ANALYSING ONION MARKET INTEGRATION IN MAJOR SOUTH AFRICAN FRESH PRODUCE MARKETS, 2009-2019

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ANALYSING ONION MARKET INTEGRATION IN MAJOR SOUTH AFRICAN FRESH PRODUCE MARKETS, 2009-2019

by

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DECLARATION

I, Ndinannyi Mudzunga, hereby declare that the dissertation submitted to the University of Limpopo for the degree Master of Agricultural Management in Agricultural Economics has not previously been submitted by myself for a degree at this or any other University, that it is my own work in design and execution, and that all the material used herein from other authors have been dully acknowledged.

Mudzunga, N (Mrs) **Date**

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DEDICATION

I dedicate this research to my late mother, Mrs Sara Muvhali, for her unwavering confidence in my ability to accomplish anything I set my mind to. May this research also encourage my three children, Zwivhuya Mudzunga, Tshanduko Mudzunga, and Asivhothe Mudzunga, to pursue education and become innovators.

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ABSTRACT

Onion is the third most important staple vegetable in South Africa, due to the gross value of vegetable production and export revenues. Almost all of South Africa's provinces grow onions, but the Western Cape (Ceres), Northern Cape, Free State, North West, and Limpopo provinces are the main producers. Fresh Produce Markets (FPMs) are the primary distribution channel for onions. Onion producers are concerned about the high degree of onion price variations in the FPMs. Markets are essential for the delivery of fresh goods as well as for price development and discovery. The study aims to analyse onion market integration in Cape Town, Bloemfontein, Durban and Johannesburg Fresh Produce Markets.

The study investigated spatial market integration among geographically separated onion markets in South Africa using average monthly prices from January 2009 to December 2019. The Augmented Engle-Granger Cointegration and Error Correction Model (ECM) were employed to examine the presence of market integration among the onion producing and onion consuming markets in the country. The time series analysis revealed that average monthly onion prices in Johannesburg move in together with those in Cape Town, Durban, and Bloemfontein over time, indicating the existence of a cointegration relationship. The ECM findings show that after a shock that causes disequilibrium, it takes economic agents around a month to get back to equilibrium. Price signals are transmitted within a month, which suggests that certain onion markets are well integrated.

Keywords: Fresh Produce Markets, Price, Market Integration, Cointegration, Error Correction Model.

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LIST OF ACRONYMS

ADL	Autoregressive Distributed Lag
AEG	Augmented Engle-Granger
BFPM	Bloemfontein Fresh Produce Market
CTFPM	Cape Town Fresh Produce Market
CV	Coefficient of Variation
DALRRD	Department of Agriculture, Land Reform and Rural Development
DFPM	Durban Fresh Produce Market
ECM	Error Correction Model
GVP	Gross Value of Production
JFPM	Johannesburg Fresh Produce Market
LOP	Law of One Price
NAMC	National Agricultural Marketing Council
FPMs	Fresh Produce Markets
PBM	Parity Bound Model
SACU	Southern African Customs Union
SADC	Southern African Development Community
TAR	Threshold Autoregressive
TECM	Threshold Error Correction Model
TVECM	Threshold Vector Error Correction Model
VAR	Vector Autoregression
VECM	Vector Error Correction Model

CHAPTER 1: INTRODUCTION

1.1 Background

Onions are grown in almost all South Africa's provinces, but the biggest producers are Western Cape (Ceres), Northern Cape, Free State, North West, and Limpopo provinces (DALRRD, 2020). Onion is the third most significant staple vegetable in South Africa, due to the gross value of vegetable production and export revenues largely from the Southern African Development Community (SADC) and Southern African Customs Union (SACU) member countries. According to (DALRRD, 2020), the onion sector in South Africa has contributed more than R2.3 billion to the total gross value of vegetables grown in the country. Additionally, the industry contributes significantly to employment through its different nodes along its value chain. Onion industry operates in a deregulated environment where the prices are determined by the forces of demand and supply and there are no restrictions on the marketing of onions. Onions are supplied all year due to varying planting seasons in the major producing provinces. In South Africa, onions are mostly consumed raw. Onions are frequently used to add flavour to a variety of foods, including casseroles, pizzas, soups, and stews.

According to the United Nations Food and Agriculture Organization (FAOSTAT 2020), China, India, Egypt, the United States, Iran, Bangladesh, and Turkey are the top onion producing countries. Egypt is the only African country ranked among the top five global onion growers. South Africa's onion exports comprised 0.8% of global exports in 2020, while the country's ranking in global exports was 22 and it is the third largest onion exporter in Africa (ITC Trademap, 2020).

In South Africa, onions are distributed through Fresh Produce Markets (FPMs), direct sales to informal traders and retailers, processors and export markets. Fresh Produce Markets are the main marketing channel with over 55% of production output distributed through this platform, followed by direct sales to informal traders and retailers, which accounted for 22%, exports account for 18% whereas only 1% of onion is processed (DALRRD, 2020). FPMs are critical for fresh produce distribution, price development, and price discovery (NAMC, 2006). Major Fresh Produce Markets are Johannesburg, Tshwane, Durban, Cape Town, and Bloemfontein due to the volume supplied and sold in these markets. The processing of onions includes canning, extracting oil, freezing, and dehydrating the onion. South Africa is a net exporter of onion, Mozambique with a 40.1% share of onion export was the primary export market of onion export originating from South Africa. Angola was in second place, followed by Zambia and the Southern African Customs Union (SACU) member countries such as Botswana and Namibia.

1.2 Problem Statement

Since the deregulation of markets in 1997, very little growth in vegetable sales has occurred in the Fresh Produce Markets (FPMs), despite a notable growth in production. The performance of FPMs in relation to agricultural production growth reveals that FPMs are finding it difficult to expand their operations and respond to the challenges of a deregulated agricultural industry. However, Fresh Produce Markets have remained the most efficient system for moving produce from growers to consumers at the best possible price and the loss of market share as the main distributor of fresh produce would reduce their effectiveness in determining the price (NAMC, 2006).

According to the Department of Agriculture, Land Reform and Rural Development (DALRRD, 2019), the national production output for onion has increased from 461 548 tons in 2009 to 723 409 tons in 2019. Despite the slow growth in vegetable sales, the onion industry is still largely dependent on FPMs as a distribution channel and the integration of fresh produce markets is vital. Onion producers are concerned about the high degree of onion price variations in the FPMs. A high price variation in a staple product that is grown all over the country is worrying and could be a sign that markets are not operating well in some locations (Rashid *et.al.,* 2010). The biggest concern is that costs for staple produce in rural areas of the country would rise. Onions are largely consumed fresh and only one percent of production is processed.

Like other vegetable products, onion industry operates in a deregulated environment where the prices are driven by the forces of demand and supply and there are no restrictions on the marketing of onions. In this open marketing environment, onion producers must have knowledge and understanding of the markets. The understanding of price relationships in the markets is important in that it makes it possible for the producer to anticipate the changes that are likely to occur in one market given changes at certain magnitude in a leading market (Rapsomanikis, 2003). This has the potential to improve decision-making among onion value chain role players such as producers, processors, traders and policy makers. The study will also assist producers in which market to supply and assist in managing price risks associated with a particular market. The study aims to analyse onion market integration in Cape Town, Bloemfontein, Durban and Johannesburg Fresh Produce Markets. The study in market integration will improve knowledge of the functioning of Fresh Produce Markets and determine if there is a need for policy interventions.

1.3 Rationale and scope of the study

The proposed study will help analyse historical information, on time series data of onion prices over 11 years (from 2009 to 2019). The proposed study is significant given the importance of onion in food security and its contribution to the South African vegetable gross value. According to (DALRRD, 2019), onions sold through the NFPMs have contributed more than R1.7 billion to the total South African vegetable gross value. South Africa has supplied 78.4% of onion to the Southern African Development Community (SADC) and 19% of the Southern African Customs Union (SACU) onion export (ITC Trade Map, 2019).

Onion producers are still largely dependent on the FPMs as a distribution channel and NFPMs must be integrated for efficient and competitive marketing of products. The understanding of price relationships in the onion markets is important in that it makes it possible for the producer to anticipate the changes that are likely to occur at one market given changes at a certain magnitude at a leading market. This has the potential to improve decision-making among onion value chain role players such as producers, processors, traders and policymakers. The study can also assist producers on which market to supply and assist in managing price risks associated with a particular market. Knowing which onion markets are the most influential will enable policymakers to pay more attention to these markets because of their potential to impact national prices (Paul *et al.,* 2017).

The subject of market integration in the agricultural sector received a lot of attention over the past decade. While so many market integration studies were undertaken in recent years, only very little attention was focused on onion market integration in the South African Fresh Produce Markets. To assess the nature of long-run price links and spatial linkages, Uchezuba (2005) conducted a study on measuring market integration for apples on the South African FPMs. Du Preez (2011) researched the integration of South African potato markets, with an emphasis on price relationships in the South African potato market. The study aimed at determining price relationships and spatial linkages between selected fresh produce markets in South Africa. Du Preez (2011), the study has recommended further research on market integration on other vegetables, specifically the competitor of potatoes, which are onions. Baiyegunhi *et al.* (2018), studied tomato market integration: a case study of the Durban and Johannesburg fresh produce markets in South Africa. The study analysed the market price integration of tomatoes in Durban and Johannesburg FPMs in South Africa, using secondary monthly time series of wholesale price data. The above studies have all established that the selected markets were integrated. However, the studied commodities have a high demand for processed by-products, which makes it easy for the producer to diversify to different distribution channels. Further research will determine if the NFPMs are an efficient market for different commodities distributed on the same platform.

1.3.1 Aim of the study

The study's primary goal is to examine onion market integration in major South African Fresh Produce Markets using monthly onion prices from January 2009 to December 2019.

1.3.2 Specific objectives of the study

The specific objectives of the study are to:

i. Analyse the existence of the market co-integration relationship between the onion prices in the major Fresh Produce Markets.
ii. Examining the short-run relationship among onion prices at Fresh Produce Markets.

1.4 Hypotheses

i. There is no market co-integration relationship between the onion prices in the major Fresh Produce Markets.
ii. There is no short-run relationship between the onion prices at Fresh Produce Markets.

1.5 Structure of the report

This study will be comprised of five chapters. Chapter 2 will give a literature review on the concept of market integration and the measurement of market integration. In addition to this, the chapter provides an analysis as well as a concise summary of empirical studies conducted in South Africa as well as worldwide studies on market integration. Chapter 3 will focus on the onion industry overview following the main aspects of the onion value chain, which include production, distribution channels and trade. Chapter 4 will outline the methodology and Chapter 5 will present the results and discussion. Chapter 6 gives a summary, conclusions, limitations and recommendations of the study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The subject of market integration in the agricultural sector received a lot of attention over the past decade. While so many market integration studies were undertaken in recent years, only very little attention was focused on onion market integration in the South African Fresh Produce Markets. The objective of this chapter is to present the research's conceptual framework and to evaluate the literature on market integration. The first subsection of this chapter starts by defining the market integration concepts, followed by a measurement of market integration and gives a brief synopsis of previous studies on the topic.

2.1.1 Agricultural market and price relations

Price is a fundamental mechanism that connects different phases of the supply chain and different locations. Pricing signals could be a useful indicator of market segmentation or possible manipulation, as well as a distortion of price information that leads to inefficient resource allocation (Habte, 2017). The use of price to connect different phases of a market chain is fundamental. Pricing signals may indicate market segmentation or possible manipulation, as well as a distortion of price information that results in inefficient resource allocation. Price shocks are conveyed from one stage of the market chain to the next, and the magnitude of adjustment to such shocks is one of the key indicators of market participants' actions at various market levels. Over time, form, and place, pricing signals direct and govern the production, consumption, and marketing decisions (Kohl and Uhl, 1998). In developing economies, there are numerous barriers to the efficient functioning of marketing specifically for agricultural commodities. In the case of South Africa, these include post-harvest infrastructures like pack houses, storage facilities, transportation and access to market information. Since prices are the most readily available and the most reliable information on developing countries marketing systems, market integration exclusively referred to events resulting in price changes (Goletti *et al.*, 1995). Most specifically, market integration is restricted to the interdependence of price changes across spatially separated locations in the markets. Well-functioning markets give remunerative pricing for farmer-sellers' produce as well as commodities at acceptable prices to a large number of consumers. The occurrence of a high degree of integration among markets is one of the most common markers of efficient market functioning.

In an integrated market, the price of a commodity is responsive to price changes in other markets for the same quality product; as a result, price differences for a particular variety of products in different markets in the area should generally not exceed the cost of transportation and handling the produce. The study of price changes for a variety of commodities in the corresponding and related markets assists in determining the extent to which the marketing system in a given region is effective (Yogisha, 2005). Roehner (1995) defines the idea of market integration as an examination of price disparities across different regions. According to him, large relative pricing differences indicate that markets are poorly integrated, whereas small relative price differences indicate that markets are well connected spatially.

2.1.2 Arbitrage

Arbitrage refers to the practice of purchasing and selling commodities in separate marketplaces to profit from price disparities (Fackler *et al.*, 2001). Arbitrage restores equilibrium prices in spatial marketplaces, according to the Law of One Price (LOP). Arbitrage is the simultaneous buying and sale of similar assets or the same asset in several marketplaces to profit from a temporary difference in terms of prices (Faminow and Benson, 1990). It's true another reason why prices of the same commodity in multiple markets tend to move in lockstep and eventually achieve a state of equilibrium (Vollrath, 2003). Arbitrage is defined by McNew and Fackler (1997) as a price-moving error-correcting mechanism a similar good towards equilibrium in two markets. After a period of adjustment, market prices return to a state of equilibrium. Modest price changes and fluctuations can be capital limitations, interest rates, and transaction costs. Trading will be limited by expenses and execution risk if the estimated gains are modest (Tsay, 1998). Arbitrage is the mechanism that prevents the movement of an object from being seen pricing on parallel markets. The profit-seeking market opens up arbitrage chances. Participants would try to take advantage of such possibilities. Purchasing low-cost excess items and reselling them in the market for higher-priced deficits (Uchezuba, 2005). Arbitrage will only take place if there is a significant price difference such that the potential reward exceeds the cost of trade (Tsay, 1998; Trenkler and Wolf, 2003). As a result, while prices of related products may diverge in the short term, arbitrage will be the factor that ensures that these prices on separate markets create an equilibrium relationship in the long run (Norman-López and Bjørndal, 2009).

2.1.3 Law of One Price

The law of one price states that, if markets are functioning properly, a homogeneous product offered in different locations sells at the same price in the same currency, with any price differences justified by transportation expenses (Rapsomanikis *et al.*, 2006) The Law of One Price (LOP), which states that if the cost involved with the space, time, and form aspects of marketing are taken into account, prices for market commodities are the same, is the basic underlying idea for market price transmission and market efficiency (Ardeni, 1989; Fackler and Goodwin, 2001). Exchange rate risk, tariffs, non-tariff obstacles, institutional factors influencing price decisions, and non-tradable inputs are all possible reasons for the LOP not to occur (Miljkovic, 1999). According to the Law of One Price, effective trade and arbitrage activities will ensure that prices in physically distant marketplaces (those adjusted for exchange rates and transportation costs) are equalized. The LOP asserts that the only thing that can cause prices of homogenous items to diverge across various locations is transaction costs or other arbitrage barriers. Although the concept of LOP appears to be fair, the empirical study demonstrates that in the short run, there are significant and persistent price differentials. If there are enough sellers to assure competition, the commodity in question is standardized, and transportation costs are modest, the rule applies (Rashid, 2007). The law of one price, however, does not apply in all circumstances. This is related to market dynamics in the short run, which generates deviations from equilibrium. These discrepancies point to market inefficiencies that could be remedied in the long run. Market integration analysis is based on the LOP theory, which states that while price discrepancies occur, prices eventually converge in the long term. The spatial markets' price changes are all going in the same direction. Co-integration tests are used to assess this co-movement and long-term relationship.

2.2 Market integration

Market integration is the study of price differences between spatially separated markets and it's a vital economic analytical tool used to understand markets better. Market integration occurs when prices among different locations or related goods follow the same patterns over a long period (Goletti *et al*., 1995 and Negassa *et al*., 2003). Thus, market integration is an indicator that explains how much different markets are related to each other. It is used to describe phenomena in which marketplaces for goods and services that are tied to one another have similar patterns of price increases or decreases. The word can also apply to a situation in which the prices of related goods and services sold in a specific geographic location begin to move in a similar pattern. When two or more markets are integrated, occurrences in one market cause similar changes or shifts in other markets that deal with related items.

The market integration studies in agriculture are important because agricultural commodities are bulky and perishable, seasonal, spatially distributed, and consumption is also spatially dispersed. Market integration safeguards that a regional balance occurs among food deficit and food surplus regions (Rapsomanikis *et al*., 2006). In a market-driven economy, price indicators guide and regulate production, consumption and marketing decision, time, product and marketing place (Baiyegunhi *et al.*, 2018). Since prices are the most readily available and the most reliable information on developing countries' marketing systems, market integration exclusively referred to events resulting in price changes (Goletti, *et al.*, 1995). Most specifically, market integration is restricted to the interdependence of price changes across spatially separated locations in the markets. The prevalence of a high degree of integration among the markets is one of the most common indicators of a market's efficient functioning.

The results of the integration study can help producers decide where, when, and how much to sell, which will affect their production methods and, as a result, resource allocation. Because of its potential applicability in policymaking, agricultural market integration has remained important in developing countries. The government can design rules providing infrastructure and information regulatory services based on information about the amount of market integration to avoid market exploitation (Kohl and Uhl, 1998).

Market integration is a different way of stabilizing prices, allocating resources efficiently, and correcting various market imperfections like monopolies, insufficiency, and costly market information. Market integration has a positive association with market efficiency and competitiveness, implying that as markets become more integrated, they become more efficient and competitive (Shrestha *et al*., 2014).

There are three types of market integration: (i) vertical market integration, which includes different stages in marketing and processing channels; (ii) spatial market integration, which refers to arbitrage across periods; and (iii) inter-temporal market integration, which refers to arbitrage across periods (Barret as cited by Uchezuba, 2005). This research looks at the spatial integration of onion prices in selected South African Fresh Produce Markets.

2.2.1 Spatial market integration

Excess demand or price shocks in one market will have the same effect on prices in the other market, according to spatial integration models (Jena, 2016). Concerns such as causation patterns, long-run equilibrium attainment, and the dynamic interplay between geographically distant markets are addressed in the study of spatial market integration (Zewdie, 2017). Spatial market integration refers to a process in which two or more markets are linked together. The study of spatial market integration aims to answer three major questions about the nature of price transmission between spatially separated markets: causality patterns, dynamic interactions, and long-run equilibrium. When the prices of a commodity in spatially dispersed markets move together and price signalling information is sent seamlessly across the markets, this is known as a market convergence (Ghosh, 2000). Successful trading between food-shortage and food-surplus areas is assisted by spatial market integration. Specialization and economic growth result because of this. Furthermore, market integration contributes significantly to food security and economic growth. It also increases the social welfare of producers and consumers, which is especially important as onions are spatially mainly produced in four provinces but consumed in the whole country.

The use of spatial market integration of agricultural products to determine overall market performance is common (Faminow and Benson, 1990). Competition among arbitragers in geographically integrated markets will ensure that a balance is reached where local prices in regional marketplaces deviate by no more than transportation and transaction costs. Information on geographical market integration indicates competitiveness, arbitrage efficacy, and price efficiency (Sexton *et al*., 1991). These marketplaces are said to be geographically integrated if price changes in one market are fully reflected in the other (Goodwin and Schroeder, 1991). According to Gonzalez-Rivera and Helfand (2001), prices in spatially integrated markets are determined simultaneously in several places, and information about any price change in one market is sent to other markets. Markets that are not integrated may send out erroneous pricing signals, causing producers' marketing decisions to be skewed and contributing to inefficient product movement (Goodwin and Schroeder, 1991), and traders may take advantage of the market at the expense of producers and consumers. Farmers specialize in producing activities where they are relatively skilled, consumers pay lower prices for acquired goods, and society is better able to reap increasing rewards from technical advancements in economies of scale in more integrated marketplaces (Vollrath, 2003).

The mechanism of spatial price transmission is not instantaneous. While commodity prices in spatially dispersed marketplaces may fluctuate in the short term, they should eventually converge in the long run, removing the opportunity for arbitrage profit (Granger, 1986; Barrett and Li, 2002). In other words, the price differential between two spatially separated marketplaces for a homogeneous product should, in the long term, be equal to or less than the transaction cost of spatial arbitrage (Baulch, 1997; Nick and Tischler, 2014). According to Bressler and King (1970), markets that conform to these criteria become efficient. Farmers also need to understand how the market works, as well as price stability and volatility, which are all dependent on the processes of spatial market integration.

Market integration leads to a co-integration interpretation, which is measured by co-integration tests, which is the spatial arbitrage condition (Fackler and Goodwin, 2002). When two spatially separated price series are co-integrated, they tend to move in lockstep over time. Prices may diverge in the short run, as shocks in one market are not immediately transmitted to other markets due to delays in transportation or information; however, arbitrage opportunities ensure that these deviations from the underlying long-run (equilibrium) relationship are only temporary.

In this study, the spatial integration of markets is assessed by the application of price analysis. The study of price signals across space reveals the degree to which markets in different places are interconnected, as well as the potential of spatial arbitrage to mitigate the price and welfare consequences of local supply and demand shocks.

2.3 Market efficiency

Market efficiency is described as a situation in which demand equals supply while expenses are kept to a minimum (Rashid *et al.*, 2010). This term implies a situation in which demand for a product is equal to supply. Because of the seasonality of the produce, markets are rarely in balance. Excess demand leads to higher prices in the market, whereas oversupply leads to lower prices. When deciding the pricing of goods sold within it, a market is efficient if it fully and accurately reflects all relevant information (Fackler and Goodwin, 2001; Lence and Falk, 2005). Efficiency in market integration analysis refers to the exhaustion of all options for market integration. Profits from arbitrage are increasing. In this situation, the prices take into account all available data on demand, supply, and transaction costs.

Market efficiency and market integration have been linked, necessitating further research into the relationship. Spatial market efficiency refers to the transmission of price variations between markets when the arbitrage condition is fully exploited, resulting in equilibrium (Negassa *et al*., 2003). Another feature is that market integration is linked to physical commodity commerce, whereas market efficiency is linked to trading partners (Hillen, 2019). It's worth noting, however, that the markets are said to be integrated when there's a full arbitrage situation present. As a result, while integration and efficiency are related, they are not the same thing, and integration tests are not a reliable indicator of market efficiency (Barrett *et al.*, 2002). Efficiency, on the other hand, is merely a prerequisite for integration (Federico, 2007). As a result, spatial market integration can be thought of as a proxy for market efficiency (Faminow *et al*., 1990).

2.4 Market integration measures

Market integration can be quantified by measuring the flow of goods or capital between marketing regions (Moodley, Kerr and Gordon, 2000). Market integration research contributes to the identification of some of the constraints that agriculture marketing encounters (Rashid *et al*., 2010). The literature on market integration demonstrates a variety of techniques for quantifying and analysing market integration. The first technique is the static method which entails the correlation coefficient and bivariate approaches. The second is comprised of dynamic methods such as granger causality tests, Ravallion, Timmer models, and the co-integration methodology. The dynamic models take into consideration the fact that prices are constantly changing. The final technique is comprised of switching regime regression models.

The switching Regime Regression Models are predicated on the fact that pricing correlations are not always linear (Bor, 2020). While the preceding techniques neglected transportation costs, relying solely on data prices, the switching regime regression is the first model that explicitly accounted for transaction costs (Du Preez, 2011). New empirical approaches have been created to evaluate the impact of transaction costs on spatial market integration as a result of the significance of transaction costs (Goodwin and Piggott, 2001). They consist of; the Error Correction Model (ECM), the Parity Bound Model (PBM), and the Threshold Autoregressive models (TAR) are examples of such models. This section will provide an overview of the most often used models and demonstrate how they have been applied to market integration research. Although different methodologies exist, this research will provide an overview of the correlation coefficient, co-integration methodology, Error Correction Models (ECM), Parity Bound Models (PBM), and Threshold Autoregression (TAR) models.

2.4.1 Static models

2.4.1.1 The correlation coefficient approach

Early research on the degree of spatial market integration relied on a simple bivariate price correlation between two price series in two competitive markets to determine the degree of spatial market integration (Negassa *et al.*, 2003). For the most part, this concept is intuitively tied to the notion that prices in integrated markets move in parallel (Goletti *et al*., 1995). Price correlation is a simple and straightforward method of determining price co-movement. The price series correlation approach is based solely on price data and ignores other information needed to determine market integration. The fact that integrated marketplaces tend to display product prices that move together is taken into account by correlation coefficient analysis. The existence of a correlation between time series price data is the foundation for static models.

To determine the correlation coefficient, it is assumed that transaction costs are constant. In a perfectly integrated market, the coefficient should be equal to 1, whereas it tends to be 0 in a segmented market. This is a simple method that only calls for two price data series to be input. Because of inflation, common tendencies, and seasonality in agricultural markets, this system was later challenged for being biased. Furthermore, the model does not account for trade reversals since it does not represent the dynamism of a marketing system (Negassa *et al*., 2003). Other academics, on the other hand, claim that a static bivariate price correlation cannot account for the dynamic character of marketing mechanisms (Heytens and Ravallion 1986). As a result, the static price findings are questionable, because the static regression may reflect erroneous market integration and inferential error; as a result, the conclusions cannot be generalized and applied to the broader marketing system (Delgado 1986, Palaskas and Harris, 1991). Furthermore, Barret (1996) and Baulch (1997) provided evidence to support their claims. They stated that the conclusions of the static model were incorrect since they were based on the assumption of stagnant price behaviour and constant transaction costs, respectively. This is because the extent of market integration is underestimated as a result of these factors. Noting that utilizing a correlation approach can lead to erroneous correlations, Goletti *et al*. (1995) advised using price disparities instead of price levels when calculating correlations. This is because price levels have a variety of difficulties, including non-stationarity price series, which contribute to the situation. There appear to be stumbling blocks and limits associated with the correlation of prices. An Autoregressive Distributive model and a Co-integration technique were proposed to analyse market integration.

2.4.2 Dynamic methods

2.4.2.1 The Co-integration technique

In the 1980s, economists created dynamic models in response to the various shortcomings of static models. The dynamic nature of prices and transaction costs is taken into account in these models. The co-integration technique, which implies the existence of long-run equilibrium, is one of the dynamic models mostly used to study market integration. Due to delivery lags and adjustment costs, dynamic market integration models recognize and specify lead/lag relationships in spatial market analysis to account for the dynamic nature of price relationships and arbitrage processes (Fackler and Goodwin, 2001). As a result, dynamic regression techniques are more effective than static regression techniques in analysing price transmission and market spatial integration. Unlike static approaches, which only look at whether markets are linked or fragmented, dynamic methods look at how quickly a given market price adjusts in response to a price shock in a connected market.

Although the cointegration approach has been widely applied to measure market integration, its efficacy has been questioned. The model's failure to account for transaction costs is one of its key weaknesses. As a result, a lack of awareness of transaction costs may hinder price transmission across geographically distant markets (Abdulai 2000; Fackler and Goodwin 2001; Goodwin and Piggot, 2001; Barrett and Li, 2002). The fact that it is difficult to measure or monitor transportation expenses, particularly in underdeveloped nations, leads to neglect of transfer costs. Cointegration analysis has now become one of the most extensively deployed approaches (Jubaedah, 2013). To study market integration, this research will utilise the co-integration technique and this technique is covered in depth in the methodology section in chapter 4.

2.4.3 Switching regime regression model

While the preceding systems neglect transportation costs, relying solely on data prices. Because of the importance of transaction costs, new empirical methodologies have been developed to address the impact of transaction costs on spatial market integration (Goodwin and Piggott, 2001). Threshold Model and Parity Bound Model are analytical methods that compress transportation costs in their models to explore market integration. The first model that explicitly accounted for transaction costs was essentially a switching regime regression model that gave estimates for transaction costs as well as the probability of occurrence (Du Preez, 2011). The Switching Regime Regression models are predicated on the fact that pricing correlations aren't always linear (Bor, 2020). Examples of switching regime regressions models are Parity Bound Model (PBM); Threshold Autoregressive Approach (TAR) and Error Correction Models (ECM).

2.4.3.1 Parity Bound Model

A new model called the Parity Bound Model (PBM) was created by (Van Campenhout, 2007 and Baulch, 1997). Numerous researchers had been evaluating market integration indirectly using price series alone. Baulch (1997), argued that transfer cost plays a significant role in market integration. Spiller and Wood (1988) described the PBM model and its implementation. PBM has been improved and applied by several researchers (Sexton, Kling and Carman, 1991; Baulch, 1997; Barrett and Li, 2002, Penzhorn and Arndt, 2002). PBM can be used to estimate incomplete time series data, which is commonly the case with pricing data from developing nations (Penzhorn and Arndt, 2002). The parity borders are the boundaries within which the prices of a homogenous good in two geographically separated markets are equal. Transfer costs dictate how different marketplaces can vary separately. When the transfer takes place, there are no barriers, and costs are proportional to the price difference between the markets to trade, then trading will lead prices in the two markets to move in lockstep, and the spatial relationship will be altered. PBM is capable of coping with trade disruptions and transaction costs that are both complicated and time varying.

Market efficiency and spatial market integration can both be distinguished using PBM (Negassa *et al*., 2003). This, however, is reliant on the availability of trade flow data, as well as information on goods prices and transaction costs. The PBM specifically allows for the risk of market-to-market trading disruptions. Concurrent price determination, as well as statistical issues caused by popular usage. PBM can assess the likelihood of being in various trade regimes, as well as offer data on the amount of market efficiency (Negassa *et al.*, 2003).

The PBM assesses the degree of market integration by contrasting three different trade regimes. Three possible trading regimes have been identified by Sexton *et al*. (1991) and Baulch (1997), as follows: The first regime is when prices differ between market locations, but the difference is equivalent to transfer costs. This indicates that there is competitive trade between the regions, and prices follow similar trends. The second regime is when prices differ between market locations, but the difference is too small for market actors to participate in trade. It shows that there is no competition between regions and that prices do not run together. And regime three is when prices differ across market places, but the difference is higher than the costs. This could imply that there is insufficient competition in the market or that there is a temporal imbalance (Lekgau, 2015). This could be due to trade barriers, price support, or a pricing structure that isn't competitive (Hillen, 2019). The chance of being in each regime is estimated using spatial pricing differentials that are equal, above, or below transaction costs (Serra *et al.*, 2006). Only regime one is consistent with market integration when production and consumption are specialized. When it is not specialized, however, both regimes two and three can suggest market integration. In developing countries, non-specialization is increasingly widespread (Penzhorn and Arndt, 2002). Market dynamics such as transaction costs, trade reversal, and autarky conditions are all taken into account by the model (Negassa *et al.*, 2003). It has also been proved to be statistically reliable and capable of detecting spatial arbitrage violations with a great degree of precision in the conditions (Baulch, 1997).

PBM, as implemented by Baulch (1997), continues to have issues with non-stationary transfer costs. Underestimation of the importance of transaction costs is a problem since they can lead to a bias in the PBM outcomes. Baulch (1997) further recognized that it's difficult for the model to account for the type of delayed price since only instantaneous spreads are employed in estimating. Secondly, the accuracy of estimations of regime probabilities is only as good as the accuracy of estimates of mean transfer costs and while the model may show a lack of market integration, it does not indicate how severe it is. PBM has been castigated for being a bivariate analysis that cannot be applied to a wide range of agricultural products (Gonzalez-

Riveraa and Helfand, 2001). It has been chastised for its underlying distributional assumptions, and the fact that it is inherently static (Van Campenhout, 2007 and Serra *et al*, 2006). According to Fackler (1996), PBM has no ties to economic theory and hence cannot be used to draw economic implications. Negassa *et al*. (2003) further emphasized the criticism on grounds that there is no connection, secondly, there is a misalignment between economic theory and the model's underlying distributional assumption utilised in the model. Furthermore, the model only works with a small number of markets, and the method takes into account short positions. When departures from equilibrium are reported as inefficiencies, they may be the result of traders.

2.4.3.2 Threshold Autoregressive Approach (TAR)

Another switching regime model, the Threshold Autoregressive Approach (TAR), was created as an upgrade to the PBM model. The TAR model examines market integration in the context of a switching regime. In comparison to correlation and co-integration methodologies, TAR also considers the effect of transaction costs when analysing market integration. Balke and Fomby's (1997) econometric modelling research advanced the TAR model by combining the non-linearity and co-integration methods. This indicates that the relationship between variables is non-linear and that the equilibrium price is not fixed. It does not rely on transaction costs data, but it does take into account their effects by establishing a threshold band where market prices are not connected (Negassa *et al.,* 2003). Transaction costs have resulted in this threshold band. The larger the band, the more volatile the price. TAR models have also been utilized to resolve flaws in other models by recognizing the possibility of data non-stationarity (Piggott and Goodwin, 2002).

The likelihood of being outside the threshold is displayed in the TAR model's results. Market integration is measured by this probability. Furthermore, the time required to eliminate the violations is determined (Abdulai, 2000). The fact that it assumes fixed transaction costs is, however, a critical flaw (Fackler *et al.*, 2001). However, the argument is that it is preferable to assume constant costs rather than ignore them. Another issue with its implementation is the time-consuming computational requirements (Sunga, 2017). The TAR was not always frequently applied because of the difficulty of identifying the threshold variable and determining the associated threshold values, as well as the lack of a simple modelling approach (Tsay, 1989). This is no longer the case, due to the emergence of simple estimate models. Nonetheless, the TAR model has flaws, the first concern is with the assumption of constant transaction costs (Piggott and Goodwin, 2002; Van Campenhout, 2007 and Negassa *et al*., 2003). The issue with assuming fixed or stationary transaction costs is that it has the potential to have significant ramifications for the validity of empirical assessments of geographic price parity (Piggott and Goodwin, 2002). A second drawback is that the model remains over-parameterized (Negassa *et al.*, 2003). Finally, inference on the threshold is complicated by the fact that the asymptotic distribution of the threshold parameter is neither normal nor free of nuisance parameters, precluding the calculation of standard errors and confidence intervals, complicating the test of the null hypothesis of no co-integration versus the alternative hypothesis of threshold co-integration (Van Campenhout, 2007 and Lo and Zivot, 2001). Co-integration and threshold models have led to the development of Error Correction Models (ECMs), which can represent dynamic price fluctuations and can link current prices to historical time series prices, when co-integration exists (Lekgau, 2015).

2.4.3.1 Error Correction Models (ECM)

Balke and Fomby (1997) extended the TAR models by pointing out the link between autoregressive models having an error correction element and Error-Correction Models that depict co-integration relationships. They also show that in the presence of threshold co-integration, typical tests for unit root and co-integration function fairly well. The model permits non-linear adjustment to long-term equilibrium (Hansen and Seo, 2002; Serra and Goodwin, 2002b). An ECM describes variables that are co-integrated within systems. An ECM defines how variables respond to changes in equilibrium or the process of maintaining long-term equilibrium (Balke and Fomby, 1997). Uncertainty in the markets is accounted for by an ECM (Mushtaq *et al*., 2008). The ECM specification's natural interpretation has gained prominence in market integration literature (Serra and Goodwin, 2002a). Threshold Error Correction Models (TECM) were created to account for transaction costs in price transmission models. A

Vector Error Correction Model (VECM) is useful for spatially linked markets were causality is unknown (Meyer, 2004).

Threshold Vector Error Correction Models (TVECM) take into account non-linear and threshold-type adjustments in error correction models. TVECM models are multivariate TAR models (Serra and Goodwin, 2002a). Because markets are multi-location, evaluating market integration requires a multivariate technique (González-Rivera and Helfand, 2001). TVECM models can investigate individual price adjustments and provide information on short-run pricing dynamics (Serra and Goodwin, 2002a). Variables in the model display distinct sorts of behaviour in each regime, resulting in diverse TVECM models (Serra and Goodwin, 2002b). Analysts recommended the use of the Threshold Vector Error Correction Model (TVECM) in error correction models to account for non-linear and threshold-type modifications. It is useful for examining short-run price dynamics. It enables asymmetrical variances to be adjusted in response to positive and negative price shocks (Serra and Goodwin, 2002(a); Bamba and Reed, 2004). The vast literature on price transmission in agricultural commodity markets has primarily used Vector Auto Regression (VAR) and Vector Error Correction (VEC) models to capture potential short-term dynamics and long-term equilibrium in price transmission (Listorti and Esposti, 2012; Arshad and Hameed, 2014), though some alternative and innovative approaches, such as the threshold model, have been used as well (Listorti and Esposti, 2012; Arshad and Hameed, 2014 and Serra *et al.,* 2006; Fousekis and Trachanas, 2016). The TVECM is being utilized more frequently in recent publications, and it has a stronger methodology than some of its predecessors. The method takes into account the non-stationarity of variables as well as non-linear and asymmetric types of variables. The importance of transaction costs is taken into account in the model (Du Prezz, 2011). This study employs the Engle and Granger (1987) Co-integration test and Error Correction Model, which were recently employed by (Baiyegunhi *et al.,* 2018), based on the research purpose and data provided.

2.5 Empirical market integration studies

In recent years, several studies have been conducted on the subject of market integration. They are examined further below within the context of the technique employed in the analysis. To avoid the limits of depending on a single metric to evaluate market integration, researchers have developed and tested some different approaches to investigate various elements of price transmission.

2.5.1Static models

To examine price correlations in numerous Kenyan markets throughout the pre and post-liberalization eras, Karugai *et al.* (2003) used correlation coefficients to evaluate price relationships in several Kenyan markets. According to the authors, the results of simple correlation coefficients were found to be quite high, ranging between 0.72 and 0.98 in the pre-liberalization period and between 0.52 and 0.89 in the post-liberalization period, with the pre-liberalization period having the highest correlation coefficients. According to Karugai *et al*. (2003), all of the correlation coefficients in the pre-liberalization period are much stronger than the equivalent coefficients in the post-liberalization period. According to the findings of the study, correlation coefficients are higher in markets that are near to one another as well as markets that are connected by more robust transportation infrastructure. In the findings, the generally held idea that shorter distances and stronger infrastructure across markets lead to lower transaction costs, making arbitrage conceivable and, as a result, encouraging market integration, appears to be supported.

Market integration can be measured using correlation coefficients, however as previously indicated, this method has numerous limitations. According to Karugai *et al.* (2003), the bivariate correlation of price differences was utilized as a second measure of integration in their analysis. The bivariate correlation method eliminates the problem of erroneous correlation that has plagued correlation analysis for many years. The findings revealed that the coefficients were much lower than the levels of the underlying prices. These values ranged from (–0.15) for the Migori-Awendo market link to (0.96) for the Kiritiri-Siakago market link before the deregulation of the economy. Following liberalization, the Kitale-Siakago link has the lowest post-liberalization correlation coefficient (-0.18), whilst the Migori-Awendo link has the highest correlation coefficient (0.43). According to the findings, the degree of integration is far lower than the correlation matrix of price levels would predict based on the data.

When looking at markets that appear to have high degrees of integration based on one metric, the study found that they do not appear to be integrated when looking at them using a second parameter. This result demonstrates both the pitfalls of relying on a single measure of market integration to evaluate market integration and the importance of reviewing a variety of approaches when analysing different components of the price transmission process, as demonstrated by the findings. This consideration led to the inclusion of the cointegration strategy approach in the research.

2.5.2 Dynamic models studies

Bor (2020) investigated the spatial market integration in Kenya's domestic avocado marketplaces. Nairobi, Mombasa, Nakuru, and Eldoret were chosen as urban markets, while Kisii was chosen as a producer and rural market for the study. The analysis used the Engle and Granger Co-integration technique to analyse monthly time series price data over ten years. The conclusion of the Engle and Granger test did not produce a long-run equilibrium to which market prices respond. The result showed that the avocado markets in the domestic market are not co-integrated and are thus divided. Furthermore, the research established that the rural producers have limited access to markets due to market segmentation and recommended that market integration would significantly improve rural livelihoods based on these findings.

Using secondary monthly time series of wholesale price data from 2008 to 2012, Baiyegunhi *et al.* (2018) examined tomato market price integration in Durban and Johannesburg fresh produce markets in South Africa. The Augmented Engle-Granger Cointegration (AEG) test was used to determine co-integration, while the Error Correction Model (ECM) was used to determine causality between Johannesburg and Durban prices. The findings revealed that the two markets were linked. Furthermore, the findings demonstrated that economic agents need roughly a month to return to equilibrium after a market shock that generates disequilibrium; the response to the shock is faster in the Durban market than in the Johannesburg market. Because of the high degree of market integration, the South African fresh produce market is very competitive, and there is no reason for government intervention to boost competitiveness or market efficiency.

Zewdie (2017) conducted a study from 2002 to 2014 on "Spatial market integration and price transmission for papaya in Ethiopia." He used the co-integration technique to analyse five Ethiopian local markets. According to his findings, four of the marketplaces were co-integrated. The rate of change in papaya pricing was gradual and varied by market. The Arbamnch market eliminated approximately half of price disturbances, therefore resolving out-of-balance situations. Worako (2015) conducted a second study in the Ethiopian environment, analysing fruits and vegetable markets from 2008 to 2015. The investigation incorporated retail prices from twenty-one Ethiopian markets. His findings suggested that some markets exhibited co-integration. Transmission of prices from the central market (Addis Ababa) to other markets took between three and seven months.

Ahmed *et al*. (2017) also used co-integration to examine market integration and price transmission in India's onion markets. They analysed monthly wholesale price data from six major Indian markets between 2006 and 2014. The findings suggested that four of the six markets were co-integrated and that there was both unidirectional and bidirectional causation between the prices in the various marketplaces. Additionally, they discovered that price changes were rapidly propagated to all other marketplaces excluding Mumbai and Kozhikode.

The co-integration method was further utilised by Oktarina (2015) to examine five Indonesian rice markets. He employed monthly retail pricing from 2004 to 2009. The results showed that three of the tested marketplaces reacted quickly to price changes. Integration analysis of fed cattle in the United States during the mandatory price reporting period was carried out by Rahman and Palash (2018) using a similar technique. For the period from 2001 to 2015, weekly steer and heifer prices were used. The sample covered five major markets in the United States. We discovered that all marketplaces were interconnected. Researchers found that most steer markets were linked to one other, however, there were no links between heifer markets.

Additionally, Zakari *et al.* (2014) utilised co-integration to better understand the relationship between global grain markets and regional grain markets in terms of market integration and price transmission. The study's international markets include Nigeria, Mali, Vietnam, Burkina Faso, and Togo, while the study's regional markets include Niger. It was decided that the best grains would be a mix of millet, sorghum, corn, and rice. Niger imports a lot of these staple goods, and the country's internal need is often supplied by these imports. Different markets reacted to the long-term equilibrium in different ways, according to the research. Price changes in international markets have a substantial impact on domestic pricing since all foreign markets showed strong price transmission to Niger.

The years 2008 to 2010 were studied by Acquah and Owuso (2012) using co-integration to examine three Ghanaian plantain marketplaces. As a major producer and user of plantations, Ghana's food security is dependent on the commodity. Plantain markets are said to be interconnected. An additional 7% of price disequilibrium was resolved within a week, and a further 16% was corrected within a month, according to the researchers.

In addition to the studies, Ghosh (2011) used the co-integration technique to conduct a spatial analysis of India's food grain markets. His research focuses on two eras: pre- and post-liberalisation. Following liberalisation, government intervention in agricultural commodity marketing was reduced. He analysed substantial data on rice and wheat prices from 1984 to 2006. His findings indicated that rice markets were not integrated before liberalisation. They are, nevertheless, substantially interwoven following that. Similarly, for rice, markets were divided prior to reform, but this significantly improved following reform. He contends that this development is the effect of post-liberalisation agriculture policies.

Goletti and Babu (1994) utilized co-integration methods to study the behaviour of maize prices in Malawi before and after the country's agricultural sector was opened up to the foreign competition. They make use of monthly retail data from eight markets collected between 1984 and 1991. In each market pair, they look for evidence of co-integration. Before market liberalization, only 18 of the 48 market pairs were co-integrated; however, aftermarket liberalization, 34 market pairs were co-integrated, bringing the total to 34. According to this, the market liberalization that took place in 1987 resulted in a better transfer of price changes from one market to another. They discover, on the other hand, that the transmission is only partial and can be quite slow.

The average amount of time it took to acclimatize to an initial shock was 5.7 months. At the end of the investigation, the symmetry of adjustment was investigated. The study discovered little indication that price hikes and price cuts were conveyed in Malawi in any way distinct from other countries.

2.5.3 Switching Regime Regression Models

Gitau *et al.* (2019) investigated integration across nine domestic maize markets in Kenya under four different regimes using the Vector Error Correction Model (VECM). The first regime was one of agricultural liberalization. The second was a subsidy regime for fertilisers, the third was an import prohibition on food items containing genetically modified organisms, and the fourth was zero-rating import tariffs. He used monthly wholesale prices to cut across all regimes. His investigation covered the years 2000 to 2016. His findings reveal that regime one had the greatest pricing spread and that all selected markets were co-integrated. Additionally, he argues that regime one had few policy interventions, implying that subsequent measures skewed maize markets. As a result, he concludes that the creation and execution of policies require increased consultation and collaboration to achieve the desired objectives.

Mtumbuka *et al.* (2014) examined nine bean markets in Malawi using the Threshold Autoregressive Approach (TAR). The findings indicated that although the bean markets were cointegrated, price transmission was unequal. Inadequate infrastructure was cited as the primary factor. The study concluded that Malawi's bean markets were well integrated. Tsiboe *et al*. (2016) used TAR to analyse eight Liberian rice markets from 2009 to 2014. Liberia imports approximately half of its rice consumption. The research focused on markets at ports of entry. The findings imply that rice markets on a local level are integrated. Within five months, positive and negative price changes were transmitted symmetrically in all marketplaces. Both analyses find that enhancing transportation and market infrastructure will significantly enhance market integration.

Du Prezz (2011) undertook a study to analyse market integration in South Africa. The study determines the existence of pricing correlations and spatial linkages between markets. The study relied on weekly data dating from June 1999 to June 2009, Johannesburg (JHB), Pretoria (PTA), Bloemfontein (BFN), Kimberley (KBY), Durban

(DBN), Cape Town (CTN), Pietermaritzburg (PMB), and Port Elizabeth (PE) fresh produce markets were chosen for the study. The Threshold Vector Error Correction Model (TVECM) was used to determine market integration. The study finding was that, in the long run, the prices of potatoes in the selected fresh produce markets are integrated. In the short run, however, there was no evidence to support the existence of a spatial link. In other words, the markets are not currently interconnected. The Johannesburg market was discovered to be the market leader, with the other markets following suit in terms of price movements. Overall, the findings support the hypothesis that Johannesburg is South Africa's main FPM. In the long run, markets are integrated, but in the short run, they are not.

Van Campenhout (2007) examined the relationship between maize prices in seven Tanzanian markets over a decade, utilizing weekly price data collected between 1989 and 2000. This was accomplished by employing a Threshold Autoregressive (TAR) model, which allows pairs of prices to be connected only when the difference between them surpasses a certain threshold. According to the findings of the study, the indicated marketing cost ranges between 2-11% of the mean of the two prices, depending on the market pair under consideration. Most of the time, smaller thresholds existed between markets that are close to each other. Larger thresholds existed between markets that are farther apart. The process of adjustment was measured by the half-life of the process, which was the number of weeks it takes for half of the total amount of adjustment to take place. The half-life of adjustment varied between 4 and 12 weeks across the six pairs of marketplaces that were investigated. The data also revealed that the rate of adjustment has slowed throughout the 11 years, with the slowdown statistically significant in four of the six market pairs studied. In addition, the threshold was reduced by 8-55%, signifying a reduction in marketing costs between marketplaces as well as a stronger link between maize prices in different locations, according to the report.

Uchezuba (2005) measured market integration for apples using the Threshold Error Correction Model, intending to evaluate the existence of long-run price connections and geographic market linkages for apples on the South African FPMs. Johannesburg, Cape Town, Tshwane, Bloemfontein, Port Elizabeth, Durban, Kimberley, and Pietermaritzburg are among the FPMs studied in this study. The FPMs were chosen based on their net market positions (surplus or deficit area), geographical distribution, trade volume, and market importance to the national apple trade flow. The investigation found a statistically significant decline in real prices in six of the eight markets examined, a statistically significant relationship in prices (price spread) between the Johannesburg FPM and five other FPMs, and that price spreads between these markets declined after deregulation, as well as that variation in real apple prices declined for five of the eight markets investigated. To see if transaction cost has a substantial effect on gauging market integration, researchers evaluated standard Autoregressive (AR) and Threshold Autoregressive (TAR) Error Correction Models. threshold vector error correction model's parameter estimates were also examined. The findings reveal that there is bidirectional and unidirectional causality between FPM pricing in Johannesburg and other markets. To explore market integration in the studied markets, regime-switching estimates demonstrate that all but one market pair had no persistent divergence from equilibrium, and no clear evidence was found to suggest increased market integration after market deregulation in 1997. The influence of positive and negative price shocks in the Johannesburg FPM on other FPMs was investigated using a nonlinear impulse response function, which found that positive and negative shocks take around six to twelve months to be completely eradicated in all markets. In general, the findings revealed considerable market integration in terms of apples for selected FPMs.

Tostao and Brorsen (2005) studied market integration in Mozambique using monthly retail maize prices and estimates of transfer costs from 1994 to 2001. The study employed the Parity Bounds Model (PBM), which differentiates between three regimes: competitive trade (when price disparities are equal to transfer costs), non-trading markets (when price differences are less than transfer costs), and disequilibrium (when price differences exceed transfer costs). The proportion of time that a market pair spends in the first two regimes is a proxy for its level of integration. The findings indicated that markets in southern Mozambique were efficient (55% of the time) by these criteria, whereas those in central Mozambique were efficient (84% of the time). Southern and central Mozambique are generally well integrated, but the costs of transport between northern and central Mozambique were prohibitively high to sustain maize trading. These results were supported by data indicating that maize trade flows within southern and central Mozambique, but little between northern and central Mozambique. A Vector-Autoregression (VAR) study confirmed that each of the six major markets' prices was related to one or two of the other markets' prices.

2.5.4 Research employing both dynamic and regime-switching models

Paul *et al.* (2017) have discovered that despite being the world's second-largest producer, India's onion prices are subject to significant temporal and regional volatility. Addressing this problem had become a serious task for the country's policymakers. Paul *et al.* (2017) undertook research to determine India's most prominent onion marketplaces. The monthly wholesale price in ten major markets was studied using Johansen co-integration and Vector Error Correction Model (VECM) techniques between 2005 and 2015. According to the findings, Hubli is the most dominant market, followed by Kolkata and Lasalgaon. The findings show that non-producing markets play a significant effect. Although market integration entails the transfer of deficits and surpluses from one market to another (Ghosh, 2003), this is not the case in the Indian onion market. A total production increase of almost 2,955 thousand MT in 2013–2014 was not enough to compensate for a 330.07 MT deficiency in one of the major producing states. For more than three months, the entire country had to pay a much higher price (August to October). This raises substantial concerns about the forces driving countrywide integrated onion markets, particularly given the fact that merchants' collusive activities can also result in spatially segregated markets.

Using 13 years of average monthly papaya prices (Habte, 2016), investigated the integration of the papaya market, price transmission, and price causality patterns using the Johansen co-integration test, Vector Error Correction Model, and Granger causality test. According to Johansen co-integration tests, four papaya marketplaces are significantly co-integrated. The speed of papaya price adjustment for the Arbaminch market was statistically significant at the 1% level and the fastest compared to other papaya price adjustments, according to a Vector Error Correction (VEC) model test. Its equilibrium price remained constant. The pace of price adjustment for the Adama market, on the other hand, was small and the slowest when compared to other market prices; its equilibrium was unstable because the price shift was outside of the equilibrium price. This implies that the information was asymmetric. According to the Granger causality test, the price of Arbamnch papaya was bi-directionally related to the Merkato and Shashemenie markets. To solve delayed price adjustment amongst multiple papaya marketplaces, the study recommended that concerned bodies should concentrate on asymmetric information.

Using monthly retail pricing data of maize grain from January 2001 to December 2010 in the selected producing and consuming states, Ikudayisi and Salman (2014) study looked at spatial market integration among Nigeria's geographically dispersed maize markets. Johansen co-integration and the Vector Error Correction Model (VECM) were used to examine the data. The states were co-integrated in the long run, and VECM only repaired divergence from equilibrium at a moderate rate. The study found that there are spatial price links within the maize market because products moved efficiently across the market, which is linked to the effectiveness of price information transmission. The study recommended that farmers should be given greater price information so that they can take advantage of price disparities across the country.

To examine the existence of market integration in arecanut, data on monthly modal prices of arecanut was obtained using Agmarknet from seven representative markets in Karnataka state. Co-integration and Error Correction Model were employed by (Patil *et al.*, 2013) to test the presence of market integration using a co-integration and error correction model, and the study's findings revealed that the arecanut markets in the state are integrated with a high rate of adjustment. As a result, it may be argued that integrated arecanut marketplaces are price transmission efficient. The study recommended that to stabilize the arecanut economy, the government must fix prices in one key market, which will be automatically propagated to other markets at a speed equal to the coefficient of error correction, lowering the cost of stabilization

Jubaedah (2013) investigated two types of spatial market integration with a focus on red chilli commodity markets using data from 23 producer markets and wholesale markets in Jakarta from January 2000 to December 2011 and January 2005 to December 2011. To assess red chilli market integration, some methodologies were applied, including the Engle-Granger co-integration test and the Error Correction Model. The methodologies used makes it possible to study price transmission, identify market integration or segmentation that occurs in Indonesian red chilli commodity markets, and characterize the long-run and short-run dynamics using these methodologies. Model 1 shows that, in general, producer markets do not co-integrate with PIKJ as the central market. These markets, on the other hand, have a short-term link. The results of spatial market integration model 2, which examine co-integration across 23 producer markets, suggest that red chili markets across producer provinces tend to integrate with time. Furthermore, changes in the price of red chillies in one producer market appear to have an instantaneous impact on the price of red chillies in other producer markets in the short run. Finally, the study found evidence that the integration of the red chilli commodity market with Indonesia is impacted by good infrastructure, location or distance between markets, and trade opportunity, which can be shown by a wide consumer area, such as population and market size.

2.6 Summary

This chapter summarized previous research on agricultural market integration. The first stage was to define the agricultural market and its price relations, as well as arbitrage and the Law of One Price (LOP), which are also important concepts of market integration. The second phase was to review the methods used to quantify market integration, followed by a review of recent relevant research conclusions.

Price is a crucial factor that connects supply chain stages and regions. Pricing signals may indicate market segmentation or suspected price manipulation, as well as poor resource allocation (Habte, 2017). A commodity's price in an integrated market responds to changes in other markets for the same quality product; thus, price discrepancies for a particular kind of product in different markets within a region should not surpass shipping and handling costs.

Arbitrage is the simultaneous buying and selling of assets on multiple markets to profit from a temporary price differential. Arbitrage occurs when the potential return outweighs the cost of the transaction (Tsay, 1998; Trenkler and Wolf, 2003). While prices of similar products may diverge in the near term, arbitrage ensures that prices on different marketplaces create an equilibrium relationship over time.

The Law of One Price argues that if markets are working properly, a homogenous commodity sold in multiple locations sells at the same price in the same currency

(Rapsomanikis *et al*., 2006). Prices in physically distant marketplaces (adjusted for exchange rates and transportation costs) will be equalized if trade and arbitrage operations are effective. But the law of one price does not apply in all cases. This relates to short-term market dynamics that cause deviations from equilibrium. These inconsistencies point to market inefficiencies that could be fixed.

Market integration literature provides several quantitative and analytical methodologies for quantifying and analysing market integration. The first technique is the static approach, which incorporates correlation coefficient and bivariate techniques. Price correlation is a straightforward technique for determining price co-movement. Price series correlation is a technique that relies entirely on price data and ignores other information necessary to assess market integration. Due to inflation, widespread trends, and seasonality in agricultural markets, this approach was eventually found to be biased. Additionally, the model does not account for trade reversals since it lacks the dynamic inherent in a marketing system (Negassa *et al*., 2003).

The second category includes dynamic approaches such as granger causality tests, Ravallion, Timmer, and co-integration. Dynamic models take into account the reality that prices fluctuate continually. In the 1980s, economists developed dynamic models in reaction to static models' numerous flaws. These models account for the dynamic nature of prices and transaction costs. Co-integration, which necessitates the existence of long-run equilibrium, is one of the most often used dynamic models for studying market integration. While the co-integration approach has been widely used to quantify market integration, its effectiveness has been questioned. One of the model's critical flaws is its failure to account for transaction costs. As a result, a lack of understanding of transaction costs may obstruct the transmission of prices across geographically dispersed markets (Abdulai, 2000; Fackler and Goodwin, 2001; Goodwin and Piggot, 2001; Barrett and Li, 2002).

The final strategy is composed of regression models for switching regimes. They include but are not limited to, the Error Correction Model (ECM), the Parity Bound Model (PBM), and the Threshold Autoregressive Models (TAR). The switching Regime Regression Models are based on the observation that not all pricing relationships are linear (Bor, 2020). While previous strategies omitted transportation costs in favour of focusing just on data prices, switching regime regression models are the first to explicitly account for transaction costs (Du Preez, 2011). The switching Regime Regression Models are based on the observation that not all pricing relationships are linear (Bor, 2020). While previous strategies omitted transportation costs in favour of focusing just on data prices, switching regime regression models are the first to explicitly account for transaction costs (Du Preez, 2011). To build the model, data on transaction costs is necessary. In less developed countries, these statistics may be difficult to obtain.

CHAPTER 3: SOUTH AFRICAN ONION INDUSTRY OVERVIEW

3.1 Introduction

This chapter provides an overview of the South African onion industry. The overview will follow the onion value chain starting from, the gross value of production, production volume and special attention will be given to distribution/marketing channels (which include fresh produce markets, direct sales, exports and processing). Analysis of the value chain allows enterprises to gain insight into crucial industry factors. Furthermore, the overview will also look at sales volume and prices of the selected markets as it is the basis of the study. An onion value chain is depicted in Figure 3.1 below.

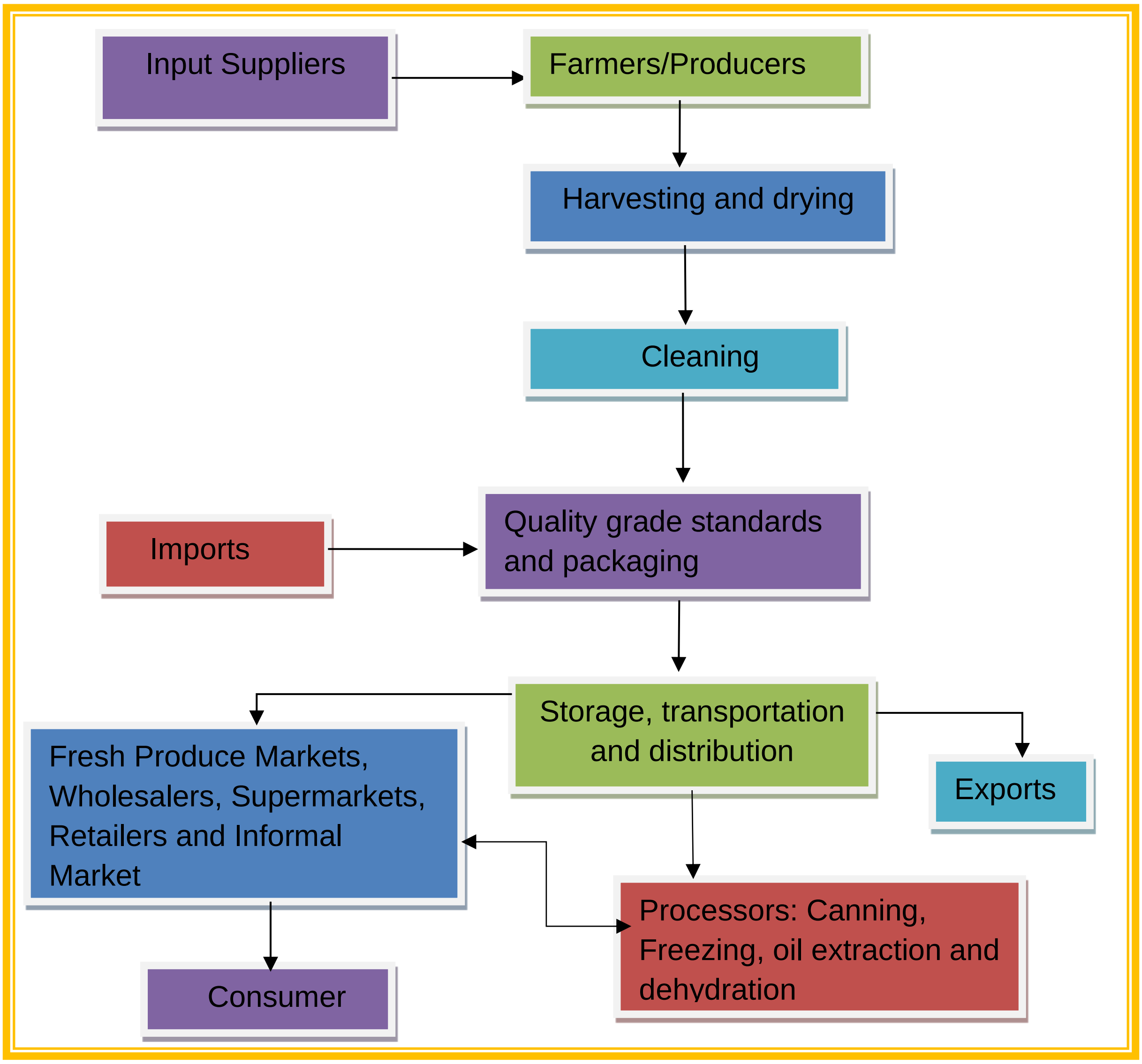

Figure 3.1: South African onion value chain

Source: Onion Marketing Value Chain Profile, DALRRD 2020

Onion Value is divided down into input providers, which are companies that provide inputs to growers. For example, seed, fertilizers, chemicals, fuel, and mechanization, are some of the inputs required for onion production. Onion growers purchase seeds and cultivate onions to be harvested later. Cleaning, grading, quality monitoring, and storage are all tasks performed by the pack-house owners. Onions are distributed and delivered on behalf of farmers through several marketing/distribution channels. Fresh produce markets, direct sales to retailers, export, and processors (add value to onions) until the product reaches end-users (consumers).

3.2 Gross value of the onion industry

The onion industry in South Africa contributes significantly to the economy through both domestic and international trade. The Gross Value of Production during eleven years is depicted in Figure 3.2.

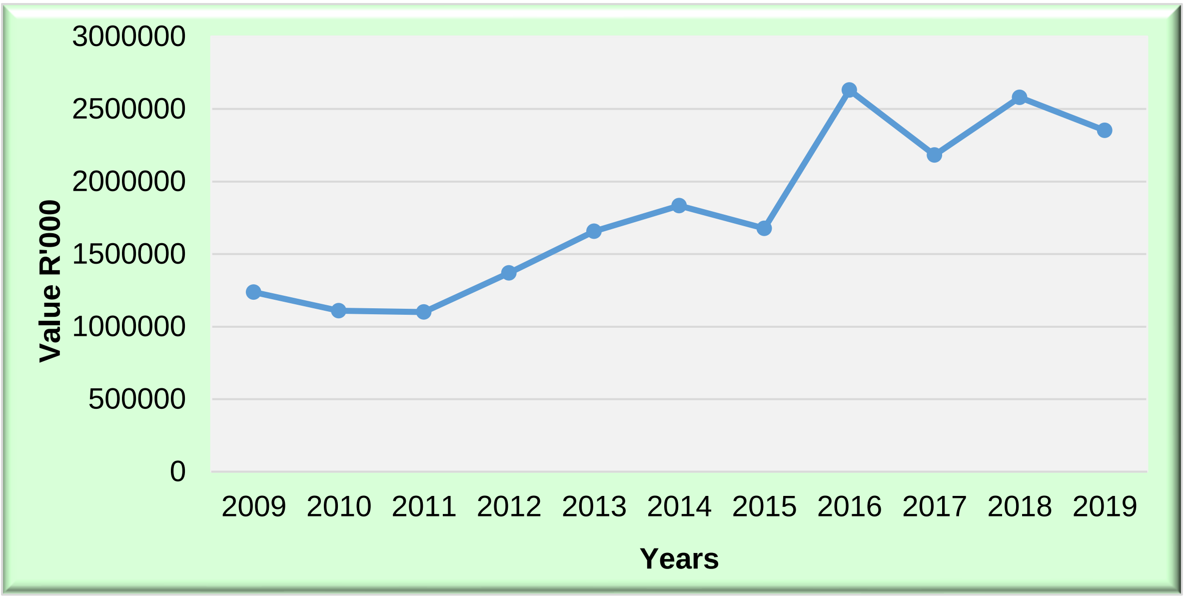

Figure 3.2: South Africa's onion Gross Value of Production (GVP)
Source: Statistics and Economic Analysis (DALRRD 2020)

The industry gross value of production in 2009 was over R123 billion; however, the following year (2010), the industry gross value declined by 10.4% compared to 2009. In 2012, the gross value grew significantly to R136 billion. The industry gross value decreased notably by 8.5% in 2015 and the highest gross value was realised in 2016, and the gross value was 263 billion. In the following year (2017) the gross value declined to R218 billion, which represents a decrease of 17%. There have been fluctuations in the industry gross value with an 18% more in 2018 and 2019, the gross value declined by 8.8% to R235 billion. The industry has shown significant improvement in gross value when compared to R123 billion recorded in the year 2009 relative to R235 billion in 2019.

3.3 South Africa’s onion production

Onions are grown practically in all South Africa's provinces, however, Western Cape (Ceres), Northern Cape, Free State, North West and Limpopo are the major producing provinces (DALRRD, 2020). According to Korkom, the Ceres region in the Western Cape has become the main distinctive brown onion growing region due to its unique climate and low disease pressure. Onions are available all year and this is attributed to different planting seasons in the major producing provinces. The major cultivars commonly marketed in Fresh Produce Markets are brown onion and red onion. China, India, Egypt, the United States, Iran, Turkey, and the Russian Federation are the top onion producers, according to the United Nations Food and Agriculture Organization (FAOSTAT 2020). According to (ITC Trade Map, 2020) Egypt remains the only African country to rank among the top ten onion growers in the world. Figure 3.3 illustrates South Africa’s onion production in 11 years.

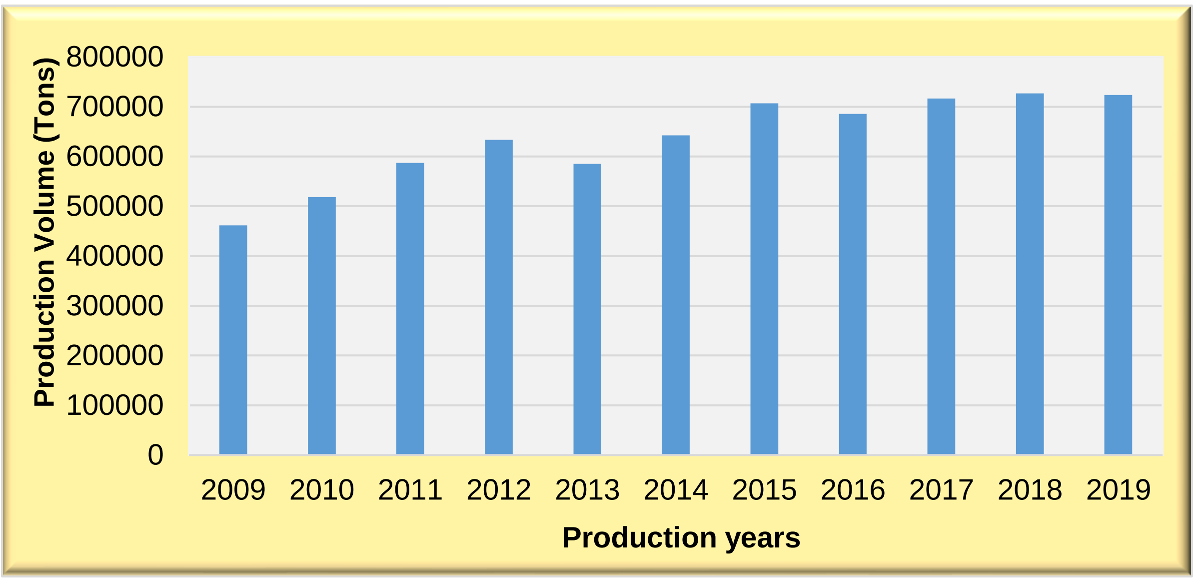

Figure 3.3: South Africa's total onion production volume

Source: Statistics and Economic Analysis (DALRRD 2020)

In 2009, South Africa has produced just above R461 000 tons of onions. From 2010 to 2011, South Africa's onion production volume increased steadily and in 2012, there was a 7.8% increment in production volume relative to 2011 output. South Africa's onion production volume decline slightly by 3% when compared to the previous year's (2012) production volume. was stable above 320 000 tons of onions. In 2014, South Africa’s onion production output grew by 9.7% and the production output was 642 080 tons. The production was just above 510 000 tons from 2010 to 2014. In 2015, onion production output was above 700 000 tons and the same trend continued from 2017 to 2019. As can be seen on the graph, South African onion production has grown notably from 461 547 tons in 2009 to 723 409 tons in 2019. South Africa is self-sufficient in onion production.

3.4 Market structure/ Distribution channels

The onion sector operates in a deregulated environment, with pricing determined by market forces such as demand and supply. However, the sector must adhere to regulations regarding the grading, packaging, and marking of onions intended for sale in the Republic of South Africa. The distribution channels for onions are depicted in Figure 3.4 below.

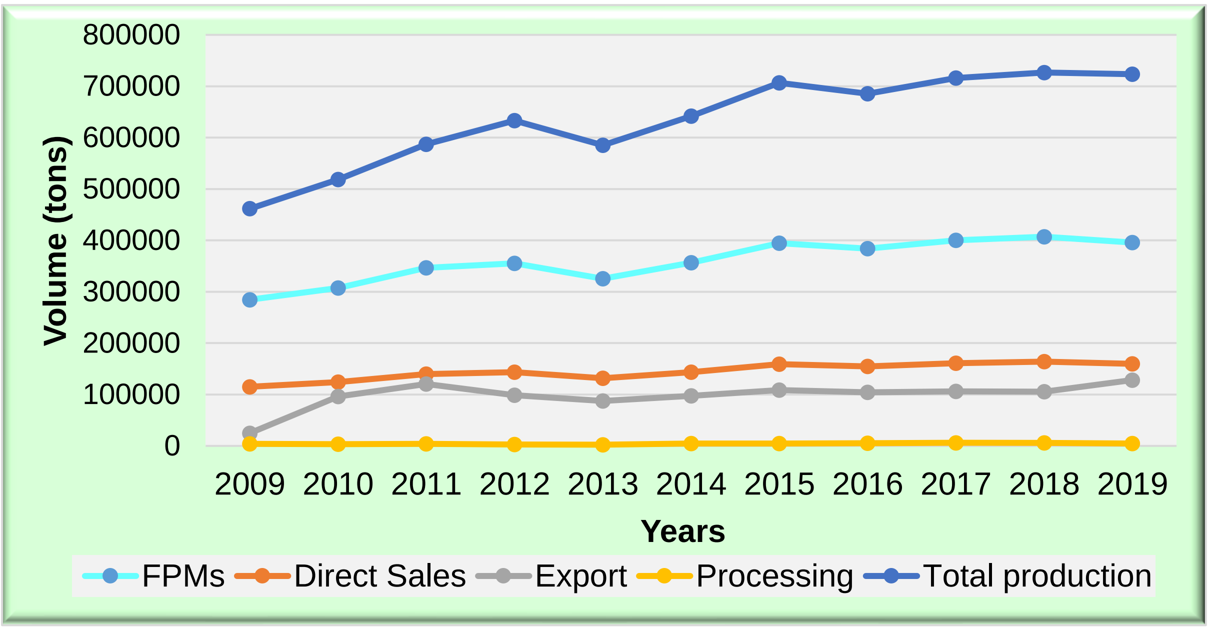

Figure 3.4: South Africa's onion distribution channels

Source: Statistics and Economic Analysis (DALRRD 2020)

Fresh Produce Markets are by far the primary distribution channel for fresh onion, followed by direct sales to retailers, which have shown a constant increase, onion exports surged in 2010 and 2011 whereas the processing of activities has shown a constant trend. Fresh Produce Markets, informal markets (Hawkers), processors, and direct selling to wholesalers and retailers are used as marketing channels by the industry. Through export agencies and marketing businesses, onions are exported to other countries and South Africa also imports onions from other countries (DALRRD, 2020). During 2019, FPMs distributed 55% of onion output, direct sales accounted for 22%, 12% was recorded as exports and 0.8% of onions were destined for processing activities (DALRRD, 2020).

3.4.1 Fresh Produce Markets

South Africa has 18 commission-based Fresh Produce Markets (FPMs), which are mostly owned and managed by local municipal authorities around the country. FPMs with approximately 55% share of production are the primary distribution channel of fresh onions (DALRRD, 2020). Fresh Produce Markets have long been praised as an important part of the agriculture industry's price-setting function and distribution of fresh produce in South Africa (NAMC, 2006). Due to their unique potential to be the most relevant and dominant pricing setting entity, FPMs play a critical role in the industry. The commission-based system, which is operated on the ground via the wholesale agent structure used by the majority of FPMs, allows South African markets to deliver this distinguishing attribute (Chikazunga, Deall, Louw and Van Deventer, 2008). Access to market information has proven to be crucial to a transparent pricing structure. Prices are determined by supply and demand factors in the end, and they are discussed and agreed upon on the market floor by buyers and brokers. Buyers at FPMs are categorised as wholesalers, retailers, informal traders (hawkers), processors and exporters (DARRLD, 2020). Onions are available throughout the year in all markets, owing to advancements in cold storage technology. Each of these FPMs have a competitive advantage above other participants in the markets due to the strategic geographical location of each of these markets and generally with no large markets. Figure 3.5 is an illustration of onion sales at Fresh Produce Markets for 11 years.

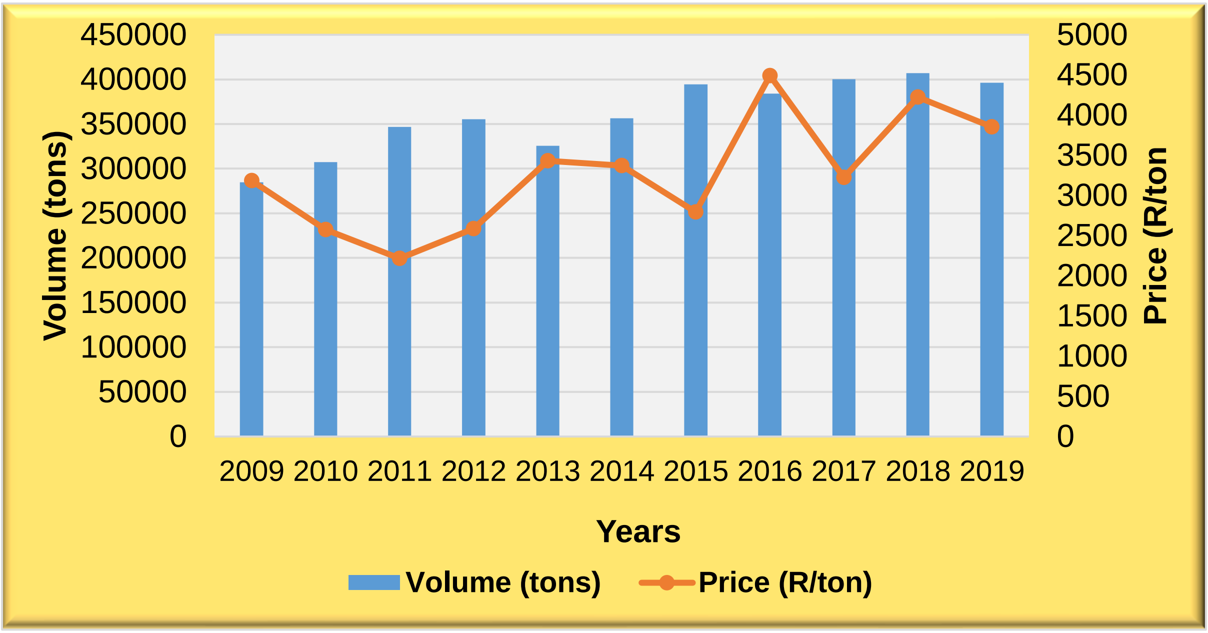

Figure 3.5: Total sales of onions at FPMs

Source: Statistics and Economic Analysis (DALRRD, 2020)

During 2009, a price of R3 182 was attained for a record low volume supplied at the FPMs. In the following years (2010 and 2011) market-priced dropped by 19% and 13% respectively as the volume supplied grew by 8% and 12% respectively. In 2012, the price of onions grew by 16% despite a 2.4% increase in the sales volume and this can be ascribed to strong demand for onions in the same year. A notable 32.7% increase in market price was recorded in 2013 when sales volume dropped by 8.4% relative to 2012 volume. During 2015, the price of onion declined sharply by 17.8% as a result of a 10.7% increment in volume supplied at the markets. A recorded high price of R4 492.08 was recorded in 2016 and the sales volume was 2,7% lower relative to the 2015 volume. In the following year (2017) the market prices dropped notably by 28.2% as volume increased by 4.2%. In 2018, the onion price appreciated notably by 31% despite a 1.7% increment in the sales volume and this can be ascribed to good uptake of onions in the same year. 2019, the onion price dropped by 8.8% despite a 2,7% decline in the volume supplied to the markets and this can be attested to poor onion uptake in the same year. During the 11 years, the onion price was unstable with the lowest price of R2 216.74 in 2012 and the highest price of R4 492.08 in 2018.

3.4.2 Volume of onion supplied at selected FPMs

Figure 3.6 below shows the volume of onion supplied at Johannesburg, Cape Town, Durban and Bloemfontein. The four Fresh Produce Markets were chosen on purpose based on their significance, geographic position, and supply volume. Tshwane Fresh Produce Market was excluded in this study due to its proximity to the Johannesburg Fresh Produce Market, which is regarded as a reference market for this study.

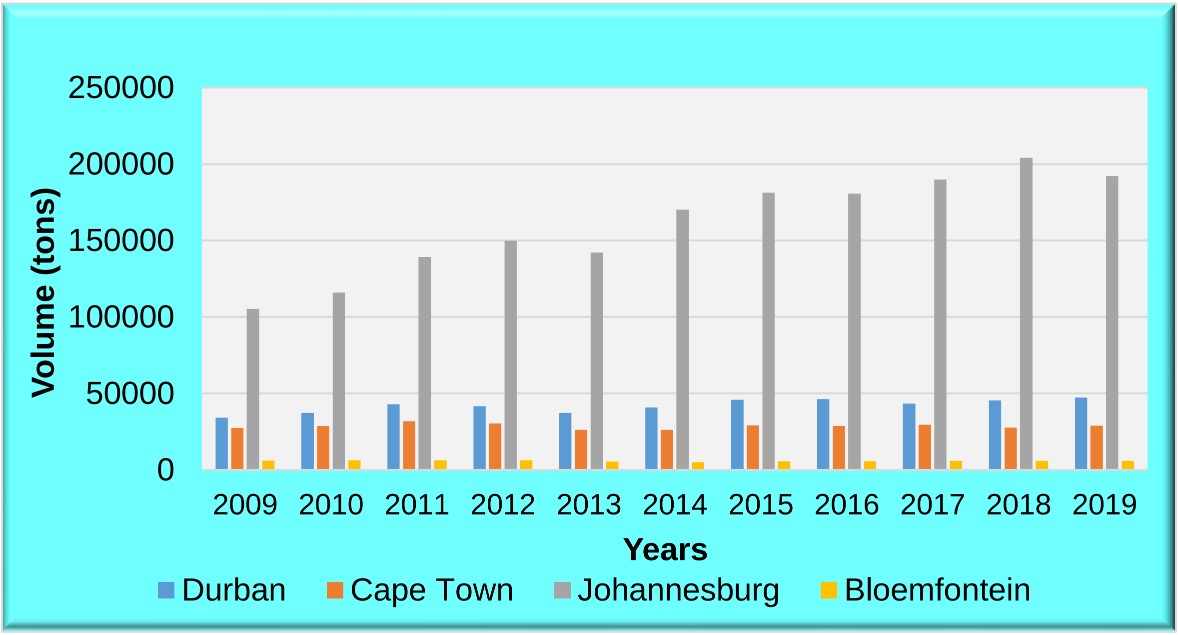

Figure 3.6: Volume of onion supplied at selected FPMs

Source: Statistics and Economic Analysis (DALRRD, 2020)

Johannesburg market has distributed the largest volume of onion, followed by Durban, Cape Town then Bloemfontein. In 2019, the Johannesburg market has distributed 49% of the total onion sold through FPMs, Durban accounted for 12%, Cape Town markets distributed 7% of onions and Bloemfontein registered 1% of onions. The selected four markets have handled 69% of onion volume distributed through FPMs. Onions are mostly produced in Western Cape however, Cape Town Market which is in the same province has distributed 12% of onions. Whereas Johannesburg market, which is in a non-producing in Gauteng province has distributed 49% of onion traded at the FPMs. Johannesburg market is viewed as a price barometer for the whole fresh produce industry and is critical to the system's credibility and fairness. As a result, the interruption to the functioning of the Johannesburg markets is felt throughout the country (Fresh Plaza, 2020). Market integration ensures that a regional balance occurs among food deficit and food surplus regions and regions producing non-food cash crops.

3.4.3 The average price at selected Fresh Produce Markets

Prices are determined by supply and demand on the FPMs (NAMC and Commark Trust, 2006). During 2019, Johannesburg market has handled approximately 49%, Durban accounted for 12%, Cape Town distributed 7% and Bloemfontein distributed 1% of the total volume distributed through FPMs markets. Figure 3.7 shows the average price of selected FPMs from 2009 to 2019.

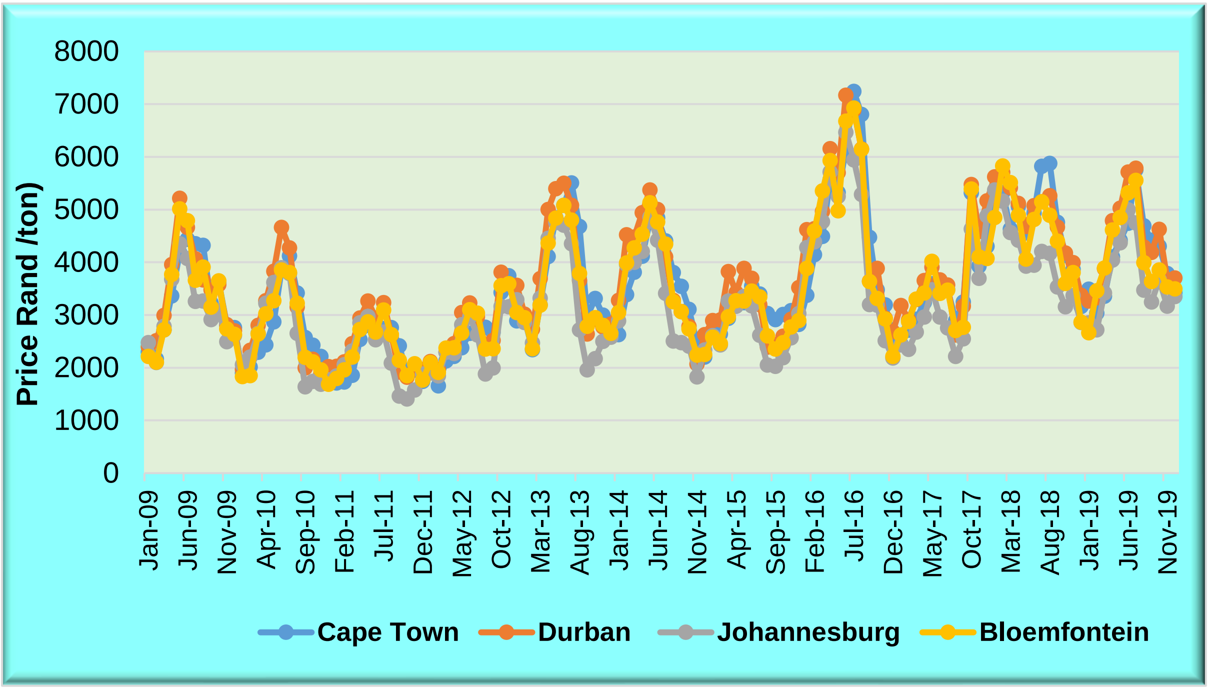

Figure 3.7: Prices of onion at selected FPMs

Source: Statistics and Economic Analysis (DALRRD, 2020)

The observed trend is that the average onion prices generally followed the same trend with some outliners over the years. Durban market is a non-producing area and it has received higher prices compared to the other markets. Cape Town Market and Bloemfontein markets are high onion production areas and have received approximately similar average prices. Johannesburg market is a consumer market and has received the least average prices. An average price of R5 214 was recorded for Durban in May 2009. The lowest average price of R1 407 was registered for the Johannesburg market in October 2011. There was a notable outliner average price of R 5 504 recorded for Durban in June 2013. A record-high average price of R7 241 was realised in the Cape Town market in July 2016. Bloemfontein has recorded a notable average price of 4 022 in May 2017 and Cape Town has a notable outlier of R5 878 average price in August 2018. In 2019, the high average price of R3 702 was recorded for the Durban market in December 2019. From 2009 to 2019, monthly average prices were unstable with a minimum price of R1 407 and the highest price of R7 241.

3.4.3 Price Variability

The coefficient of variation is calculated to make insights regarding price variability The computation of the Coefficient of Variation (CV) and its link between selected spatial marketplaces is shown in Table 3.1 below.

Table 3.1: Price variability

Markets	Mean	Standard Deviation	Coefficient of Variation(CV)
Cape Town	3484.3	1138.6	32.68
Durban	3662.3	1184.1	32.33
Johannesburg	3168.4	1046.5	33.03
Bloemfontein	3448.3	1130.5	32.78

Source: Statistics and Economic Analysis (DALRRD, 2020), Author's computation

Price fluctuation, both high and low, causes problems in spatial markets and has unfavourable repercussions (Pindyck, 2004). In spatial marketplaces, irregular price patterns are widespread, and they affect both consumers and suppliers. Excessive price variation is mainly a result of a lack of market integration across space. On the other side, little or no price variation has frequently been the result of governmental interventions, such as pan-territorial pricing, which was widespread in African countries in the 1970s and 1980s (Rashid *et al*.,2010). The analysis illustrates that the coefficient of variations is almost the same, which means there is a low-price variation in the selected markets.

3.4.4 Johannesburg Fresh Produce Market

The Johannesburg Fresh Produce Market (JFPM) with a turnover of R4.6 billion, continues to be Africa's/fastest SADC's growing market (Joburgmarket, 2022). The market is situated in City Deep, Johannesburg's southern suburbs. JFPM was established as a private corporation, completely owned by the City of Johannesburg Metropolitan Municipality, following the political transition in South Africa (City of Johannesburg). The corporation was transformed into a State-Owned Company (SOC) in 2000, following the South African Companies Act (Act No. 71 of 2008). The company employs 313 people and is Africa's largest fresh produce market in terms of the volume of the fresh product exchanged (Joburgmarket, 2022). JFPM's role in ensuring food security for Johannesburg residents is critical. Farmers from all around South Africa and beyond have access to JFPM trade facilities, where their food is promoted and exposed to thousands of buyers every day. Thousands of jobs are created across the agricultural value chain by Johannesburg Fresh Produce Market, Market Agents, and tenants operating within the market facilities.

The JFPM is critical in determining the pricing for the fresh produce business in South Africa since it accounts for 44.9 % of the Fresh Produce Markets in both volume and turnover (Joburgmarket, 2022). For operating and maintaining a competitive marketing system and infrastructure that allows fresh produce trading to take place, including a computerized sales system, cash collections, cleaning, and security, the market is paid a fixed 5% commission. Market agents are paid a commission of 5% to 7% of the gross value of the commodity they sell. The commission is agreed between the producer and the market agent and varies depending on the commodity. The Market serves over 5 000 farmers from all over South Africa, who send their fresh products to be transacted with a big buyer base of about 10,000 people every day. The Market contains 55 cold rooms that can hold 4 561 pallets of fresh produce. Trade takes place in three (3) Food hubs totalling 65 000m2: Fruit Hub, Potato and Onion Hub, and Vegetable Hub. Figure 3.8 below illustrates the onion sales from 2009 to 2019.

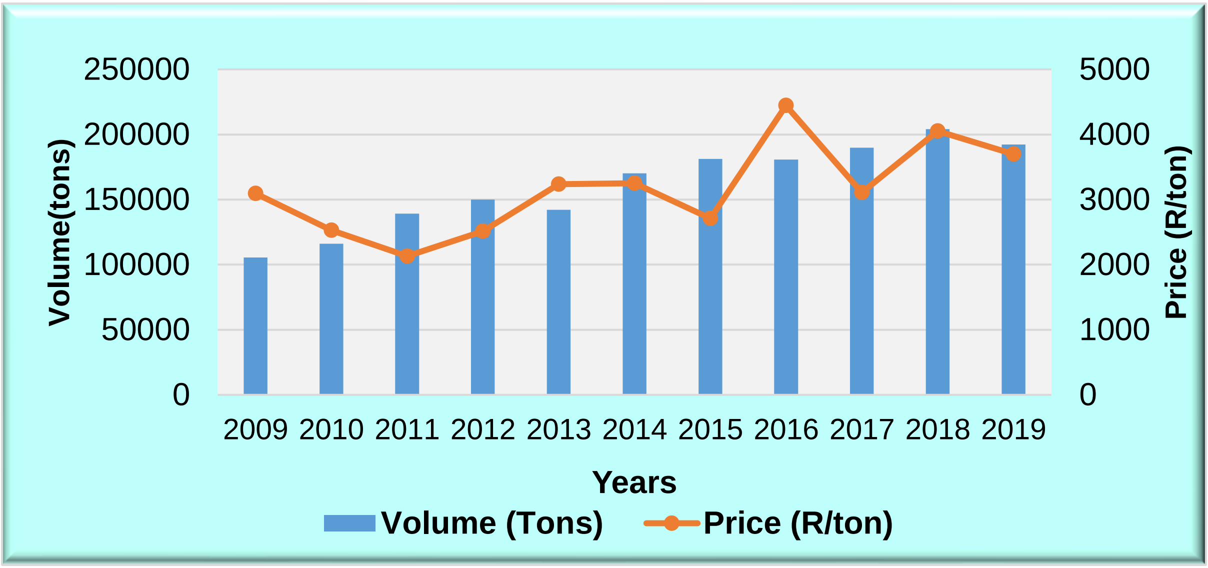

Figure 3.8: Onion sales at Johannesburg Fresh Produce Market

Source: Statistics and Economic Analysis (DALRRD, 2020)

Figure 3.8 shows that in 2009, JFPM has distributed just above 105 000 tons of onion. In the following years, the sales volume grew steadily and the notable increase was in 2012 with 149 941 tons. The sales volume dropped to 142 217 tons in 2013, which represents a 5% decline in sales volume. A record-high volume of 204 127 tons was recorded in 2018 and in 2019, sales volume declined to 192 237 tons. The average sales volume during the study period is 122 221 tons The sales prices were varying with the lowest price of R2 131per ton and the highest price of R4 444 per ton.

3.4.5 Durban Fresh Produce Market

The Durban Fresh Produce Market (DFPM) is located about 9 kilometres from the city's centre, on the outskirts of the major business district, far enough to avoid the traffic congestion typical of a city setting while still close enough to adequately support the city's commercial hub. The Durban Market has established itself as a powerful competitor in the business, ranking as the third-largest public commission market in South Africa in terms of both sales and tonnage of output (Durbanmarket, 2022). This facility used to be the only one with cooled sales halls, which were recently upgraded to include air curtains at all main entrances. The Durban Market has been successful in guaranteeing the upkeep of its superb facilities, which include thirty ripening rooms and eight bulk cold storage rooms that can hold 804 pallets of fresh produce. Cold storage is offered as part of the market service to its suppliers and buyers. Durban Market operates on a commission-based system, as do all public markets in South Africa. This arrangement allows the market's owner, the eThekwini Municipality, as well as the market's six market agents, to earn commission from producers for the services they provide (Durbanmarket, 2022). Figure 3.9 is an illustration of onion sales at Durban Fresh Produce Market.

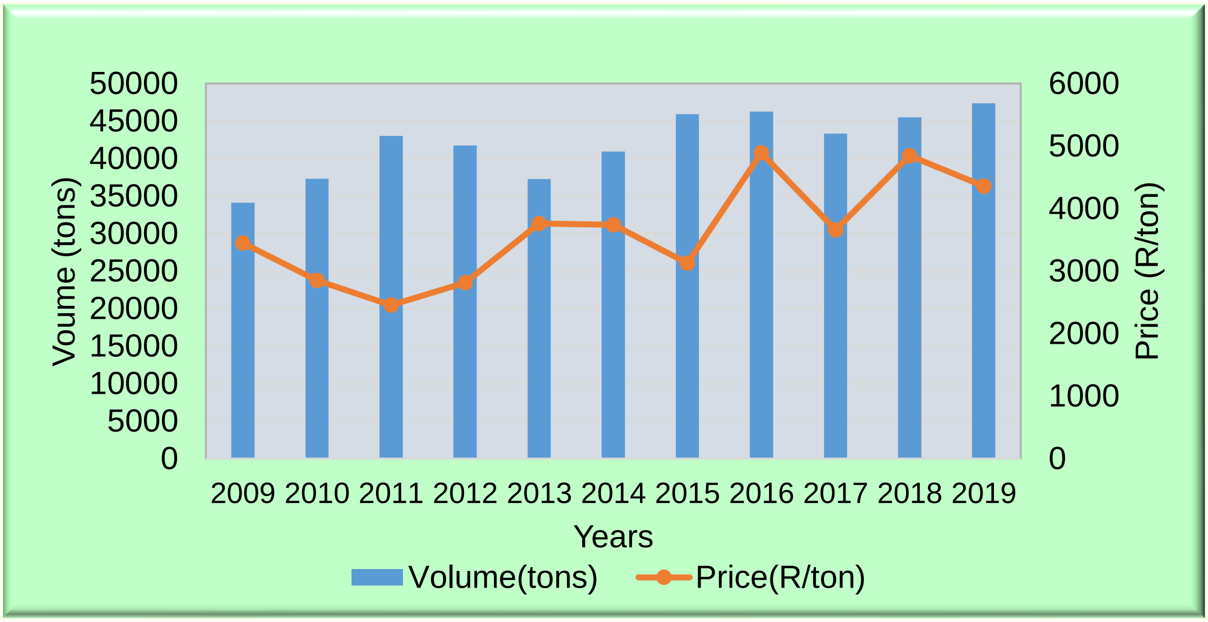

Figure 3.9: Sales of onion at Durban fresh produce markets

Source: Statistics and Economic Analysis (DALRRD, 2020)

Figure 3.9 shows that in 2009, DFPM has distributed just above 34 000 tons of onion. In the following years, the sales volume grew steadily and the notable increase was in 2011 with 43 008 tons. The sales volume dropped to 41 758 tons in 2012, which represents a 3% decline in sales volume. A notable higher volume of 45 909 tons was recorded in 2015 and in 2016, sales volume increased further to 46 274 tons. The highest sales volume of 47 347 tons was recorded in 2019. The average sales volume during the study period is 42 063 tons The sales prices were inconsistent with the lowest price of R2 454 per ton and the highest price of R4 889 per ton.

3.4 6 Cape Town Fresh Produce Market

The Cape Town Fresh (Epping) Produce Market (CTFPM)is one of South Africa's oldest and largest fresh produce markets. The Market was purchased from the City of Cape Town in 2004 and is the country's only privatized fresh produce market and the first to involve brokers and buyers as shareholders. The market has a diverse ownership basis, with producers and market agents holding a 26% stake in the firm since 2007 (ctmarket, 2022). The Cape Town Market is a statutory fresh produce market run by a commission system. All produce has a commission of 12,5%, except potatoes, which have a reduced commission. There are many competitors at the Cape Town Market, none of whom are regulated. The market serves over 5500 farmers who provide the fresh product to the market agents, who then sell it to over 8000 registered buyers. It has various cool rooms that can store over 800 pallets of produce at optimal temperatures to keep the cold chain running smoothly. Five well-established market agencies facilitate customers' transactions (ctmarket, 2022). Figure 3.10 is an illustration of onion sales at Cape Town Fresh Produce Market.

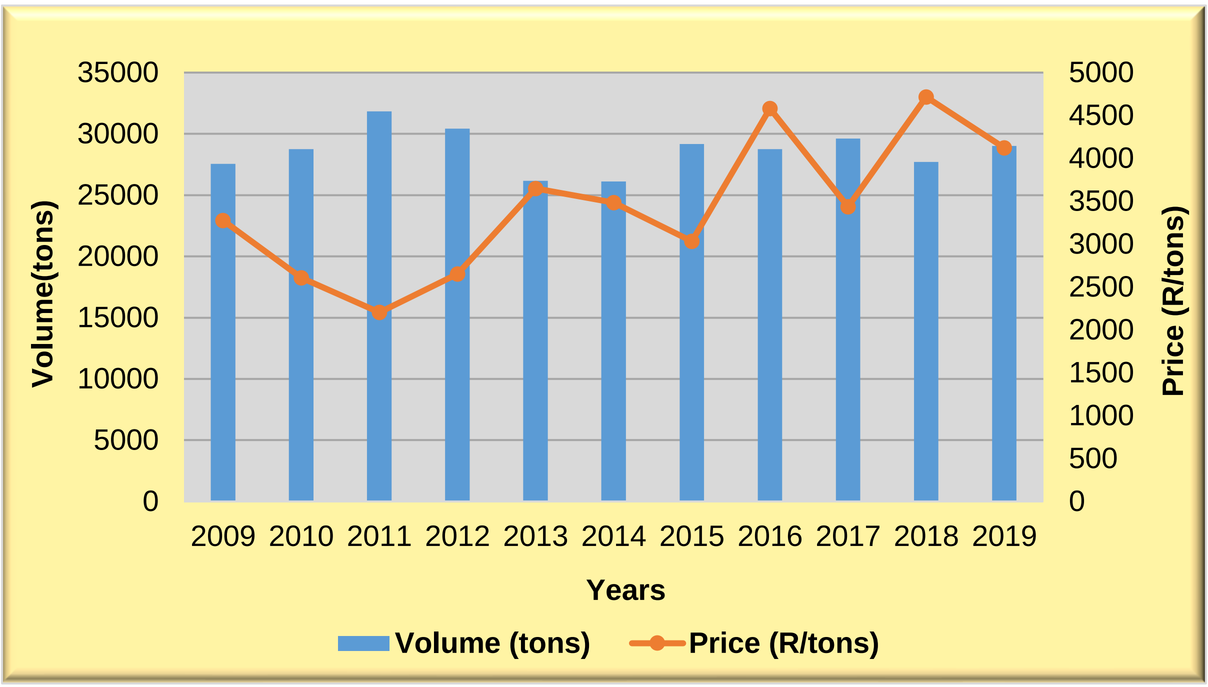

Figure 3.10: Sales of onion at Cape Town Fresh Produce Market
Source: Statistics and Economic Analysis (DALRRD, 2020)

Figure 3.10 shows that in 2009, CTFPM has distributed just above 27 000 tons of onion. In the following years, the sales volume grew steadily and the notable increase was in 2011 with 31 828 tons. The sales volume dropped to 30 421 tons in 2012, which was a 4.4% drop in sales volume. During 2013 and 2014, there was a notable decrement in volume supplied in the market and the volume was just about 26 000 tons. As of 2016, a notable higher volume of 29 165 tons was recorded in 2015. The highest sales volume of 29 603 tons was recorded in 2017. The average sales volume during the study period is 28 643 tons The sales prices were inconsistent with the lowest price of R2 204 per ton and the highest price of R4 716 per ton.

3.4.7 Bloemfontein Fresh Produce Market

Bloemfontein Fresh Produce Market (also known as Mangaung) is in the city of Bloemfontein, Free State province. The Free State province is one of the main onion-producing areas This study will use the name Bloemfontein market as the data was collected under this name. Bloemfontein Fresh Produce Market was established in 1981 and is part of the Mangaung Metropolitan Municipality. It is one of the country's 18 municipally owned Fresh Produce Markets. Producers send their produce to the market through Agents who work on their behalf. Because not all the produce is grown in the Free State, the producers or farmers are spread around the country. The Agents sell the produce on the market based on supply and demand. A commission of around 7% to 10% is paid to the agents. The infrastructure is owned by the municipality, which is also responsible for its upkeep. The municipality oversees allocating Agents' operating space. The municipality receives a 5% commission on all revenue collected DALRRD, 2020). Figure 3.11 below is an illustration of onion sales at Bloemfontein Fresh Produce Market.

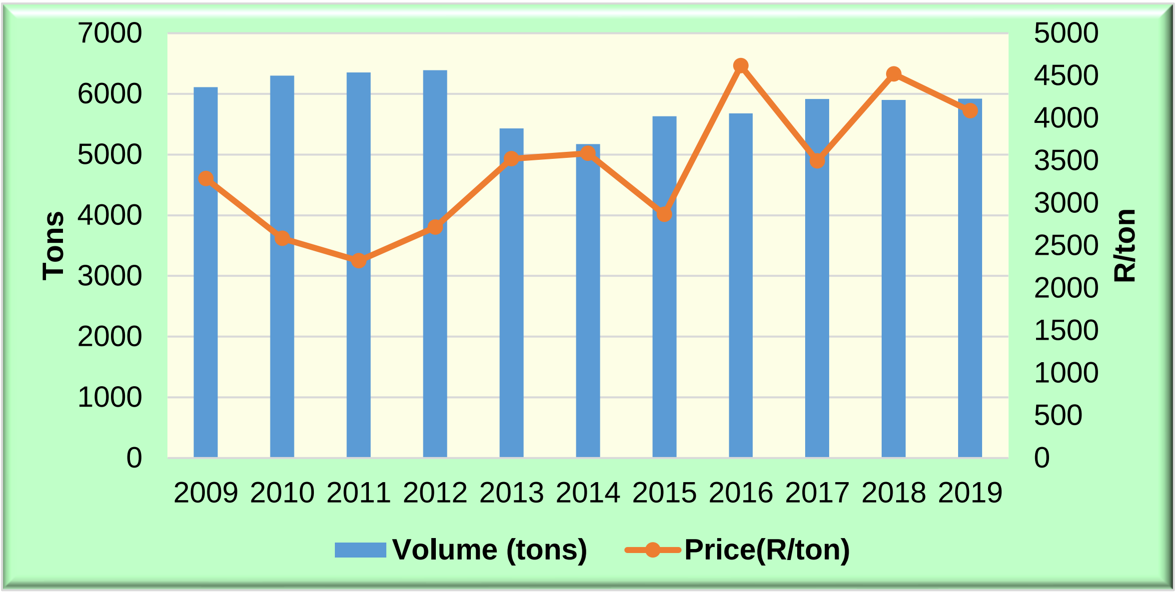

Figure 3.11: Sales of onion at Bloemfontein Fresh Produce Market

Source: Statistics and Economic Analysis (DALRRD, 2020)

Figure 3.11 shows that from 2009 to 2012, onion sales volume was stable at above 6 100 tons and the lowest average price was recorded in 2011. A record-high sales volume was recorded in 2012 with 6 393 tons. A record low sales volume was recorded in 2014 and from 2015 to 2016, sales volume was stable at just above 5 600 tons. During 2018 and 2019, the sales volume was stable at just above 5 900 tons. The average sales volume during the study period is 5 892 tons. The sales prices were varying with the lowest price of R2 321 per ton and the highest price of R4 617 per ton.

3.4.8 South Africa onion exports

In 2019, South Africa with an export volume of 128 641 tons, was the second biggest onion exporter on the African continent after Egypt (ITC Trade Map, 2020). South Africa's onion exports accounted for 0.8% of global exports, placing it 19th in the world onion exports (ITC Trade Map, 2020). South Africa’s onion export has recorded a value of R60,2 million in 2019 (ITC Trademap, 2020). South Africa is competitive in terms of onion exports to the rest of the globe. Table 2 below is an illustration of South Africa’s onion export destination in 2019.

Table 3.2: List of top countries importing onion exported from South Africa.

Importers	Value exported in 2019 (USD thousand)	Trade balance 2019 (USD thousand)	Share in South Africa's exports (%)	Quantity exported in 2019 (Tons)	Unit value (USD/ unit)	Ranking of partner countries in world imports
World	32308	30314	100	128641	251	
Mozambique	12953	12953	40.1	67947	191	46
Angola	6066	6066	18.8	20100	302	68
Zambia	2693	2693	8.3	11967	225	122
Botswana	2047	2047	6.3	5140	398	110
Namibia	1591	588	4.9	4386	363	111
United Kingdom	1586	1586	4.9	3619	438	3
Netherlands	1223	1000	3.8	2704	452	5
Eswatini	1178	1178	3.6	6192	190	123
Lesotho	940	940	2.9	2293	410	131
Congo	373	373	1.2	720	518	87
Belgium	307	307	1	546	562	10

Source: ITC Trade Map, 2020.

As illustrated in Table 3.2 African countries were the primary recipients of onion exported from South Africa. Notable volumes of onions were exported to European countries. African region has accounted for 86% share and European region has received 11.6% share of onion exports originating from South Africa. Figure 3.12 shows South Africa’s onion imports from 2009 to 2019.

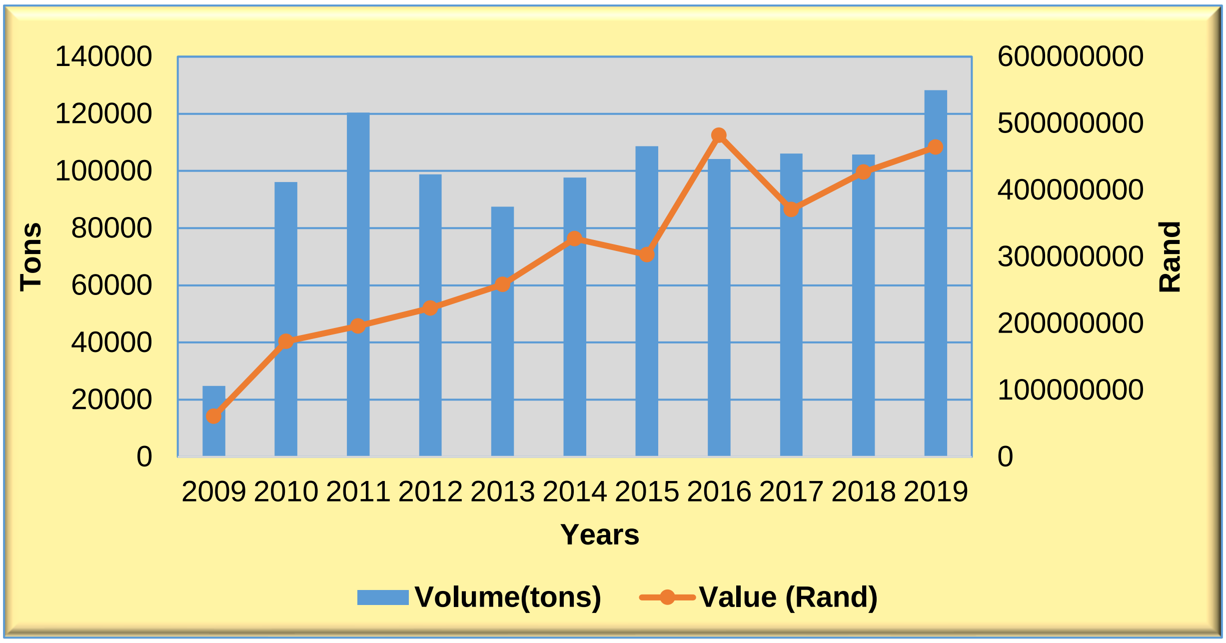

Figure 3.12: South Africa's onion exports
Source: Quantec Easy data, 2020

In 2019, Mozambique with a 40.1% share was the primary export market for South Africa's onion. Angola was in second place with an 18.8% share, Zambia has accounted for 8.3% and Botswana has registered a 6.3% share of South Africa's onion exports. According to (ITC Trademap, 2020), the Netherlands, China, India, the United States of America, Egypt, Spain and New Zealand are the top countries exporting onions. Egypt is the only African country amongst the top ten onion exporters in the world since is also to Egypt being one of the top onion-producing countries. In the same year (FAO, 2020), it was relatively cheaper for Mozambique to import onion from South Africa when comparing other import values for neighbouring countries like Botswana, Namibia and Lesotho.

3.4.9 South Africa's onion import

South Africa is self-sufficient in terms of onion production and it's by far a net exporter of onions. In 2019, South Africa's imports represented 0.1% of world imports for onion and its ranking in world imports was 105. In 2019, Namibia with a share of 50.3% was the primary supplier of onion imported by South Africa, followed by Spain, Netherlands, Kenya and China. Egypt is amongst the top ten producers in the world and it has supplied 6% of South Africa's onion imports. There was 4.8% of onion imports, which were not allocated. It was cheaper for South Africa to import onion from China, Namibia and Egypt relative to imports sourced from Kenya, Zimbabwe and Spain. Globally, the United States of America, Viet Nam, United Kingdom, Netherlands, Germany, Malaysia, Canada, Japan, France and Belgium are top onion importers.

Table 3.3: List of supplying markets for onion imported by South Africa in 2019

Exporter	Value imported in 2019 (USD thousand)	Trade balance 2019 (USD thousand)	Share in South Africa's imports (%)	Quantity imported in 2019 (Tons)	Unit value (USD/ unit)	Ranking of partner countries in world exports
World	1994	30314	100	4076	489	
Namibia	1003	588	50.3	2814	356	61
Spain	422	-412	21.2	213	1981	7
Netherlands	223	1000	11.2	375	595	1
Egypt	120	-120	6	250	480	6
Area Nes	96	96	4.8	261	368	
Kenya	62	-52	3.1	13	4769	34
China	43	-43	2.2	135	319	2
France	21	90	1.1	13	1615	10
Zimbabwe	2	156	0.1	1	2000	

Source: ITC Trademap, 2020

Figure 3.13 is an illustration of South Africa's onion imports from 2009 to 2019.

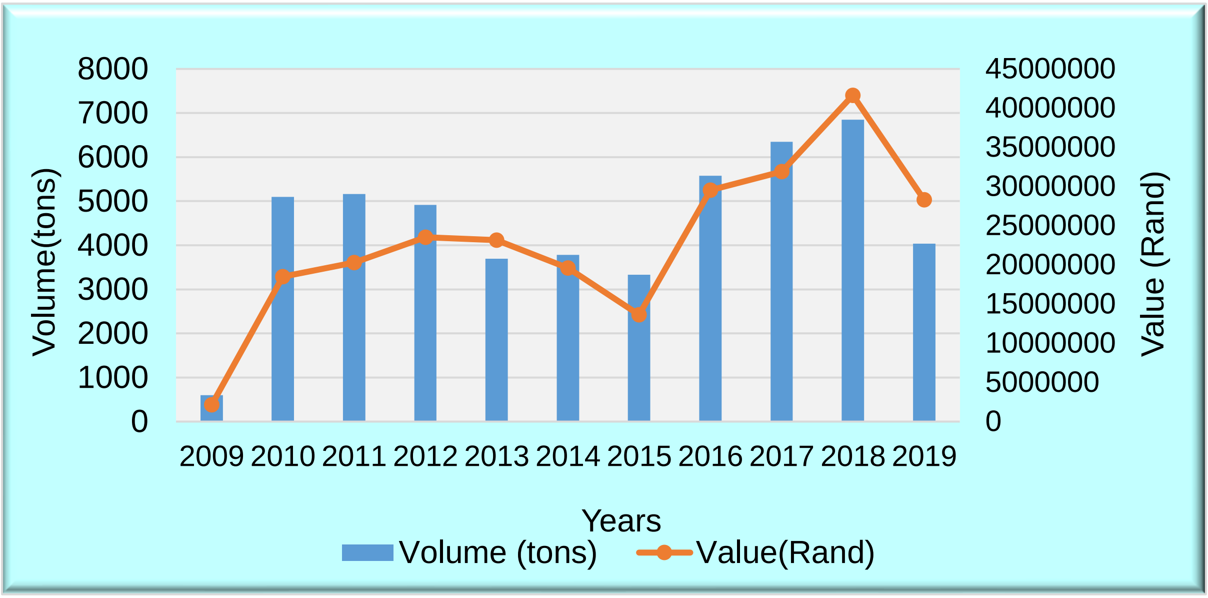

Figure 3.13: South Africa's onion imports

Source: Quantec Easydata, 2020

In 2009, South Africa's onion import was just 500 tons. There was a surge in onion import and from 2010 to 2011, the import volume was above 5 000 tons. During 2012, South Africa's onion imports declined slightly by 4.8% and in 2013, the imports declined further to 3 698 tons. In the following years (2013 to 2015), the import volumes were stable at above 3 300 tons. From 2016, the import volume increased steadily to reach a record high in 2018 with 6 848 tons of imported onion. In 2019, South Africa's onion import decrease drastically to 4 039 tons which represent a 41% decline in imports.

3.4.10 Processing

In South Africa, onion processing entails canning, oil extraction, freezing, and dehydration. Onion is used in everyday cooking in South Africa and they are the most used to add flavour to a variety of recipes, including casseroles, pizzas, soups, and stews. Onion may also be used as the major component, such as onion soup or onion chutney. Onions are used as a garnish on sandwiches and salads. In addition, onions are commonly used as a condiment, on sandwiches, side dishes, and appetizers, and as a cooking ingredient in a variety of recipes. Figure 3.14 illustrates the volumes and values of processed onion for 11 years.

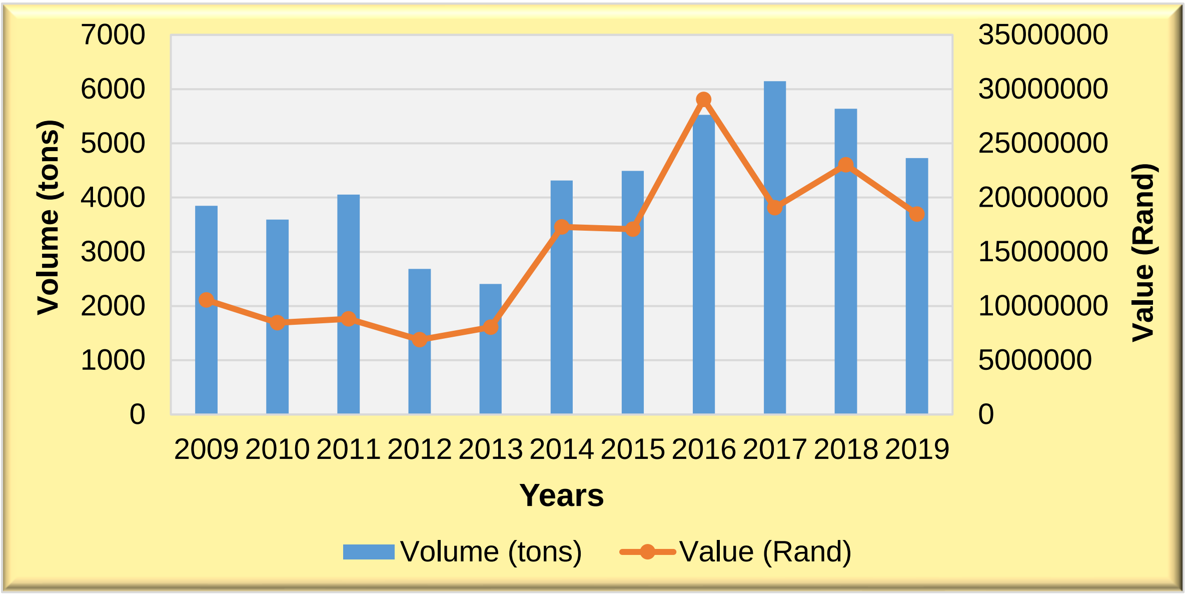

Figure 3.14: South Africa's onion processing

Source: Statistics and Economic Analysis (DALRRD, 2020)

The onion is a common ingredient in South African cooking, and it's used to thicken curries and gravies. Pickled onions with vinegar are served as a snack. The rise in demand for convenience ready-to-eat foods has been attributed to an increase in volume destined for onion canning and freezing activities (DALRRD, 2020). Figure 3.14 above shows that South African onion processing activities are less significant when compared with the production output. In 2019, an average of 0.8% of the total production output was processed (DALRRD, 2020). The processed volumes have been inconsistent. From 2009 to 2010, the processed volume was stable at above 3 500 tons and the value of processed onion was very low. In 2011, the processed volume grew notably by 12.8% relative to the 2010 processed volume. There was a notable decline in processed volumes in 2012 and 2013, just above 2000 tons were processed. There was a notable increase in processing activities from 2014 to 2019, above 4 000 tons were processed. In the same years, the processed onion recorded a higher value.

3.5 Market Infrastructure

The FPMs chosen for this research are geographically dispersed. Table 3.4 summarizes the characteristics of the local markets and the travel distance between them and the major market (Johannesburg).

Table 3.4: Spatial separation of selected Fresh Produce Markets

Market	Average volume per annum (tons)	Road distance between JFPM and other markets in Kilometers
Johannesburg	122 221	
Durban	38 887	578
Cape Town	30 079	1 402
Bloemfontein	5 092	398

Source: Uchezuba, 2005 and author computation

Cape Town and Bloemfontein markets are located in onion surplus-producing provinces. Johannesburg and Durban are located in provinces that are onion deficit. Cape Town is over a thousand kilometres from the Johannesburg market. Durban market is located 578 kilometres away from JFPM, whereas Bloemfontein is located 398 kilometres away.

3.6 Summary

The purpose of this section was to provide a descriptive overview of the onion industry in South Africa. The chapter presents an overview of the sector, with a focus on distribution and marketing channels which, include Fresh Produce Markets, direct sales, exports and processing. Furthermore, as the study's basis, the overview looked at the sales volume and pricing of the selected markets. Onions are produced in almost every province in South Africa however, the Western Cape (Ceres), Northern Cape, Free State, North West, and Limpopo are the top producers (DALRRD, 2020). The production of onions in South Africa has grown drastically from 461 547 tons in 2009 to 723 409 tons in 2019. The industry's gross value has increased significantly from R123 billion reported in 2009 to R235 billion in 2019. In 2019, onions accounted for 14% of the total gross value of South African vegetables (DALRRD, 2020).

The onion industry is a deregulated one, with pricing decided by market forces including demand and supply. Fresh Produce Markets dispersed 55% of onion output in 2019, with direct sales accounting for 22%, exports accounting for 12%, and processing operations accounting for 1% (DALRRD, 2020). FPMs are by far the most important distribution channel for fresh onions, followed by direct sales to retailers, which have been steadily increasing. Onion exports increased dramatically in 2010 and 2011, but processing operations have remained stable. FPMs in South Africa have long been regarded as a key aspect of the agriculture industry’s price-setting function and distribution of fresh produce (NAMC, 2006).

FPMs play a significant role in the industry because of their unique capacity to be the most important and dominant pricing setting organization. From 2009 to 2019, the average price of selected FPMs followed the same pattern year after year, with a few exceptions. Because the Durban market is a non-producing area, it receives greater pricing than the other markets. The markets in Cape Town and Bloemfontein, both of which produce a lot of onions, have earned around the same average price. The Johannesburg market is a consumer market with the lowest average price.

CHAPTER 4: METHODOLOGY

4.1 Introduction

The purpose of this chapter is to examine the data that was used, as well as the procedures that were employed, to meet the study's primary objectives. The study will examine the spatial market integration of onion between four Fresh Produce Markets located in different provinces around South Africa. The objective of this market integration analysis is to use price changes in one market to measure the extent of price movements in another market., to examine the long-run and short-run dynamics of onion market integration in South Africa. Additionally, the chapter discusses theoretical concepts underlying co-integration. The approaches used in this study are based on those implemented by Baiyegunhi *et al*. (2018).

4.2 Study area

The study will focus on measuring spatial market integration using average monthly onion prices along four FPMs, Johannesburg (JFPM), Cape Town (CTFPM), Durban (DFPM) and Bloemfontein (BFPM) in the Republic of South Africa. The four fresh produce markets were selected purposefully on their importance, geographic location and the volume supplied to these markets. Johannesburg market is situated in Gauteng province and Bloemfontein is located in Free State Province and these provinces are inland. Durban and Cape Town are located in KwaZulu Natal. And Western Cape provinces which are coastal provinces. JFPM was further selected as a reference market for this study because this market is critical in determining the pricing for the fresh produce industry and in 2019, it has distributed 55% of onion distributed through Fresh Produce Markets. Cape Town and Bloemfontein markets are located in high production provinces, while Durban and Johannesburg markets are placed in high onion consumption provinces. Furthermore, these selected markets account for more than 69% of the total onion distributed through South African Fresh Produce Markets (DALRRD, 2020).

4.3 Data set and source

The study used historical secondary data on average monthly onion prices in Johannesburg Cape Town, Durban and Bloemfontein Fresh Produce Markets. The data observed is from January 2009 to December 2019. The prices are in the South African currency, which is (Rand/ton). The total number of observations is 132, which is an acceptable amount to undertake research and is considered a large sample (Baiyegunhi *et al.*, 2018). The data on selected FPMs were obtained from the Abstract of Agricultural Statistics, which is published annually in the Department of Agriculture, Land Reform and Rural Development (DALRRD): Directorate Economic Analysis and Statistics website.

4.4 Data analysis technique

The study used the Co-integration technique and the Error Correction Model (ECM) to evaluate the market price integration of onions in Johannesburg, Cape Town, Durban and Bloemfontein Fresh Produce Markets in South Africa. The evaluation will involve three procedures: (i) evaluating the stationary of onion prices in the Johannesburg, Cape Town, Durban and Bloemfontein markets by using the Augmented Dickey-Fuller test, (ii) The Augmented Engle-Granger Co-integration test will determine whether there is a co-integration relationship between onion prices among the selected market prices, and (iii) Error Correction Model will examine the short-run relationships between onion prices in the selected markets.

4.4.1 Stationarity

The idea of stationarity can be used to summarize the statistical features of series. A stationary series has a finite covariance structure and a constant mean. Such a series does not vary systematically over time, but rather tends to return to and fluctuate around its mean value in a more or less constant range. A non-stationary series, on the other hand, has statistical features that are time dependent. Trends in non-stationary series can be stochastic or deterministic. Variables with stochastic trends are referred to as “integrated,” and they have systematic but unpredictable variation, as opposed to deterministic trends, which have entirely predictable variation. By differencing, a stochastic tendency in a series can be erased. While conclusions about the comparability of the statistical qualities of distinct economic series can be formed by comparing the number of times the series must be differenced to attain stationarity, the differenced series has statistical properties that are invariant about time. If a variable must be differenced d times to ensure stationarity, it is integrated of order d, written *I*(d).

4.4.2 Unit root

Stationarity and non-stationarity are tested using unit root tests. A stationary series is one in which the price disruptions it generates are independent of time. This means that neither the variance nor the mean change over time. Stationarity checks are critical because they determine the sequence in which components are integrated. This is the number of times a series is differenced for it to become stationary. Because time series data contains trend components, these tests are a crucial precondition for analysing them (Acquah and Owuso, 2012). When a series is non-stationary, it must be transformed to avoid estimate errors. The Augmented Dickey-Fuller test (ADF) and the Phillips Perron test are two tests that are used to check for stationarity. When the error series follows a negative moving average process, however, the Phillips-Perron test is ineffective, hence the ADF test is recommended (Jena, 2016). The original concept behind measuring market integration, according to Goletti *et al*. (1995), is to consider the relationship between prices in spatially divided markets. To arrive at a fair collection of market integration steps, a time series analysis of price data will be performed.

Since nearly all economic time series have a unit root or non-stationarity problem, it is risky to conduct any significant regression with them because the results are likely to be skewed (Gujarati, 2003). As a result, the first step in doing co-integration analysis is to pre-test time series to validate the order of unit root. When two or more time-series variables of the same order are integrated, the Johansen co-integration technique can be used to investigate the number of co-integrating relationships (Enders, 1995).

4.4.3 Co-integration

Co-integration is an econometric term that simulates the presence of a long-run equilibrium between economic time series. Two or more series are said to be co-integrated if a linear combination of them is stationary although they are nonstationary individually (Wei and Xiu, 2006). A co-integration analysis is used to see if there is a long-term correlation between many time series. Engle and Granger (1987) as well as Engle and Yoo (1987) developed and implemented it in earlier work. Co-integration analysis ensures that deviations from the equilibrium between two economic variables that are individually stationary in the short run are also stationary in the long run.

Co-integration approaches have been used to evaluate the LOP and examine the degree to which various regions are mutually integrated regularly in the investigation of spatial price correlations (McNew and Fackler, 1997). Market linkages are investigated using co-integration tests (Asche *et al.,* 2004). The concept of co-integration was born out of a worry of false regression. When time-series display long-term patterns or significant seasonal components, spurious regression will emerge (Boisseleau and Hewicker, 2002). Granger was the first to bring the notion of co-integration into economic literature in 1981. Even while short-run variations may be noticed, the principle of co-integration indicates that economic factors should prevent persistent long-run deviations from equilibrium (Goodwin and Schoeder, 1991 and Negassa *et al*., 2003). Individual economic variables such as price may drift apart over time, but specific pairs of such variables should not diverge in the long run (Goodwin and Schroeder, 1991). As a result of co-integration, market margins are allowed to be unstable, as long as they are stable in the long run (Barrett, 1996). According to Goodwin and Schroeder (1991), various factors affect co-integration, e.g., transaction cost, the risk associated with transacting business and the influence of volume of trade. Low-volume markets tend large price variability and the distance between markets has a great influence on transaction costs. This viewpoint is supported by the findings of Goletti *et al*. (2005) in describing the influence of structural factors in determining market integration. Co-integration has become a must-have for any economic model that uses non-stationary time series data. If the variables do not cointegrate, we have the issue of false regression, and the findings become almost useless. Cointegration, on the other hand, occurs when the variables cointegrate (Nkoro and Uko, 2016).

4.4.4 Order of integration conceptual framework

This study applied the proposed time-series approaches to chosen commodity markets in a sequence indicated in figure 15 in light of the foregoing discussion on the empirical tools that can be used to examine the theoretical components of market integration and price transmission.

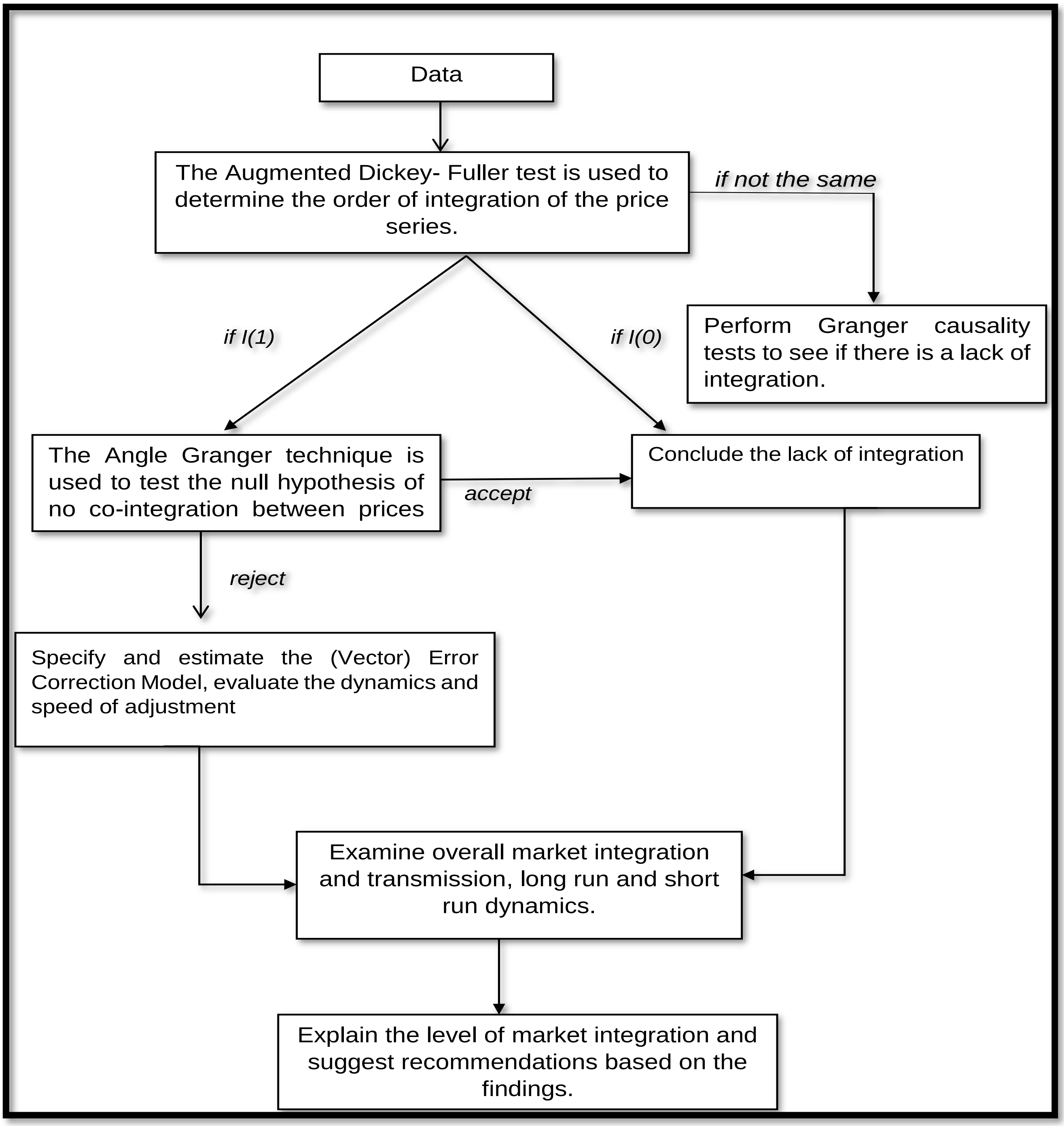

Figure 4.1: Order of integration

Source: Rapsomanikis *et al.,* 2003

The tests are performed in the following order: the first step, the Augmented Dickey-Fuller (Dickey and Fuller, 1979) test was used to determine the order of integration for each pair of prices. If the series has a different sequence of integration, it is concluded that markets are not integrated. If the series is determined to be I(0), Autoregressive Distributed Lag (ADL) model is utilised to examine the relationship's dynamics. To analyse price transmission between marketplaces or along the supply chain, a Vector Autoregression (VAR) framework is used to test for Granger Causality.

(ii) If the tests show that the series are integrated in the same order (say, I(1)), a test of the null of non-co-integration is performed against the alternative hypothesis of one co-integrating vector using the Engle and Granger procedure (1987). Prices co-move and markets are integrated, according to evidence against the null hypothesis of no co-integration. The study does not impose or test for any constraints on the estimation of the cointegrating parameter. As mentioned earlier in this section, relying on the amount of the parameter to determine the level of price transmission can be misleading. If it is inferred that the markets are not integrated and/or that the analysis is unable to conclude that price transmission along the supply chain is complete if the null of non-co-integration is not rejected. (iii) If tests show that the price series are co-integrated, the short-run dynamics and the pace of adjustment, are examined Granger (1969, 1988). (iv) the study assesses overall transmission and explains the market integration and long-run and short-run dynamics. It is worth noting that the aforementioned testing framework misses out on aspects that influence market integration and price transmission. In other words, the study can't tell if transaction costs, policy intervention that insulates domestic markets, or the degree of market power exercised by supply chain players impact price transmission and market integration. As a result, an attempt is made to supplement the findings with some qualitative data on the primary elements that may influence the spread of integration. After that, recommendations are made in light of the findings and conclusions. A detailed analytical procedure is specified as follows:

4.4.5 Data analysis tool

An econometric statistical tool called STATA/SE version 12 was used to analyse the time-series data. This tool is mostly used in time series econometrics analysis to determine the relationship between variables, and it includes frequencies, tabulations, descriptive statistics, correlations, and co-integration. The tool's ability to econometrically relate non-stationary data to determine the nature of time series (Unit root testing) and to assist in the estimate of co-integrated parameters through the Augmented Engle-Granger (AEG) Co-integration test is critical to this research. Finally, the tool may be utilized on stationarity data to generate short-run dynamics relationships using the Error Correction Model (ECM) estimation process.

4.4.6 Augmented Dickey-Fuller (ADF) unit root test

The Augmented Dickey-Fuller (ADF) unit root test was used to investigate the stationarity of onion prices in major fresh produce markets from January 2009 to December 2019. Using an autoregressive model, a unit root test determines whether a time-series variable is non-stationary. The data series in this analysis will be checked for stationarity using Dickey and Fuller's (1981) ADF test, which involves determining whether or not a time series has unit roots. The null hypothesis of a unit root (i.e., non-stationary time series data) will be compared to the alternative hypothesis of the data series being stationary. The ADF test is based on the Dickey-Fuller test, which compares the null hypothesis of > 0 to the alternative hypothesis of > 0 in the following equation:

$$\Delta Y_t = \delta Y_{t-1} + \varepsilon_t \quad \ldots\ldots(1)$$

where: Δ is the first difference operator, Yt is time series data (monthly prices) and εt is a random error term. If δ is found to be zero, the conclusion is that the time series Yt is nonstationary.

If δ is negative, Yt is stationary (Dickey and Fuller, 1979). The DF test assumes that the error terms are individually and identically distributed. However, this is an assumption that is not frequently satisfied in economic time series data. Therefore, it is a limited/low power test (Gujarati and Porter, 2009). By adding the lagged difference terms of the regression as shown in equation (2), the ADF test changes the DF test to account for potential autocorrelation in the error terms.

$$\Delta Y_t = \alpha + \delta Y_{t-1} + \gamma t + \Sigma \lambda_i \Delta Y_{t-1} + \varepsilon_t \ldots\ldots (2)$$

where Δ is the first difference operator, *Y*t is time-series data; *α* is the intercept; the product value of *γ* and *t* denotes a deterministic time trend; $\Delta Yt{-}1$ are the lagged difference terms of the time series data, and *εt* is a random error term.

The null hypothesis for the unit root test is that there is a unit root (i.e. non-stationarity), with the alternative hypotheses of stationarity. A variable is said to be non-stationary if the value of its ADF statistics is less than the critical value, in which case the null hypothesis will be acknowledged. If the ADF statistics is greater than the critical value, the null hypothesis is dismissed. When the ADF t-statistics is smaller in absolute terms than the critical values, the variable is said to be non-stationary. If a non-stationary variable must be differenced once to become stationary, it is said to be integrated of order I, and it is expressed as *I*(1). A stationary variable is integrated of order zero and it's written as *I*(0).

4.4.7 The Augmented Engle-Granger (AEG) Co-integration test

The Augmented Engle-Granger (AEG) Co-integration test was used to determine whether there is a co-integrating link between onion prices in Johannesburg (dependent market) and those in Cape Town, Durban, and Bloemfontein. It is critical to test for the presence of a co-integration relationship between integrated variables of order one, *I*(1), based on the theory that such a relationship exists. The variables are said to be co-integrated if they are individually integrated in the same order and there is at least one stationary linear combination of these variables. The co-integrated variables will never drift too far apart and will be drawn together by their long-term relationship. Testing for co-integration entails determining whether or not there is a long-term relationship between economic variables. To verify the co-integration, the Engle-Granger method, often known as the two-step estimate methodology, will be utilized. The first stage of the AEG two-step procedure involves the estimation of the following static co-integrating regressions:

$\ln T_{jt} = \alpha_0 + \alpha_1 \ln T_{ct} + \mu_{1t}$ ……………………………………………………………(3)

$\ln T_{jt} = \alpha_0 + \alpha_1 \ln T_{dt} + \mu_{2t}$……………………………………………………..............(4)

$\ln T_{jt} = \alpha_0 + \alpha_1 \ln T_{bt} + \mu_{3t}$…………………………………………………………...(5)

where: t = 1, 2..., T; ln is a natural logarithm; T_{jt},T_{ct},T_{dt} and T_{bt} are average monthly onion prices in Johannesburg, Cape Town, Durban and Bloemfontein respectively; α_0 is a non-zero drift; α_1 is the slope coefficient of data series; μ_{1t}, μ_{2t} and μ_{3t} are the residual series.

The second stage of the AEG co-integration test involves testing the stationarity of the residuals. These are calculated as:

$$\mu_{1t} = \ln T_{jt} - (\alpha_0 + \alpha_1 \ln T_{ct}) \quad (6)$$

$$\mu_{2t} = \ln T_{jt} - (\beta_0 + \beta_1 \ln T_{dt}) \quad (7)$$

$$\mu_{3t} = \ln T_{jt} - (X_0 + X_1 \ln T_{bt}) \quad (8)$$

where t; ln; T_{jt}; T_{ct}; T_{dt}; T_{bt}; α_0; β_0; X_0 $\alpha 1$; $\beta 1$; X_1; μ_{1t}, μ_{2t} and μ_{3t} are defined as above. The AEG test was estimated as follows:

$$\Delta\mu t = \alpha + \delta\mu_{t-1} + \gamma t + \Sigma\lambda_i\Delta\mu_{t-1} + \varepsilon t \quad (9)$$

where α symbolizes a non-zero drift, and the product value of γ and t denotes a deterministic time trend, μ_t is the estimated residual series, Δ is the first difference operator, while ε_t is white-noise residuals. If the residual series is stationary (i.e. $\delta < 0$) there is a co-integration relationship. Otherwise, there is no long-term link between the two series.

4.4.8 The Error Correction Model (ECM)

Error Correction Model (ECM) was be used to investigate the short-run link between onion prices at Fresh Produce Markets. The Error Correction Model (ECM) corrects for short-run disequilibrium between variables. If two variables are co-integrated, the Granger representation theorem states that their relationship can be represented as an ECM (Gujarati and Porter, 2009). Error correction is a method of capturing changes in a dependent variable that aren't based on the explanatory variable's level, but rather on how much an explanatory variable deviates from an equilibrium relationship with the dependent variable (Townsend, 1998). The ECM was specified as follows:

$\Delta \ln T_{jt} = \alpha_0 + \alpha_1 \Delta \ln T_{ct} + \alpha_2 \mu_{1t-1} + \varepsilon_{1t}$ ………………………………………………… (10)

$\Delta \ln T_{jt} = \alpha_0 + \alpha_1 \Delta \ln T_{dt} + \alpha_2 \mu_{2t-1} + \varepsilon_{2t}$ …………………………………………………(11)

$\Delta \ln T_{jt} = \alpha_0 + \alpha_1 \Delta \ln T_{bt} + \alpha_2 \mu_{3t-1} + \varepsilon_{3t}$ ……………………………………………… (12)

where Δ is the first difference operator; $\ln T_{jt}$, $\ln T_{ct}$, $\ln T_{dt}$ and $\ln T_{bt}$ are logged average monthly prices in Johannesburg, Cape Town, Durban and Bloemfontein respectively; μ_{1t-1} is the lagged value of the error term and ε_t is a white noise error term. ECM was used to determine the short-run dynamics between average monthly prices in Johannesburg (dependant variable) and Cape Town, Durban and Bloemfontein markets. The term Error Correction Model is derived from the fact that it has a self-regulating mechanism: after deviations, it returns automatically to its long-run equilibrium. Granger causality means that a lead-lag relationship between variables in the time series is evident. However, this does not mean that if a structural change in one series occurs, the other will change as well, but rather that the turning point in one series precedes the turning points of the other (Granger and Weiss, 1983).

4.5 Summary

The analytical methodologies employed in the study were discussed in this chapter, as well as a conceptual framework for market integration. The emphasis is on the study area description, data set, and data analysis tools. The methods for determining the time series' statistical attributes were explained. Testing for the stationary of all variables in the model is an important stage in the co-integration study. The Augmented Dickey-Fuller test was utilised to assess the stationary of onion prices and the Augmented Engle-Granger Co-integration test were used to evaluate long-term relationships between pricing variables of Johannesburg, Cape Town, Durban, and Bloemfontein markets. An Error Correction Model was utilized to analyse the dynamic relationship that exists between onion market prices. The analyses' empirical result is presented in Chapter 5.

CHAPTER 5: EMPIRICAL RESULTS AND DISCUSSION

5.1 Introduction

The findings of a study on onion market integration in major South African fresh produce markets are presented in this chapter. Monthly onion prices were used to determine whether there was any co-integration between the Fresh Produce Markets in Bloemfontein, Cape Town, Durban, and Johannesburg. The study's objectives are to (i) Examine the price stationarity of onions in selected Fresh Produce Markets between January 2009 and December 2019; (ii) Determine whether or if there is a market co-integration link between onion prices in important markets and (iii). Investigating the short-term link between onion prices in Fresh Produce Markets. Hypotheses of the study are: (i) Fresh Produce Market onion prices are non-stationary; (ii) In the major Fresh Produce Markets, there is no market co-integration relationship between onion prices and (iii) Onion pricing at Fresh Produce Markets has no short-term relationship.

To meet the objectives, the study used the Augmented Dickey-Fuller (ADF) unit root test to investigate the stationarity of onion prices in major Fresh Produce Markets. Secondly, the Augmented Engle-Granger (AEG) Co-integration test was utilised to determine whether there is a co-integrating link between onion prices. Lastly, Error Correction Model (ECM) was employed to investigate the short-run relationship between onion prices at Fresh Produce Markets. The statistical software STATA/SE version 12 was employed in this research. The remainder of the chapter is organized in the following manner: Sections 5.2 and 5.3 analyse the data sources and statistical features of price data on levels using the ADF unit root tests and Augmented Engle-Granger Co-integration. The results are presented in Sections 5.2 and 5.3. is Error Correction Model and its results are discussed under Section 5.4 and the chapter concludes with a summary.

5.2 Data and statistical properties

Market prices data from January 2009 to December 2019, were acquired from the DALRRD Statistics and Economic Analysis Directorate. Bloemfontein, Cape Town, Durban, and Johannesburg were the four FPMs selected for the study. On the findings, the market's initial letter will be utilized to identify the market. Formal and informal tests were employed to examine onion market integration between the FPMs. The informal test made use of diagrams, while the formal test made use of unit root testing.

5.2.1 Stationarity test

Time series data must be examined for the presence of unit root for the Error Correction Model to be viable. When the ADF t-statistics is smaller in absolute terms than the critical values, the variable is said to be non-stationary. If a non-stationary variable must be differenced once to become stationary, it is said to be integrated of order I, and it is expressed as $I(1)$. A stationary variable is integrated of order zero and it's written as $I(0)$. Table 5.1 shows the results of the unit root test applied to monthly onion prices in selected FPMs in South Africa. The unit root test results were acquired utilizing the Augmented Dicky Fuller (ADF) test process. Unit root tests in levels and the first difference of these series for all specified markets have been done.

Table 5.1: Augmented Dicky Fuller (ADF) unit root test results

Variable		ADF Statistic	Critical values			Lags
			1%	5%	10%	
Level form	$\ln T_{jt}$	-3.381	-3.500	-2.888	-2.578	0
	$\ln T_{ct}$	-3.057	-3.500	-2.888	-2.578	0
	$\ln T_{dt}$	-3.302	-3.500	-2.888	-2.578	0
	$\ln T_{bt}$	-3.481	-3.500	-2.888	-2.578	0
First difference form	$D\ln T_{jt}$	-9.164	-3.500	-2.888	-2.578	0
	$D\ln T_{ct}$	-9.539	-3.500	-2.888	-2.578	0
	$D\ln T_{dt}$	-9.273	-3.500	-2.888	-2.578	0
	$D\ln T_{bt}$	-9.770	-3.500	-2.888	-2.578	0

The findings of the ADF test revealed that the null hypothesis of non-stationarity was accepted at a 1% level of significance. Both price variables' ADF test statistics at their level form were significant at least 1%. This means that at the 1% significance level, the null hypothesis of non-stationarity (or the presence of a unit root) could not be rejected, meaning that both variables were non-stationary in their level form. For both variables in their difference form, however, the null hypothesis was rejected at all levels of significance. That is, in their first difference form, all variables were stationary. Cointegration necessitates non-stationary variables in their level form and stationary variables in their first difference form. This is consistent with Alexander and Wyeth (1994), Chirwa (2000), Yusuf *et al.* (2006), Adeoye *et al.* (2011) and Baiyegunhi *et al.* (2018) findings that commodity prices are stationary at the order of first difference. As a result, the test of all the onion price data series was integrated in the same order, i.e. *I*(1), and had no unit root, cointegration could be used.

5.3 The Augmented Engle-Granger (AEG) Co-integration test

To determine the existence of a long-run relationship between the price variables, a co-integration test was performed on all variables. The cointegration test is used to establish whether a long-run relationship exists between two non-stationary series. After determining the unit root, the Augmented Engle-Granger (AEG) Co-integration test was used to determine cointegration. Table 5.2 shows the results of the AEG cointegration test for residual stationarity.

Table 5.2:The Augmented Engle-Granger (AEG) Co-integration test

Dependent variable	Constant	Independent variables			Model
		$\ln T_{ct}$	$\ln T_{dt}$	$\ln T_{bt}$	
$\ln T_{jt}$	0.982 (0.009)	0.867 (0.000)	-	-	1
$\ln T_{jt}$	-0.023 (0.882)	-	0.985 (0.000)	-	2
$\ln T_{jt}$	0.278 (0.258)	-	-	0.955 (0.000)	3

Model 1: R^2 = 0.74, AdjR^2 = 0.73, F = 364, p value = 0.000,
Model 2: R^2 = 0.95, AdjR^2 = 0.95, F = 2684, p value = 0.000,
Model 3: R^2 = *0.89,* AdjR^2 = 0.89, F = 1000, p value = 0.000,
where: R^2 = coefficient of variation, AdjR^2 = Adjusted coefficient of variation, values in parentheses are p values and values in braces are t-statistics

Model 1 is a double log model of monthly average onion prices in Johannesburg as a function of monthly average onion prices in Cape Town. Model 2 is a double log function of the average monthly onion prices in Johannesburg as a function of the average onion prices in Durban. Model 3 is a double log model of monthly average onion prices in Johannesburg as a function of monthly average onion prices in Bloemfontein. The results reveal that the coefficients in all three regressions are statistically significant at all levels of significance, as evidenced by statistically significant F-statistics.

This means that at least one of the variables in each model contributes to the explanation of the dependent variable. All three models account for 74%, 95%, and 89% of the variation in the dependent variable, respectively. Table 5.2 further shows that a 1% increase in average monthly onion prices in the Johannesburg market causes an increase of about 0.87% in average monthly onion prices in the Cape Town market, a 1% increase in average monthly onion prices in the Johannesburg market causes an increase of about 0.99% in average monthly onion prices in Durban market, and a 1% increase in average monthly onion prices in Johannesburg market causes an increase of about 0.96% in average monthly onion prices in Bloemfontein.

Table 5.3: Summary of Augmented Engle-Granger (AEG) Co-integration test

Variable		AEG_{τ}	Critical τ values			Lags
			1%	5%	10%	
Level form	$\ln T_{jt} - \ln T_{ct}$	-4.794	-3.500	-2.888	-2.578	0
	$\ln T_{jt} - \ln T_{dt}$	-6.039	-3.500	-2.888	-2.578	0
	$\ln T_{jt} - \ln T_{bt}$	-5.896	-3.500	-2.888	-2.578	0

At all degrees of significance, the AEG_{τ} value had an absolute value greater than the absolute critical value. As a result, the null hypothesis of non-stationarity in the residuals and the absence of cointegration was rejected, and it was determined that in the long run, the average monthly onion prices in Johannesburg move in together with those in Cape Town, Durban, and Bloemfontein. In other words, all markets have a cointegration connection. These findings show that onion prices in all markets are part of a single integrated market with a shared price determination process, rather than being separate and independent markets. This implies that, even though regional markets are geographically separated and spatially divided, spatial pricing relationships reveal that onion prices are linked, implying that all onion exchange sites occur within the same economic framework. Granger and Weiss (1983) showed that cointegrated variables can be created by an Error Correction Model which signifies Granger representation Theorem. The study uses an Error Correction Model to explore the short-term dynamics of cointegrated series.

5. 4 Error Correction Model (ECM)

Even when market integration through cointegration has been established, there may be disequilibrium in the short run, implying that price adjustment across markets may not occur instantly. Spatial price modifications may take some time. When price series are integrated and cointegrated, Engel and Granger (1987) showed that the Error Correction Model (ECM) can be used to examine their short-run dynamics, which considers short and long-run disequilibrium in the markets, as well as the time it takes to eliminate disequilibrium. The residuals from the cointegration regression were then employed in the second stage as estimates of real disequilibrium errors in an ECM once the residuals were confirmed to be stationary (a sign of cointegration). The ECM provides short-run dynamism within the context of a long-run stable relationship generated by the variables' cointegration (Nkoro and Uko, 2016). Table 8 summarizes the results of the ECM.

Table 5.4 : Error Correction Model (ECM)

Dependent variable	Constant	Independent variables				Model
		$\Delta \ln T_{ct}$	$\Delta \ln T_{dt}$	$\Delta \ln T_{bt}$	ECM_{t-1}	
$\Delta \ln T_{jt}$	-0.00099 (0.924)	1.019 (0.000)	-	-	-0.378 (0.000)	4
$\Delta \ln T_{jt}$	-0.00129 (0.788)	-	1.038 (0.000)	-	-0.448 (0.000)	5
$\Delta \ln T_{jt}$	-0.00122 (0.876)	-	-	0.975 (0.000)	-0.429 (0.000)	6

Model 4: R^2 = 0.60, AdjR^2 = 0.59, F = 94.76, p value = 0.000,
Model 5: R^2 = 0.91, AdjR^2 = 0.91, F = 679.85, p value = 0.000,
Model 6: R^2 = *0.77,* AdjR^2 = 0.77, F = 216.64, p value = 0.000,
where:R^2 = coefficient of variation, AdjR^2 = Adjusted coefficient of variation, values in parentheses are p values and values in braces are t-statistics

The ECM was used to see if there is a short-run relationship between average monthly prices in Johannesburg and average monthly prices in Cape Town, Durban, and Bloemfontein markets. The ECMs were significant at all levels for both models (i.e. 4, 5, and 6), showing that a percentage change in average monthly onion prices in Johannesburg is relevant in explaining percentage changes in average monthly onion prices in Cape Town, Durban, and Bloemfontein markets. When prices are cointegrated, the attractor coefficient EMC_{t-1} (which helps to absorb shocks and maintain prices in a long-term equilibrium relationship) is frequently negative and statistically significant (Baiyegunhi *et al*., 2018). The higher the attractor's value, the faster the price adjusts to its equilibrium level.

Table 8 shows that the coefficients on the lagged error components were both negative and statistically significant at the 1% and 5% levels, as expected. The lagged error term's coefficient indicates how quickly the dependent variable adapts to equilibrium. As a result, the rate at which average monthly onion prices in Cape Town return to equilibrium is 37.8% (model 4), 44.8% (model 5) in Durban, and 42.9% in Bloemfontein (model 6). This means that it takes roughly a month for economic agents to return to equilibrium after a market shock that generates disequilibrium. As a result, Cape Town is the first market to respond to the Johannesburg market shock, followed by Bloemfontein and Durban. The rapid adjustment of prices by Cape Town and Bloemfontein may be due to the fact that a relatively minor shift in the reference market would have a relatively large impact on changes in the onion source markets. Differences in transaction costs, location of the markets and other distortions within the selected markets could also be a reason for the variation in adjustment rates between the markets.

CHAPTER 6: SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

The market integration studies in agriculture are significant since agricultural commodities are bulky and perishable, seasonal, physically spread, and consumption is similarly spatially dispersed. Market integration protects that a regional balance occurs among food deficit and food surplus regions. In a market-driven economy, price indicators influence and regulate production, consumption and marketing decision, time, product and marketing place (Baiyegunhi *et al*., 2018). Since prices are the most readily available and the most dependable information on developing nations' marketing systems, market integration exclusively referred to events resulting in price adjustments (Goletti *et al*., 1995). Most specifically, market integration is constrained to the interdependence of price movements across physically distinct places in the markets. The presence of a high degree of integration among the markets is one of the most common markers of a market's efficient functioning.

The purpose of this study is to examine the onion market integration of major South African Fresh Produce Markets. The research was carried out under the framework of three objectives, which were to investigate the stationarity of onion prices in major Fresh Produce Markets; to examine the existence of a market co-integration relationship between onion prices in major markets; and to examine the short-run relationship between onion prices in major Fresh Produce Markets. The Augmented Dickey-Fuller (ADF) unit root test was used to assess the price stationarity of onions in major fresh produce markets. Second, the Augmented Engle-Granger (AEG) Co-integration test was employed to examine if onion prices were linked. Onion pricing at Fresh Produce Markets were also examined using the Error Correction Model (ECM).

The existing literature was examined firstly by an explanation of the concepts underlying market integration, which included agricultural market and price linkages; arbitrage; and the Law of One Price. The models that are used to measure market integration were also reviewed. To circumvent the limitations of relying on a single measure to evaluate market integration, researchers have proposed and tested several different ways to explore various elements of price transmission, each of which has its advantages and disadvantages. The majority of the research evaluated discovered the existence of market integration for a variety of agricultural products.

According to an overview of the South African onion industry, onion is the third most important staple vegetable in South Africa, owing to the gross value of vegetable production and export earnings mostly from the SADC and SACU region. South Africa has favourable climatic conditions for year-round onion production, and effective marketplaces are essential for onion distribution. The onion industry operates in a free market system, with FPMs serving as the primary channel of distribution, were supply and demand dictate prices (NAMC and Commark Trust, 2007 and Louw *et al*.,2004). In South Africa, there are 18 Fresh Produce Markets, and the four markets chosen for this study comprise 69% of the overall onion market share distributed through FPMs. FPMs continue to be a significant distribution channel for onions and must be integrated for effective and competitive marketing. The Johannesburg market is regarded as a pricing barometer for the entire fresh produce industry, and its reputation and fairness are important to the system's credibility and fairness. As a result, the disruption in the operation of the Johannesburg markets is felt across the country (Fresh Plaza, 2020).

Prior to conducting any tests, the study has analysed the data's time series qualities. The presence of a unit root in the price series was determined in this study, and appropriate measures were made to convert the series to a stationary process where necessary. Unit root tests were conducted on the variables using an ADF test. When two non-stationary data series are linearly combined, they are said to be co-integrated. To determine the existence of a long-run relationship between the price variables, an Augmented Engle-Granger Co-integration test was performed on all variables. Even when cointegration is established, there may be near-term disequilibrium, meaning that price adjustment across markets may not be instantaneous. Engel and Granger (1987) demonstrated that when price series are integrated and cointegrated, the Error Correction Model (ECM) can be used to examine their short-run dynamics, which takes into account short-run and long-run market disequilibrium, as well as the time it takes to eliminate disequilibrium. The residuals from the cointegration regression were proved to be stationary, they were used in the second stage as estimates of real disequilibrium errors in an ECM.

This study's data series were shown to be non-stationary at the level form and stationary at first difference. According to the results of the Augmented Engle-Granger Co-integration test, average monthly onion prices in Johannesburg move in together with those in Cape Town, Durban, and Bloemfontein in the long run, confirming the existence of a co-integration connection. Even though the prices were integrated and cointegrated, the Error Correction Model was utilized to investigate their short-run dynamics. According to the ECM results, it takes around a month for economic agents to return to equilibrium following a shock that causes disequilibrium. Cape Town is the first market to respond to the market shock in Johannesburg, followed by Bloemfontein and Durban. This can be attributed to Cape Town and Bloemfontein being situated in onion surplus-producing provinces.

6.2 Conclusion

The onion ranks third among South Africa's basic vegetables in terms of the gross value of vegetable production and export revenues. Fresh Produce Markets (FPMs) continue to be a major distribution channel for onion farmers, and FPMs must be integrated to ensure effective and competitive marketing of products.

The study's goal was to examine onion market integration in major South African Fresh Produce Markets. The primary objective was to investigate the presence of a market co-integration relationship between onion prices in the major markets. The study's findings indicate that in the long run, the average monthly onion prices at Johannesburg Fresh Produce Market move in lockstep with those in Cape Town, Durban, and Bloemfontein, implying a cointegration relationship in onion pricing. Thus, the 'Law of One Price' holds, as Johannesburg prices are comparable to those in Cape Town, Durban, and Bloemfontein. Market integration is especially important in improving livelihoods because when markets are connected, farmers make more money by selling their produce were it is much more expensive (Jena, 2016). This condition will persist until prices level down, benefiting both buyers and sellers. Due to the seasonality and secular tendencies of agricultural marketing, farmers do not always have a choice as to where to sell; integration gives them the chance to have options and choose which market is more cost-effective to supply.

According to the ECM findings, it takes around one month for economic agents to re-establish equilibrium following a shock that induces disequilibrium. Since the price signals are communicated within a month, it implies that selected onion markets are strongly integrated (Baiyegunhi *et al*., 2018). Market integration promotes regional balance by balancing Cape Town and Bloemfontein markets which are located in surplus production provinces, while Durban and Johannesburg are net consumer markets. The factors affecting inter-market price correlations and the rate of adjustment were not determined. The results of the study show that selected Fresh Produce Markets provide an effective channel for the distribution of onions.

6.3 Limitation of the study

Within the varied horticulture sector, this study focuses on one product (onion). This study's theoretical focus is on spatial market integration and the Law of One Price. For this analysis:

- To avoid spurious results, the study heading was changed from the initial permitted topic due to issues found during the data reading method. The topic was approved using data from the years 2000 to 2019. Nevertheless, after many outliers were discovered throughout the data processing process, the study's focus was shifted to a more controllable data set concentrated on a shorter time period between 2009 and 2019, rather than the initial longer period. Due to its massive sample size and high dimensionality, big data poses special computational and statistical issues, such as scalability, memory bottleneck, noise generation, spurious correlation, incidental indigeneity, and measurement inaccuracies, according to (Fan *et al*., 2014). These issues could lead to inaccurate statistical inferences, which could lead to erroneous scientific findings and conclusions. On the other side, the current data set remains large enough to yield accurate study results (Baiyegunhi *et al*., 2018).
- The study assumes that onions sold locally are homogeneous. This is the case of the nature of the pricing data used in the study.

- The main onion market is the Johannesburg Fresh Produce Market. This is since the market distributes more than 55% of the total volume.
- The main determinants of pricing are supply and demand. Many additional factors influence price, but they are all held constant in this research. There were no transaction charges accounted for.
- Because of dataset restrictions and availability, the study was unable to utilize the econometric model to find factors, such as transport and transaction costs, market power and domestic policies that affect market integration.
- The factors affecting inter-market price correlations and the rate of adjustment were not determined.

6.4 Recommendations

Fresh Produce Markets are critical to South Africa's food security because they provide a stable, transparent pricing structure as well as a necessary service to consumers and sellers across the country. This study on onion markets integration has confirmed that average monthly onion prices in Johannesburg move in together with those in Cape Town, Durban, and Bloemfontein markets over time, indicating the existence of a cointegration relationship. Market integration studies are required to keep track of market performance, marketing efficiency, and government intervention. As selected Fresh Produce Markets are cointegrated, the government has the option of proactively enhancing existing market functions. Since market integration can improve market efficiency, policy should address factors that enhance market integration. They include improved access to market information and the development of market infrastructure, such as buildings, roads, and storage facilities. Improved access to market information will significantly aid farmers in deciding which market to supply, taking transaction costs into account. It is recommended that future research should address factors that enhance market integration of the Fresh Produce Markets

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APPENDIX A: DATA OF ONION PRICES FOR BLOEMFONTEIN, CAPE TOWN, DURBAN AND JOHANNESBURG FRESH PRODUCE MARKETS

Months	Cape Town Price (Rand/Ton)	Durban Price (Rand/Ton)	Johannesburg Price (Rand/Ton)	Bloemfontein Price (Rand/Ton)
Jan-09	ZAR 2,304.14	ZAR 2,396.26	ZAR 2,474.62	ZAR 2,217.80
Feb-09	ZAR 2,166.94	ZAR 2,511.97	ZAR 2,103.00	ZAR 2,108.60
Mar-09	ZAR 2,718.89	ZAR 2,994.69	ZAR 2,785.12	ZAR 2,718.95
Apr-09	ZAR 3,362.42	ZAR 3,957.17	ZAR 3,680.46	ZAR 3,770.61
May-09	ZAR 4,184.21	ZAR 5,213.54	ZAR 4,352.79	ZAR 5,016.58
Jun-09	ZAR 4,437.03	ZAR 4,661.11	ZAR 4,071.55	ZAR 4,790.52
Jul-09	ZAR 4,353.04	ZAR 4,070.03	ZAR 3,263.31	ZAR 3,659.27
Aug-09	ZAR 4,324.53	ZAR 3,669.03	ZAR 3,266.69	ZAR 3,911.30
Sep-09	ZAR 3,229.55	ZAR 3,476.89	ZAR 2,916.28	ZAR 3,153.40
Oct-09	ZAR 3,629.51	ZAR 3,577.94	ZAR 3,084.40	ZAR 3,651.64
Nov-09	ZAR 2,818.58	ZAR 2,814.82	ZAR 2,496.68	ZAR 2,738.97
Dec-09	ZAR 2,762.33	ZAR 2,702.49	ZAR 2,609.31	ZAR 2,637.39
Jan-10	ZAR 1,903.34	ZAR 1,967.64	ZAR 2,057.98	ZAR 1,831.31
Feb-10	ZAR 2,015.36	ZAR 2,331.91	ZAR 2,201.25	ZAR 1,850.45
Mar-10	ZAR 2,295.35	ZAR 2,807.22	ZAR 2,653.76	ZAR 2,640.04
Apr-10	ZAR 2,436.52	ZAR 3,269.82	ZAR 3,221.29	ZAR 3,025.71
May-10	ZAR 2,874.14	ZAR 3,832.01	ZAR 3,617.93	ZAR 3,275.17
Jun-10	ZAR 3,861.17	ZAR 4,661.11	ZAR 3,897.87	ZAR 3,853.65
Jul-10	ZAR 4,122.60	ZAR 4,275.92	ZAR 3,791.51	ZAR 3,804.90
Aug-10	ZAR 3,418.83	ZAR 3,148.54	ZAR 2,656.07	ZAR 3,221.25
Sep-10	ZAR 2,573.79	ZAR 1,996.95	ZAR 1,641.63	ZAR 2,199.80
Oct-10	ZAR 2,431.13	ZAR 2,163.23	ZAR 1,741.88	ZAR 2,112.45
Nov-10	ZAR 2,219.06	ZAR 1,892.13	ZAR 1,690.54	ZAR 1,962.85
Dec-10	ZAR 1,742.19	ZAR 2,019.61	ZAR 1,775.72	ZAR 1,689.84
Jan-11	ZAR 1,710.64	ZAR 2,029.06	ZAR 1,846.56	ZAR 1,796.33
Feb-11	ZAR 1,728.72	ZAR 2,114.00	ZAR 2,061.11	ZAR 1,963.42
Mar-11	ZAR 1,860.61	ZAR 2,461.58	ZAR 2,320.27	ZAR 2,203.42
Apr-11	ZAR 2,539.94	ZAR 2,945.26	ZAR 2,850.89	ZAR 2,724.85
May-11	ZAR 2,807.93	ZAR 3,266.53	ZAR 2,974.36	ZAR 2,869.70
Jun-11	ZAR 2,671.78	ZAR 2,946.05	ZAR 2,531.19	ZAR 2,676.51
Jul-11	ZAR 2,746.31	ZAR 3,239.30	ZAR 2,677.00	ZAR 3,096.71
Aug-11	ZAR 2,761.05	ZAR 2,622.18	ZAR 2,088.31	ZAR 2,626.50
Sep-11	ZAR 2,418.77	ZAR 1,918.39	ZAR 1,464.92	ZAR 2,143.30
Oct-11	ZAR 1,870.59	ZAR 1,819.78	ZAR 1,407.02	ZAR 1,854.53
Nov-11	ZAR 1,955.35	ZAR 1,971.63	ZAR 1,580.04	ZAR 2,078.09
Dec-11	ZAR 1,742.24	ZAR 1,967.65	ZAR 1,879.42	ZAR 1,768.68
Jan-12	ZAR 1,936.78	ZAR 2,122.10	ZAR 1,900.99	ZAR 2,100.47
Feb-12	ZAR 1,655.95	ZAR 1,970.32	ZAR 1,844.88	ZAR 1,913.66

Months	Cape Town Price (Rand/Ton)	Durban Price (Rand/Ton)	Johannesburg Price (Rand/Ton)	Bloemfontein Price (Rand/Ton)
Mar-12	ZAR 2,128.73	ZAR 2,296.52	ZAR 2,293.34	ZAR 2,373.59
Apr-12	ZAR 2,215.54	ZAR 2,462.19	ZAR 2,271.31	ZAR 2,378.32
May-12	ZAR 2,381.25	ZAR 3,048.86	ZAR 2,819.91	ZAR 2,658.85
Jun-12	ZAR 2,654.52	ZAR 3,230.94	ZAR 2,963.22	ZAR 3,105.03
Jul-12	ZAR 2,875.10	ZAR 2,968.87	ZAR 2,624.40	ZAR 3,038.50
Aug-12	ZAR 2,765.82	ZAR 2,418.95	ZAR 1,881.87	ZAR 2,354.06
Sep-12	ZAR 2,673.52	ZAR 2,518.23	ZAR 2,000.53	ZAR 2,361.30
Oct-12	ZAR 3,429.20	ZAR 3,813.18	ZAR 3,163.50	ZAR 3,560.01
Nov-12	ZAR 3,747.58	ZAR 3,596.89	ZAR 3,156.26	ZAR 3,593.77
Dec-12	ZAR 2,888.23	ZAR 3,564.01	ZAR 3,288.56	ZAR 3,050.06
Jan-13	ZAR 2,935.45	ZAR 3,018.46	ZAR 2,859.54	ZAR 2,950.63
Feb-13	ZAR 2,342.04	ZAR 2,732.83	ZAR 2,468.86	ZAR 2,362.45
Mar-13	ZAR 3,194.33	ZAR 3,692.33	ZAR 3,323.80	ZAR 3,190.55
Apr-13	ZAR 4,113.30	ZAR 5,002.39	ZAR 4,454.34	ZAR 4,367.74
May-13	ZAR 4,844.49	ZAR 5,399.78	ZAR 4,756.11	ZAR 4,840.12
Jun-13	ZAR 5,082.53	ZAR 5,503.76	ZAR 4,706.23	ZAR 5,082.31
Jul-13	ZAR 5,509.14	ZAR 5,084.96	ZAR 4,350.99	ZAR 4,801.12
Aug-13	ZAR 4,683.55	ZAR 3,657.28	ZAR 2,722.58	ZAR 3,785.90
Sep-13	ZAR 2,969.23	ZAR 2,639.22	ZAR 1,960.03	ZAR 2,789.49
Oct-13	ZAR 3,313.00	ZAR 2,922.26	ZAR 2,171.30	ZAR 2,951.89
Nov-13	ZAR 2,998.96	ZAR 2,774.93	ZAR 2,502.95	ZAR 2,806.09
Dec-13	ZAR 2,604.15	ZAR 2,832.55	ZAR 2,581.98	ZAR 2,652.70
Jan-14	ZAR 2,628.97	ZAR 3,278.11	ZAR 2,893.22	ZAR 3,048.09
Feb-14	ZAR 3,390.38	ZAR 4,520.99	ZAR 3,959.15	ZAR 3,991.06
Mar-14	ZAR 3,813.66	ZAR 4,478.25	ZAR 4,003.95	ZAR 4,277.12
Apr-14	ZAR 4,116.86	ZAR 4,943.05	ZAR 4,208.02	ZAR 4,537.28
May-14	ZAR 4,789.91	ZAR 5,373.33	ZAR 4,857.37	ZAR 5,131.42
Jun-14	ZAR 4,842.27	ZAR 5,000.88	ZAR 4,421.98	ZAR 4,766.42
Jul-14	ZAR 4,411.09	ZAR 4,107.38	ZAR 3,411.10	ZAR 4,348.55
Aug-14	ZAR 3,806.77	ZAR 3,276.70	ZAR 2,508.90	ZAR 3,256.02
Sep-14	ZAR 3,544.27	ZAR 3,066.30	ZAR 2,479.47	ZAR 3,065.14
Oct-14	ZAR 3,108.66	ZAR 2,784.30	ZAR 2,411.71	ZAR 2,740.24
Nov-14	ZAR 2,470.93	ZAR 2,068.90	ZAR 1,826.17	ZAR 2,239.12
Dec-14	ZAR 2,203.39	ZAR 2,630.33	ZAR 2,338.99	ZAR 2,252.22
Jan-15	ZAR 2,698.00	ZAR 2,897.08	ZAR 2,612.62	ZAR 2,582.16
Feb-15	ZAR 2,644.13	ZAR 2,910.02	ZAR 2,434.60	ZAR 2,459.06
Mar-15	ZAR 2,938.24	ZAR 3,827.32	ZAR 3,268.05	ZAR 2,970.58
Apr-15	ZAR 3,166.77	ZAR 3,427.31	ZAR 3,168.10	ZAR 3,270.33
May-15	ZAR 3,237.50	ZAR 3,883.20	ZAR 3,353.43	ZAR 3,267.46
Jun-15	ZAR 3,551.83	ZAR 3,700.08	ZAR 3,176.24	ZAR 3,455.18

Months	Cape Town Price (Rand/Ton)	Durban Price (Rand/Ton)	Johannesburg Price (Rand/Ton)	Bloemfontein Price (Rand/Ton)
Jul-15	ZAR 3,400.48	ZAR 3,200.02	ZAR 2,619.52	ZAR 3,344.75
Aug-15	ZAR 3,030.17	ZAR 2,392.31	ZAR 2,053.11	ZAR 2,605.11
Sep-15	ZAR 2,913.80	ZAR 2,440.54	ZAR 2,027.08	ZAR 2,358.28
Oct-15	ZAR 3,013.37	ZAR 2,599.83	ZAR 2,190.42	ZAR 2,477.56
Nov-15	ZAR 3,086.28	ZAR 2,922.47	ZAR 2,567.22	ZAR 2,777.44
Dec-15	ZAR 2,825.10	ZAR 3,519.74	ZAR 3,031.22	ZAR 2,897.18
Jan-16	ZAR 3,377.17	ZAR 4,622.17	ZAR 4,281.69	ZAR 3,883.58
Feb-16	ZAR 4,146.31	ZAR 4,637.52	ZAR 4,391.49	ZAR 4,598.44
Mar-16	ZAR 4,494.35	ZAR 4,966.25	ZAR 4,774.46	ZAR 5,355.25
Apr-16	ZAR 5,566.42	ZAR 6,158.44	ZAR 5,714.11	ZAR 5,930.49
May-16	ZAR 5,325.75	ZAR 5,702.42	ZAR 5,254.39	ZAR 4,980.90
Jun-16	ZAR 6,127.45	ZAR 7,171.87	ZAR 6,468.86	ZAR 6,679.96
Jul-16	ZAR 7,241.09	ZAR 6,892.43	ZAR 5,946.77	ZAR 6,925.78
Aug-16	ZAR 6,805.56	ZAR 6,150.45	ZAR 5,287.56	ZAR 6,142.06
Sep-16	ZAR 4,476.29	ZAR 3,644.37	ZAR 3,202.04	ZAR 3,638.45
Oct-16	ZAR 3,479.15	ZAR 3,884.46	ZAR 3,190.59	ZAR 3,318.20
Nov-16	ZAR 3,194.83	ZAR 2,939.29	ZAR 2,514.72	ZAR 2,928.24
Dec-16	ZAR 2,575.62	ZAR 2,680.84	ZAR 2,184.77	ZAR 2,216.97
Jan-17	ZAR 2,454.04	ZAR 3,182.62	ZAR 2,434.05	ZAR 2,624.14
Feb-17	ZAR 2,714.91	ZAR 2,907.04	ZAR 2,349.49	ZAR 2,879.56
Mar-17	ZAR 2,919.29	ZAR 3,295.57	ZAR 2,680.65	ZAR 3,303.31
Apr-17	ZAR 3,235.12	ZAR 3,652.63	ZAR 2,963.24	ZAR 3,415.68
May-17	ZAR 3,595.86	ZAR 3,912.71	ZAR 3,481.97	ZAR 4,022.04
Jun-17	ZAR 3,511.67	ZAR 3,668.96	ZAR 2,965.86	ZAR 3,413.49
Jul-17	ZAR 3,483.17	ZAR 3,569.00	ZAR 2,757.71	ZAR 3,474.63
Aug-17	ZAR 2,897.24	ZAR 2,621.20	ZAR 2,214.94	ZAR 2,709.83
Sep-17	ZAR 3,246.79	ZAR 3,168.80	ZAR 2,549.93	ZAR 2,770.61
Oct-17	ZAR 5,320.47	ZAR 5,477.41	ZAR 4,631.95	ZAR 5,392.10
Nov-17	ZAR 3,927.18	ZAR 4,581.96	ZAR 3,696.32	ZAR 4,101.74
Dec-17	ZAR 4,306.02	ZAR 5,169.52	ZAR 4,884.40	ZAR 4,075.64
Jan-18	ZAR 5,269.28	ZAR 5,622.99	ZAR 5,371.01	ZAR 4,853.08
Feb-18	ZAR 5,322.96	ZAR 5,706.16	ZAR 5,159.40	ZAR 5,826.58
Mar-18	ZAR 4,630.41	ZAR 5,415.86	ZAR 4,565.04	ZAR 5,514.89
Apr-18	ZAR 5,065.02	ZAR 5,117.00	ZAR 4,418.36	ZAR 4,895.93
May-18	ZAR 4,559.43	ZAR 4,682.76	ZAR 3,931.51	ZAR 4,063.06
Jun-18	ZAR 4,934.13	ZAR 5,078.44	ZAR 3,948.24	ZAR 4,816.46
Jul-18	ZAR 5,821.86	ZAR 5,146.65	ZAR 4,210.38	ZAR 5,150.40
Aug-18	ZAR 5,877.70	ZAR 5,263.06	ZAR 4,173.12	ZAR 4,895.29
Sep-18	ZAR 4,762.40	ZAR 4,666.96	ZAR 3,534.12	ZAR 4,404.04
Oct-18	ZAR 4,127.80	ZAR 4,179.38	ZAR 3,159.72	ZAR 3,597.69

Months	Cape Town Price (Rand/Ton)	Durban Price (Rand/Ton)	Johannesburg Price (Rand/Ton)	Bloemfontein Price (Rand/Ton)
Nov-18	ZAR 3,867.07	ZAR 3,993.46	ZAR 3,369.08	ZAR 3,808.57
Dec-18	ZAR 3,162.86	ZAR 3,378.42	ZAR 2,861.08	ZAR 2,864.94
Jan-19	ZAR 3,492.73	ZAR 3,265.80	ZAR 2,856.03	ZAR 2,663.23
Feb-19	ZAR 3,036.29	ZAR 3,330.32	ZAR 2,721.58	ZAR 3,459.39
Mar-19	ZAR 3,356.29	ZAR 3,878.88	ZAR 3,419.39	ZAR 3,889.80
Apr-19	ZAR 4,103.85	ZAR 4,789.96	ZAR 4,043.69	ZAR 4,617.57
May-19	ZAR 4,417.83	ZAR 5,025.94	ZAR 4,373.04	ZAR 4,851.08
Jun-19	ZAR 4,740.93	ZAR 5,714.35	ZAR 4,999.84	ZAR 5,319.02
Jul-19	ZAR 5,758.15	ZAR 5,784.57	ZAR 4,750.08	ZAR 5,554.64
Aug-19	ZAR 4,691.71	ZAR 4,295.67	ZAR 3,475.37	ZAR 3,995.82
Sep-19	ZAR 4,417.48	ZAR 4,192.52	ZAR 3,249.12	ZAR 3,634.72
Oct-19	ZAR 4,306.96	ZAR 4,625.73	ZAR 3,670.64	ZAR 3,855.77
Nov-19	ZAR 3,786.51	ZAR 3,675.59	ZAR 3,169.91	ZAR 3,535.65
Dec-19	ZAR 3,423.57	ZAR 3,702.47	ZAR 3,354.25	ZAR 3,497.96