Identifying possible misspecification in South African soybean oil future contracts

By

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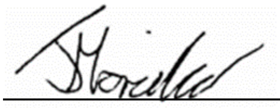
DECLARATION

I, Jean-Pierre Nordier, declare that the dissertation, which I hereby submit for the degree MSc Agricultural Economics at the University of Pretoria, is my own work and has not been submitted for a degree at this or any other tertiary institution.



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ABSTRACT

Soybean crushing[1] plants operate on a crush margin, which is the monetary difference between the combined sales value of mainly soybean meal and soybean oil and the cost of raw soybeans. However, given the high volatility in the prices of these three products, crushing plants normally secure these prices simultaneously. If not, they are vulnerable to the relative price variation between these three products.

Futures markets, such as the Johannesburg Stock Exchange (JSE) Commodities Derivatives Market (CDM) (previously known, and hereafter referred to, as the South African Futures Exchange (SAFEX)), provide futures contracts that can be used as a mechanism for securing these prices. Soybean crushing plants would usually buy soybean futures contracts whilst simultaneously selling soybean meal and soybean oil futures contracts (in a ratio aligned with

[1] Soybean crushing plants use soybeans (100%) to produce soybean meal (80%), soybean oil (18%) and low protein soybean hulls (2%), through a process known as ‘crushing’.

production), thereby securing the processing plant's gross margin or better known in the industry as the 'crush margin'. But this is only viable given adequate liquidity[2] within these futures contracts (which is not the case for SAFEX soybean oil futures contracts). Furthermore, if South Africa is a net importer of the underlying commodity, as is the case with soybean oil, the CBOT[3] contract, as traded on SAFEX futures' price normally represents the majority of the import cost[4] also known as the import parity cost. Therefore, with most soybean oil usually being imported from Argentina, one would expect SAFEX soybean oil futures contracts to reflect the cost of imported soybean oil from Argentina (which are significantly different at times through the season).

However, currently (2020), the SAFEX soybean oil futures contract is a CBOT contract, that is dual listed and cash-settled[5]. The research study seeks to determine whether this is a misspecification and whether or not SAFEX soybean oil futures contracts should rather be based on the Argentina fob soybean oil prices which is a much better representation of South Africa's import parity and local industry prices. If correct, it may also explain why market participants are reluctant to utilize SAFEX listed CBOT soybean oil futures contracts, explaining the low trading volumes and inadequate liquidity.

Hence, the study used the Engle-Granger (1987) cointegration approach, alongside a range of diagnostic tests to evaluate the existence of adequate long and short-run cointegration relationships amongst a linear combination of data variables underlying the current specifications of SAFEX soybean oil futures contracts versus that of an alternative linear combination of data variables that are cash settled of Argentina fob prices (settlement values). Essentially evaluating its efficiency under Eugene Fama's semi-strong-form of market

[2] Liquidity can be considered as the most important constituent for successfully creating an agricultural futures contract, implying the existence of willing buyers and sellers should a participant wish to buy/ sell a futures contract (Van der Vyver, 1994).
[3] Today formally known as the United States (US) CME Group and previously known as the Chicago Board of Trade (CBOT).
[4] In practice, the US FOB (Gulf of Mexico) values for soybean oil accurately reflects the CBOT soybean oil futures contract. To determine the SA import parity price, shipping and offloading costs as well as local transport costs and import taxes are added to the US fob value. The added-on costs are normally stable, however, the CBOT or US FOB (Gulf of Mexico) value, converted to Rand, is very volatile and it is this value that participants would like to secure.
[5] Overseas agricultural futures contracts that are dual listed on SAFEX are always cash settled (compared to local contracts that are physical settled), meaning the underlying physical commodity is not exchanged, only the monetary difference between the trade and closing price.

efficiency, in an attempt to identify possible misspecification by referencing CBOT settlement values as opposed to Argentina settlement values that could ultimately lead to greater participation and improved liquidity.

The study however failed to produce overwhelming statistical evidence for using Argentina settlement values as opposed to CBOT settlement values. Diagnostic tests revealed possible misspecification amongst the long-run equilibrium relationships for both CBOT and Argentinian soybean oil future prices, while concluding for no-misspecification amongst CBOT soybean oil future prices in the short-run. These results suggest that SAFEX soybean oil futures contracts does not incorporate all the information used by market participants in forming a prediction of subsequent spot market prices in the long-run. But does however incorporate sufficient information for such practices in the short-run, attracting speculators[6] who hope to profit from short-term price variations in the absence of hedgers (typically soybean crushers) who in turn seek to employ effective long-term hedging strategies.

Therefore, the study rather pointed towards using CBOT settlement values until South Africa becomes self-sustainable, meeting local demand with local production. In such case, a local physically settled soybean oil futures contract should be listed that accurately reflects local supply and demand conditions, given the collective participation amongst the majority of market participants within the South African soybean industry.

[6] Speculators are those participants that seek to gain from short-term price movements in future markets, buying and selling futures contracts within a relatively short time frame, hoping to earn a monetary profit from their endeavours (SAIFM, 2017).

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LIST OF ACRONYMS

ADF	Augmented Dickey Fuller
AFMA	Animal Feed Manufacturers Association
ARC	Agricultural Research Council
ARG_OILS	Argentina soybean oil futures
ARIMA	Autoregressive Integrated Moving Average
CBOT	Chicago Board of Trade
CDM	Commodities Derivatives Market
CEC	Crop Estimates Committee
CIF	Cost Insurance Freight
DCE	Dalian Commodity Exchange
ECM	Error Correction Model
EMH	Efficient Market Hypothesis
FOB	Free On Board
FOR	Free On Rail
GMO	Genetically Modified Organisms
ITC	International Trade Centre
JSE	Johannesburg Stock Exchange
LM	Lagrange Multiplier
MMT	Million Metric Tons
MT	Metric Tons
NAMC	National Agricultural Marketing Council
NYMEX	New York Mercantile Exchange

OLS	Ordinary Least Squares
PP	Phillips Perron
RESET	Regression Equation Specification Error Test
RWH	Random Walk Hypothesis
SA	South Africa
SA_OILS	South African soybean oil futures
SAFEX	South African Futures Exchange
UK	United Kingdom
US	United States
US_OILS	CBOT soybean oil futures
USDA	United States Department of Agriculture
USITC	United States International Trade Commission
VEC	Vector Error Correction
ZAR	South African Rand

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CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

Currently (2020), there are seven different varieties of oilseeds being produced across the world, each with distinguishing characteristics (USDA, 2019). Soybeans continue to dominate the world's oilseed industry and accounted for 59% of the 2019/20 global oilseed production, followed by rapeseed (12%) and sunflower seed (9%) (USDA, 2019). Three countries dominate global production, namely: Brazil, which accounts for the largest portion (37%) of the 2019/20 global soybean production, followed by the United States (US) (29%) and Argentina (16%), with South Africa only accounting for 0.35% (Figure 1.1). These three countries also constitute the largest portion of the world's soybean exports, whilst China accounts for the majority (57%) of the 2019/20 global soybean imports, constituting 28% of total global soybean crushing (USDA, 2019). From a global production perspective, 2019/20 could be considered a 'normal' year.

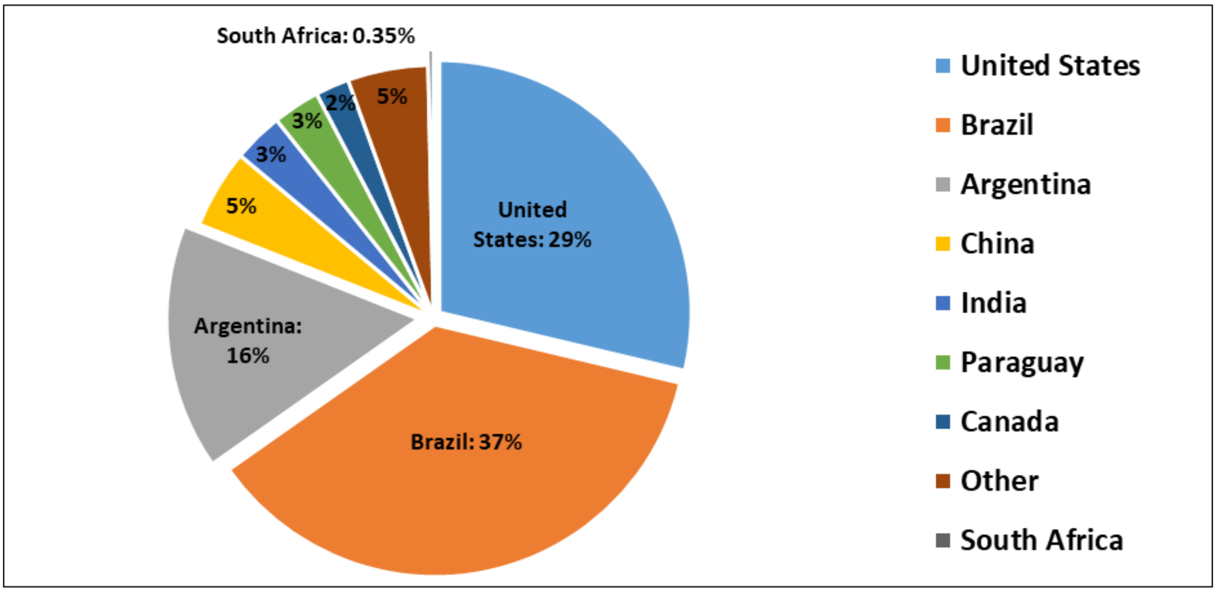


Figure 1.1 Distribution of soybean production by country: 2019/20 season (%)

Source: CEC (2019) and USDA (2019)

Soybeans are used to produce soybean meal (80%), soybean oil (18%) and low protein soybean hulls (2%), through a process known as 'crushing'. Globally, China is known for being the biggest producer of soybean meal, followed by the US and Brazil (USDA, 2019). Soybean meal, together with maize, is commonly used as a key ingredient in the manufacturing of feed, this is particularly true in the poultry industry. Soybean meal typically contains 51% crude protein and 13% neutral detergent fibre (Table 1.1). Soybean oil on the other hand contains linoleic acid (an essential fatty acid to human nutrition) which is used to produce soy lecithin and refined soybean oil. Soy lecithin is generally utilized as a natural emulsifier or stabilizer in food products, while refined soybean oil is predominantly used for cooking oil blends. Soybean oil could also be used in the production of biofuels and other industrial products (Wilmar, 2018). Currently (2019/20) China is also leading the way in global soybean oil production (27%), followed by the US (20%) and Argentina (16%), with South Africa only accounting for 0.44% (SAGIS[c], 2019 & USDA, 2019), usually importing the majority of its soybean oil from Argentina (SARS, 2019).

Lastly, low protein soybean hulls mainly consist of the soybean's outer-shell, typically containing 9% crude protein and 74% neutral detergent fibre (Table 1.1). It can only be used as a supplementary feed source to ruminants, since monogastric species are unable to digest feed with such high fibre content (Balsi, 2000). Being the largest producer of soybean meal and soybean oil (followed by the US, Argentina and Brazil), and unable to meet its own demand, China relies heavily on soybean imports (USDA, 2019).

Table 1.1 Nutrient comparison of soybean seeds, soybean meal and soybean hulls

	Soybean Seeds (%)	Soybean Meal *(Solvent Extracted)* (%)	Soybean Hulls (%)
Total digestible nutrients	93.00	84.00	77.00
Crude protein	40.00	51.00	9.40
Ether extract	19.40	2.00	2.50
Crude fiber	8.00	5.00	35.00
Neutral detergent fiber	15.00	13.00	74.00
Acid detergent fiber	11.00	11.00	47.00
Ash	5.00	7.00	5.00
Calcium	0.27	0.40	0.60
Phosphorus	0.64	0.73	0.22
Potassium	2.00	2.40	1.70
Sodium	0.02	0.04	0.01
Sulfur	0.24	0.47	0.09
Magnesium	0.29	0.30	0.00

Source: Balsi (2000)

Soybean crushing plants operate on a crush margin, i.e. the monetary difference between the combined sales value of mainly soybean meal and soybean oil, and the cost of raw soybeans (CME Group, 2015). Bringing forth their vulnerability to price variation in these three products (soybeans, soybean meal and soybean oil). Futures markets, such as the Johannesburg Stock Exchange (JSE) Commodities Derivatives Market (CDM) (previously known, and hereafter referred to, as the South African Futures Exchange (SAFEX)), usually provide adequate derivative instruments[7] for managing these price risks making for possible an effective hedging[8] strategies. Soybean crushing plants would usually buy soybean futures contracts, i.e. taking a long position in the futures market (known as a long anticipatory hedge), thereby offsetting the risk against higher soybean prices, whilst simultaneously selling soybean meal and soybean oil futures contracts (in a ratio aligned with production), thereby offsetting the risk against lower soybean meal and soybean oil prices (known as a short anticipatory hedge). This strategy allows soybean crushing plants to ‘lock-in’ their crushing margin. The crushing plant will again close the positions, first the long soybean futures when it buys the physical

[7] A derivative instrument can be defined as a financial security, i.e. futures contracts or options, of which the value is derived from an underlying asset.
[8] Hedging can be defined as a forward pricing investment strategy used to reduce one’s risk against adverse asset price movements in cash markets.

stock, and second the short futures (meal and oil contracts) when it sells the physical product (the sequence could be the opposite as long as the futures positions are replaced by physical positions). After having taken the appropriate positions in the futures market, soybean crushing plants would be ensured of an adequate crushing margin, covering the factory operational costs and their net profit, as long as they correctly offset the futures positions with physical positions. If prices in the futures and/ or physical market move, in- or out-of-sync, the loss in one of the positions will always be offset by similar gain in the other.

The main challenge for the soybean crusher is when to execute the futures positions. As seen in Table 1.2, if the difference between soybean commodity prices vs. meal and oil prices (gross margin) is big enough, the crusher will 'lock-in' an adequate gross margin for covering its operational costs, leading to a sufficient crush margin. However, as seen in Table 1.3, when the difference is too small the crusher may have to wait otherwise it will 'lock-in' a mediocre gross margin which may be insufficient.

Table 1.2 Sufficient soybean crush margin

Soybean Crush Margin	Procedure	Example
SAFEX soybean futures price (R/MT)	A	R6 020.00
SAFEX soybean meal price (R/MT)	B	R4 798.40
SAFEX soybean oil price (R/MT)	C	R1 963.62
Gross margin (R/MT)	**(-A+B+C)**	**R742.02**
Opperational costs (R/MT)	D	R686.00
Estimated soybean crush margin (R/MT)	**(-A+B+C-D)**	**R56.02**

Source: Nordier (2018[a]) and Refinitiv (2020)

Table 1.3 Insufficient soybean crush margin

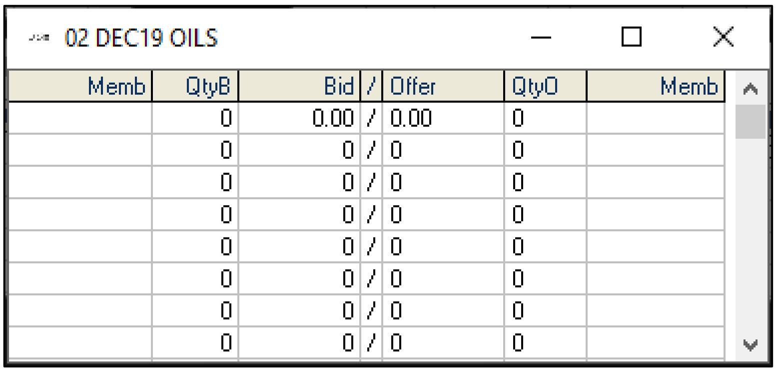
Soybean Crush Margin	Procedure	Example
SAFEX soybean futures price (R/MT)	A	R6 170.00
SAFEX soybean meal price (R/MT)	B	R4 798.40
SAFEX soybean oil price (R/MT)	C	R1 963.62
Gross margin (R/MT)	**(-A+B+C)**	**R592.02**
Opperational costs (R/MT)	D	R686.00
Estimated soybean crush margin (R/MT)	**(-A+B+C-D)**	**-R93.98**

Source: Nordier (2018[a]) and Refinitiv (2020)

1.2 PROBLEM STATEMENT

In 2009, SAFEX expanded its product range from physically settled grain derivatives to a range of commodities that are cash settled[9] off a foreign referenced market, namely the CME Group (previously known, and hereafter referred to, as the Chicago Board of Trade (CBOT)) in the US. This included soybean oil futures that, according to its contract specifications, continue to reference CBOT prices despite having very little to no liquidity (JSE, 2018).

Liquidity, can be considered as the most important constituent for successfully creating an agricultural futures contract. Liquidity implies that there exist willing buyers and sellers should a participant wish to buy/ sell a futures contract (Van der Vyver, 1994). Consequently, the absence of liquidity (Figure 1.2) could restrain participants from closing their long or short anticipatory hedge, which may result in monetary losses. Thereby, igniting an additional risk factor to a derivative instrument that has been designed to reduce risk. Therefore, participants are compelled to hedge with more liquid soybean oil futures traded on overseas markets as opposed to SAFEX.


02 DEC19 OILS

Memb	QtyB	Bid	/	Offer	QtyO	Memb
	0	0.00	/	0.00	0	
	0	0	/	0	0	
	0	0	/	0	0	
	0	0	/	0	0	
	0	0	/	0	0	
	0	0	/	0	0	
	0	0	/	0	0	
	0	0	/	0	0	

Figure 1.2 Illiquid December 2019 soybean oil futures traded on SAFEX
Source: JSE (2019)[a]

[9] Meaning the underlying physical commodity is not exchanged, only the monetary difference between the trade and closing price. This settlement method is used when the market/ country's imports of the underlying commodity exceeds its production.

In addition to the above mentioned, Scheepers (2005:15) states that the specifications of a contract could influence its liquidity and ultimately contribute to its efficiency. Therefore, since South Africa is a net importer of soybean oil, one could argue for SAFEX soybean oil futures to reflect the cost of such imports (import parity). This is true because a South African crushing plant competes against these imports and would opt to sell soybean oil at the highest possible price, i.e. import parity, since importers would not choose to sell soybean oil at a price lower than the cost of such imports.

Therefore, with most of the country's soybean oil being imported from Argentina (SARS, 2019), one would expect SAFEX soybean oil futures to reflect the cost of importing soybean oil from Argentina. Hence, referencing Argentinian free-on-board (fob)[10] prices as opposed to CBOT fob[11] prices, which could in turn, increase the liquidity and efficiency of SAFEX soybean oil futures.

1.3 RESEARCH OBJECTIVES

The overarching aim of this study is to evaluate and identify possible misspecification in SAFEX soybean oil futures, using co-integrating relations amongst SAFEX and CBOT soybean oil future contract prices (as set out in the JSE's contract specifications (JSE, 2019[b])) as opposed to using Argentinian soybean oil fob prices. The research aim is accompanied by the following sub-objectives:

(1) Evaluate the order of integration for establishing stationarity amongst all data variables in the study, through the use of informal (graphical depictions) and formal (Augmented Dickey Fuller (ADF) and Phillips Perron (PP)) unit root testing techniques.

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[10] Free-on-board (fob) refers to the underlying commodity's price, i.e. assuming delivery without the charge (freight) to ship from country of origin

[11] In practice, the US fob value for soybean oil accurately reflects the CBOT soybean oil futures contract. To determine the SA import parity price, shipping and offloading costs as well as local transport costs and import taxes are added to the US fob value. The added-on costs are normally stable, however, the CBOT or US fob value, converted to Rand, is very volatile and it is this value that participants would like to secure.

(2) Test for long-run cointegration[12] amongst CBOT fob, Argentinian fob and SAFEX soybean oil prices (an efficient market requirement), using the Engle-Granger (1987) cointegration approach.

(3) Establish Error-Correction-Models (ECM's) between CBOT fob, Argentinian fob and SAFEX soybean oil future prices, using Ordinary Least Squares (OLS) regression. These ECMs will be used to evaluate cointegration amongst these data variables in the short-run, using the Engle-Granger cointegration approach.

(4) Use the Jarque-Bera (1987), White (1980) and Breusch-Godfrey (1978) diagnostic tests, as theoretical justification for the interpretation of results. Together with Ramsey's (1969) Regression Equation Specification Error Test (RESET) to evaluate possible misspecification amongst the long-run and short-run co-integrating relationships.

The abovementioned sub-objectives could possibly illustrate the use of co-integrating regression techniques for evaluating the efficiency of commodity futures markets.

1.4 HYPOTHESIS

The research study will identify possible long-run and short-run co-integrating relationships amongst SAFEX, CBOT and Argentinian soybean oil future prices under Engle-Granger's cointegration research hypothesis:

H_0: *No cointegration exist amongst CBOT fob, Argentinian fob and SAFEX soybean oil futures contract prices, i.e. there is no evidence of a long-run or short-run equilibrium relationship between these prices.*

[12] Cointegration: The case where a linear combination of two series, that is integrated of order one, I(1), is integrated of order zero, I(0). Meaning, two or more series move closely together to form a long-run equilibrium relationship (Wooldridge, 2013).

Followed by diagnostic testing, with special emphasis on James Ramsey (1969), RESET test for identifying possible misspecification, in terms of inclusion of irrelevant variables or the exclusion of relevant variables, under the research hypothesis:

H_0: No misspecification amongst data variables for both long-run and short-run equilibrium relationships as set out by Engle-Granger's cointegration techniques.

1.5 ACADEMIC VALUE AND CONTRIBUTION

The study will address the importance of liquidity in commodity futures contracts, whilst proposing the use of cointegrating analysis for evaluating the efficiency thereof. Paying special attention to the liquidity issue SAFEX soybean oil futures contracts face.

The study will also outline the intricacies of its contract specifications and the interconnection between international markets. This will be done by providing statistical evidence that justifies the fashion in which these contracts are used and the potential inefficiency thereof. Accentuating the need for South Africa to become self-efficient within its soybean oil supply through the expansion of its crushing members.

1.6 CHAPTER DEDICATION

The study consists of six chapters. Chapter 1 served as the introduction. Chapter 2 provides an essential overview of South Africa's soybean industry as to aid the reader in understanding the interconnection between the soybean, soybean meal and soybean oil markets of South Africa. It also provides key statistics and procedures in support of this study.

Chapter 3 serves as a literature review, starting off with a short discussion on the development of market analysis techniques as a catalyst to one of the most recognized hypotheses in financial market literature, i.e. the Efficient Market Hypothesis (EMH). This is followed by literature studies on using the EMH for evaluating the efficiency in various commodity future markets, while identifying an estimation technique that is concluded in this chapter.

The methodology, Chapter 4, presents the estimation technique used in this study. It consists out of four sections, the first being the theoretical framework, justifying the study's data variables with a soybean oil import parity calculation. This is followed by the empirical framework, describing the data variables together with an economic interpretation for the expected signs of the various regression models, followed by the study's data sources. Thereafter, the third section, provides a theoretical overview of the estimation technique. Lastly some concluding remarks are made.

Chapter 5 presents the findings of the unit root tests, together with the long-run equilibrium relationships between South African soybean oil futures prices, CBOT fob soybean oil future prices and Argentina fob soybean oil future prices. This is followed by the study's cointegration and short-run equilibrium results, which is evaluated through various diagnostic tests.

This study is concluded with Chapter 6 which provides an overall conclusion together with recommendations and a proposal for further research.

CHAPTER 2 OVERVIEW OF THE SOUTH AFRICAN SOYBEAN INDUSTRY

2.1 INTRODUCTION

The overarching purpose of this chapter is to provide the reader with an adequate background surrounding the interconnected soybean, soybean meal and soybean oil markets. Especially with the South African soybean industry being renowned as one of the most complex and specialized agricultural industries in the country (JSE, 2019[d]). Participants need to acquire an in depth understanding of the intricacies surrounding supply and demand relations together with the sensitivities toward various substitutes and relying sectors.

Therefore, the first section of this chapter outlines the history of soybean production in South Africa. This is followed by discussions on the processing, value addition and utilization of South Africa's soybeans. Thereafter, this chapter provides essential information related to South Africa's supply and demand for soybean by-products, concluding with price formulation in combination with payable tariffs and levies.

2.2 HISTORY OF SOYBEAN PRODUCTION IN SOUTH AFRICA

The soybean originates from Eastern Asia, China, Japan and parts of India. It can be described as an annual legume with a branched leafy stem, in which the leaves and pods are covered with stiff hairs. The pods are germinated on short stalks (densely clustered around the stem) with a relatively small spherical bean, varying in colour, i.e. black to white; green; yellow; or brown. But it was not until Joseph Burtt-Davy (1910), a government botanist and agrostologist at that time, had successfully grown soybeans on the Springbok Flats (Limpopo) of South Africa in 1903 that farmers started producing soybeans in the country. Unfortunately, the unfamiliarity of soybeans amongst farmers and the country's varying geological distributions, impeded its adaptation to regular farming practises (Burtt-Davy, 1910).

In 1930 WS Hall recommended that soybeans be cultivated in a region with relatively high rainfall, i.e. the KwaZulu-Natal Province, arguing that soybeans could be used as a supplementary feed source in livestock production systems. It was however not until the implementation of the Genetically Modified Organisms (GMO) Act 15 of 1997 allowing the usage of GMO seed (with greatly improved capabilities) that production surpassed 100 000 metric tons (MT) (Figure 2.1). An added advantage was also that the new GMO varieties enabled farmers to produce soybeans under relatively lower rainfall conditions in Mpumalanga. This enabled soybeans to become the fastest growing field crop over the past decade (BFAP, 2018).

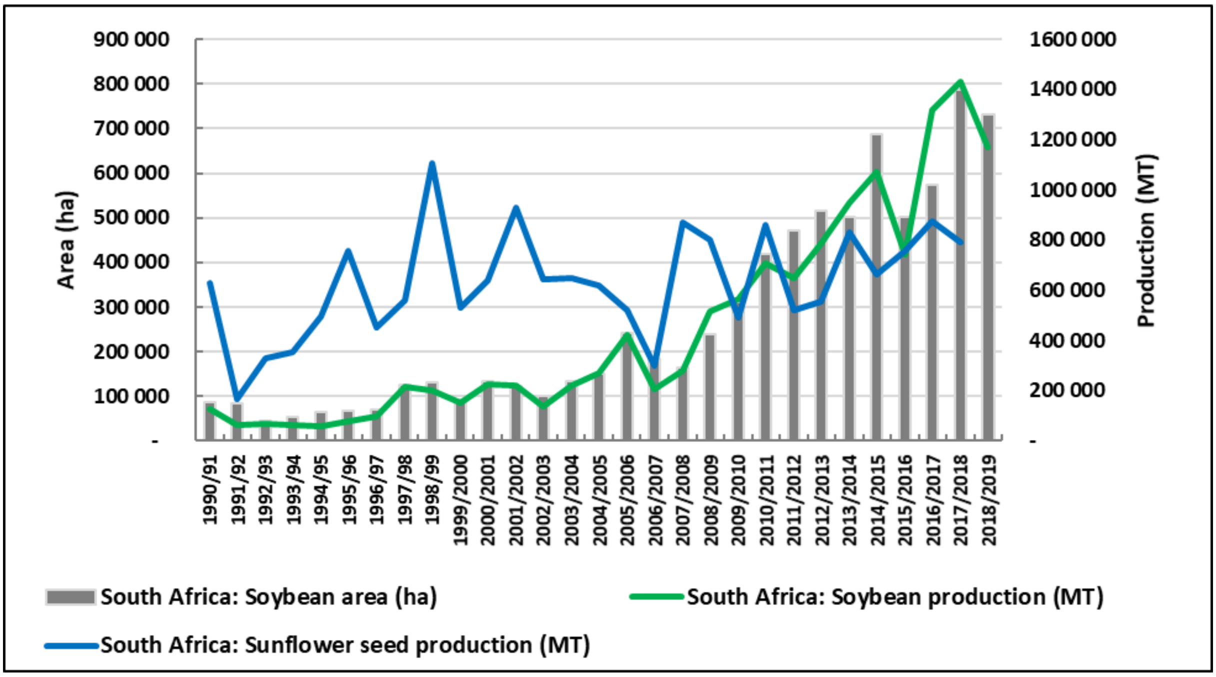

Figure 2.1 South African historic soybean plantings (ha) and production (MT)

Source: CEC (2019)

It was only during the 2009 production season that soybean production surpassed that of sunflower seed production (Figure 2.1), when farmers realized three distinct benefits of using soybeans in rotation with other summer grain crops (Helmers, Yamoah, & Varvel, 2001 and Henning & Strydom, 2003):

(1) The diversification amongst other summer grain crops allows low returns in one season for a specific crop to be combined with high returns from a different crop;

(2) Using soybeans in rotation with other summer grain crops could reduce yield variability and increase overall yields, as opposed to monoculture practices; and

(3) Rotations could also aid in reduced production costs.

This is especially evident during the 2017/18 production season, when farmers were faced with low maize prices, rotating to the production of soybeans (combining low returns in one crop with high returns in another). Consequently, the area planted under maize decreased by 309 750 hectares (ha) whilst the area planted under soybeans increased by 213 250 ha, to 787 200 ha (CEC, 2019). With most soybeans planted under dryland cropping conditions in the Free State (44%) and Mpumalanga (39%), average yields between 1.5 ton/ ha and 1.95 ton/ ha were achieved, as opposed to average yields of between 2.75 ton/ ha and 3.31 ton/ ha under irrigation in Limpopo (3%) and Kwazulu-Natal (5%) (CEC, 2019). It is furthermore predicted that national soybean plantings could reach as much as 1.23 million ha by 2028, subsequently leading to an estimated production of 3.50 million MT. Given newly developed soybean cultivars (BFAP, 2019; CEC, 2019 and De Beer, 2018) and an increase in the demand for locally produced soybean meal, soybeans are becoming the fastest growing field crop industry. Particularly considering that animal feed manufacturers could become inclined to replace imported soybean meal with locally produced soybean meal as locally produced soybean meal has been found to be equivalent, and in some instances even superior, in terms of broiler growth (Barnard & Van der Vyver, 2019).

2.3 SOUTH AFRICAN SOYBEAN CULTIVARS

There are many different varieties of soybean cultivars being used in South Africa. The most important characteristic in cultivar selection is the length of the growing season. This is because, unlike other summer grain crops, soybeans are very sensitive to frost and day length (De Beer & Bronkhorst, 2018). Therefore, the South African Agricultural Research Council (ARC) recently (2018) conducted soybean cultivar trials for the identification of such varieties best suited to South Africa's different production localities. Table 2.1 categorises these localities under warm, moderate and cool production regions, together with irrigated or dry land production schemes. Where most of the country's soybeans are cultivated and produced (De Beer, 2018).

Table 2.1 Soybean production localities according to warm, moderate and cool climatic profiles

Warm (I) – Irrigation, (D) – Dry land	**Moderate** (I) – Irrigation, (D) – Dry land	**Cool** (I) – Irrigation, (D) – Dry land
Brits - North West (I)	Bapsfontein - Mpumalanga (I)	Bethlehem - Free State (I)
Groblersdal – Limpopo (I)	Bergville - Kwazulu-Natal (I)	Clarens - Free State (D)
Hopetown – Northern Cape (I)	Cedara - Kwazulu-Natal (D)	Clocolan - Free State (D)
Marble Hall – Mpumalanga (I)	Dundee - Kwazulu-Natal (D)	Delmas - Mpumalanga (D)
	Greytown - Kwazulu-Natal (D)	Kestell - Free State (D)
	Kroonstad - Kwazulu-Natal (D)	Kinross - Mpumalanga (D)
	Potchefstroom – North West (I)	Kokstad – Kwazulu-Natal (D)
	Stoffberg - Mpumalanga (D)	Middelburg - Mpumalanga (D)
	Verkeerdevlei – Free State (I)	

Source: De Beer (2018)

The outcome of the trials conducted by the ARC suggest that the newly developed soybean cultivars (Annexure 1) could achieve exceedingly higher yields in cool (2.5 ton/ ha to 3.4 ton/ ha), moderate (2.6 ton/ ha to 3.4 ton/ ha) and warm (2.5 ton/ ha to 3.6 ton/ ha) production regions as opposed to between 1.5 ton/ ha and 3.1 ton/ ha in the past (De Beer, 2018). Furthermore, most of the country's soybeans are planted during the months of October and November, whilst the planting of soybeans suited to warm regions could be extended up to December (De Beer, 2018).

2.4 SOYBEAN PROCESSORS VALUE ADDITION AND UTILIZATION

2.4.1 Soybean processing

Unlike summer grains, the demand for domestic soybeans and sunflower seed is limited by the country's crushing capacity (Van der Vyver, Nordier & Verwey, 2018). Therefore, the increase in soybean production from 205 000 MT during the 2006/07 marketing year to 1.07 million MT during the 2014/15 marketing year (Figure 2.2), encouraged local investors to expand South Africa's annual crushing capacity by almost 1.2 million MT to 1.9 million MT (Van der Vyver *et al*, 2018).

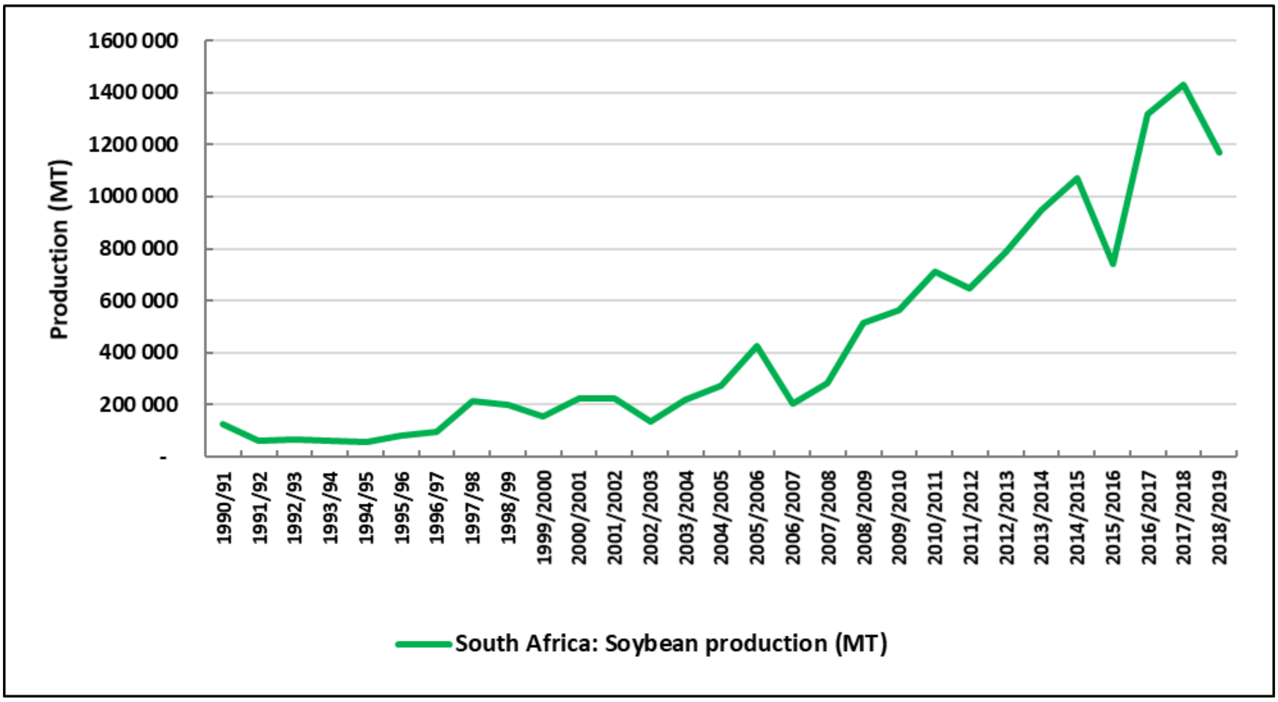

Figure 2.2 Soybean production in South Africa (MT)

Source: CEC (2019)

According to Table 2.2, South Africa's crushing capacity for soybeans and sunflower currently (2020) stand at 1.99 million MT and 852 000 MT respectively. Noble Resources (Pty) Ltd. operates the largest soybean crushing plant with an annual crushing capacity of 605 000 MT, accounting for 30% of the country's annual soybean crushing capacity. The crushing plants of Wilmar Continental Oil Mills (Pty) Ltd. and Majesty Oil Mills are dual crushing plants[13], bringing the country's total crushing capacity for sunflower seed and soybeans to a total of 2.50 million MT.

[13] Dual crushing plants have the ability to switch between the crushing of sunflower seed and soybeans.

Table 2.2 South African oilseed crushing capacity (MT/year)[14]

Company	Location	Product range	Sunflower seed (Only) (MT/year)	Soybeans (Only) (MT/year)
Noble Resources (Pty) Ltd	Standerton	Soybeans	-	605 000
Nedan (Pty) Ltd	Potgietersrus	Soybeans	-	326 000
Russellstone	Bronkhorstspruit	Soybeans	-	240 000
Central Edible Oil (Pty) Ltd (CEOCO)	Boksburg	Dual	216 000	120 000
	Delmas	Soybeans	-	48 000
Wilmar Continental Oil Mills (Pty) Ltd	Randfontein & Viljoenskroon	Dual	192000	
VKB Agriculture (Pty) Ltd	Villiers	Soybeans	-	186 000
Willowton Oil & Cake Mills	Pietermaritzburg	Sunflower seed	96 000	-
	Isando	Dual	120000	120000
Majesty Oil Mills	Krugersdorp	Dual	156000	
Nola	Randfontein	Soybeans	-	120 000
Gauteng Oil & Cake Mills (Pty) Ltd	Nasrec	Dual	72 000	180 000
Drak Oil Mills	Winterton	Soybeans	-	48 000
South Africa crushing capacity: Sunflower seed (MT/year)				**852 000**
South Africa crushing capacity: Soybeans (MT/year)				**1 993 000**
South Africa crushing capacity: Sunflower seed & Soybeans (MT/year) *				**2 497 000**

Source: JSE 2019[d], Nordier (2018[a]) and Van der Vyver *et al* (2018)

Figure 2.3, illustrates how the significant increase in the country's soybean crushing capacity caused the volume of soybeans being crushed to increase from 139 400 MT during the 2006/07 marketing year to 861 631 MT during the 2014/15 marketing year, continuously surpassing that of sunflower seed. It is also evident that during the 2018/19 marketing year 1.95 million MT of oilseeds were crushed, 78% of the country's total capacity of 2.50 million MT. Reason being that crushing plants usually operate at 85% to 90% of its full capacity and could be shut down for various reasons such as routine maintenance or the lack in adequate profit margins for covering variable costs (Myburgh, 2019).

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[14] * Calculated by adding the crushing capacity for sunflower seed (852 000 MT) and soybeans (1 993 000 MT) and subtracting the crushing capacity for dual crushing plants (348 000 MT).

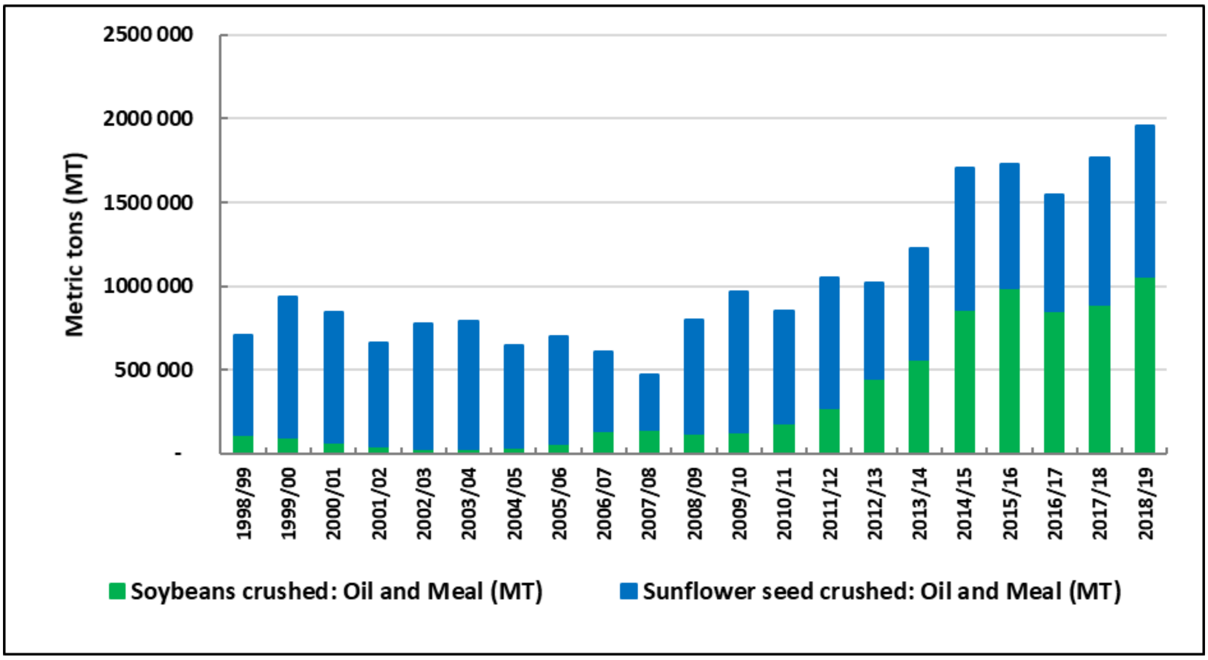

Figure 2.3 South African historic soybean and sunflower seed processing (MT)

Source: SAGIS 2019[a]

2.4.2 Value addition

As mentioned in Section 1.1, soybean crushing plants procure soybeans, used to produce soybean meal (80%), soybean oil (18%) and low protein soybean hulls (2%), using a three-stage process (Figure 2.4).

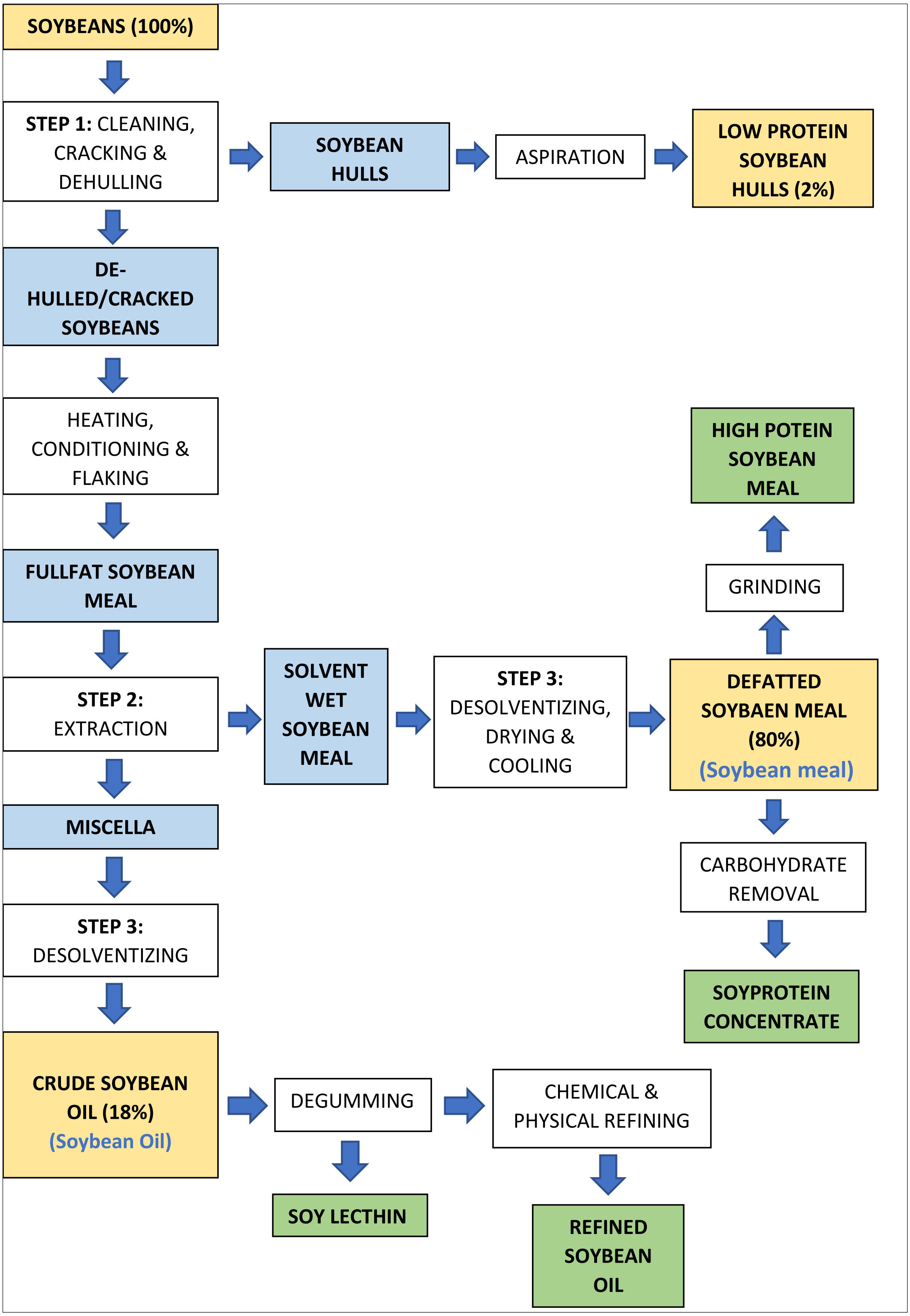

Figure 2.4 Process flow - soybean meal and soybean oil production

Source: Balsi (2000) and Wilmar (2018)

Firstly, soybeans are cleaned and cracked, whereby low protein soybean hulls are removed through aspiration (a process that uses terminal velocity as a function of kernel density to separate any dust and foreign material), which usually accounts for 2% of the soybean's original mass. Thereafter, the cracked soybeans are conditioned to an appropriate temperature and moisture content (preventing the soybeans from turning into flour under mechanical pressure) after which the soybeans undergo flaking, producing 0.3 millimetre (mm) full-fat soybean meal flakes (on average, 8% of full-fat soybean meal is sold as a supplementary energy source in animal diets). Secondly, hexane is added to extract crude soybean oil from the meal, through a process known as extraction, forming miscella (an oil rich extract) and solvent wet soybean meal.

Finally, the miscella and solvent wet soybean meal is then separated and sent to desolventisers, that removes any undrained hexane. Leaving crude soybean oil (commonly referred to as soybean oil and usually accounts for 18% of the soybean's original mass) which is the physical product to which soybean oil futures relate (CME Group, 2020 and JSE, 2019[b]) and wet soybean meal. The wet soybean meal is dried and cooled to a moisture content of 12%, i.e. defatted soybean meal (commonly referred to as soybean meal and usually accounts for 80% of the soybean's original mass) which is the physical product to which soybean meal futures relate (CME Group, 2020 and JSE, 2019[b]).

The crude soybean oil then undergoes a degumming process that separates soy lectin from the oil. Which is then refined even further (see Section 2.4.2.2), while the defatted soybean meal is grounded and screened into high protein soybean meal, or undergo the process of carbohydrate removal to produce soy protein concentrate (see Section 2.4.2.3).

2.4.2.1 Low protein soybean hulls

As mentioned in Section 1.1, low protein soybean hulls mainly consist of the soybean's outer-shell, typically containing 9% crude protein and 74% neutral detergent fibre. However, it can only be used as a supplementary feed source to ruminants (cattle), since monogastric species (poultry and swine) are unable to digest feed with such high fibre content (Balsi, 2000). Therefore, it is removed during the first stage and sold at a relatively constant price to cattle feed manufacturers and nearby farmers.

2.4.2.2 Crude soybean oil

Referring back to Section 1.1, crude soybean oil (soybean oil) contains linoleic acid (an essential fatty acid to human nutrition), used to produce soy lecithin and refined soybean oil (Figure 2.4) usually sold to food processors, service and retail industries. Soy lecithin is generally used as a natural emulsifier or stabilizer in food products, while refined soybean oil is usually used for cooking oil blends. Soybean oil could also be used in the production of biofuels and other industrial products (Wilmar, 2018).

2.4.2.3 Defatted flakes

Defatted flakes can be processed into soy protein concentrate or high-protein soybean meal (soybean meal) (Figure 2.4). Soy protein concentrate is used as supplementary feed source in aquaculture systems. While soybean meal is commonly used as a supplementary feed source in poultry production systems, containing 47% crude protein and 3.3% neutral detergent fibre (Wilmar, 2018). The amino acid profile complements the digestibility of grain, thereby enhancing the feed conversion ratio (CIGI, 2010). As a result, crushing plants usually sell soybean meal to local animal feed manufacturers.

2.5 SOUTH AFRICAN SUPPLY AND DEMAND FOR SOYBEAN BY-PRODUCTS

The production of soybean meal in South Africa increased significantly from 65 000 MT during the 1998/99 marketing season to an estimated 1 065 000 MT in 2018/19. However, it was not until the 1.20 million MT expansion in the country's crushing capacity that domestic production surpassed the volume of imports, causing the average volume of soybean meal exports to increase from 8 000 MT/ year to 78 500 MT/ year (Figure 2.5).

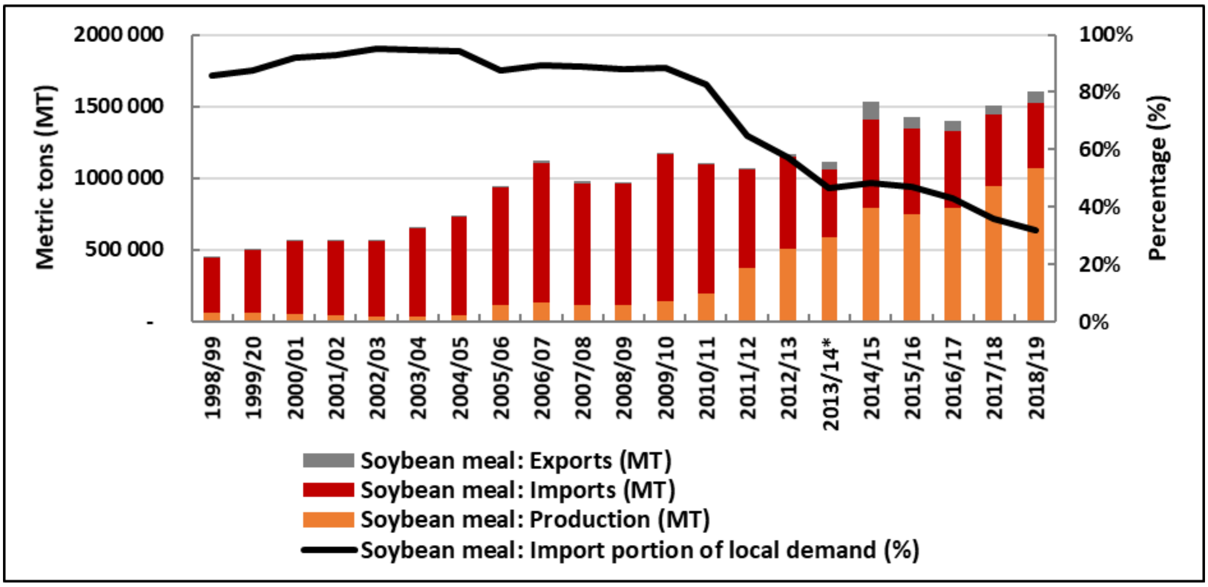

Figure 2.5 South Africa: Historic soybean meal production, imports and exports (MT)[15]
Source: USDA (2019)

The members of the Animal Feed Manufacturers Association of South Africa (AFMA) procured 40% of locally produced soybean meal and 94% of imported soybean meal during the 2017/18 marketing season, constituting 61% of the country's domestic soybean meal demand (AFMA, 2018 & USDA, 2019). However, most of its members prefered imported soybean meal (467 441 MT in 2017/18) above locally produced soybean meal (380 069 MT in 2017/18). This is despite the fact that locally produced soybean meal is on par with imports (predominantly originating from Argentina) (BFAP, 2018 & NAMC, 2011).

South Africa's soybean oil production followed the same trend, increasing from 15 000 MT during the 1998/99 marketing season to an estimated 247 000 MT in 2018/19. Only surpassing the import portion of domestic demand[16] during the 2018/19 season (Figure 2.6). This could be attributed to the current surplus in the country's soybean stock levels, placing downward

[15] * 1.2 million MT expansion in the country's crushing capacity to 1.9 million MT/ year
[16] Domestic demand = domestic production + imports - exports

pressure on domestic soybean prices; hence, higher profit margins for crushing soybeans. However, during times without excess soybean stocks, local crushers fail to compete with mega crushing plants in Argentina. Therefore, given the country's current crushing capacity of two million MT, soybean oil imports would remain a significant share of domestic demand (BFAP, 2018). On average, 59% of the country's soybean oil imports originate from Argentina (SARS, 2019).

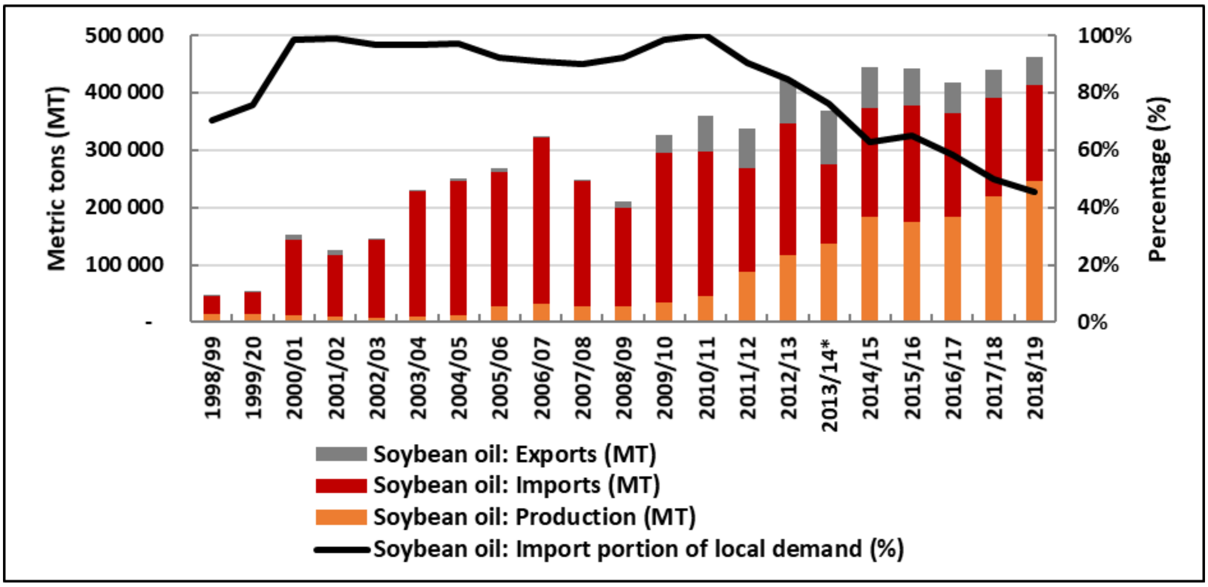

Figure 2.6 South Africa: Historic soybean oil production, imports and exports[17]
Source: USDA (2019)

2.6 PRICE FORMULATION IN THE SOUTH AFRICAN SOYBEAN INDUSTRY

The South African soybean industry operates in a deregulated market (NAMC, 2008), allowing buyers and sellers to negotiate soybean, soybean meal and soybean oil prices on SAFEX. On SAFEX the price for soybeans generally trades between the lowest cost of importing soybeans, i.e. import parity (usually from Argentina) and the highest price of exporting soybeans i.e. export parity (Figure 2.7).

[17] * 1.20 million MT expansion in the country's crushing capacity to 1.90 million MT/ year.

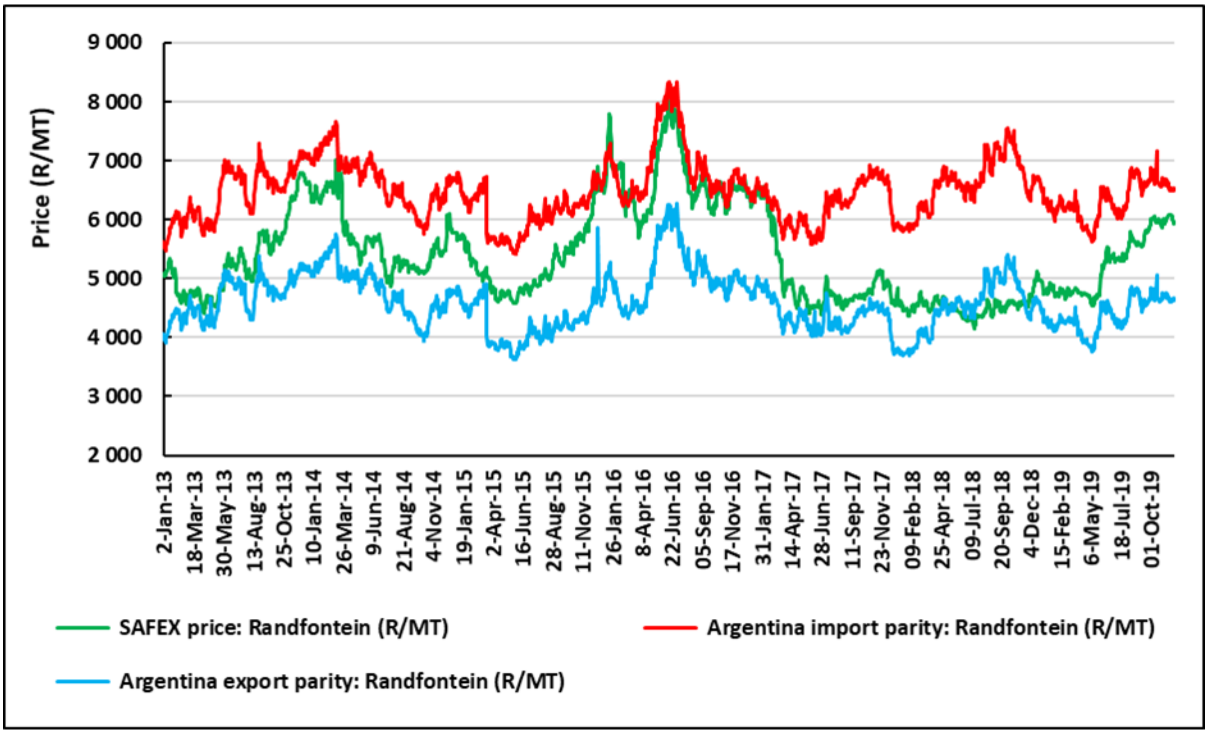

Figure 2.7 Historic soybean price levels (R/MT)

Source: GrainSA (2019)

2.6.1 Procedure for estimating soybean import and export parity levels

In the case of excess demand, we expect the price of soybeans to trade close to import parity. Calculated using the fob price at which soybeans are being imported, accompanied by an insurance premium (usually 0.3% of the fob value), covering unforeseen circumstances during transit, in addition to the applicable import tariff (refer to section 2.6.3) and shipping cost (freight rate). Then applying a currency conversion from the international currency to local currency, using a one-month forward exchange rate, giving the Cost, Insurance, Freight (CIF) charge in domestic currency. The forward exchange rate is calculated by adding one-month forward points to the current exchange rate. Forward points are quoted by market making banks, for example, as 640 / 700. Thus, if the current exchange rate is given as 14.22 South African Rand per US Dollar (ZAR/ US$), the forward exchange rate would be 14.29 ZAR/ US$ (SAIFM, 2017). Now adding the finance and discharging cost gives the Free-On-Rail (FOR) cost at the local port of entry. Finally adding the cost of transporting the soybeans from the harbour to the local silo gives the import parity level (Table 2.3).

Table 2.3 Soybean import parity price calculation[18]

Soybean import parity	Procedure
International price* (US$/MT)	A
Insurance (0.3% of A) (US$/MT)	B
Import tariff** (US$/MT)	C
Freight rate (US$/MT)	D
Cost, Insurance and Freight (CIF) (US$/MT)	(A+B+C+D) = **E**
Exchange rate (ZAR/US$)	F
Cost, Insurance and Freight (CIF) (ZAR/MT)	(E x F) = **G**
Financing cost (ZAR/MT)	H
Discharging cost: Domestic harbour (ZAR/MT)	I
Free On Rail (FOR) (ZAR/MT)	(G + H + I) = **J**
Rail cost: Domestic harbour to Silo (ZAR/MT)	K
Soybean: Import parity (ZAR/MT)	J + K = **L**

Source: SAGIS (2019[b])

During times of excess supply, soybean prices are expected to fall to export parity. Calculated by applying a currency conversion, from the international currency to local currency (using a one-month forward exchange rate) to the competing international fob price at which soybeans are being imported. After which harbour costs, such a loading fees are added, giving the domestic fob price. Lastly a silo premium and the cost of transporting the soybeans from the local silo to the harbour is added, i.e. export parity level (Table 2.4).

Table 2.4 Soybean export parity price calculation[19]

Soybean export parity	Procedure
International price (US$/MT)	A
Exchange rate (ZAR/US$)	B
Harbour costs (ZAR/MT)	C
Domestic FOB price (ZAR/MT)	(A x B) + C = **D**
Transportation cost (ZAR/MT)	E
Silo premium* (ZAR/MT)	F
Soybean: Export parity (ZAR/MT)	(D + E + F) = **G**

Source: Van der Vyver (2018)

[18] * Usually the underlying commodity's free-on-board (fob) price for country of origin.
** Refer to Table 2.6 for the specific import tariff.

[19] * The premium paid over and above the SAFEX price for stock in the specific silo.

2.6.2 South African soybean oil futures contract specifications

As shown in Table 2.5, soybean oil futures, currently trading on SAFEX, are cash settled of a CBOT settlement value, meaning the underlying physical commodity (soybean oil) is not exchanged, only the monetary difference between the trade (willing buyer and seller dealt with each other on the exchange at a mutually agreed quoted price) and closing price. These prices are derived from CBOT soybean oil future prices, while using the US$/ ZAR exchange rate quoted on the currency futures market to convert it from a US$ based to a ZAR based settlement value.

Table 2.5 SAFEX soybean oil future contract specifications as set out by the JSE

Underlying instrument and the determination of the final settlement value
"A soybean oil futures contract meeting all specifications as listed and traded on CBOT, a subsidiary of the CME Group Inc. The JSE reserves the right to amend the contract specifications including settlement methodology should these be amended by the reference exchange." "The final settlement price for cash settlement of the contract will require two components, a CBOT settlement value and a Rand Dollar exchange rate which will be rounded to two decimals."

Source: JSE (2019[b])

However, only 67 soybean oil future contracts traded for July 2019 expiry during the month of May 2019 (representing 1 655 MT of soybean oil), which is only 5% of the 32 878 MT of soybean oil produced in South Africa during the months June and July 2019. While 92 042 May 2019 soybean future contracts (representing 4 602 100 MT of soybeans) traded during the same time period (May 2019), which is 2300% of the 199 152 MT of soybeans crushed during the months of June and July 2019[20] (SAGIS 2019[a and c] & Refinitiv, 2020). Thereby highlighting the liquidity issue (as mentioned in Section 1.2) and the fact that domestic soybean crushing

[20] Soybean crushers would usually buy soybean futures contracts that represents two months of physical stock used in the production of soybean meal and soybean oil, while selling soybean oil futures contract that expires two months after the soybean futures contracts.

plants likely use international soybean oil futures for managing their price risk as opposed to SAFEX soybean oil futures.

2.6.3 Tariffs and levies payable

South Africa utilises import tariffs on soybeans and its by-products to protect local soybean producers and processors from competing imports. Table 2.6 depicts various tariffs being applied to products that originate from countries of different trade regimes, as published by the International Trade Centre (ITC). Argentina forms part of the Mercosur trade regime, meaning import levies of 8% on soybeans, 20% on soybean meal and 10% on soybean oil fob values are payable by the company importing the products from Argentina[21] to South Africa (ITC, 2019 and CFR, 2020).

Table 2.6 Import tariffs according to the ITC

Commodity/ Product	Rate of duty applicable on FOB value				
	GENERAL	**EU**	**EFTA**	**SADC**	**MERCOSUR**
Soybeans	8%	Free	8%	Free	8%
Soybean meal	20%	Free	20%	Free	20%
Soybean oil	10%	Free	10%	Free	10%

Source: ITC (2019)

The South African government also wish to support breeders for developing soybean varieties (Annexure 1) that could improve the country's export earnings and food security in the near future. Therefore, according to Sections 13 and 15 of the Marketing of Agricultural Products Act, a levy of R65/ MT will be payable by the buyer of soybeans, over and above the market price of soybeans, for the period 1 March 2019 to 28 February 2020. Thereafter, a levy of R80/ MT will be payable by the buyer, for the period 1 March 2020 to 28 February 2021. These payments should be made in favour of the South Africa (SA) Cultivar and Technology Agency

[21] The Argentinian government currently (2020) levies an export tax of 30% on the country's soybean, soybean meal and soybean oil exports. However, this is calculated on the fob values, paid by the exporter which subtracts it from the price paid to Argentina producers (USDA, 2016).

by month-end following the month in which the soybeans have been procured (South Africa, 2018).

2.7 CONCLUSION

This chapter achieved its overall objective, giving an in-depth understanding of the interconnective soybean, soybean meal and soybean oil markets, which is known as the most complex and alluding agricultural markets in the country. It also highlighted soybeans as one of the fastest growing summer grain industries in South Africa, with enhanced crop rotation practices, increased crushing capacity and newly implemented subsidies for soybean cultivar development.

Chapter 2 also emphasised the interconnected nature between both domestic and international markets, together with the sensitivities toward various substitutes and relying sectors. Furthermore, this chapter also served as an introduction to comprehend the problem soybean crushing plants face with them unable to utilize domestic soybean oil futures in a similar fashion to those listed internationally for hedging crush margins. As a result, highlighting the need to ensure accurate and adequate transparency in the price formulation for domestic soybean oil futures, in an effort to increase the international competitiveness of the South African futures market in hedging soybean crush margins. Increasing the international competitiveness of the South African futures market for hedging soybean crush margins is essential for achieving the estimated future growth in local soybean production and relying sectors.

CHAPTER 3 LITERATURE REVIEW

3.1 INTRODUCTION

The objective of this chapter is to present the reader with a summarized overview of the development in financial analysis techniques in future markets, followed by key literature studies for evaluating the efficiency characteristics in future markets (both locally and internationally). This, which will be used to identify an appropriate estimation technique for achieving the research objective of this study.

Therefore, Chapter 3 starts off with the development of fundamental and statistical analysis in future markets (Section 3.2). Followed by the works of Eugene Fama, Paul Samuelson and Stephen LeRoy that lead to a hypothesis that formed the cornerstone for evaluating efficiency in future markets (Section 3.3). The third section (Section 3.4) then focusses on regression techniques that were developed and previously used for evaluating the efficiency of commodity futures markets, paying special attention to agricultural commodities.

Since SAFEX is considered a developing or emerging market, market efficiency characteristics in South African agricultural futures has not been investigated extensively (Dreyer, 2019) and as a result this section greatly relies on literature for international commodity futures markets. The chapter is then concluded in Section 3.5.

3.2 PREHISTORY OF FINANCIAL ANALYSIS IN FUTURE MARKETS

John Burr Williams (1938:29-33) and Benjamin Graham and David Dodd (1934:14-41) pioneered the use of fundamental analysis in future markets. Their analysis is based on the principle that the future price of any security tends to converge towards its ‘intrinsic’ or ‘fundamental’ value. Thus, financial advisors recommended participants to buy (sell) a security that is priced below (above) its fundamental value, making a profit in the futures market when the disparity is eliminated. Projecting the fundamental value of listed securities involves the estimation of future supply and demand, the regulatory environment and any information relevant to the security’s future profitability (LeRoy, 1983; Spooner, 1984).

However, Alfred Cowles (1933) demonstrated that these recommendations, presumably based on fundamental analysis, failed to generate sufficient profit in future markets. He argued for new methods, using statistic and probability analysis that could offer more consistent ways of forecasting price actions in future markets. Hereafter, Holbrook Working (1934) developed the Random Walk Hypothesis (RWH) which states that successive price changes are independent. But if this were the case, any pattern of sequential price variation would be an illusion (Kendall, 1953), leaving as many questions unanswered as it resolved. Hence, the need for further research led to the so-called Efficient Market Hypothesis (EMH).

3.3 THE EFFICIENT MARKET HYPOTHESIS

Proponents of the EMH believe it constitutes the cornerstone of financial markets (Delcey, 2019). That said, Eugene Fama (1965[a]) is known to have pioneered the term ‘efficient market’ as a market where prices always ‘fully reflect’ available information, replacing the RWH by Holbrook Working. Fama suggests that independence within a given security would incorporate a price mechanism that fails to predict the true nature of financial markets. Partly because the market has two types of sophisticated participants: (1) those that are more capable at estimating the effect of new-market information on the fundamental value of a security, while (2) others are more capable at doing statistical analysis of price behaviour. Thus, these participants would exploit any discrepancies that exist between the future price of a security and its fundamental value, causing efficient market prices to fluctuate randomly around its fundamental value.

However, Paul Samuelson (1965) first analysed the role of current future contract prices as an estimator for spot market prices in commodity markets, proposing the so-called martingale[22] definition of market efficiency. Samuelson argued for a stochastic process[23] (x_t) to be a martingale with respect to a sequence of information sets ($\emptyset_t$). That is, today's future price (x_t) would be the best unbiased estimator of tomorrow's spot market price (x_{t+1}), given a sequence of information sets ($\emptyset_t$), where:

$$\boldsymbol{E(x_t \mid \emptyset_t) = x_{t+1}}$$

Equation 3.1 Generalized market efficiency theorem

Source: Samuelson (1965)

Hereafter, Eugene Fama (1970) expanded his definition of an efficient market, suggesting three forms: (1) *Weak-form:* where historic information is a true reflection of current market prices. (2) *Semi-strong-form:* all publicly available information is fully reflected in current market prices and the (3) *Strong-form:* all information (public & private) are fully reflected in current market prices.

But, according to Stephen LeRoy (1983), the theory of efficient markets is based on economic principles of competitive equilibrium. Hence, analysing efficient financial markets require the assumption that comparative advantage exist from the differences in information that market participants hold (LeRoy, 1983). Meaning, financial markets require participants to express opposite views that arise from their differences in available information, simultaneously quoting both bid and offer prices. For example, if it were universally known that the price of a security listed on a financial market is about to rise, all participants would bid to buy the security beforehand; hence, no offers to sell the security, causing no one to gain from their participation in the future market once the higher price for the security actually materializes. Thus, the optimal condition would be that of a Semi-strong form, since future markets would cease to exist under the strong-form of market efficiency.

[22] A betting strategy used to ensure a favourable outcome with an arbitrarily high probability.

[23] This is a sequence of random variables indexed by time. Meaning, if past conditions were different, we would fail to generate similar variables over the same time period.

3.4 INVESTIGATING THE EFFICIENCY OF COMMODITY FUTURE MARKETS

Most studies employ regression analysis to investigate the efficiency of commodity future markets, i.e. regressing spot market prices on a previous future prices (Singh, 2014). Barry A. Goss (1981) examined the forward pricing role of future markets for copper, tin, lead and zinc, using the OLS estimation procedure, i.e. investigating the linear relationship between a dependent variable and various explanatory variables. Goss considered Samuelson's hypothesis of market efficiency (future prices being unbiased estimators of subsequent spot market prices) under the linear relationship:

$$A_t = \alpha + \beta P_{t-i} + \varepsilon_t$$

Equation 3.2 Implied linear relationship between spot and future market prices

Source: Goss (1981)

with (A_t) being the spot price and (P_t) the three months future price for tin, lead and zinc, *i* = 1, 2 or 3 month lags, (ε_t) the unexplained variation and (t) is the time in months. The regression estimates ($\widehat{\alpha}$, $\widehat{\beta}$, and $\widehat{p}$,), their standard errors, together with $\overline{R^2}$ values, Durbin-Watson and Wallis test statistics, revealed efficient copper, tin and zinc future markets under Samuelson's hypothesis (Goss, 1981).

However, commodity prices usually appear to be integrated of order one, I(1). Meaning, commodity prices are non-stationary and need to be differenced to allow for stationarity. Why is this important? If a series is non-stationary, I(d) where d > 0, the use of OLS may produce spurious results (Granger *et al.*, 1974; Crowder, 1993; and Wooldridge, 2013). Gordon Rausser and Colin Carter (1983) evaluated the efficiency characteristics for US soybean, soybean meal and soybean oil futures using an Autoregressive Integrated Moving Average (ARIMA) procedure, under monthly average prices considered to be non-stationary. This procedure allows for an initial differencing step to render these data variables stationary, after which the researchers used the mean-square error prediction criteria to compare the forecasting accuracy of soybean, soybean meal and soybean oil ARIMA models with those of the CBOT futures market as well as random walk representations. Concluding for the multivariate ARIMA models of soybeans and soybean meal futures to have outperformed the futures market in estimating future market prices, which was not the case for soybean oil ARIMA models. Therefore, identifying possible inefficiencies in the US futures market for soybeans and soybean meal.

Thereafter, Robert Engle and Clive Granger (1987) developed a far superior cointegration regression analysis (recognised as the Engle-Granger Cointegration technique) for testing market efficiency, given non-stationary variables. Aulton, Ennew and Rayner (1997) used this technique to evaluate the efficiency of future markets for agricultural commodities in the United Kingdom (UK), specifically that of wheat, potatoes and pig meat. First, the researchers established the order of integration for each series (wheat, potato and pig meat prices), then proceeded to test for cointegration. Once the respective price series for wheat, potatoes and pig meat were found to be cointegrated the researchers used OLS to test for market efficiency. The results were varied, suggesting efficiency in wheat futures, but inefficiencies in potato and pig meat futures, with inefficiencies being correlated with relatively low volumes of trade (Aulton *et al.*, 1997).

However, Soren Johansen & Katarina Juselius (1990) also derived a cointegration regression analysis, using a maximum-likelihood method for evaluating market efficiency, given non-stationary variables under a k^{th}-order Vector Error Correction (VEC) model:

$$\Delta Y_t = \varphi D_t + \pi Y_{t-1} + \sum_{i=1}^{k-1} \tau_i \Delta Y_{t-i} + \varepsilon_t$$

Equation 3.3 VEC model for evaluating market efficiency

Source: Johansen *et al.* (1990)

with (Y_t) being an ($n \times 1$) vector and (D_t) a deterministic term of vector seasonal dummy variables, together with (ε_t) being the unexplained variation in the model, which Holly Wang and Ke Bingfan (2005) used to evaluate market efficiency in Chinese wheat and soybean futures. The Johansen's cointegration approach suggested the existence of a long-run equilibrium relationship between Chinese soybean futures prices and underlying cash market prices. However, the researchers failed to find any adequate short-run equilibrium relationships, concluding for efficient Chinese soybean future markets using long-run price information.

Wiseman, Darrock and Ortmann (1999) also applied cointegration regression techniques for testing the efficiency of South Africa's white maize futures market. Analysing whether lagged future prices for the July 1997 and July 1998 white maize future contacts could be used to predict subsequent spot market prices. Their results showed no-cointegration amongst future and spot market prices for the earlier and less liquid July 1997 white maize futures contract, but the existence of a long-run cointegrating relationship between future and spot market prices for the July 1998 white maize futures contract with higher market liquidity. Hence, the increase in liquidity could improve market efficiency (Wiseman *et al*., 1999).

Kerry McCullough and Barry Strydom (2013) also used the Engle-Granger cointegration approach to re-evaluate the efficiency of the South African white maize futures market. However, contrary to the study conducted by Wiseman *et al.* (1999), McCullough and Strydom applied a natural log transformation to the data sets. This would address possible issues that may arise from non-linear relationships between data variables (Wooldridge, 2013). The researchers were also able to acquire near spot price data for longer time periods that was not available in earlier studies. Hence, the study produced different results, showing the existence of long-run co-integrating relationships and ultimately an efficient futures market for white maize in South Africa (McCullough *et al*., 2013).

3.5 CONCLUDING REMARKS

This chapter managed to provide the reader with literature on the development of financial analysis techniques. It also presented literature on the development of the EMH, suggesting Eugene Fama's semi-strong form of market efficiency, where all publicly available information is fully reflected in current market prices as the cornerstone for evaluating the efficiency of commodity futures markets. Chapter 3 also achieved its objective, presenting literature for evaluating the efficiency characteristics in futures markets, which presented the Engle-Granger cointegration approach as an appropriate estimation technique to evaluate and identify possible misspecification in SAFEX soybean oil futures.

Despite limited literature available, previous studies on South African futures markets did establish long-run co-integrating relationships amongst futures market prices. However, published research to date have failed to establish adequate co-integrating relationships in the short-run, which might persist in this study due to the interconnective nature between a mathematical expectation and one's emotional state for short term decisions in financial markets. Furthermore, previous studies also suggest using time series data over longer time periods, which would accommodate for varying production and economic anomalies within the agricultural sector over time.

CHAPTER 4 METHODOLOGY

4.1 INTRODUCTION

This overarching objective of this chapter is to present both theoretical and empirical aspects of this study's research method. Consisting of four sections, Chapter 4 starts off with a theoretical framework (Section 4.2), explaining the procedure for estimating soybean oil import parity levels, justifying the variables used for the regression analysis, followed by the concept of cointegration. The second section provides the reader with an empirical framework (Section 4.3), specifying the data variables, expected signs and the data sources of the study. The third section provides a theoretical overview of the estimation technique (Section 4.4). Followed by the fourth and final section that concludes the chapter (Section 4.5).

4.2 THEORETICAL FRAMEWORK

4.2.1 Soybean oil price formulation

As mentioned in Sections 1.2 and 2.6, South Africa is considered a net importer of soybean oil. Hence, soybean oil future prices would usually trade at or near import parity, as set out in Table 4.1. Taking the CBOT fob value that's quoted in US cents (USc) per pound (lbs) to US$ per MT and adding the Argentinian premium[24], giving the Argentina fob value in US$ / MT. Then, adding the insurance, freight and import tariff (refer to Section 2.6.1) that is usually fixed and rarely changes, brings one to the CIF value in US$ / MT. Converted to ZAR / MT using a one-month forward exchange rate and adding the finance and discharging costs takes it to the FOR value in ZAR / MT. Finally adding the cost of transporting the imported soybean oil from the

[24] The value that Argentina fob trades over or below the CBOT values. These values are quoted by broker dealers and do not trade on a formal exchange.

harbour to Randfontein[25], while accounting for a local discount or premium (premium when aggregate demand exceeds aggregate supply and a discount when aggregate supply exceeds aggregate demand) takes one to the Randfontein import parity value, and ultimately the estimated price for South African soybean oil futures trading on SAFEX.

Table 4.1 Estimating soybean oil import parity (R/MT)[26]

Soybean Oil	Procedure	Example
CBOT FOB value (USc/lbs)	A	34.77
Conversion (US$/MT)*	A x 22.0467 = B	766.56
Argentina Premuim/discount (US$/MT)**	C	28.66
Argentina FOB value (US$/MT)	**(B+C) = D**	**795.22**
Insurance (US$/MT)	D x 0.3% = E	2.39
Freight rate (US$/MT)	F	60.00
Import tariff (US$/MT) (@ 10%)	D x 10% = G	79.52
Cost, Insurance & Freight (CIF) (US$/MT)	**(D+E+F+G) = H**	**937.13**
Exchange rate (ZAR/US$)	I	14.17
Cost, Insurance & Freight (CIF) (ZAR/MT)	**(H x I) = J**	**13 279.17**
Financing cost (ZAR/MT)	K	128.00
Discharging cost: Durban harbour (ZAR/MT)	L	50.00
Free-On-Rail (FOR) Durban (ZAR/MT)	**(J+K+L) = M**	**13 457.17**
Transport cost: Durban to Crushing Plant (ZAR/MT)	N	200.00
Soybean Oil: Discount/Premuim (ZAR/MT)	P	-
Soybean Oil: Import Parity (ZAR/MT)	**(M+N+P) = O**	**13 657.17**

Source: Refinitiv (2020)

However, this study will only use the CBOT fob, Argentina fob and the ZAR/ US$ exchange rate variables to evaluate possible misspecification in South African soybean oil futures, since these are the only values that vary from one day to the next (Nordier, 2018[a]), complying with the requirement of sample variation in explanatory variables for regression analysis (Wooldridge, 2013).

[25]Randfontein is the JSE's reference delivery point, meaning the transport cost (location differential) form the JSE to Randfontein is zero.

[26] * (USc / pound (lbs)) x 22.0467 = US$/MT (CME, 2015).

** This is the value that Argentina fob prices trades above or below the CBOT price.

4.2.2 Understanding the concept of cointegration

First, consider the difference between non-stationary and stationary time series data variables. Non-stationary time series data variables are those with varying mean, variances and covariances, trending upwards or downwards over time. Furthermore, non-stationary variables contain one or more unit roots (d), also known as the order of integration, where data variables are said to be integrated of order d, containing d number of unit roots, written as I(d), if after being differenced d times it becomes stationary. Therefore, stationary time series data variables do not contain a unit root, and are considered as integrated of order zero, I(0), having a constant mean, variance and covariances over time (Wooldridge, 2013).

Now consider Michael P. Murray's (1994) tale of the drunk and her dog. A drunk lady (Y_t) steps out of a bar with her dog (X_t). The lady follows a random walk, while her dog wanders aimlessly without a leash, moving further apart with the passing of time (both Y_t and X_t are non-stationary variables) where it becomes more and more difficult to estimate the distance between them. But if the drunk lady holds the dog on leash (ε_t) they could only move as far from each other as the leash allows them to. Therefore, cointegration is the event were the leash (ε_{tz}), a residual[27] in the long-run equilibrium relationship[28] between the drunk lady and her dog, is stationary. This coincides with the formal definition by Clive W.J. Granger, (1981) for cointegration as the event were the residual term (ε_{tz}) in a long-run equilibrium relationship of two or more non-stationary data variables ($x_{t1}, x_{t2,\dots,}x_{tz,}$ *for all integers* $z \geq 1$*; and* Y_1) that are integrated of order one, I(1):

$$Y_1 = \alpha + \beta x_{t1} + \beta x_{t2} + \cdots + \beta x_{tz} + \varepsilon_{tz} ,$$
$$t = 1,2 \dots , Z \ \ with \ \ Y_1 \sim I(1) \ \& \ x_t \sim I(1)$$

Equation 4.1 Cointegration amongst various first order non-stationary data variables

Source: Granger *et al.* (1981) & Wooldridge (2013)

[27] Residual is the difference between the actual and estimated value of a variable.

[28] A linear combination of two or more time series data variables: $x_{t1}, x_{t2,\dots,}x_{tz,}$ for all integers $z \geq 1$; and Y_1 .

is proofed to be stationary, I(0), using Equation 4.2 under the null hypothesis of $\rho^* = 0 \sim non - stationary\ residuals$ (Wooldridge, 2013).

$$\Delta\varepsilon_{tz} = \rho^*\varepsilon_{t-1} + \sum_{i=1}^{\rho-1} \rho_i^*\Delta\varepsilon_{t-i} + \omega_t, \qquad where\ \omega_t\ is\ I(0)$$

Equation 4.2 ADF stationarity test with no intercept or trend

Source: Wooldridge (2013)

4.3 EMPIRICAL FRAMEWORK

4.3.1 Definition of data variables

Daily closing prices for spot month[29] South African soybean oil futures (SA_OILS) quoted in ZAR/ MT as published by the JSE (JSE, 2019[c]).

Daily fob closing prices for spot month CBOT soybean oil futures (US_OILS) quoted in USc/ lbs as published by Refinitiv, on a Thomson Reuters DataStream subscription (Refinitiv, 2020).

Daily fob closing prices for spot month Argentina soybean oil futures (ARG_OILS) quoted in US$/ MT as published by Refinitiv, on a Thomson Reuters DataStream subscription (Refinitiv, 2020).

Daily closing ZAR/ US$ (ZAR) exchange rate quotes as published by Refinitiv, on a Thomson Reuters DataStream subscription (Refinitiv, 2020).

[29] The spot month in futures markets refer to the earliest month on which a listed future would expire (cash settled futures) or become deliverable (physical settlement futures) (CME, 2015 & JSE, 2019[b]).

4.3.2 Expected signs

As mentioned in Sections 2.6.2 and 4.2.1, South African soybean oil future prices usually trade at or near import parity levels. Therefore, we expect a positive relationship between South African, CBOT fob and Argentina fob soybean oil future prices. Furthermore, CBOT fob and Argentina fob price are quoted in a US denominated currency, hence, there should also be a positive relationship between South African soybean oil future prices and the ZAR/ US$ exchange rate.

4.3.3 Data sources

Daily time series data for the period 25 June 2010 to 27 September 2019 was taken from a Thomson Reuters DataStream subscription, one of the world's leading and most reliable sources of financial data (Refinitiv, 2020), in combination with daily time series data retrieved from the JSE's website (JSE, 2019[c]), giving 2 313 observations for each variable.

4.4 ESTIMATION TECHNIQUE

As mentioned in Section 3.4, Robert Engle and Clive Granger developed a cointegration procedure (recognised as the Engle-Granger Cointegration technique) for testing market efficiency with first order integrated data variables. Starting with unit root tests to determine the order of integration for all data variables (Section 4.4.1), followed by cointegration tests to verify the existence of long-run equilibrium relationships (Section 4.4.2). Then estimating short-run equilibrium relationships or ECMs (Section 4.4.3), followed by various diagnostic tests (Section 4.4.4), paying special attention to Ramsey's RESET test for possible misspecification (Engle *et al.*, 1987).

4.4.1 Unit root tests

The Engle-Granger Cointegration technique requires time series data variables to portray a common order of integration for establishing stationarity amongst data variables (Engle *el al.*, 1987). Time series data is considered stationary if for every group of time indices $1 \leq T_1 < T_2 < \ldots < T_n$, the joint distribution of data variables $(x_{t1}, x_{t2, \ldots}, x_{tn})$ is similar to the joint distribution of $(x_{t1+z}, x_{t2+z, \ldots}, x_{tn+z})$ for all integers $z \geq 1$, meaning their mean, variance and covariances are constant over time. As mentioned in Section 4.2.2, non-stationary time series data variables are those with varying mean, variances and covariances over time, producing spurious results, causing the validity of the standard assumptions to be questioned. This is because the F test statistic (F-statistic) and t test statistic (t-statistic) values will not follow their normal distributions (Wooldridge, 2013).

Consider one of the most recognized non-stationary time series distributions, a random walk with a drift:

$$Y_t = \gamma + \gamma_{t-1} + \varepsilon_t , t = 1,2, \ldots,$$

Equation 4.3 Random walk time series distribution with a drift

Source: Wooldridge (2013)

which could be made stationary by differencing the model, using the first order autoregressive process, giving:

$$Y_t = \theta\gamma_{t-1} + \varepsilon_t , t = 1,2, \ldots,$$

Equation 4.4 Linear time series distribution

Source: Wooldridge (2013)

Then, if and only if $1 < \theta < -1$, Equation 4.4 will be rendered stationary. The study will start off with a visual inspection test, similar to that of Figure 4.1, with the ZAR time series data displaying a typical non-stationary trend, after being differenced the data set becomes stationary (constant mean, variance and covariance over time).

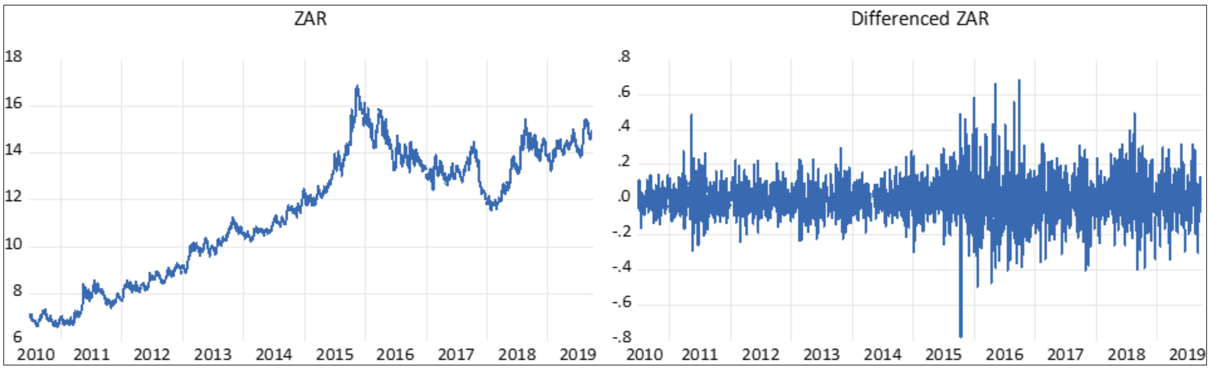

Figure 4.1 Visual representation of stationary vs. non-stationary time series data

Source: IHS Markit (2017)

Thereafter, the study will employ the most widely used formal unit root tests in economic literature, the Augmented Dickey Fuller (ADF) and Phillips Perron (PP) tests for testing stationarity amongst the time series data variables (refer to Section 4.3.1) (Wooldridge, 2013). The ADF test is based on the null hypothesis that an underlying time series data variable is integrated of order one, I(1). That is, it contains a unit root and need to be differenced once, after which it becomes stationary and tested under three possible structures. A random walk with a drift, Equation 4.3, a random walk without a drift, Equation 4.5, and a deterministic trend with a drift, Equation 4.6.

$$Y_t \;=\; \gamma_{t-1} + \;\varepsilon_t\, , t = 1,2, \ldots,$$

Equation 4.5 Random walk time series distribution without a drift

Source: Wooldridge (2013)

$$Y_t \;=\; \alpha + \;\beta t + \varepsilon_t\, , t = 1,2, \ldots,$$

Equation 4.6 Time series distribution with a deterministic trend and a drift

Source: Wooldridge (2013)

Table 4.2 sets out the ADF test used to ensure stationarity amongst SAFEX soybean oil prices (SA_OILS), evaluating the t-statistic against critical values of the 1%, 5% and the 10% levels of significance. SA_OILS produced an ADF t-statistic of -0.79. This is greater than the -1.62, -1.94 and -2.57 at the 10 %, 5 % and 1 % levels of significance. Hence, we fail to reject the null hypothesis of SAFEX soybean oil prices (SA_OILS) to be I(1) and conclude that SA_OILS has a unit root, which is considered to be stationary.

Table 4.2 Augmented Dickey Fuller (ADF) Unit Root Test on level SAFEX soybean oil prices

Null Hypothesis: SA_OILS has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=26)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.792590	0.3729
Test critical values:	1% level	-2.565963	
	5% level	-1.940961	
	10% level	-1.616607	

*MacKinnon (1996) one-sided p-values.

Source: IHS Markit (2017)

Peter C.B. Phillips and Pierre Perron (1988), developed the PP test, following the ADF test for stationarity. The PP test allows a wide range of weakly dependent and heterogeneously distributed data variables (potential regression bias as a result of omitted variables where the dependent variable is correlated with the residual term) to be tested for stationarity (Phillips *et al.*, 1988 and Wooldridge, 2013). It is evaluated against the same three structures as in Equation 4.3, Equation 4.5 and Equation 4.6 using non-parametric methods to solve possible serial correlation amongst residual terms in the absence of lagged variables.

Table 4.3 sets out the PP test that follow the ADF test used to ensure stationarity for SA_OILS, amid possible heterogeneity bias. We would fail to accept the null hypothesis of SA_OILS having a unit root (being non-stationary), if the PP t-statistic is smaller than the critical values at the 1%, 5% and 10%, levels of significance. Contrary to the ADF t-statistic, we notice the

PP t-statistic of -0.79 being greater than -1.62 (10% level of significance), -1.94 (5% level of significance) and -2.57 (1% level of significance), pointing towards stationarity.

Table 4.3 Phillips Perron (PP) unit root test on level SAFEX soybean oil prices

Null Hypothesis: SA_OILS has a unit root
Exogenous: None
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-0.794011	0.3722
Test critical values:	1% level	-2.565963	
	5% level	-1.940961	
	10% level	-1.616607	

*MacKinnon (1996) one-sided p-values.

Source: IHS Markit (2017)

Therefore, SA_OILS need to be differenced (Table 4.4), giving a PP t-statistic of -46.97, which is smaller than -1.62 (10% level of significance), -1.94 (5% level of significance) and -2.57 (1% level of significance), substantiating non-stationarity after being differenced.

Table 4.4 Phillips Perron (PP) unit root test on differenced SAFEX soybean oil prices

Null Hypothesis: D(SA_OILS) has a unit root
Exogenous: None
Bandwidth: 12 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-46.96809	0.0001
Test critical values:	1% level	-2.565963	
	5% level	-1.940961	
	10% level	-1.616607	

*MacKinnon (1996) one-sided p-values.

Source: IHS Markit (2017)

4.4.2 Engle-Granger cointegration test

The Engle-Granger cointegration test is a relatively simple test that is used to identify the presence of a long-run co-integrating relationship amongst variables (Wooldridge, 2013). This study will test whether the residual (ε_{USt}) from a linear combinations of data variables underlying the specifications of South African soybean oil futures (Section 2.6.3) using CBOT fob soybean oil future prices, Equation 4.7, and the residual (ε_{ARGt}), substituting CBOT with Argentina fob soybean oil future prices, Equation 4.8, are stationary, I(0).

$$SA\_OILS_t = US\_OILS_t + ZAR_t + C_{US}{}^{30} + \varepsilon_{USt}, \quad t = 1,2 \dots 2313$$

Equation 4.7 Linear combination of data variables underlying the specifications of SAFEX soybean oil futures using CBOT fob values

$$SA\_OILS_t = ARG\_OILS_t + ZAR_t + C_{ARG}{}^{31} + \varepsilon_{ARGt}, \quad t = 1,2 \dots 2313$$

Equation 4.8 Linear combination of data variables underlying the specifications of SAFEX soybean oil futures using Argentina fob values

Using a long-run relationship to evaluate the null hypothesis of no-cointegration, using the underlying p-values at the 1%, 5% and 10% levels of significance,

4.4.3 Estimating the Error-Correction-Model (ECM)

Once cointegration amongst these linear combinations, Equation 4.7 and Equation 4.8, has been established, can we estimate the Error-Correction Model's (ECM's), using the lagged

[30] Constant parameter of the regression model that describe the direction and strength of the relationship between South African soybean oil future contract prices and the variables used to estimate South African soybean oil future contract prices (Wooldridge, 2013).
[31] Constant parameter of the regression model that describe the direction and strength of the relationship between South African soybean oil future contract prices and the variables used to estimate South African soybean oil future contract prices (Wooldridge, 2013).

residuals (ε_{USt-1} & ε_{ARGt-1}) from the long-run co-integrating relationships, together with the first difference forms (D):

$$D(SA\_OILS_t) = \varepsilon_{USt-1} + D(US\_OILS_t) + D(ZAR_t) + C_{US}, \quad t = 1,2 \dots 2313$$

Equation 4.9 ECM for the data variables underlying the specifications of SAFEX soybean oil futures using CBOT fob values

$$D(SA\_OILS_t) = \varepsilon_{ARGt-1} + D(ARG\_OILS_t) + D(ZAR_t) + C_{ARG}, \quad t = 1,2 \dots 2313$$

Equation 4.10 ECM for the data variables underlying the specifications of SAFEX soybean oil futures using Argentina fob values

Correcting any disequilibrium that might have occurred in the previous period $(t-1)$, outlying the short-run equilibrium relationship, where the coefficients indicate the speed of adjustment towards equilibrium.

4.4.4 Diagnostic tests

This study employed a range of diagnostic tests as a theoretical justification for the interpretation of results. This included a test by Carlos Jarque and Anil Bera (1987), known as the Jarque-Bera test for normality, measuring the difference in kurtosis (the sharpness of a distribution's peak) and skewness of a time series variable to those from normally distributed random variables, under the null hypothesis of a symmetric and mesokurtic distributed series. Followed by White's test for heteroskedasticity, a langrage multiplier test, developed by Halbert White (1980), to ensure equality amongst variances under the null hypothesis of no heteroskedasticity. When $Var(\varepsilon|x)$ depends on *x*, the residual (ε) exhibits heteroskedasticity, which could invalidate standard inference procedures (Wooldridge, 2013).

Then using Trevor Breusch (1978) and Leslie Godfrey (1978) tests as one, known as the Breusch-Godfrey Lagrange Multiplier (LM) test for serial correlation (autocorrelation) under the null hypothesis of no autocorrelation up to the p^{th} order. Autocorrelation exists where there is some correlation amongst residuals of different time periods, which could render spurious results (Wooldridge, 2013). Finally using Ramsey's RESET test, developed by James Ramsey (1969), for identifying possible misspecification in terms of inclusion of irrelevant variables or the exclusion of relevant variables, while evaluating the correlation between the estimators and residual terms.

4.5 CONCLUSION

In conclusion, the chapter achieved its objectives. Presenting the theoretical framework of this study, which explained the process of estimating South African soybean oil prices as a basis from which the required data variables were chosen. Thereafter, explaining the difference between stationary and non-stationary data variables, in conjunction with cointegration amongst data variables. Followed by the empirical framework which defined the various data variables, together with an economic interpretation of the expected signs and a brief overview of the data sources.

Thereafter, the chapter presented the estimation technique to be used, starting off with a theoretical overview of the various unit root tests, which will be used to ensure all data variables are integrated of the same order as a requirement for the Engle-Granger cointegration approach used to evaluate the existence of potential long-run equilibrium relationships amongst the proposed combination of data variables as set out in the explanation of the price formulation of South African soybean oil future prices. Chapter 4 also managed to explain the method for identifying any short-run equilibrium relationships, including the various diagnostic tests used as a theoretical justification for the interpretation of results (including Ramsey's RESET test for identifying possible misspecification amongst the linear combination of data variables in both long-run and short-run equilibrium relationships).

CHAPTER 5 PRESENTATION OF FINDINGS AND INTERPRETATION OF RESULTS

5.1 INTRODUCTION

The purpose of this chapter is to provide the estimation results, which will be used to achieve the study's research objective, i.e. identifying possible misspecification in SAFEX soybean oil futures contracts. Chapter 5 starts off with informal (graphical) and formal (ADF and PP) unit root tests (Section 5.2). This is followed by the Engle-Granger cointegration test results in Section 5.3, identifying and evaluating possible long-run equilibrium relationships between the constituents of SAFEX soybean oil futures prices, after which the study tries to identify and evaluate possible short-run equilibrium relationships amongst the same variables (Section 5.4). Then in Section 5.5, the study employs a range of diagnostic tests as a theoretical justification for both long-run and short-run equilibria that may or may not exist. Lastly some concluding remarks are made in accordance with the study's research hypothesis (Section 1.4) in Section 5.6.

5.2 UNIT ROOT TEST RESULTS

Figure 5.1 depicts a visual representation of SA (exchange traded), US (fob) and Argentina (fob) soybean oil prices, together with the ZAR/US$ exchange rate. Notice the downward trend in US and Argentina soybean oil prices, alongside a prevailing upward trend in the ZAR/ US$ exchange rates, with a slight upward trend in SA soybean oil prices, accompanied by various structural breaks (unexpected changes over time). This suggest that the mean, variance and covariance for these data variables seem to vary across time. After being differenced in Figure 5.2, the data series become stationary with constant means, variances and covariances over time, substantiating non-stationarity amongst the data variables in level form.

Figure 5.1 Visual representation of SA, US and Argentina soybean oil prices alongside the ZAR/ US$ exchange rates in level form

Source: IHS Markit (2017)

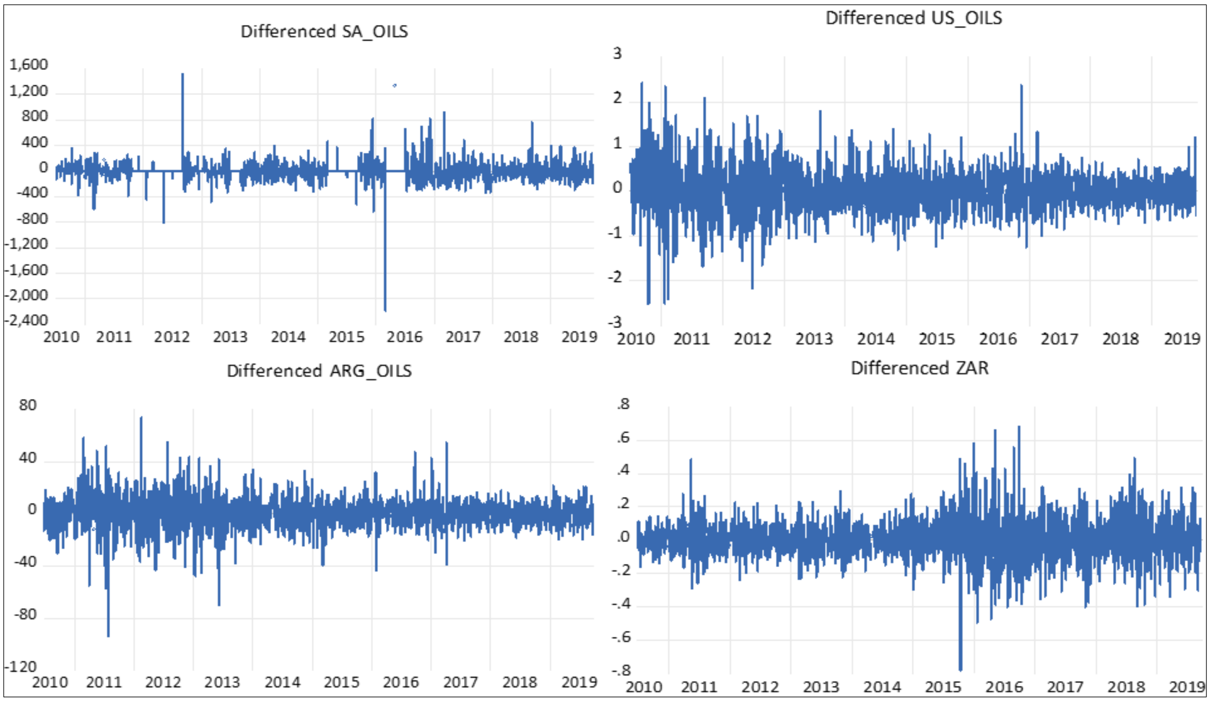

Figure 5.2 Visual representation of SA, US and Argentina soybean oil prices alongside the ZAR/ US$ exchange rates in differenced form

Source: IHS Markit (2017)

Figure 5.3 depicts the visual representation of SA soybean oil future trading volumes, with no clear indication of stationarity or non-stationarity characteristics. Emphasising, the importance of employing the formal ADF and PP unit root tests to confirm these results.

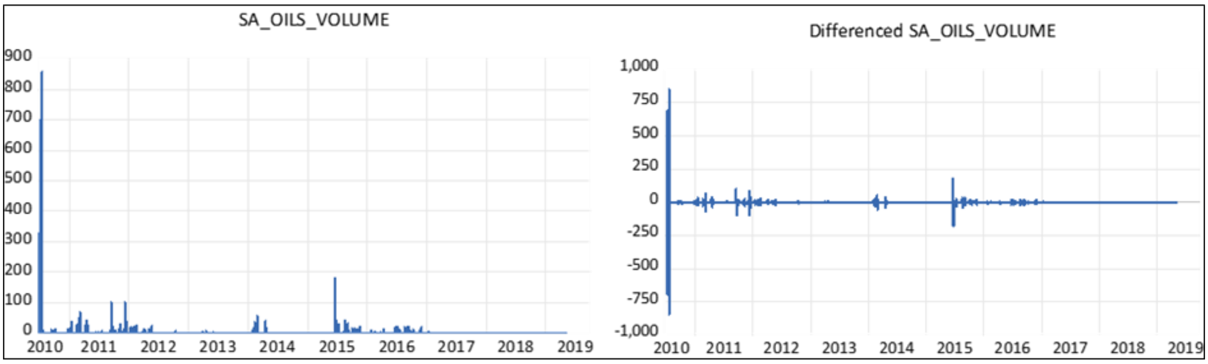

Figure 5.3 Visual representation of SA soybean oil futures trading volumes in level and differenced form

Source: IHS Markit (2017)

Tables 5.1 to 5.3 depicts the ADF and PP unit root test results for all the time series data variables used in this study. Both the ADF and PP tests strongly agree that SA, US and Argentina soybean oil prices, including the ZAR/ US$ exchange rates are non-stationary in level form, after becoming stationary once differenced, hence I(1). However, SA soybean oil futures trading volumes seem to be stationary in both the level and differenced form, hence I(0). But cointegration tests require all data variables used to be of the same order of integration. Thus, the study will focus on I(1) data variables, excluding SA soybean oil futures trading volumes in the cointegration analysis.

Table 5.1 ADF and PP unit root test results for SA, US and Argentina soybean oil prices in level and differenced form[32]

	Model	Augmented Dickey-Fuller (ADF)		Phillips-Perron (PP)		Conclusion
		Lags	τ_τ , τ_μ , τ	Band-width	PP	
sa_oils	Trend & intercept	0	-3.01	6	-3.09	Non-stationary
	Intercept	0	-2.82*	6	-2.90**	
	None	0	-0.79	11	-0.79	
Δsa_oils	Trend & intercept	0	-46.97***	12	-46.97***	Stationary
	Intercept	0	-46.97***	12	-46.97***	
	None	0	-46.97***	12	-46.97***	
us_oils	Trend & intercept	0	-1.55	10	-1.57	Non-stationary
	Intercept	0	-1.43	11	-1.43	
	None	0	0.07	12	0.07	
Δus_oils	Trend & intercept	0	-47.40***	13	-47.40***	Stationary
	Intercept	0	-47.40***	12	-47.40***	
	None	0	-47.40***	12	-47.40***	
arg_oils	Trend & intercept	0	-1.64	1	-1.56	Non-stationary
	Intercept	0	-1.59	1	-1.56	
	None	0	-0.05	3	-0.023	
Δarg_oils	Trend & intercept	0	-50.61***	0	-50.61***	Stationary
	Intercept	0	-50.61***	0	-50.61***	
	None	0	-50.62***	0	-50.62***	

Source: IHS Markit (2017)

Table 5.2 ADF and PP unit root test results for SA soybean oil futures trading volumes in level and differenced form[33]

	Model	Augmented Dickey-Fuller (ADF)		Phillips-Perron (PP)		Conclusion
		Lags	τ_τ , τ_μ , τ	Band-width	PP	
sa_oils_volume	Trend & intercept	0	-46.28***	35	-51.38***	Stationary
	Intercept	0	-46.02***	35	-51.54***	
	None	0	-45.83***	35	-51.75***	
Δsa_oils_volume	Trend & intercept	10	-23.81***	30	-262.36***	Stationary
	Intercept	10	-23.76***	30	-262.39***	
	None	10	-23.75***	30	-262.44***	

Source: IHS Markit (2017)

32 * Statistically significant at a 10% level
** Statistically significant at a 5% level
*** Statistically significant at a 1% level

33 * Statistically significant at a 10% level
** Statistically significant at a 5% level
*** Statistically significant at a 1% level

Table 5.3 ADF and PP unit root test results for ZAR/ US$ exchange rates in level and differenced form[34]

	Model	Augmented Dickey-Fuller (ADF)		Phillips-Perron (PP)		Conclusion
		Lags	τ_τ , τ_μ , τ	Band-width	PP	
zar	Trend & intercept	0	-2.50	3	-2.50	Non-stationary
	Intercept	0	-0.90	1	-0.90	
	None	0	-1.57	2	-1.57	
Δzar	Trend & intercept	0	-47.47***	3	-47.47***	Stationary
	Intercept	0	-47.48***	3	-47.48***	
	None	0	-47.46***	1	-47.46***	

Source: IHS Markit (2017)

5.3 ENGLE-GRANGER COINTEGRATION RESULTS

5.3.1 Long-run relationships

Table 5.4 together with Equation 5.1, depicts the OLS coefficients and test-statistics for the long-run relationship between SA_OILS, US_OILS and ZAR:

$$SA\_OILS_t = 119.2496(US\_OILS_t) + 481.2402(ZAR_t) - 954.3332, \qquad t = 1,2 \dots 2313$$

Equation 5.1 OLS estimation results for the long-run equilibrium relationship between the data variables underlying the specifications of SAFEX soybean oil futures using CBOT fob values

Source: IHS Markit (2017) & Table 5.4

The Adjusted R-squared ($Adj. R^2$) value of 0.3546 (Table 5.4), indicates that 35.46% of the variation in SA_OILS can be explained by the long-run relationship in Equation 5.1. However,

[34] * Statistically significant at a 10% level
** Statistically significant at a 5% level
*** Statistically significant at a 1% level

according to econometric literature, an $Adj.R^2$ value below 0.7 is considered inconclusive for statistical inference (Wooldridge, 2013).

Table 5.4 OLS long-run regression results using US_OILS

Dependent Variable: SA_OILS
Method: Least Squares
Date: 02/08/20 Time: 07:29
Sample (adjusted): 6/25/2010 5/07/2019
Included observations: 2313 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
US_OILS	119.2496	3.665146	32.53612	0.0000
ZAR	481.2402	13.49457	35.66178	0.0000
C	-954.3332	290.4047	-3.286218	0.0010

R-squared	0.355186	Mean dependent var	9201.426
Adjusted R-squared	0.354628	S.D. dependent var	934.9350
S.E. of regression	751.0805	Akaike info criterion	16.08220
Sum squared resid	1.30E+09	Schwarz criterion	16.08965
Log likelihood	-18596.06	Hannan-Quinn criter.	16.08492
F-statistic	636.2147	Durbin-Watson stat	0.043164
Prob(F-statistic)	0.000000		

Source: IHS Markit (2017)

Table 5.5 together with Equation 5.2 depicts the OLS coefficients and test-statistics for the long-run relationship between SA_OILS, ARG_OILS and ZAR:

$$SA\_OILS_t = 4.368074(ARG\_OILS_t) + 348.7210(ZAR_t) - 1447.371, \quad t = 1,2 \dots 2313$$

Equation 5.2 OLS estimation results for the long-run equilibrium relationship between the data variables underlying the specifications of SAFEX soybean oil futures using Argentina fob values

Source: IHS Markit (2017) & Table 5.5

The $Adj.R^2$ value of 0.3712 (Table 5.5), indicates that 37.12% of the variation in SA_OILS can be explained by the long-run relationship in Equation 5.2.

Table 5.5 OLS long-run regression results using ARG_OILS

Dependent Variable: SA_OILS
Method: Least Squares
Date: 02/08/20 Time: 07:31
Sample (adjusted): 6/25/2010 5/07/2019
Included observations: 2313 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ARG_OILS	4.368074	0.128946	33.87526	0.0000
ZAR	348.7210	9.670804	36.05915	0.0000
C	1447.371	211.2464	6.851576	0.0000

R-squared	0.371772	Mean dependent var	9201.426
Adjusted R-squared	0.371228	S.D. dependent var	934.9350
S.E. of regression	741.3580	Akaike info criterion	16.05614
Sum squared resid	1.27E+09	Schwarz criterion	16.06359
Log likelihood	-18565.93	Hannan-Quinn criter.	16.05886
F-statistic	683.5045	Durbin-Watson stat	0.040192
Prob(F-statistic)	0.000000		

Source: IHS Markit (2017)

Therefore, despite the use of statistical inference, we notice a slightly higher degree of variability in SA_OILS being explained by ARG_OILS (37.12%) as opposed to US_OILS (35.46%) (Table 5.4 and Table 5.5). Furthermore, the coefficients for US_OILS, ARG_OILS and ZAR in Equation 5.1 and Equation 5.2 is positive and economically significant as set out in Section 4.3.2 of this study.

5.3.2 Cointegration results

Table 5.6 presents the Engle-Granger cointegration results for the long-run relationship between SA_OILS, US_OILS and ZAR, alongside a p-value of 0.0008 for the dependant variable SA_OILS. This is less than 0.1, 0.05 and 0.01, meaning we reject the null hypothesis of no-cointegration at a 1% level of significance.

Table 5.6 Engle-Granger cointegration test results using US_OILS

Date: 02/08/20 Time: 07:42
Series: SA_OILS US_OILS ZAR
Sample (adjusted): 6/25/2010 5/07/2019
Included observations: 2313 after adjustments
Null hypothesis: Series are not cointegrated
Cointegrating equation deterministics: C
Automatic lags specification based on Schwarz criterion (maxlag=26)

Dependent	tau-statistic	Prob.*	z-statistic	Prob.*
SA_OILS	-4.991135	0.0008	-49.61058	0.0005
US_OILS	-4.763521	0.0020	-47.73169	0.0007
ZAR	-4.796583	0.0017	-48.53272	0.0006

*MacKinnon (1996) p-values.

Source: IHS Markit (2017)

Table 5.7 presents the Engle-Granger cointegration results for the long-run relationship between SA_OILS, ARG_OILS and ZAR, alongside a p-value of 0.0022 for the dependant variable SA_OILS. This is also less than 0.1, 0.05 and 0.01, hence rejecting the null hypothesis of no-cointegration at a 1% level of significance. Thus, these results indicate that there exists a long-run co-integrating relationship between the variables as set out in Equation 5.1 and Equation 5.2 from the previous section (Section 5.3.1).

Table 5.7 Engle-Granger cointegration test results using ARG_OILS

Date: 02/08/20 Time: 07:45
Series: SA_OILS ARG_OILS ZAR
Sample (adjusted): 6/25/2010 5/07/2019
Included observations: 2313 after adjustments
Null hypothesis: Series are not cointegrated
Cointegrating equation deterministics: C
Automatic lags specification based on Schwarz criterion (maxlag=26)

Dependent	tau-statistic	Prob.*	z-statistic	Prob.*
SA_OILS	-4.735696	0.0022	-45.46134	0.0012
ARG_OILS	-4.254700	0.0115	-36.59748	0.0073
ZAR	-4.192036	0.0140	-35.76034	0.0086

*MacKinnon (1996) p-values.

Source: IHS Markit (2017)

5.4 Error Correction Models

Table 5.8, together with Equation 5.3 represents the ECM and ultimately the short-run dynamics between SA_OILS, US_OILS and ZAR.

$$D(SA\_OILS_t) = -0.008352(\varepsilon_{USt-1}) - 3.899677(D(US\_OILS_t)) + 31.56401\,(D(ZAR_t)) - 1.280483\,,\quad t = 1,2 \ldots 2313$$

Equation 5.3 ECM for the data variables underlying the specifications of SAFEX soybean oil futures using CBOT fob values – Estimation results

Source: IHS Markit (2017) & Table 5.8

This ECM produced an $Adj. R^2$ value of 0.0019, which is far below the minimum requirement of 0.7, hence the study failed to produce a short-run equilibrium relationship amongst SA_OILS, US_OILS and ZAR, as set out in the soybean oil future contract specifications as explained in Section 2.6.2. However, the speed of adjustment coefficient of 0.0083 (absolute value for the coefficient of the lagged residual term) in Table 5.8, seems to be statistically significant at a 5% level of significance, validating economic justification.

Table 5.8 US_OILS ECM results

Dependent Variable: D(SA_OILS)
Method: Least Squares
Date: 02/08/20 Time: 09:37
Sample (adjusted): 6/28/2010 5/07/2019
Included observations: 2312 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESIDUAL_US_OILS(-1)	-0.008352	0.003705	-2.254464	0.0243
D(US_OILS)	-3.899677	5.617512	-0.694200	0.4876
D(ZAR)	31.56401	22.93198	1.376419	0.1688
C	-1.280483	2.761685	-0.463660	0.6429

R-squared	0.003196	Mean dependent var	-1.410900
Adjusted R-squared	0.001901	S.D. dependent var	132.8556
S.E. of regression	132.7293	Akaike info criterion	12.61623
Sum squared resid	40660176	Schwarz criterion	12.62617
Log likelihood	-14580.36	Hannan-Quinn criter.	12.61985
F-statistic	2.466814	Durbin-Watson stat	1.940992
Prob(F-statistic)	0.060448		

Source: IHS Markit (2017)

Table 5.9, together with Equation 5.4 represents the ECM and ultimately the short-run dynamics between SA_OILS, ARG_OILS and ZAR.

$$D(SA\_OILS_t) = -0.014162(\varepsilon_{ARGt-1}) - 0.190757(D(ARG\_OILS_t)) + 34.91252\,(D(ZAR_t)) - 1.266553\,, \quad t = 1,2 \ldots 2313$$

Equation 5.4 ECM for the data variables underlying the specifications of SAFEX soybean oil futures using Argentina fob values – Estimation results

Source: IHS Markit (2017) & Table 5.9

Unfortunately, this ECM also produced an $Adj.R^2$ value (0.0059) far below the minimum requirement of 0.7. But this is higher than the $Adj.R^2$ value of ECM using US_OILS (0.0019), with a speed of adjustment coefficient of 0.0083 (Table 5.8), as compared to the speed of adjustment coefficient of 0.014 (Table 5.9) for the ECM using ARG_OILS. Hence, these results suggest using ARG_OILS instead of US_OILS, since it appears to correct any disequilibrium that might have occurred in the previous period at a faster pace (Wooldridge, 2013), proving greater efficiency under Eugene Fama's semi-strong form of the EMH (Section 3.3 and Section 3.5).

Table 5.9 ARG_OILS ECM results

Dependent Variable: D(SA_OILS)
Method: Least Squares
Date: 02/08/20 Time: 09:38
Sample (adjusted): 6/28/2010 5/07/2019
Included observations: 2312 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESIDUAL_ARG_OILS(-1)	-0.014162	0.003732	-3.794943	0.0002
D(ARG_OILS)	-0.190757	0.233914	-0.815503	0.4149
D(ZAR)	34.91252	22.89167	1.525119	0.1274
C	-1.266553	2.756138	-0.459539	0.6459

R-squared	0.007174	Mean dependent var	-1.410900
Adjusted R-squared	0.005884	S.D. dependent var	132.8556
S.E. of regression	132.4642	Akaike info criterion	12.61223
Sum squared resid	40497911	Schwarz criterion	12.62217
Log likelihood	-14575.74	Hannan-Quinn criter.	12.61585
F-statistic	5.559213	Durbin-Watson stat	1.936767
Prob(F-statistic)	0.000845		

Source: IHS Markit (2017)

5.5 DIAGNOSTIC TEST RESULTS

5.5.1 Long-run equilibrium

Table 5.10 depicts the diagnostic test results for the long-run equilibrium model using US_OILS, Equation 5.1. The Jarque-Bera test for normality produced a test statistic (p-value) of 0.200, hence we fail to reject the null hypothesis of symmetric and mesokurtic distributed series (normally distributed residuals) at a 1% (p-value > 0.01), 5% (p-value > 0.05) and 10% (p-value > 0.1) level of significance. Furthermore, White's test produced a p-value of 0.000, that rejects the null hypothesis at 10% level of significance, concluding the existence of heteroskedasticity (invalidating standard inference procedures). The Breusch-Godfrey's LM test also produced a p-value of 0.000, suggesting serial correlation amongst data variables.

Finally, Ramsey's RESET test produced a p-value of 0.000, rejecting the null hypothesis of no misspecification at a 10% level of significance. Hence the long-run equilibrium relationship between SA_OILS, US_OILS and ZAR seem to exclude relevant time series data variables or include irrelevant time series data variables.

Table 5.10 US_OILS long-run equilibrium diagnostic test results

Test	Test-Statistic	P-value	Conclusion
Jarque-Bera	3.14	0.200	Residuals are normally distributed
White	535.98	0.000	Heteroskedasticity of a high degree
Breusch-Godfrey	2214.88	0.000	Serial correlation up to 1 lag
Ramsey reset	370.60	0.000	Possible misspecification

Source: IHS Markit (2017)

Table 5.11 depicts the diagnostic test results for the long-run equilibrium model using ARG_OILS, Equation 5.2. According to the Jarque-Bera test for normality, the residuals are not normally distributed across time. White's test reveals the presence of heteroskedasticity amongst variables, invalidating standard inference procedures. The Breusch-Godfrey LM test also reveals the existence of serial correlation amongst data variables and most importantly Ramsey's RESET test suggests possible misspecification amongst these time series data variables. Therefore, the long-run equilibrium relationship between SA_OILS, ARG_OILS and ZAR seem to exclude relevant time series data variables or include irrelevant time series data variables.

Table 5.11 ARG_OILS long-run equilibrium diagnostic test results

Test	Test-Statistic	P-value	Conclusion
Jarque-Bera	43.98	0.000	Residuals are not normally distributed
White	168.84	0.000	Heteroskedasticity of a high degree
Breusch-Godfrey	2220.97	0.000	Serial correlation up to 1 lag
Ramsey reset	62.95	0.000	Possible misspecification

Source: IHS Markit (2017)

5.5.2 Short-run equilibrium

Table 5.12 depicts the diagnostic test results for the short-run equilibrium model using US_OILS, Equation 5.3. The Jarque-Bera test for normality produced a test statistic (p-value) of 0.000, which rejects the null hypothesis of normally distributed residuals. Furthermore, White's test produced a p-value of 0.042, that rejects the null hypothesis at 10% level of significance, concluding the existence of heteroskedasticity in some moderate form. The Breusch-Godfrey's LM test produced a p-value of 0.150, hence we fail to reject the null hypothesis of no serial correlation amongst the time series data variables at 10%, 5% and 1% level of significance. Finally, Ramsey's RESET test produced a p-value of 0.401, which is greater than 0.1, hence we also fail to reject the null hypothesis of no misspecification amongst the time series data variables at a 10%, 5% and 1% level of significance. Therefore, the JSE contract specifications for South African soybean oil future contracts does not seem to be mis specified in the short-run.

Table 5.12 US_OILS short-run equilibrium diagnostic test results

Test	Test-Statistic	P-value	Conclusion
Jarque-Bera	233820.30	0.000	Residuals are not normally distributed
White	17.48	0.042	Heteroskedasticity of some moderate form
Breusch-Godfrey	2.07	0.150	No serial correlation up to 1 lag
Ramsey reset	10.53	0.401	No Misspecification

Source: IHS Markit (2017)

Table 5.13 depicts the diagnostic test results for the short-run equilibrium model using ARG_OILS, Equation 5.4. According to the Jarque-Bera test for normality, the residuals are not normally distributed across time. White's test produced a p-value of 0.023, that rejects the null hypothesis at 10% level of significance, also concluding the existence of heteroskedasticity in some moderate form. The Breusch-Godfrey's LM test produced a p-value of 0.123, hence we fail to reject the null hypothesis of no serial correlation amongst the time series data variables at 10 %, 5% and 1% level of significance. Finally, Ramsey's RESET test produced a p-value of 0.032, which is greater than 0.01 but smaller than 0.05. Hence, we accept the null hypothesis of no misspecification at a 1% level of significance but reject the null hypothesis at a 5% and 10% level of significance. Further supporting the statement for South African soybean oil future not being mis specified in the short-run.

Table 5.13 ARG_OILS short-run equilibrium diagnostic test results

Test	Test-Statistic	P-value	Conclusion
Jarque-Bera	231394.00	0.000	Residuals are not normally distributed
White	19.23	0.023	Heteroskedasticity of some moderate form
Breusch-Godfrey	2.38	0.123	No serial correlation up to 1 lag
Ramsey reset	4.04	0.032	Possible misspecification

Source: IHS Markit (2017)

5.6 CONCLUSION

The overarching purpose of this chapter was achieved. Identifying the stationarity amongst the various data variables, using both informal (graphical) and formal (ADF and PP) unit root tests. Thereafter, the Engle-Granger cointegration analysis justified the existence of a co-integrating relationship amongst South African, CBOT and Argentinian soybean oil future prices. But, according to the long-run and short-run equilibrium relationship test statistics, we notice a slightly greater degree of variability in South African soybean oil prices being explained by the use of Argentinian soybean oil future prices as opposed to CBOT soybean oil future prices. Furthermore, the long-run equilibrium relationship between SA_OILS and ARG_OILS, Equation 5.2, produced an $Adj. R^2$ value of 0.3712, while the short-run equilibrium relationship, Equation 5.4, produced an $Adj. R^2$ value of 0.0058, meaning the variation in South African soybean oil prices are better explained by the underlying variables in the long-run as opposed to the short-run, while no statistical inference could be performed, since the $Adj. R^2$ values were below 0.7.

The diagnostic test results in Section 5.5, identified heteroskedasticity, serial correlation and possible misspecification amongst the long-run equilibrium relationships for both CBOT and Argentinian soybean oil future prices. While applying Ramsey's RESET test to the short-run equilibrium relationship between South African and CBOT soybean oil future prices, we noticed no-misspecification amongst the variables as set out in the JSE's contract specifications in the short-run, as opposed to possible misspecification when using Argentinian soybean oil future prices.

CHAPTER 6 CONCLUSION AND RECOMMENDATIONS

6.1 IN A NUTSHELL

As mentioned in Section 1.1 of this study, soybean crushing plants operate on a crush margin, which can be secured beforehand by an effective hedging strategy. However, as explained in Section 1.2, such hedging strategies require a liquid soybean oil futures contract for this to become a reality. Liquidity is considered one of the key criteria for a successful futures contract. Currently this is not the case with SAFEX soybean oil futures, referencing CBOT fob prices (JSE, 2018), which might ignite additional risk factors to a derivative instrument that has been designed to reduce risk.

Section 1.2 also explained that the specifications of futures contracts could influence its efficiency and ultimately contribute to its liquidity and with most of the country's soybean oil being imported from Argentina (SARS, 2019), one would expect SAFEX soybean oil futures to reflect the cost of imported soybean oil from Argentina. Hence, referencing Argentinian fob prices as opposed to CBOT fob prices, should increase the efficiency and liquidity of the SAFEX soybean oil futures contract.

This is analysed under Eugene Fama's semi-strong-efficient market hypothesis, where all publicly available information is fully reflected in current market prices. Using the Engle-Granger cointegration procedure to test whether the residual (ε_{USt}) from a linear combinations of data variables underlying the specifications of South African soybean oil futures using CBOT fob soybean oil future prices and the residual (ε_{ARGt}), substituting CBOT with Argentina fob soybean oil future prices are stationary, I(0). Which can then be used to evaluate the existence of various long-run and short-run equilibrium relationships (Section 5.3).

6.2 CONCLUDING REMARKS

As mentioned in Section 1.2 & 2.6.2, there is very little participation in SAFEX soybean oil futures contracts that, according to its contract specifications, are cash settled of CBOT settlement values, while the majority of the country's soybean oil originates from Argentina. Hence, the study used the Engle-Granger (1987) cointegration approach to evaluate the existence of adequate long and short-run cointegration relationships amongst a linear combination of data variables underlying the current specifications of SAFEX soybean oil futures versus that of an alternative linear combination of data variables that are cash settled of Argentina settlement values. Essentially evaluating its efficiency under Eugene Fama's semi-strong-form of market efficiency (where all publicly available information is fully reflected in current market prices, Section 3.3), attempting to identify possible misspecification by referencing CBOT settlement values as opposed to Argentinian settlement values that could ultimately lead to greater participation and improved liquidity.

The study did however fail to produce statistically significant long and short-run equilibrium relationships between CBOT and Argentina settlement values, despite cointegrating relationships. Hence, it appears that there isn't a significant difference in the accuracy of using Argentinian settlement values as opposed to that of CBOT for estimating subsequent spot market prices for SAFEX soybean oil futures contracts, that usually represents the price at which soybean crushers or importers would sell soybean oil in South Africa. The study then employed a range of diagnostic tests for a theoretical justification of these results. Identifying possible misspecification amongst the variables for both CBOT and Argentinian cash settlement values in the long-run, as-well as Argentinian cash settlement values in the short-run, which was not the case for the CBOT settlement values in the short-run. Thus, pointing towards short-run market efficiency in SAFEX soybean oil futures contracts referencing CBOT settlement values.

In conclusion, SAFEX soybean oil futures contracts that is based on CBOT settlement values does not incorporate all the information used by market participants in forming a prediction of subsequent spot market prices in the long-run. But does however incorporate sufficient information for such practices in the short-run, attracting speculators[35] that hope to profit from short-term price variations in the absence of hedgers (typically soybean crushers) that seek to employ effective long-term hedging strategies. The implication is that South African soybean crushers would most likely continue using more liquid international markets for securing their crushing margin until the country becomes self-sustainable, meeting local demand with local production through an increase in both soybean production and crushing capacity. While simultaneously catering for more players within the soybean crushing industry that would ultimately improve the accuracy and transparency in the price formulation for domestic soybean oil futures in the long-run. Leading the way towards more liquid and self-efficient local physically settled SAFEX soybean oil futures contracts, given the collective participation amongst the majority of these players.

6.3 PROPOSAL FOR FURTHER RESEARCH

The result of the study recommends future research in the following areas:

- Conducting an in-depth analysis for the ease of access into South Africa's soybean industry. Providing policy recommendations that could curb potential oligopolistic market structures and ultimately improve the liquidity and international competitiveness of SAFEX soybean, soybean oil and soybean meal futures contracts.

- The potential for the JSE to list a local physically settled soybean oil futures contract once the country becomes self-sustainable. While identifying the needs of South African soybean crushers, tailoring these contract specifications to meet those needs, while establishing their willingness to utilise such futures contracts.

[35] Speculators are those participants that seek to gain from short-term price movements in future markets, buying and selling futures contracts, within a relatively short time frame. Hoping to earn a monetary profit from their endeavours (SAIFM, 2017).

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ANNEXURE 1

Table A1. 1 Newly developed soybean cultivars suited to warm, moderate and cool production localities

Warm	Moderate	Cool
PAN 1454 R	PAN 1454 R	SSS 5052 (tuc)
PHB 94 Y 80 R	PHB 94 Y 80 R	PAN 1454 R
SSS 5449 (tuc)	SSS 5449 (tuc)	DM 6.8i RR
PHB 96 T 06 R	SSS 6560 (tuc)	SSS 6560 (tuc)
SSS 5052 (tuc)	LS 6248 R	LS 6161 R
LS 6248 R	SSS 5052 (tuc)	LS 6248 R
LS 6161 R	LS 6161 R	PHB 96 T 06 R
NS 6448 R	PHB 96 T 06 R	NS 5909 R
SSS 6560 (tuc)	NS 5909 R	SSS 5449 (tuc)
NS 5909 R	DM 6.8i RR	NS 6448 R
DM 6.8i RR	NS 6448 R	PAN 1623 R
DM 5953 RSF	PAN 1623 R	PHB 94 Y 80 R
PAN 1623 R	DM 5953 RSF	PAN 1521 R
PAN 1521 R	PAN 1521 R	DM 5953 RSF

Source: De Beer (2018) and Own data

Table A1. 2 SAFEX soybean oil future contract specifications (Part 1)

Underlying Instrument
A soybean oil futures contract meeting all specifications as listed and traded on CBOT, a subsidiary of the CME Group Inc. The JSE reserves the right to amend the contract specifications including settlement methodology should these be amended by the reference exchange.
Contract Months
March, May, July, September and December.
Listing Programme
Ensure a minimum of three expiries are always available for trade.

Source: JSE (2019[b])

Table A1. 3 SAFEX soybean oil future contract specifications (Part 2)

Expiry Dates & Times
Last trading date of the contract will be the second last business day preceding the first business day of the contract month at 12h00 South African time. The clearance date of the contract will be the first business day of the contract month. The final cash settlement value will only be finalised and released the following business day after trading has ceased. The final variation margin will therefore be settled one day after last trading day and initial margin returned on the clearance day. The clearance day can further be defined as the day on which all remaining open positions are closed off automatically by the clearing solution.
Determination of the final Cash Settlement Value
The final settlement price for cash settlement of the contract will require two components, a CBOT settlement value and a Rand Dollar exchange rate which will be rounded to two decimals. The CBOT settlement value will refer to an average of 30 iterations referencing trades in the underlying derivative contract, taken every 1 minute for a period of 30 minutes ending 10h30 Chicago time (SA Summer: 18h01–18h30 and SA Winter: 17h01–17h30) on 1st position day, as per the CBOT product calendar. Conversion factor to be applied: 1 metric ton = 2204, 62 pounds. Eg 29 June 2017 for the July2017 expiry. The Dollar Rand exchange rate required to determine the final settlement price in South African Rand per ton will be on the same basis applied to the currency futures market, namely: a 5 minute process with iterations recorded every 30 seconds where the last spot trade within the 30 second interval will be recorded and then averaged over the 5 minute period. The close out process will run from 09h55 to 10h00 New York time. The two variables are calculated to 4 decimals and rounded off to 2 decimals for the final Rand settlement value. Final settlement value is published the following business day. In the event that any of the reference markets are not available to determine the final settlement value, the JSE will consider all relevant facts, information and circumstances to determine the final cash settlement value in order to ensure that it reflects a fair market value.

Source: JSE (2019[b])

Table A1. 4 SAFEX soybean oil future contract specifications (Part 3)

Contract Size
1 contract = 25 metric tons.
Quotations
In South African currency per metric ton.
Minimum Price Movement
20 RSA cents per ton.
Settlement Method
Cash settled in South African Rand (ZAR).
Initial Margin Requirements
Please consult the web page for the latest initial margin requirements. The exchange also provides for calendar spread margin (offset between different expiry months) as well as series spread margin for selected products. It is important to include the difference in the initial margin requirements when determining the total series spread margin.
Daily Mark-to-market
As per the defined Commodity Derivatives mtm process referencing bids, offers and trades on the local SA contract. JSE reserves the right to consider the CBOT or KCBT mtm price from time to time to align expiries that are not liquid.
Exchange Fees
R16.14 per contract (incl VAT).
Daily price limits
No price limits will be applicable.
Position Limits
No speculative position limits apply however the JSE may at its discretion implement limits as per Rule 10.4 and defined in the Derivative Directives.

Source: JSE (2019[b])

ANNEXURE 2

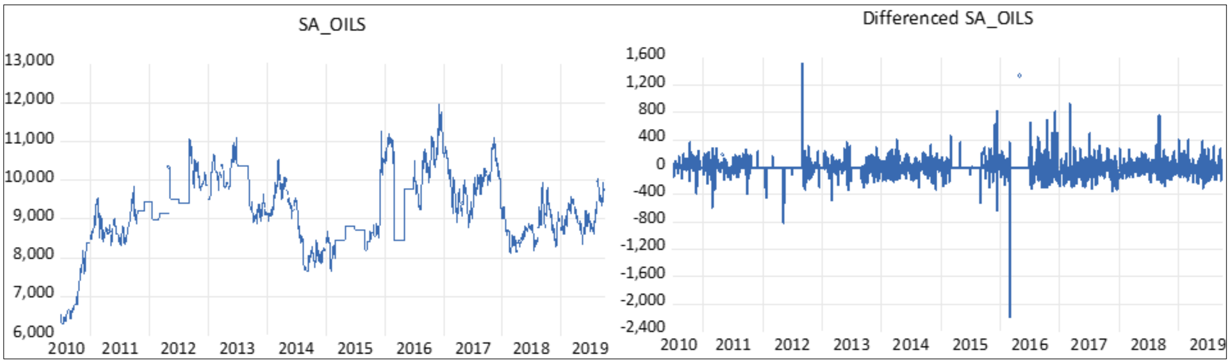

Figure A2. 1 Visual representation of SA_OILS and Differenced SA_OILS data series

Source: IHS Markit (2017)

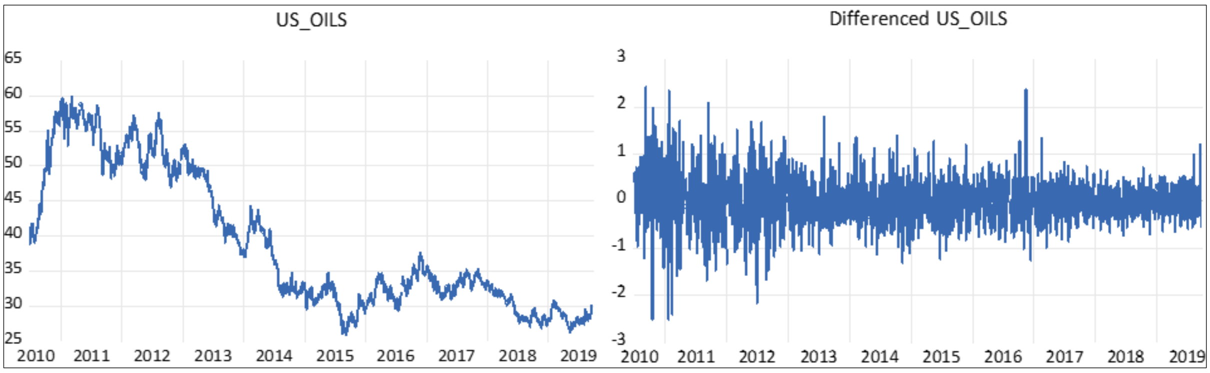

Figure A2. 2 Visual representation of US_OILS and Differenced US_OILS data series

Source: IHS Markit (2017)

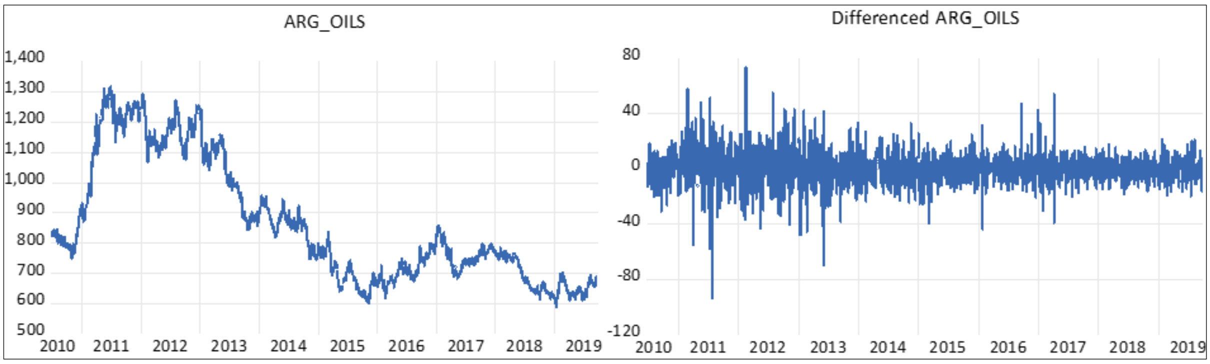

Figure A2. 3 Visual representation of US_OILS and Differenced US_OILS data series

Source: IHS Markit (2017)

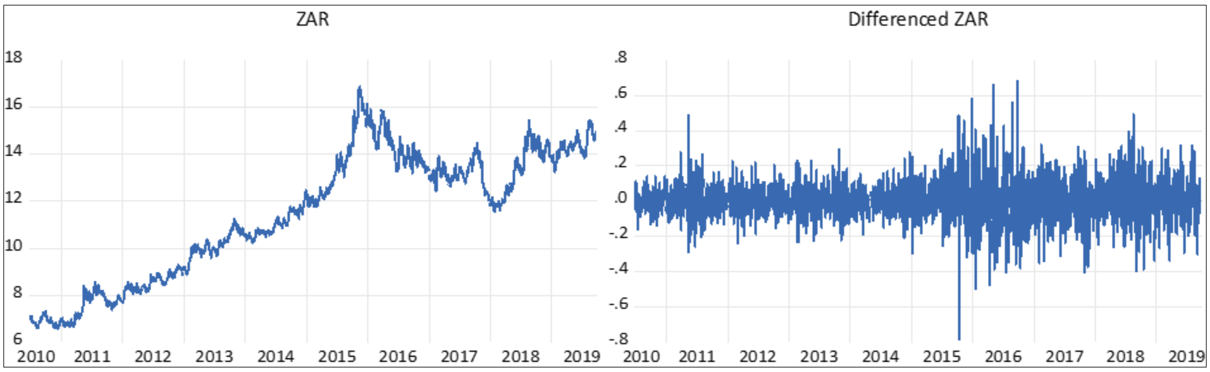

Figure A2. 4 Visual representation of ZAR and Differenced ZAR data series

Source: IHS Markit (2017)