore, a stock to use of more than 22% is associated with the optimal price to sell the March/July white maize spread. The exchange rate associated with the optimal price for March/July 2018 was R11.81/\$, March/July 2019 was R12.09/\$,

March/July 2012 was R6.70/\$, March/July 2015 was R10.66/\$ and March/July 2011 was R7.64/\$. Therefore, an exchange rate of less than R12.09/\$ is associated with the optimal price to sell the March/July white maize spread.

However, it must be noted that the March/July white maize spread is a function of various factors. Therefore, the levels of the independent variables as identified above would change if any one of the other independent variables changes. Hence it is not sufficient to identify an opening stock, stock to use and/or exchange rate that is associated with an optimal price of the March/July white maize spread. Instead, a model must be developed that will allow for the prevailing or expected exchange rate, opening stock and stock to use to substituted into the model to produce the predicted optimal price of the March/July white maize spread.

#### **4.4.2 Normal versus surplus and deficit years**

It is important to distinguish surplus and deficit years from normal years so that models derived from these years are not used to forecast future spreads. Normal years are those years where the local production of white maize is lower or higher than the local consumption of white maize by less than a month's consumption of white maize. Surplus years are those years where the local production exceeds the local consumption by more than a month's consumption of white maize. Deficit years are those years where the local production is less than the local consumption by more than a month's consumption of white maize.

Table 4.23 below indicates white maize production and consumption for each marketing season from 2009/10 to 2019/20 white maize marketing season. It also indicates the months of consumption. According to table 4.23, surplus years comprise of the 2009/10 to 2015/16 marketing season as well as the 2017/18 white maize marketing season. The deficit year was seen in 2016/17 marketing season. The normal years consist of the 2018/19 and the 2019/20 maize marketing seasons.

Table 4.23: Normal, surplus and deficit years

|                  | Local      |             |                 |                       |
|------------------|------------|-------------|-----------------|-----------------------|
| Marketing season | Production | Consumption | Deficit/Surplus | Months of Consumption |
|                  |            |             |                 |                       |
| 2009/10          | 6 775 000  | 4708000     | 2 067 000       | 3.27                  |
| 2010/11          | 7 830 000  | 6190000     | 1 640 000       | 3.15                  |
| 2011/12          | 6 052 000  | 5553000     | 499 000         | 1.19                  |
| 2012/13          | 6 903 656  | 5206000     | 1 697 656       | 3.92                  |
| 2013/14          | 5 606 800  | 4886036     | 720 764         | 1.69                  |
| 2014/15          | 7 710 000  | 5952631     | 1 757 369       | 4.73                  |
| 2015/16          | 4 735 000  | 4344207     | 390 793         | 1.01                  |
| 2016/17          | 3 408 500  | 4350567     | -942 067        | -2.45                 |
| 2017/18          | 9 916 000  | 6607559     | 3 308 441       | 5.69                  |
| 2018/19          | 6 540 000  | 6323348     | 216 652         | 0.50                  |
| 2019/20          | 5 545 000  | 5492062     | 52 938          | 0.12                  |

It is evident from Table 4.23 that the 2018/19 and the 2019/20 marketing season were normal years. However, the P-values of both seasons indicate that the contribution of the variables to the price of the spread is not significant. Hence the model derived from both seasons will not be used to forecast future spreads.

#### 4.4.3 The effect of the opening stock, stock to use and exchange rate on the March/July white maize spread

A regression was run on the data set from 2009/10 to 2019/20 maize marketing season. Each regression had a different R-squared. The March/July 2014 white maize spread had the highest R-squared of 93.11% followed by March/July 2012 with 86.16%, March/July 2017 with 77.05%, March/July 2013 with 74.30% and March/July 2016 with 71.17%.

Economic theory suggests that an increase in supply results in a decrease in price (Kramer, 2019). The increase in supply is equivalent to suggesting an increase in the stock to use ratio and an increase in the opening stock. As mentioned earlier in chapter 2, the nearby month (March white maize contract) reacts more to a change in

market conditions than the further month (July white maize contract). It was also mentioned in chapter 2 that an appreciation of the rand against the united states dollar will increase the spread and thus a depreciation of the rand against the united states dollar will decrease the March/July white maize spread.

The model derived from the data on the March/July 2014 white maize spread is in line with economic theory for the exchange rate and the opening stock but it is not in line with economic theory as far as the stock to use ratio is concerned. The stock to use ratio is significant at a 5% significance level whilst the exchange rate and opening stock are significant at 1%. The model derived from the data on the March/July 2012 white maize spread is in line with economic theory for the exchange rate and the stock to use ratio but it is not in line with economic theory as far as the opening stock is concerned. The exchange rate is significant at 1% while the stock to use ratio and the opening stock are not significant at all. The model derived from the data on the March/July 2017 white maize spread is in line with economic theory for the exchange rate, stock to use ratio and the opening stock. The exchange rate and stock to use ratio are significant at 1% while the opening stock is not significant at all. The model derived from the data on the March/July 2013 white maize spread is in line with economic theory for the stock to use ratio but it is not in line with economic theory as far as the exchange rate and opening stock is concerned. The exchange rate is significant at 1%, the opening stock is significant at 5% but the stock to use ratio is not significant at all. The model derived from the data on the March/July 2016 white maize spread is in line with economic theory for the stock to use ratio but it is not in line with economic theory as far as the exchange rate and opening stock is concerned. The exchange rate is significant at 1%, the stock to use ratio is significant at 5% but the opening stock is not significant at all.

Models derived for the data of the March/July 2014, March/July 2012, March/July 2013 and March/July 2016 will not be considered in the forecasting of future movements of the March/July white maize spread because the relationship between one or more of their independent variables and the dependant variable are not in line with economic theory. However, the relationship between all the independent variables and the dependent variable in the March/July 2017 white maize spread is in line with economic theory. Therefore, the model derived from the data from the March/July 2017 white

maize spread will be suitable for forecasting future price movements in the March/July white maize spread.

$$\text{Spread} = -403.63 - 202.40 \times \text{exchange rate} + 52.79 \times \text{stock to use} \\ + 150.81 \times \text{opening stock}$$

It must be noted that a drought was experienced in the 2016/17 marketing season which resulted in a below normal white maize crop. Nevertheless, considering that a considerable amount of the variation in the dependent variable is caused by the independent variables, the relationship between the independent variables and the dependent variable is in line with economic theory as well as the significance of two of the independent variables, the model derived from data from the March/July 2017 white maize spread emerges as the preferred model to be used for forecasting future price movements in the March/July white maize spread.

#### **4.5 Chapter summary**

It is evident in the results above that the March/July white maize spread is a function of the exchange rate, stock to use and opening stock. The extent to which the independent variables (exchange rate, stock to use and opening stock) account for the variation in the dependent variable (March/July white maize spread) differs from season to season. The significance of the contribution of each independent variable also changes from one season to another. The following section makes conclusions and recommendations of the study.

## **Chapter 5: Conclusions and Recommendations**

### **5.1 Chapter overview**

Chapter 5 comprises of conclusions made based on the results. The limitations of the study were established particularly with regards to assumptions made based on insufficient availability of data and time constraints. Recommendations were given in areas that were outside the scope of this study.

### **5.2 Research questions resolution**

**What is the optimal price to sell the March/July white maize spread under the prevailing circumstances and conditions at the time?**

This question was addressed in chapter 4 under the heading discussion of results. A model derived from the data from the March/July 2017 white maize spread was identified as a suitable model for predicting the optimal price to sell future March/July white maize spreads. The model allows for the substitution of the prevailing or expected independent variables (opening stock, exchange rate and stock to use) to determine the best price to sell the March/July white maize spread given the prevailing circumstances and conditions at the time.

**What is the ending/opening stock associated with the optimal price to sell the March/July white maize spread?**

This question was addressed in chapter four under the heading discussion of results. It was discovered that an opening stock of more than 1 362 000 tons is associated with the optimal price to sell the March/July white maize spread. It was mentioned in chapter two under the heading ending/opening stock that an increase in the opening stock will increase the volatility of white maize futures prices. It was also mentioned under the heading related research that the greater corn stocks are compared to demand, the more positive the spread would widen. An increase in the opening stock would increase the white maize reserves compared to demand and ultimately contribute to a widening of the March/July white maize spread. Therefore, the optimal

prices of the March/July white maize spread will be seen at an opening stock of and above 1 362 000 tons.

### **What is the exchange rate associated with the optimal price to sell the March/July white maize spread?**

This question was addressed in chapter four under the heading discussion of results. It was found that an exchange rate of less than R12.09/\$ is associated with the optimal price to sell the March/July white maize spread. It was indicated in chapter two under the heading exchange rate that an appreciation of the rand against the united states dollar will increase the March/July white maize spread. Therefore, the optimal prices of the March/July white maize spread will be seen at exchange rates of and below R12.09/\$.

### **What is the stock to use ratio associated with the optimal price to sell the March/July white maize spread?**

This question was addressed in chapter four under the heading discussion of results. It was found that a stock to use of more than 22% is associated with the optimal price to sell the March/July white maize spread. It was also indicated in chapter two under the heading related research that a calendar spread would increase with increasing stock to use and decrease with decreasing stocks to use ratios. Therefore, the optimal prices of the March/July white maize spread will be seen at stock to use ratios of and above 22%.

## **5.3 Limitations**

The study assumes that the supply and demand of other grains such as yellow maize and wheat as well as oilseeds such as soybean and sunflower do not have an impact on white maize prices. Yellow maize is mainly used as animal feed (CEC, 2020). However, when yellow maize prices are considerably higher than white maize prices,

yellow maize is substituted with white maize in the animal feed industry. This results in a higher demand for white maize which supports white maize prices and thus puts pressure on the March/July white maize spread.

The March/July white maize spread is usually illiquid in March of the previous year, for instance, the March 2010 July 2010 white maize spread is normally illiquid in March 2009. Therefore, the data gathered during the illiquid period, namely March 2009 may not reflect the true value of the March 2010 July 2010 spread but rather the difference between the mark-to-market prices of the SAFEX March 2010 white maize contract and the July 2010 white maize contract as determined by the JSE.

The preferred model was derived from data gathered during a drought year. The drought caused below normal production of white maize. The uncertainty is whether the preferred model can be used to forecast the price of the March/July white maize spread for normal years and surplus years.

The study did not investigate the impact of rainfall on the March/July white maize spread as initially intended. This was due to insufficient rainfall information obtained for each province. The data obtained needed to be more concentrated on the area of study not in cities.

## **5.4 Recommendations**

Agricultural derivative traders must forecast the opening stock, exchange rate and stock to use ratio of white maize on a monthly basis from March to February the following year and substitute the values in the model derived from the March/July 2017 white maize spread to predict the best price to sell the March/July white maize spread. This will result in twelve predicted prices of the March/July white maize spread from March to February the following year.

Market conditions change daily, therefore they will need to regularly adjust their forecasts by making new calculations. One may be tempted to sell all their positions in one month that has the highest predicted spread. However, from a risk management perspective this will not be recommended. To wait for some months in the future to

sell all positions bears considerable risk because market conditions may change and result in a drop in the predicted price. This could result in a considerable financial loss for the trading firm.

The author recommends that traders must divide the total positions that they must sell across all the twelve months. They can allocate more positions to sell in months with higher predicted spreads and less positions to months with lower predicted spreads. Ultimately, they will benefit from best price in each month and possible obtain a high average price while minimising their risk.

### **5.5 Future research**

Future studies on the March/July white maize spread must:

- exclude illiquid months and only start analysing the spread when there is a reasonable amount of liquidity.
- assess the impact of the early white maize deliveries that start being delivered in March on the March/July white maize spread.

### **5.6 Concluding remarks**

The March/July white maize spread is a function of various variables. The suggested model measures the simultaneous impact of all three independent variables when predicting the March/July white maize spread. The best price to sell the March/July white maize spread will not necessarily cover 50% or more of the carry costs. White maize spread fundamentals may cause the spread to trade close to zero. The objective is to anticipate that and sell the spread close to zero that would be the best price for that particular season. The author acknowledges that it will be practically impossible to sell the March/July white maize spread at the highest price given the large amount of white maize positions that need to be moved from March to July and because there are several other sellers on the market who may push the price down by selling aggressively. Nevertheless, selling as close to that highest price as possible should be sufficient.

## References

AgWeb, 2014. What are old crop – new crop corn spreads telling us? Available from: [https://www.agweb.com/blog/the\\_ted\\_spread/what\\_are\\_old\\_crop\\_new\\_crop\\_corn\\_spreads\\_telling\\_us](https://www.agweb.com/blog/the_ted_spread/what_are_old_crop_new_crop_corn_spreads_telling_us) (Accessed: 25 November 2020)

Bryman, Bell, Hirschsohn, Dos Santos, Du Toit, Masenge, Van Aardt and Wagner 2014. Research methodology

Chicago Mercantile Exchange, (2019). Overview of Grain Intercommodity Spreads. Available from: <https://www.cmegroup.com/education/courses/introduction-to-grains-and-oilseeds/overview-of-grain-intercommodity-spreads.html> (Accessed: 29 March 2019)

Crop Estimates Committee, (2019). Supply and Demand: Marketing Year Since 1997. Available from: [http://www.sagis.org.za/sd\\_marketing\\_year.html](http://www.sagis.org.za/sd_marketing_year.html) (Accessed: 1 April 2019).

Competition Tribunal, 2009. Case NO: 110/CR/Dec06. In the matter between: Competition Commission of South Africa and Senwes Limited. Available at: [www.comptrib.co.za](http://www.comptrib.co.za) (Accessed: 14 May 2021)

Department of Agriculture, Forestry and Fisheries, (2017). A Profile of the South African Maize Market Value Chain. Available from: <https://www.nda.agric.za/doaDev/sideMenu/Marketing/Annual%20Publications/Commodity%20Profiles/field%20crops/Maize%20Market%20Value%20Chain%20Profile%202017.pdf> (Accessed: 26 March 2019).

Department of Agriculture, Forestry and Fisheries, (2016). Trends in the Agricultural Sector. Available at: <https://www.daff.gov.za/Daffweb3/Portals/0/Statistics%20and%20Economic%20Analysis/Statistical%20Information/.Trends%20in%20the%20Agricultural%20Sector%202016.pdf> (Accessed: 2 April 2019).

DWA (Department of Water Affairs). (2013). National Water Resource Strategy (2nd ed). Pretoria, South Africa. Available from: <http://www.dwa.gov.za/documents/Other/Strategic%20Plan/NWRS2-Final-email-version.pdf> (Accessed: 5 October 2019).

Evans, G.R., (2019). Put and Call Options. Available at: <https://www.palmislandtraders.com/books/finance/ch9options.pdf> [Accessed: 30 September 2020]

Greyling J, (2015). A look at the contribution of the agricultural sector to the South African economy. Available from: <https://www.grainsa.co.za/a-look-at-the-contribution-of-the-agricultural-sector-to-the-south-african-economy> (Accessed 5 October 2019).

Johannesburg Stock Exchange, (2013). Agricultural Derivatives. Available from <https://www.jse.co.za/trade/derivative-market/commodity-derivatives/agricultural-derivatives> (Accessed: 29 March 2019).

Johannesburg Stock Exchange, (2019). Contract Specifications – Futures. Available from: <https://www.jse.co.za/content/JSEContractSpecificationItems/Grain%20Contract%20Specifications%202019.pdf> (Accessed: 5 October 2019)

Johannesburg Stock Exchange, (2020). Agriculture.stats. Available from: <https://www.jse.co.za/downloadable-files?RequestNode=/Safex/agriculture.stats> (Accessed: 5 January 2020)

Kramer, L. (2019). How does the law of supply and demand affect prices? Available at: <https://www.investopedia.com/ask/answers/033115/how-does-law-supply-and-demand-affect-prices.asp> [Accessed: 15 December 2020]

Monk M.J., Jordaan H. and Grove B., (2010). Factors affecting the price volatility of July futures contracts for white maize in South Africa. Available from: <https://www.researchgate.net/publication/233140774> (Accessed: 5 October 2019).

Napier, D.R. (2016). Spread Trading in Corn futures Market. Available from: <http://scholarworks.uark.edu/etd/1519> (Accessed: 10 April 2020)

National Agricultural Marketing Council, (2019). South African Supply and Demand Estimates January 2019 Report. Available from: <https://www.namc.co.za/wp-content/uploads/2019/02/SASDE-Report-01-Feb-2019.pdf> (Accessed: 28 March 2019).

National Department of Agriculture, (2016). Impact of Drought on Crop Production and The Food Value Chain. BRANCH: POLICY, PLANNING AND MONITORING AND EVALUATION. Available from: <https://www.nda.agric.za/doaDev/sideMenu/others/CCDM/docs/Impact%20of%20drought%20on%20crop%20production%20and%20food%20value%20chain%208%20July%202016.pdf> (Accessed: 5 October 2019).

Nations, S. (2014). The Complete Book of Option Spreads and Combinations. Strategies for Income Generation, Directional Moves, and Risk Reduction. Available at: <http://1.droppdf.com/files/DMI91/the-complete-book-of-options-spreads-2014.pdf> [Accessed: 07 October 2020]

Nkhuoa PG, 2017. WATER FOOTPRINT ASSESSMENT OF MAIZE AND ASSOCIATED BROILER PRODUCTION IN SOUTH AFRICA. Available at: <https://pdfs.semanticscholar.org/76a3/1115120594de031ee7becbbc4033789e97a1.pdf> (Accessed: 5/10/2019)

Seok, J., Wade Brorsen, B. and Li, W. (2013). Calendar Spread Options for Storable Commodities. Available from: <https://econpapers.repec.org/scripts/search.pf?ft=calendar+spread> (Accessed: 5 April 2020).

South African Grain Information Service, 2020. Crop Estimate Reports. Available at: [https://www.sagis.org.za/cec\\_reports.html](https://www.sagis.org.za/cec_reports.html) (Accessed: 3 January 2020)

South African Grain Information Service, 2020. Monthly Supply and Demand Since 1997. Available at: [https://www.sagis.org.za/sd\\_monthly.html](https://www.sagis.org.za/sd_monthly.html) (Accessed: 15 January 2020)

Van der Wath, 2011. Tools for analysing the SA maize market. Available at: <http://www.essa2011.org.za> (Accessed: 12 May 2021)

# Appendices

## Appendix A

Approval letter



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## Appendix B

### Instruments used



data predictions  
(1).xls



Regression (1).txt

## Appendix C

Turn it in report



TURN IT IN  
REPORT.pdf

## Appendix D

Certificate from language editor



proof of english  
editing letter(Phoka