A STUDY ON THE INTEGRATION OF POTATO MARKETS IN SOUTH AFRICA

by

LEANDRÉ DU PREEZ

Submitted in partial fulfilment of the requirements for the degree of

M.Sc. Agric

Department of Agricultural Economics

Faculty of Natural and Agricultural Sciences

University of the Free State

Bloemfontein

November 2011

Supervisors

Prof. Z.G. Alemu

Prof. B. Grové

DECLARATION

I, Leandré du Preez (née Barnett), hereby declare that this dissertation is submitted by me for the degree of Master of Science in Agricultural Economics, at the University of the Free State. To the best of my knowledge, this is my own original work with the exception of such references used. This thesis has not been previously published or submitted to any University for a degree. I further cede copyright of the dissertation in favour of the University of the Free State.

Leandré du Preez

DEDICATION

I would like to dedicate this work to my parents

André and Anne-Marie Barnett

who stood by me and inspired me to pursue my studies
who do not know the end of self sacrifice and
who always give without reckoning.

To my husband

Chris du Preez

for his support, understanding, motivation and selflessness.

ACKNOWLEDGEMENT

First and most importantly I would like to thank Jehovah God for granting the capability and opportunity to pursue and complete my studies.

It is impossible to thank everyone that I am grateful to; for their support, guidance or motivation throughout my study years. Many people have played important roles in the outcome and completion of my studies and helped directly or indirectly in more ways than one.

First it goes without saying to deeply thank my two supervisors, Prof. Z.G. Alemu and Prof. B. Grové for their invaluable guidance, support and motivation. Both played important, yet different roles in the completion of this study. Their suggestions, corrections and criticisms were highly appreciated. Prof. Grové's attention to detail is gruelling, yet invaluable.

Next, my study would be incomplete without expressing my greatest gratitude towards Prof. Johan B. Willemse for his intellectual and emotional support throughout my years at the Department of Agricultural Economics. His support, guidance and wisdom are invaluable to more than one in the Department.

I am also deeply grateful to all my old colleagues and friends at the Department of Agricultural Economics at the University of the Free State. People that believed in me, supported me, cried and laughed with me. Your love and support is immense. To name a few: Ms. Nicolette Matthews, Ms. Lize Terblanché, Mrs. Louis Hoffman, Mrs. Annely Minnaar, Dr. Godfrey Kundhlande, Dr. Kit le Clus, Ms. Reneilwe Maenetja, Ms. Esté van der Merwe and Mr. Henry Jordaan, who all contributed in more ways than one. Ms. Nicolette Matthews deserves a special mention for all her efforts.

I am grateful to Potatoes South Africa, specifically Mr. Pieter van Zyl, for the input provided into the industry and the opportunity to do this study.

A word of gratitude is also extended to my current employer Mr. J.G. Boyes for allowing me ample study leave to complete my studies. Without this time my studies would not have been completed.

I am further deeply grateful to my family, friends and in-laws who have been pillars of strength throughout my studies. There are far too many to mention individually but a special thanks goes to two close friends Ms. Alta Hattingh and Ms. Mariana Erasmus who gave valuable guidance and support. Also to my aunt, Mrs. Susan Pearson, and my grandmother, Mrs. Susan Barnett, I am grateful for their keen interest and support.

I am also grateful to my parents, André and Anne-Marie Barnett, and my two brothers, David and Ramon Barnett, whose love, support, interest and encouragement helped me through the years. All that you have done, said and gave is infinite. I am blessed to have you all in my life.

And last, but not least, a special word of thanks to my husband, Chris du Preez, for his love and support throughout my studies and everything that comes our way.

ABSTRACT

Potatoes are the most important vegetable product in South Africa and the third most important food crop in the world. Potatoes are planted in all the regions and sold on all of the Fresh Produce Markets of South Africa. The markets serve as the price setter for the industry and producers are not sure about the movement and the fairness of prices they receive. Marketing strategies are based on price information and producers cannot accurately determine their strategy if price information is incorrect or unavailable. The study therefore investigated the integration of potato markets in South Africa based on price data.

The primary objective of the study is to analyse market integration within the potato industry of South Africa. The existence of price relationships and spatial linkages between markets are determined by the study. Market integration was determined by applying the Threshold Vector Error Correction Model (TVECM). The TVECM is used more often in recent literature and is methodologically stronger than some of its predecessors. The method allows for non-stationarity of variables and considers the possibility of non-linear and asymmetric type of variables. The pivotal role played by transaction costs are incorporated into the model. The study also tested whether a two or three regime model would best fit the data, instead of imposing a specific regime. The data used in the study is weekly data ranging from January 1999 to June 2009. The study was done on eight selected Fresh Produce Markets (FPM) namely Johannesburg (JHB), Pretoria (PTA), Bloemfontein (BFN), Kimberley (KBY), Durban (DBN), Cape Town (CTN), Pietermaritzburg (PMB) and Port Elizabeth (PE).

The following results were obtained. First, on the statistical properties of the variables - all price variables are non stationary. Based on co-integration analyses long run relationships between all market pairs considered were found. The market pairs are thus co-integrated or integrated in the long run. Second, after results suggested non-linearity, decisions were made to test for the presence of market integration in the short run by fitting TVECM. A set of two and three regime TVECM were estimated. Overall, results indicated that in the short run, the markets are not integrated. In addition, results from regime switching showed no discernible pattern on the time of switches between regimes.

In conclusion the results from the direction of causality test indicated a one directional flow with Johannesburg FPM being the main destination market. Overall, results attest to a prior expectation that Johannesburg is the leading FPM in South Africa. Markets are integrated in the long run but are not integrated in the short run.

Key words: Prices, Markets, Arbitrage, Law of One Price (LOP), Market Integration, Co-integration, Transaction Costs, Non-linearity, Asymmetry, Vector Autoregressive Models, TVECM.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

ADF – Augmented Dickey-Fuller

AgriBEE – Agricultural Black Economic Empowerment

AIC – Akaike Information Criterion

BFN – Bloemfontein

CTN – Cape Town

DBN – Durban

DF – Dickey-Fuller

DF-ECM – Dynamic Factor Error Correction Model

DRC – Democratic Republic of Congo

ECM – Error Correction Model

ECT – Long-term equilibrium

FPE – Final Predictor Error

FPM – Fresh produce markets

GAR – Generalised Autoregressive

GDP – Gross Domestic Product

GNP – Gross National Product

HQC – Hannan-Quinn Information Criterion

JHB – Johannesburg

KBY – Kimberly

LOP – Law of One Price

LR – Likelihood Ratio

ML – Maximum Likelihood

M-TAR – Momentum-TAR

NAMC – National Agricultural Marketing Council

OLS – Ordinary Least Squares

PBM – Parity Bound Model

PC – Principal Components

PE – Port Elizabeth

PMB – Pietermaritzburg

PROKON – Product control for agriculture

PSA – Potatoes South Africa

PTA – Pretoria

SA – South Africa

SACU – South African Customs Union

SETAR – Self-Exciting Threshold Autoregressive

SIC – Schwartz Information Criterion

STAR – Smooth Transmission Autoregression

TAR – Threshold Autoregressive

TECM – Threshold Error Correction Model

TVAR – Threshold Vector Autoregressive

TVECM – Threshold Vector Error Correction Model

UK – United Kingdom

US – United States

VAR – Vector Autoregressive

VECM – Vector Error Correction Model

CHAPTER 1
INTRODUCTION

1.1 Background and Motivation

Potatoes are the single most important vegetable product in South Africa. Potatoes contribute to three percent of total South African agriculture and were valued at an estimated R2.88 billion in the 2006/07 production year (PSA, 2010). The potato is the third most important food crop in the world, after rice and wheat, and can be classified as the world's number one non-grain food commodity (FAO, 2008). According to the International Potato Center (CIP) (2009) potatoes yields more nutritious food more quickly on less land and in harsher climates than any other major crop.

Potato production provides livelihood for many and has notable multiplier effects up and downstream in the supply chain. The production of potatoes contributes to the input, transport, processing, retail, packaging and formal and informal trade sectors. Increasing the output of the potato sector could assure a greater number of employment opportunities that could lead to poverty reduction (PSA, 2010; NAMC & Commark Trust, 2006). Potatoes are planted throughout the year in South Africa (SA) and sold on any of the Fresh Produce Markets (FPM) of SA. The markets serve as the public price setting mechanism and are used throughout the industry to set prices for potatoes. Given the fact that potato prices are determined on the markets, the efficient functioning of these markets are of vital importance.

An efficient market is a market where all available information is always fully reflected in the prices (Boisseleau & Hewicker, 2002). Marketing decisions are based on market price information and markets that are not properly integrated may communicate wrongful price information (Van Campenhout, 2007). Market integration is the study of price differences between spatially separated markets and is an important economic analytical tool used to understand markets better (Lohano & Mari, 2006; Vollrath, 2003; Xia, Susanto & Rosson, 2007). The correct price signal will not be transmitted through the marketing channels if the markets are not integrated (Basu, 2006; Baulch, 1997; Fackler & Tastan, 2008).

If markets are not integrated it could result in the inefficient allocation of resources (Mushtaq, Gafoor & Dad, 2008). Serra and Goodwin (2002b) found that market integration results in more efficient use of resources and an increase in productivity and overall production.

Market integration affects economic growth, provokes structural change, adjusts the location of economic activity, and influences the viability of agricultural enterprises (Xia *et al.,* 2007). Where markets are integrated it is possible for farmers to specialise in production activities in which they have comparative advantage. Consumers will benefit as well by being able to buy goods at the lowest possible prices. Society as a whole can benefit by economies of scale and increasing returns from technological innovations (Lohano & Mari, 2006; Vollrath, 2003; Xia *et al.,* 2007).

Inaccurate price signals might distort the marketing decisions of farmers and cause inefficient product movement. Traders will be able to exploit the market for their benefit while harming producers and consumers. Farmers will also fail to specialise according to long-term comparative advantage and their gains from trade will not be realised (Lohano & Mari, 2006; Basu, 2006; Baulch, 1997; Fackler & Tastan, 2008; Van Campenhout, 2007). Surpluses produced by farmers could cause depressed farm prices and diminishing income if it is not correctly allocated. Inefficiencies in the market and prices may constrain sustainable agricultural development and worsen income inequalities (Mushtaq *et al.*, 2008).

Integrated markets perform better in improving per capita income and standards of living (Kose, Prasad & Terrones, 2003). Fafchamps (1992) found that food market integration reduced the need for food self-sufficiency and also stated that improving food crop productivity has limited potential for agricultural growth if food markets are not integrated. Van Campenhout (2007) found that the connectedness of markets have been found to contribute greatly to rural households' escape from poverty. He emphasises the importance of price movements in poverty alleviation and famine relief, by expressing his surprise in the lack of famine prevention initiatives that make use of price data. Moser, Barrett and Minten, (2009) states that integrated markets play a crucial role in dampening the effects of shocks and in reducing seasonal poverty and food insecurity (Kose *et al.*, 2003).

Market integration is the tool that ensures that a regional balance is maintained between food-deficit and food-surplus regions, and regions producing non-food cash crops, since food will always move to where the demand and associated higher price is. Localised scarcities and abundances may result in an undue strain on the population if price transmission does not occur to normalise the market (Goletti, Ahmed & Farid, 1995). Van Campenhout (2007) stated that the existence, extent and persistence of famines in market economies are closely linked to market integration in the sense that the connectedness of the markets in the regions ultimately determines how long an initially localised scarcity can be expected to persist. He also stated that given the importance of food security in the developing world it is surprising that there are not more studies being conducted on market integration.

Market integration also has important policy implications. Policy formulation and implementation is aided by the knowledge of how markets are linked by prices (Elston, Hastie & Squires, 1999; Negassa, Myers & Gabre-Madhin, 2003; Xia *et al.,* 2007). In agriculture, market integration plays an important role in the successful implementation of, for example, price stabilisation policies (Van Campenhout, 2007; Goletti & Babu, 1994). Price stabilisation and market liberalization can only be successful when you have the detailed picture of the process of transmission between markets (Goletti *et al.*, 1995; Thompson, Sul & Bohl, 2002; Goletti & Babu, 1994). Market integration can be used to answer whether government intervention is required in the markets or not (Basu, 2006; Goletti & Babu, 1994). The management of market reform requires an understanding of the markets and an in depth study of the activities of various market participants are needed to produce relevant policy recommendations (Negassa *et al.*, 2003).

Markets that are integrated will ensure that policies at the macro level influence the decisions made on the micro level (Moser *et al.*, 2009). The reverse is also true where welfare improvements, for example, at the micro level will aggregate into macro level growth (Moser *et al.,* 2009). Where markets are integrated it will thus prevent the duplication of policy implementation or intervention (Goletti *et al.*, 1995). The effectiveness of policies depend on the dynamics of market integration and costs associated with incorrect policies can be massive (Mushtaq *et al.*, 2008; Negassa *et al.*, 2003). The study of market integration can also be used to evaluate the impact of policies (Fackler & Tastan, 2008; Van Campenhout, 2007).

The need for market integration studies in agriculture are of importance because agricultural commodities are bulky and perishable. Production is seasonal and production and consumption points are spatially dispersed, causing transport to be costly and hence require special attention. Transaction cost is an important component in spatial price analysis and thus the study of market integration (Shrestha & Frechette, 2003). Barrett (1996) argues that market integration testing is important because the findings clarify the market conditions which are central to economic modelling. The existence of market integration can also indicate the extent to which barriers to trade affects the competitiveness of producers (Norman-López & Bjørndal, 2009).

If there are persistent deviations from market integration it may imply the existence of riskless profit opportunities for spatial traders (Goodwin & Piggott, 2001). Lack of arbitrage between markets indicates wrongful market design and the existence of inefficient price transmission (Boisseleau & Hewicker, 2002). Moser *et al.* (2009) indicates a vast number of literatures that documents significant and puzzling forgone arbitrage opportunities in developing countries. The study of the interdependence of prices on markets is justifiably important (Franken & Parcell, 2003). The study of market integration will reveal the performance of agricultural markets, which will give an indication of the fairness of prices received by farmers and paid by consumers.

1.2 Problem Statement

South African potato producers are currently unsure about the movement and fairness of prices received on the market. Potato producers are unable to accurately base their marketing decisions on the price information they receive from the markets. Producers do not have knowledge on the actual flow of information and products between the markets. Consequently potato producers are unable to specialise and benefit from gains of trade. Resources are not allocated efficiently and produce may be send to markets with oversupply and lower prices, instead of moving to markets with shortages and higher prices.

Information on market integration has been widely used over the last few decades. In agriculture, spatial market integration has been widely used to indicate the overall performance of the market. The information gives an indication of competitiveness, the effectiveness of arbitrage and the efficiency of pricing in the markets (Lohano & Mari, 2006). Various authors have used market integration studies in agriculture and the methods used differ and were developed over the years. Correlation and co-integration analysis were on the forefront of these market integration analysis (See Moser *et al.,* 2009; Mustaq *et al.,* 2008; Asche, Gordon & Hannesson, 2004; Ismet *et al.,* 1998; González-Rivera & Helfand, 2001; Xia *et al.,* 2007; and Pede & McKenzie, 2005) but is criticised for not taking transaction costs and non-linearity into account.

The Parity Bound Model (PBM) has also been used in agriculture, and even though it takes transaction costs into account it makes use of actual data which is often difficult to obtain (See Baulch, 1997; Negassa *et al.,* 2003; and Padilla-Bernal, Thilmany & Loureiro, 2003). In recent years the Threshold Autoregressive (TAR), Threshold Vector Autoregressive (TVAR) and Threshold Vector Error Correction Models (TVECM) have been the models mostly applied to market integration studies (See Pigott & Goodwin, 2002; Van Campenhout, 2007; Goodwin & Pigott, 2001; Serra, Gil & Goodwin, 2006; Agüero, 2004; Lohano & Mari, 2006; Serra & Goodwin, 2002a; Goodwin & Harper, 2000; Meyer, 2004; and Alemu & Worako, 2011, amongst others). The autoregressive models was criticised for their failure to take asymmetric adjustments into account. The threshold models account for non-linearity and asymmetry in the data and allows for transactions costs. These models identify thresholds that the prices must exceed before price adjustments will take place. The number of thresholds determines the number of regimes in the model.

Potato markets have been studied by Basu (2006) in West Bengal but no study has been done on the South African potato industry. Uchezuba (2005) studied market integration on the apple markets within South Africa and Jooste, Jordaan, Alemu and Spies (2006) studied the market integration on the Fresh Produce Markets of South Africa by using the TVAR model.

This study focuses explicitly on the potato market of South Africa and takes transaction costs and non-linearity and thus asymmetries in price adjustments into account. In addition, the study tests whether a two- or a three regime model best fits the data, instead of assuming a three regime model as done in the other studies. The model applied in this study could be used to study the performance of markets in other sectors or commodities as well as in other countries.

1.3 Objective of the study

The primary objective of this study is to analyse market integration within the potato markets of South Africa. The study of market integration will determine the existence of price relationships and spatial linkages between markets. Market integration was determined after analysing the importance of the potato industry in South Africa.

To determine market integration a number of specific objectives had to be met and included:

i. Determination of the direction of causality and the identification of the market leader.
ii. Analysis to determine the presence of market integration in the short- and long run.
iii. Determination of thresholds and the number of regimes.
iv. Analysis of regime switching and impulse response functions.

1.4 Organisation of the Study

The remainder of the sections are organised as follow. Chapter two gives the background and discusses the importance of the potato industry and potatoes as a commodity for South Africa. Thereafter Chapter three defines market integration, discusses the methodological progression for market integration, gives a discussion on some of the most influential methods to date and then gives the historical application of market integration studies. This is done by means of an in-depth literature review. The data and methods used in this study are discussed in Chapter four. The Threshold Vector Error Correction Model (TVECM) is used in this study to study market integration. Not only does it account for all the factors that have shaped the methodological evolution of market integration tests, but it is also applied more often in recent studies. Chapter five presents the results obtained in this study from applying the methods motivated in Chapter four. Chapter six provides a summary of the study and gives some conclusions drawn and recommendations made for future studies.

CHAPTER 2
INDUSTRY OVERVIEW

2.1 Introduction

Potatoes are South Africa's single most important vegetable product. South Africa, the only exporter in Southern Africa, is ranked 31st on the list of global potato production, supplying 0.5% of the world's total production. Angola, Mozambique and Zambia are the most prominent export destinations, accounting for 83% of all potato exports from South Africa (NAMC & Commark Trust, 2006).

South Africa's potato output has grown strongly over the past 15 years to a record 1.97 million tons in 2007, compared to the 1.2 million tons of 1990 (FAO, 2008). Potatoes contribute to three percent of total South African agriculture. The value of this contribution was estimated at R2.88 billion in the 2006/07 production year (PSA, 2010). Potatoes are planted in 16 regions across South Africa and sold to any of the 19 South African markets (NAMC & Commark Trust, 2006; PSA, 2010).

Potato consumption is increasing for both fresh and processed potatoes. Consumers spent almost R12 billion on potato products in 2007/08, a 23% growth from the previous year. The South African potato processing industry has grown over the past ten years at a rapid pace (PSA, 2010). The processing of potatoes grew by 100% between 1995 and 2005 (NAMC & Commark Trust, 2006).

Potato production provides livelihoods and has notable multiplier effects up and downstream in the supply chain in the input, transport, processing, retail, packaging and formal and informal trade sectors. Increasing the output of the potato sector could assure that a greater number of employment opportunities are created. In terms of poverty reduction this would imply the best outcome (NAMC & Commark Trust, 2006). This chapter provides an overview of the potato industry by investigating the history and importance of the potato and the importance of the industry. In addition, the potato supply chain is unravelled and the organisational structure and polices within the sector are discussed.

2.2 Historical background

2.2.1 World

The potato has been consumed in the Andes Mountains of South America for many years. About 200 species of wild potatoes are found in the Americas. The Conquistadores went to the Andes in search of gold, but found potatoes, *Solanum tuberosum,* which they took back to Europe. The first evidence of potato growing in Europe dates from 1565, on Spain's Canary Islands. The potato was cultivated on the Spanish mainland by 1573. Potatoes were grown in London in 1597 and reached France and the Netherlands soon after. European sailors took tubers to consume on ocean voyages which made the potato reach India, China and Japan early in the 17th century (FAO, 2008; CIP, 2009).

The potato reached Ireland and Irish immigrants took the tuber named the "Irish potato" to North America in the early 1700s. In Russia the potato was initially called the "devil's apple", but even despite initial hesitation, European farmers began growing potatoes on a large scale. The potato became a staple crop across northern Europe by 1815. The Industrial Revolution was transforming society, and with urbanisation the potato became the first modern "convenience food" in the United Kingdom (FAO, 2008; CIP, 2009; Kiple & Ornelas, 2000). Table 2-1 shows production and consumption of potatoes per continent. Asia and Europe is by far the largest producers in terms of area planted and quantity harvested. Together they account for 84% and 82% of world harvested area in hectares and total tonnage respectively. Africa is the third largest at 8% and 5% respectively. North America yields the highest tons per hectare at more than double the yield per hectare as compared to the other regions. Africa yields the lowest tonnage per hectare. Europe has the highest per capita consumption at 87.8kg per capita and Africa the lowest at 13.9kg per capita.

Table 2-1: Potato production (2007) and consumption (2005) per continent

	Production			**Consumption**	
Region	**Harvested area (ha)**	**Quantity (tons)**	**Yield (tons/ha)**	**Total food (tons)**	**kg per capita**
Africa	1 541 498	16 706 573	10.8	12 571 000	13.9
Asia/Oceania	8 732 961	137 343 664	15.7	94 038 000	23.9
Europe	7 473 628	130 223 960	17.4	64 902 000	87.8
Latin America	963 766	15 682 943	16.3	11 639 000	20.7
North America	615 878	25 345 305	41.2	19 824 000	60.0
World	**19 327 731**	**325 302 445**	**16.8**	**202 974 000**	**31.3**

Data Source: FAO, 2008

The genetic similarity of the potato varieties made them highly vulnerable to pests or diseases that could spread quickly between the varieties. In 1844/1845, a mould disease, late blight, destroyed potato fields across continental Europe, from Belgium to Russia. In Ireland, late blight destroyed three potato crops between 1845 and 1848. The potato supplied 80% of calorie intake and this crop loss lead to famines that caused the deaths of one million people. The Irish catastrophe led to intensive efforts to develop more productive and disease-resistant varieties. Breeders in Europe and North America produced many of the modern varieties that laid the foundation for massive potato production in both regions for most of the 20th century (FAO, 2008; Kiple & Ornelas, 2000; CIP, 2009).

In the 20th century the potato emerged as a global food. The Soviet Union's annual potato harvest reached 100 million tons. Germany and Britain dedicated huge areas of arable land to potato production. Countries like Belarus and Poland produced more potatoes than cereals. The potato came into its own as a snack food. In the 1920s the invention of the mechanical potato peeler helped make potato crisps America's top-selling snack. A restaurant chain founded by the McDonald brothers in the United States in 1957 spent millions of dollars to "perfect the French fry". And McCain, a Canadian firm, began making frozen French fries in 1957. McCain expanded to open 57 production facilities on six continents and now supplies one third of all French fried potatoes produced internationally (FAO, 2008).

As stated by FAO (2008) "the potato has an extraordinarily rich past and a bright future". Even though production in Europe is declining, the potato has more than enough room for expansion in the developing world, where its consumption is less than a quarter than that of developed countries. Table 2-2 indicates the top ten potato producers in the world.

Table 2-2: Top ten potato producers of the world (2007)

Rank	Producer Country	Tons
1	China	72 040 000
2	Russian Federation	36 784 200
3	India	26 280 000
4	United States of America	20 373 267
5	Ukraine	19 102 000
6	Poland	11 791 072
7	Germany	11 643 769
8	Belarus	8 743 976
9	Netherlands	7 200 000
10	France	6 271 000

Data Source: FAO, 2008

From Table 2-2 the three largest producers are China, the Russian Federation and India at 33%, 17% and 12% respectively. Together they account for 62% of the world production in tons.

2.2.2 Africa

Potatoes arrived late in Africa, around the turn of the 20th century. In recent decades, production has been in continual expansion, rising from 2 million tons in 1960 to a record 16.7 million tons in 2007. Potatoes are grown under a wide range of conditions. Egypt and South Africa have mostly irrigated commercial farms while in the intensively civilised tropical highland zones of Eastern and Central Africa it is mainly a small farmer's crop. In sub-Saharan Africa, the potato is a preferred food in many urban areas, and an important crop in the highlands of Cameroon, Kenya, Malawi and Rwanda (FAO, 2008). In Lesotho, many farmers are also shifting from maize to potato production. Table 2-3 lists the top eleven African producers. The four largest producers account for 59% of total production in Africa. South Africa is ranked third and produces 13% of Africa's potato production.

Table 2-3: Top eleven potato producers in Africa (2007)

Rank	Producer Country	Tons
1	Egypt	2 600 000
2	Malawi	2 200 402
3	South Africa	1 972 391
4	Algeria	1 900 000
5	Morocco	1 450 000
6	Rwanda	1 200 000
7	Nigeria	843 000
8	Kenya	800 000
9	Uganda	650 000
10	Angola	615 000
11	Ethiopia	525 657
Total	**Africa**	**16 706 573**

Data Source: FAO, 2008

2.2.3 South Africa

Dutch seafarers heading for East Asia probably brought the potato to South Africa in the 1600s. Apparently sailors encouraged potato growing at ports of call so they could resupply with fresh tubers during ocean voyages (FAO, 2008; Kiple & Ornelas, 2000). Since then the potato has become a vital commodity and important food crop for SA. The following section discusses the importance of potatoes and the sections thereafter discuss the South African potato industry to the full.

2.3 Importance of the potato industry

The world population is estimated to grow on average by more than a hundred million people per year in the next two decades (CIP, 2009). Ensuring food security for present and future generations remains a key challenge facing the international community (FAO, 2008). Few issues have attracted the attention of economists, as has the role of agriculture in economic development and poverty (Cervantes-Godoy & Dewbre, 2010). Cervantes-Godoy and Dewbre (2010) emphasises the historical relationship between different rates of poverty reduction and the differences in agricultural performances, specifically referring to agricultural productivity. They name four links between agriculture and poverty reduction and these include: 1) direct impact of increased productivity on rural income, 2) cheaper food, 3) contribution to economic growth and the creation of non-farm opportunities and 4) the stimulation of economic transition towards manufacturing and services.

Cervantes-Godoy and Dewbre (2010) go on to say that when both the direct and indirect effects of agricultural growth are taken into account such growth is more poverty reducing than growth in non-agricultural sectors. They studied 25 developing countries over different geographical regions, systems of governance and economic management and found that in twenty out of the twenty five countries' agriculture contributed positively to poverty reduction.

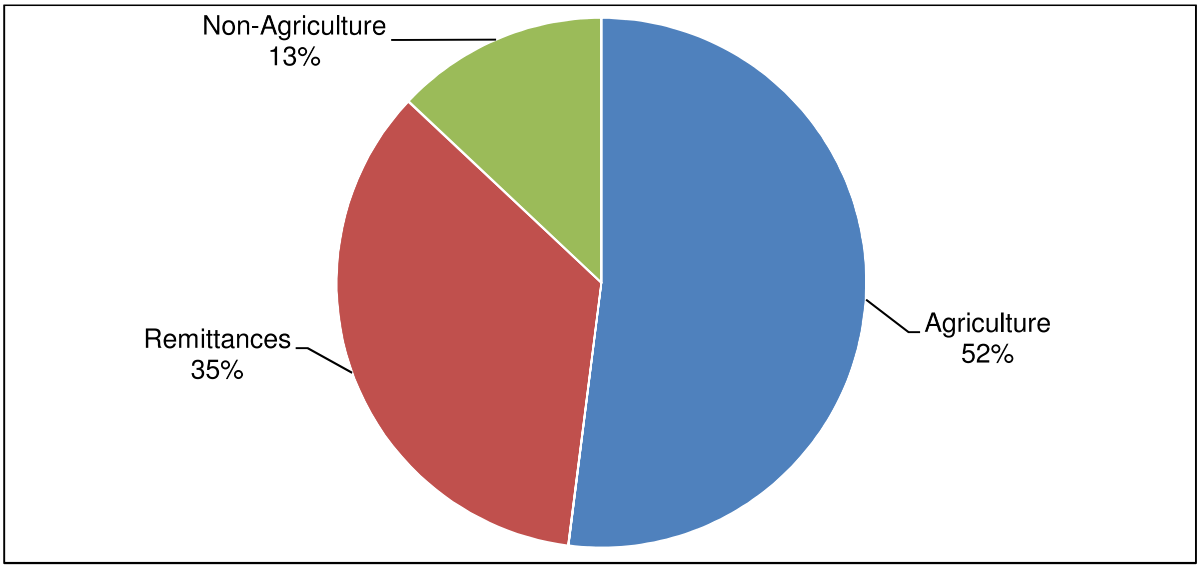

Figure 2-1: The total average contribution to poverty reduction
Source: Cervantes-Godoy and Dewbre, 2010

Figure 2-1 supports the fact that an increase in agricultural income is the most important contributor to poverty reduction. The combined Gross Domestic Product (GDP) of the agricultural sector along with its forward and backward linkages is believed to be closer to eight percent rather than the recorded three percent (Vink & Van Rooyen, 2009).

The potato is a vital part of the global food system. Developing countries could especially benefit if they recognise the potential of the potato to drive economic development and sustain rural livelihoods. Jacques Diouf (2009) made the following statement: *"The potato is on the frontline in the fight against world hunger and poverty"* (FAO, 2008). The FAO (2008) supports the potato in meeting these challenges for four reasons: i) potatoes are a truly global food, ii) potatoes feed the hungry, iii) potatoes are good for you and iv) demand for potatoes is growing. These points are supported by others who state that the potato is the most important root and tuber crop in the world, it is a major source of carbohydrate and are rich in protein, calcium and vitamin C and have a good amino acid balance in the diet. The potato is the third most important crop in the world, after rice and wheat. The potato yields more nutritious food more quickly on less land and in harsher climates than any other major crop (CIP, 2009).

In 2007, world potato production reached a record of 325 million tons and can be classified as the world's number one non-grain food commodity. There has been a remarkable increase in potato production and demand in Asia, Africa and Latin America. Output rose from less than 30 million tons in the early 1960s to more than 165 million tons in 2007. China is now the world's biggest potato producer. Even though harvests in Africa and Latin America are smaller, production reached record levels in 2005 (FAO, 2008).

An increase in the demand of agricultural products and thus of potatoes are expected due to urbanisation, population growth and a demand for a safe and reliable supply of food from sub-Saharan Africa (NAMC & Commark Trust, 2006). Consumption is expanding strongly in developing countries which make the potato a highly recommended food security crop that can help low income farmers and vulnerable consumers (FAO, 2008).

Based on a study by the NAMC and Commark Trust (2006) the potato industry contributes the following to the South African economy:

- Creation of job opportunities.
- Large downstream and upstream effect through industry linkages.
- Export earnings for the country.
- Empowerment of traders in the informal sector.

- Food to neighbouring countries.
- Improved welfare of the general population through productivity increase.
- Opportunities for emerging small-scale farmers.
- Income generation in small towns and rural areas.

2.4 The potato supply chain

There are several role players in the potato subsector, each of whom has different and specific roles in the potato value chain (NAMC & Commark Trust, 2006). This section briefly discusses the role players within the supply chain of the potato industry. Figure 2-2 gives a schematic representation of the potato supply chain.

The South African potato supply chain, involves mainly two types of potatoes; 88% is table potatoes while 12% is seed potatoes (Louw, Madevu, Jordaan & Vermeulen, 2004; Tukkies, 2010; NAMC & Commark Trust, 2006). Table potatoes are produced for consumption and seed potatoes for regeneration. Table potatoes are either marketed in their natural state or processed. Potatoes can be processed into either crisps, French fries and mixed vegetables. The processed products are then further distributed to the end consumer through the institutional-, wholesale- and retail markets (Louw *et al.,* 2004).

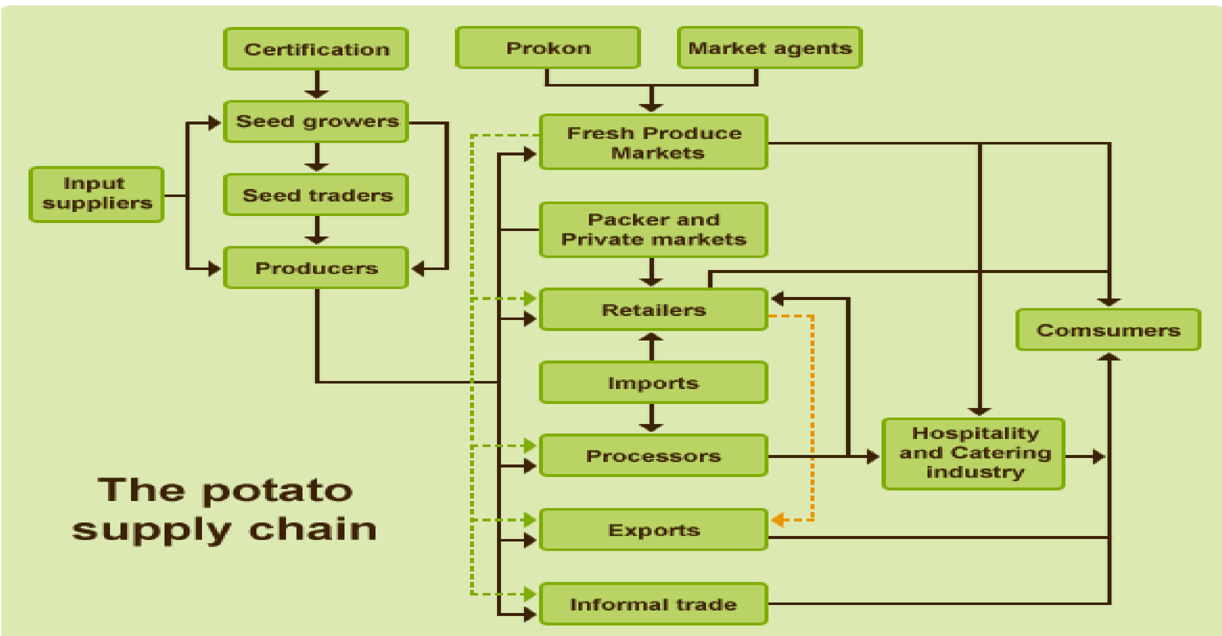

Figure 2-2: The potato supply chain
Source: PSA, 2010

Throughout the supply chain there is a flow of information, products and money. All of the key elements are included in the figure from the input suppliers, producers, processors, exports and the consumers. Because potatoes are produced for fresh consumption and for processing, potatoes can leave the value chain at any time or move along the entire span of the value chain. From production to the final consumer value is added at each level (Tukkies, 2010). The fresh produce markets present only one part of this supply chain.

2.5 Production

Ever since the 20th century, potato production has been in continual expansion, rising from two million tons in 1960 to a record 16.7 million tons in 2007 (FAO, 2008). Africa now supplies eight percent of the world's potato production (PSA, 2010). And demand is still increasing since the number of countries in sub-Saharan Africa considering South Africa as a reliable source of food, has increased the possible market size for South African potatoes (NAMC & Commark Trust, 2006).

In South Africa, the production levels of potatoes have shown a steady increase over the years. Production rose by 23% between 1991 and 2005. It is believed that 84% of the total production increases may be ascribed to the combined effect of irrigation and research (NAMC & Commark Trust, 2006). Currently the gross value of South African potato production accounts for about 60% of major vegetables, 13% of horticultural products and 3% of total agricultural production.

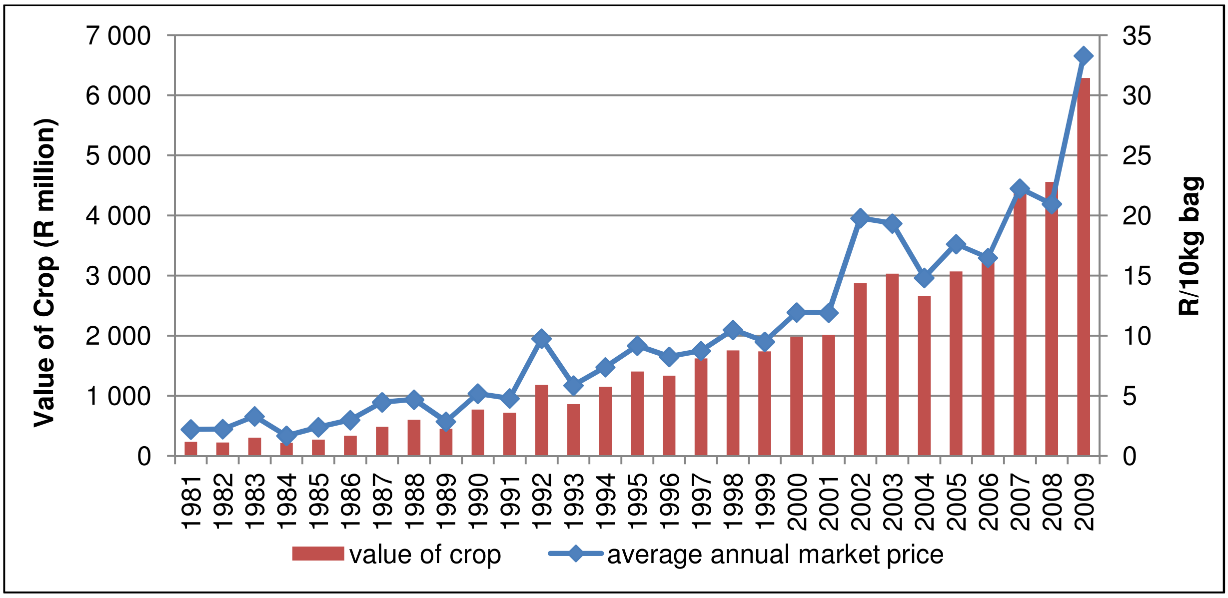

Figure 2-3: Producer value versus average annual prices of potatoes in SA
Source: PSA, 2010

Figure 2-3 shows the value of the potato crop against the average annual price on the market in Rand per 10kg bag from 1981 to 2008 (PSA, 2010). In all the years the market price moved above the value of the crop; but from 2006 onwards the price started to move below the value of the crop. The growth in the value of the crop and in the market price indicates growth within the potato industry.

Figure 2-4 illustrates the movement away from dryland production towards irrigated production. Production from dryland has decreased dramatically while irrigated potato production has increased (PSA, 2010). This trend is in all probability attributable to the increased productivity that irrigated production offers potato producers and the reduction of risk associated with rainfall, particularly low rainfall (NAMC & Commark Trust, 2006).

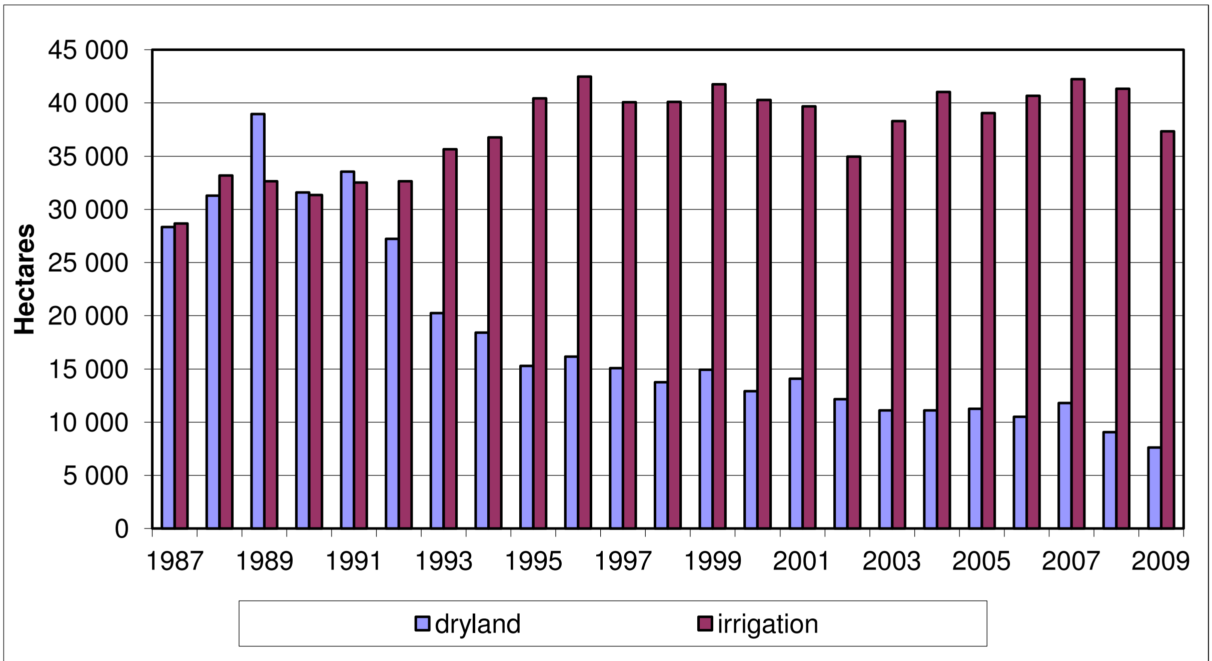

Figure 2-4: Dry land versus Irrigated potato production in SA
Source: PSA, 2010

It is estimated that the total South African crop are produced by 1 700 independent potato producers (of which around half that number are expected to be emerging small-scale farmers) and 66 000 farm workers (NAMC & Commark Trust, 2006; Louw *et al.,* 2004). Potatoes are mainly grown in rotation with maize and wheat (FAO, 2008). South African producers are fortunate to be able to produce potatoes through the whole year (PSA, 2010; NAMC & Commark Trust, 2006). Potatoes are mostly grown on relatively large farms, increasingly under irrigation, with yields averaging around 34 tons per hectare (FAO, 2008).

The total number of commercial producers in 2009 were 639, 42 less than in 2008 (PSA, 2010).

Figure 2-5 graphically illustrates the total annual production of potatoes from 1990 to 2009. The amount of 10kg bags produced indicates that production is increasing. The number of hectares planted has steadily been declining from 1990 while per hectare yield of potatoes has been increasing. The decrease in the area planted to potatoes is due to the increase in the relative yield of potatoes, which, in its turn, can be ascribed to research, the shift away from dry land potato production to irrigated potato production and the technological advances in the agronomic sciences including disease control, breeding, fertilisation, weed control, and nutritional and water requirements (NAMC & Commark Trust, 2006; Louw *et al.,* 2004; PSA, 2010).

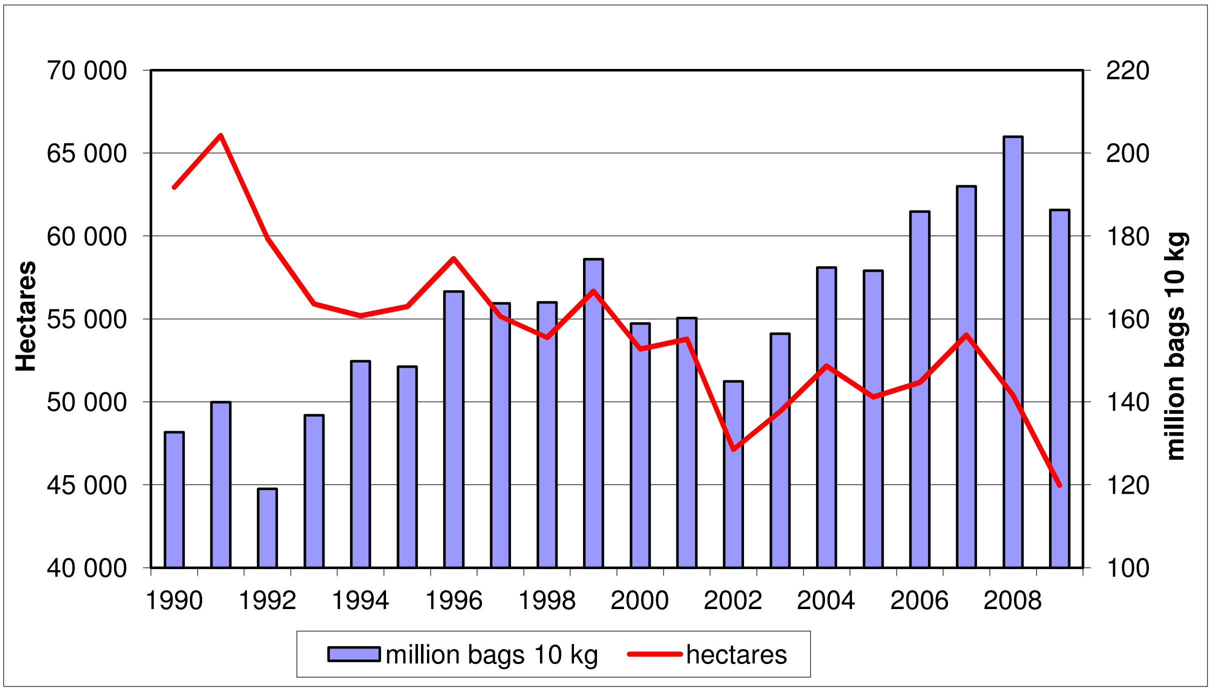

Figure 2-5: Hectares planted and crop size of potatoes in SA
Source: PSA, 2010

Successful potato production is to a large extent dependent on the quality of the planting material. The susceptibility of the potato to several transmissible diseases implies that it is not possible to multiply the same seed source for an indefinite period of time. The South African potato industry has a sophisticated seed potato industry which plays a vital role in the growth of the ware potato and processing industries. Seed potato growers supply the potato industry with healthy planting material. The Potato Certification Service ensures that planting material is multiplied according to certain requirements. Only laboratories registered with the Department of Agriculture and accredited by the Independent Council for the Certification of Seed Potatoes are allowed to conduct laboratory tests on seed tubers with regard to certain bacterial diseases and viruses before certification is confirmed (PSA, 2010). Potato production takes place across South Africa with all nine provinces making a contribution to production (NAMC & Commark Trust, 2006). Figure 2-6 summarises South Africa's total potato production per province. The four largest production regions measured in percentage of total 10kg pockets are Limpopo (21%), Western Free State (16%), Sandveld (14%) and the Eastern Free State (11%). These regions account for 62% of total volumes.

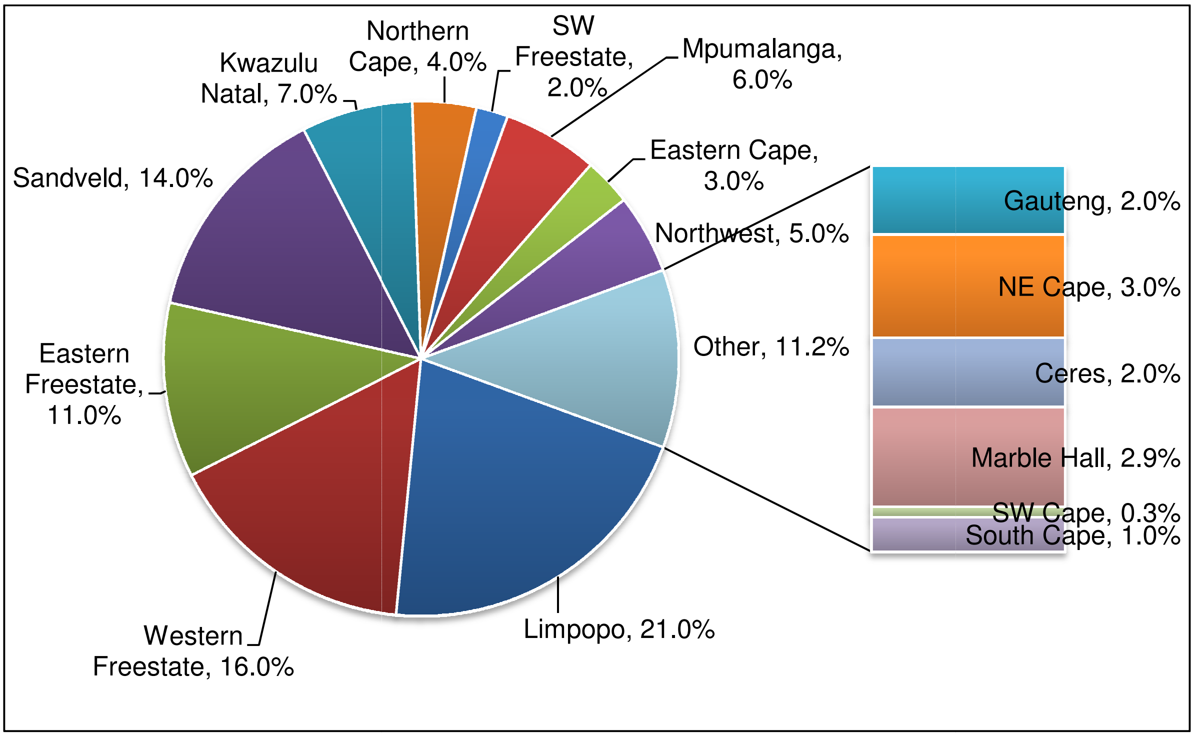

Figure 2-6: SA potato production per region (2009)
Date Source: PSA, 2010

Figure 2-7 summarises South Africa's total potato production according to cultivar. The three largest cultivars measured in percentage of total potato crop are Mondial (65%), BP1 (14%) and Up-To-Date (5%). These cultivars account to 84% of the total volumes. The other 16% consist of Buffelspoort, Vanderplank, Darius, Fabula, Avalanche, Valor and others. Mondial has shown significant growth over the last years. The reason behind this growth is mainly due to higher yields realised with Mondial compared to other older traditional cultivars. Mondial also shows relatively high resistance to scab, which occurs if you plant too quickly in the same soil (PSA, 2010).

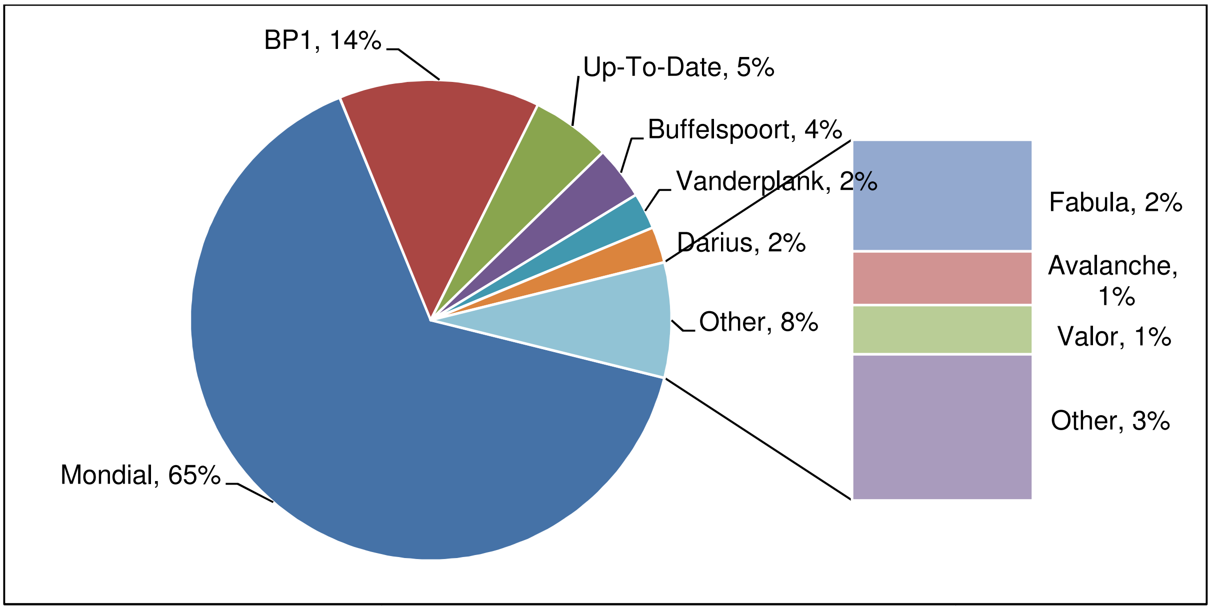

Figure 2-7: Main cultivars sold on FPMs (2009)
Data Source: PSA, 2010

Figure 2-8 shows the relative size of the three largest cultivars being produced with reference to the percentage of total hectares being planted, the percentage of cultivars being sold on the fresh produce markets, and as a percentage of certified seeds. In all three categories Mondial represents the highest percentage of potatoes. These three cultivars also represent almost 80% of all potatoes being sold on the fresh produce markets.

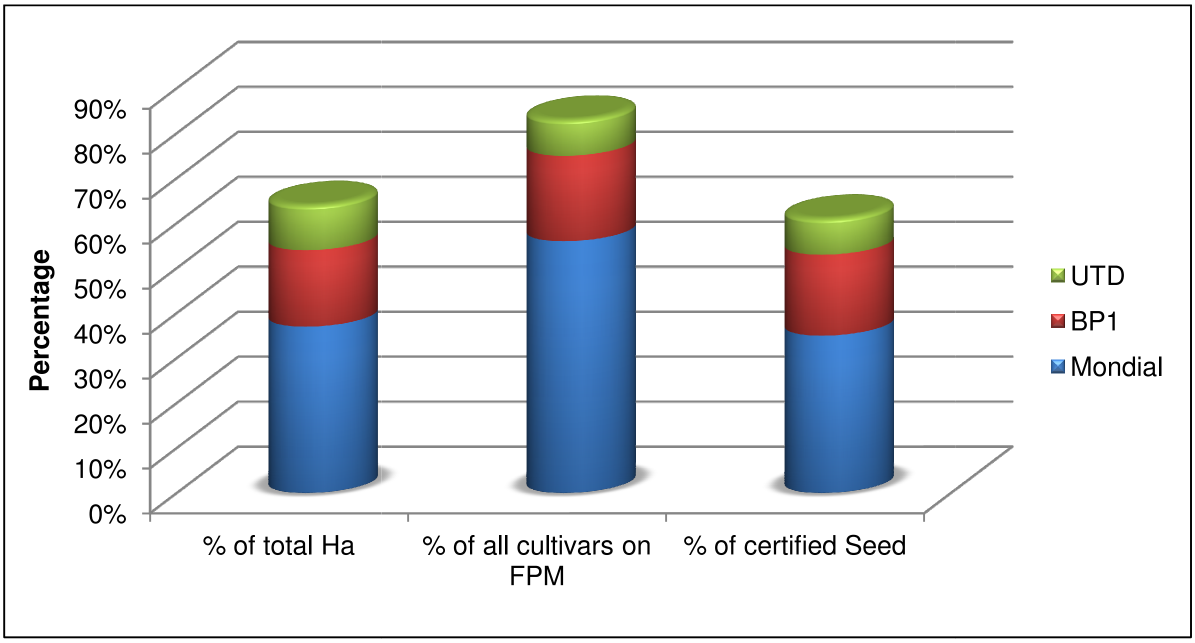

Figure 2-8: Three largest cultivars in South Africa (2007/2008)
Data Source: PSA, 2010

2.6 Processing

The processing sector is a significant component of the potato industry (Louw *et al.,* 2004). Although the SA processing industry is growing fast, it is still behind in size when it's compared with the potato processing industries in developed countries (PSA, 2010). The South African processing industry has doubled over the past five years and is still expanding (Louw *et al.,* 2004).

According to PSA (2010) the processing industry now represents 19% of the total potato crop and the growth in the industry can be ascribed to the following factors: 1) the expansion of the fast food industry, 2) the higher average income of the population, 3) the enlargement of processing facilities and 3) the rapid rate of urbanisation.

Currently the industry uses 380 000 tons of fresh potatoes of which 320 000 tons are contracted from producers and the balance purchased from the fresh produce markets. These volumes represent the formal figures of the processing industry, taking into account that a substantial quantity of the potatoes bought by individuals also ends up in restaurants, cafés and other fast food outlets in the form of French fries (PSA, 2010). Figure 2-9 indicates the growth in the tonnage of potatoes that are distributed to the processing industry from 1997 to 2009.

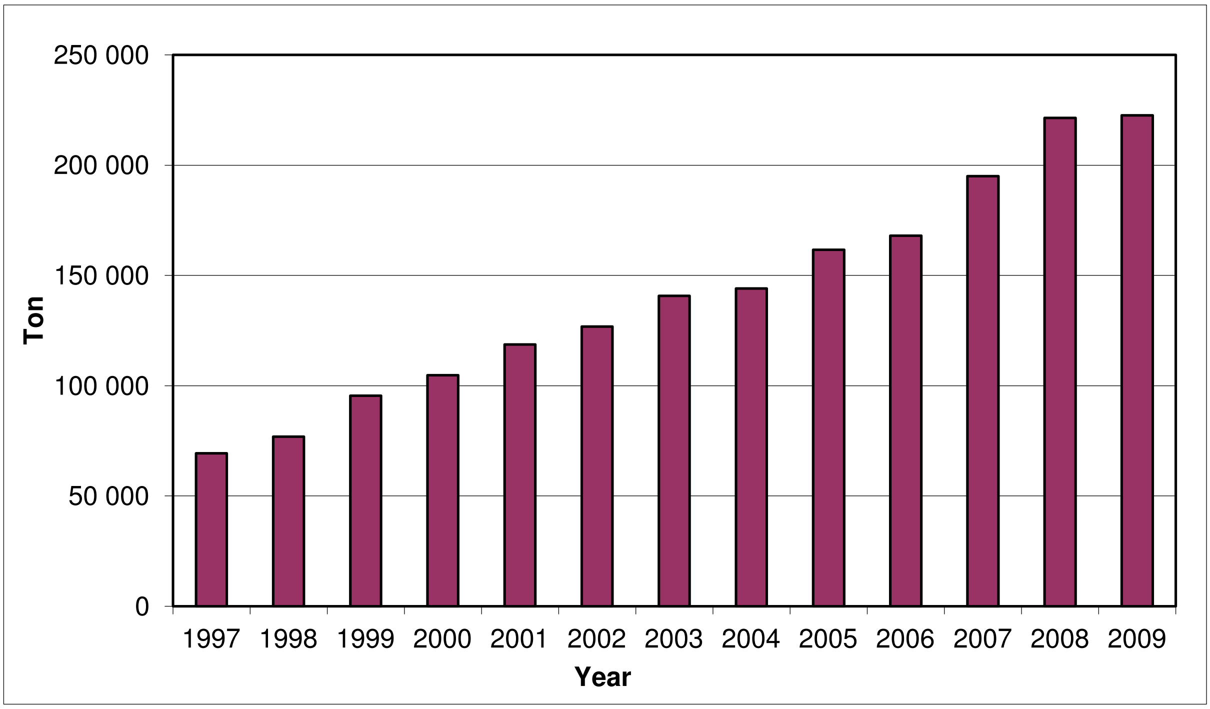

Figure 2-9: Growth in potato volumes send to processing (1997-2009)
Source: PSA, 2010

Figure 2-10 shows the regional contribution of potatoes to the processing industry. The two largest contributing provinces are the Eastern Free State and Limpopo province.

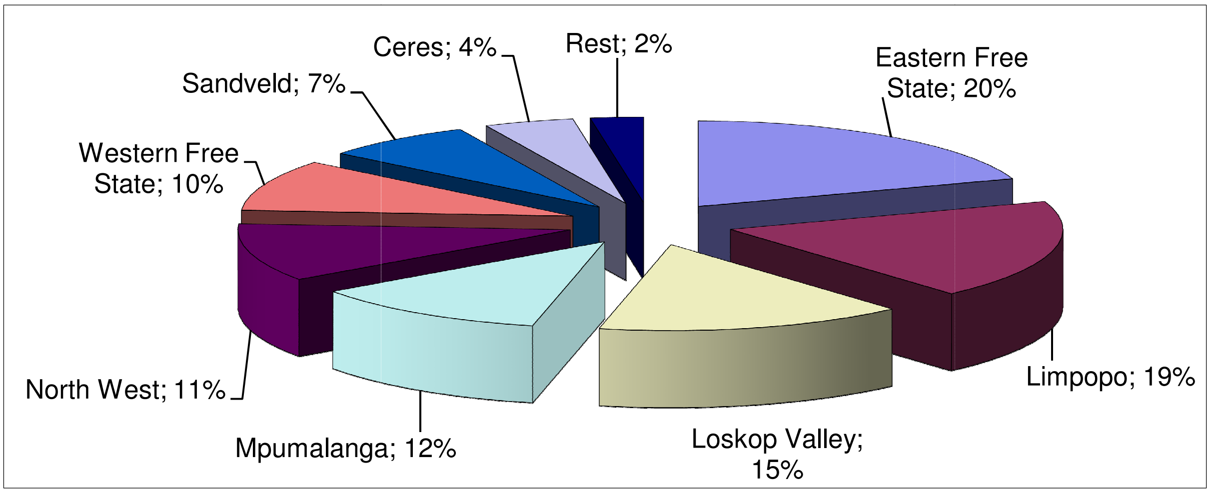

Figure 2-10: Regional contribution to processing industry (ton)
Source: PSA, 2010

The largest part of the processing industry is made up of processing potatoes into French fries, frozen and chilled products and crisps. Besides these processing categories, the industry also produces mixed vegetables (canned and frozen), baby food, reconstructed potato products and a small quantity of potato starch. From 2005 South Africa also started to import raw potatoes for processing (PSA, 2010). Figure 2-11 shows the growth in the tonnage of potatoes that are offered to the French fries market both local and imported quantities.

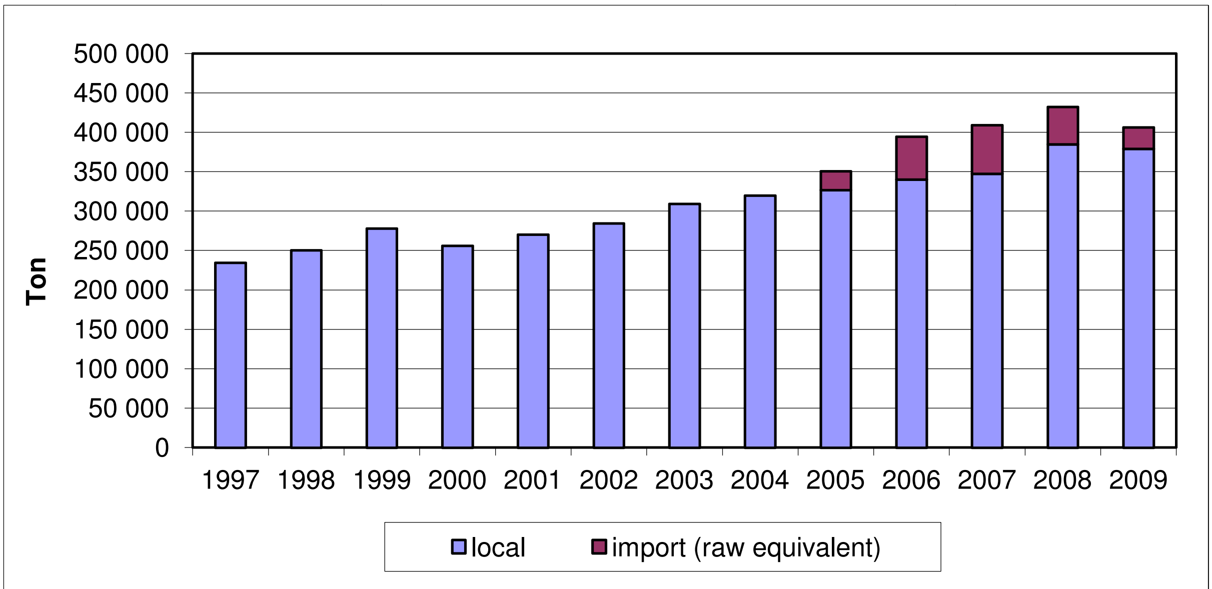

Figure 2-11: Potatoes offered to the frozen French fries market (1997-2009)
Source: PSA, 2010

The end-use product determines the potato cultivars selected. For households a firm potato cultivar may be favoured when making salads because they do not break easily, while another cultivar is favoured for mashing and baking because it is brittle. Similar to the household sector, processors have preferences for certain cultivars and quality standards depending on their needs (Louw *et al.,* 2004).

Some of the role players that do repackaging themselves include hawkers, hawkers' buyers, exporters, retailers, wholesalers and supermarkets. A leading retailer/processor in the South African quick service restaurant and casual dining services, Famous Brands Limited, currently holds a monopoly in this trading environment. They are responsible for 1 502 franchised restaurants which include: Steers, Wimpy, Debonairs, FishAways, Whistle Stop, House of Coffees, Brazilian Café, Baltimore and TruFruit. Market on Wheels, a private supplier to various restaurants and fast food diners in the Pretoria region, delivers fresh produce to almost 120 restaurants (Tukkies, 2010).

2.7 Markets and prices

The potato industry operates in a free market environment which makes the availability of information a necessity in achieving success (PSA, 2010). The FPM is the preferred marketing channel for potatoes. Most municipal markets are owned by the local authorities. The markets function on a commission on sales basis (NAMC & Commark Trust, 2006).

Supply and demand on the FPMs determines potato prices (NAMC & Commark Trust, 2006; Louw *et al.,* 2004). The demand for potatoes is relatively inelastic and the supply is highly elastic. The potato prices are therefore highly elastic and also directly dependent on the supply of potatoes on the fresh produce markets (Louw *et al.,* 2004).

The FPMs are a R8 billion industry. South Africa has 19 markets. Based on the total volumes sold the four largest markets are Johannesburg (30%), Pretoria (19%), Cape Town (12%) and Durban (9%). These four markets handle 70% of all volumes. The remaining 30% volume is handled by the other 15 markets (PSA, 2010). Figure 2-12 shows the relative sizes of the markets.

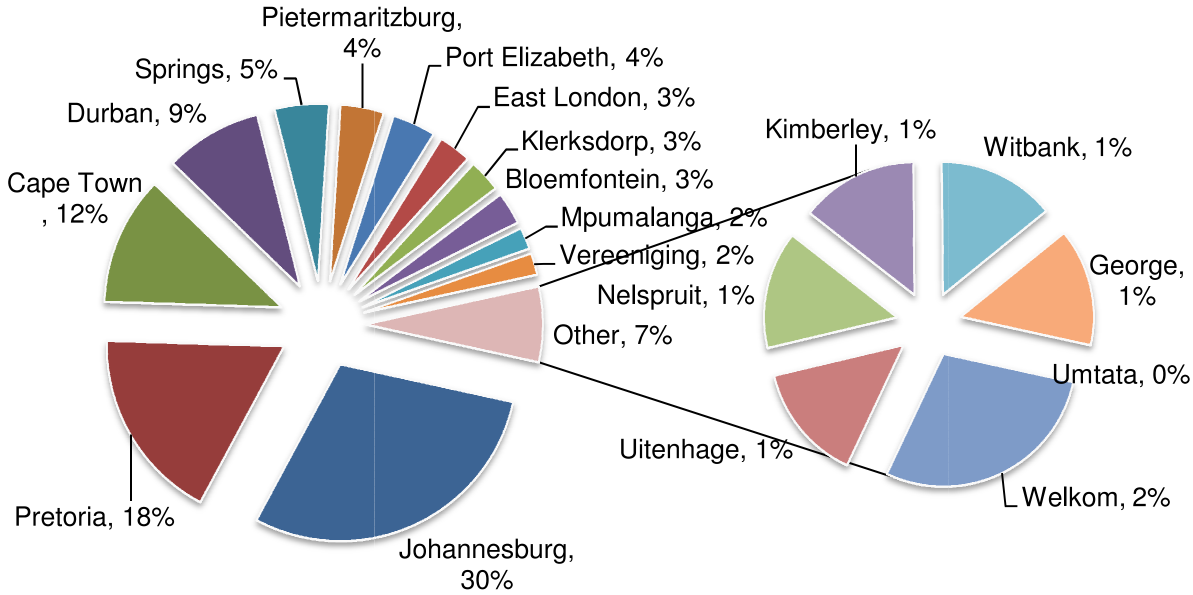

Figure 2-12: Relative size of the FPMs (total volume of pockets sold)
Data Source: PSA, 2010

Class 1 potatoes represent 72% of potatoes sold on FPMs and 45% of these are Class 1 medium potatoes (PSA, 2010). The FPMs play an important role in the distribution of fresh produce from the producer to the consumer. JHB is labelled as the price setter for the products. The steady supply of potatoes that is available on the fresh produce market makes it a reliable supplier of produce. The FPMs are also used for price formation by supermarkets, wholesalers and retailers (Tukkies, 2010).

During 2005 a total of 59% of all potatoes were distributed through fresh produce markets (NAMC & Commark Trust, 2006). This declined to a mere 47% in 2008. The percentage of total crop that goes to the market is decreasing even though the volumes received is moving relatively sideways (PSA, 2010). This effect is shown in Figure 2-13, where the decrease in the percentage of total crop that goes through the market is clearly visible. The remaining potatoes are captured by direct sales from producers to wholesalers, retailers, processors, some informal traders and consumers. The informal sector for potatoes is growing significantly. Between 1995 and 2005 the informal sector grew by 59%, and it is still growing. One possible reason for the growth could be due to some substitution of other staple foods that are showing a decline in per capita consumption (NAMC & Commark Trust, 2006).

The informal traders buy 10kg pockets and re-sell them loose or in 1–2kg plastic bags. They purchase potatoes either on FPMs or directly from farmers. The formal retail sector includes large retailers such as Fruit & Veg City, Pick 'n Pay, Shoprite-Checkers, Spar and Woolworths. The sector also includes smaller retailers such as Green Grocers and independent stores. The formal retail sector concentrates on the sale of high quality fresh produce in smaller containers or as loose fresh produce. Some formal retail sectors perform their own packaging, branding and advertising of fresh potatoes (Louw *et al.,* 2004).

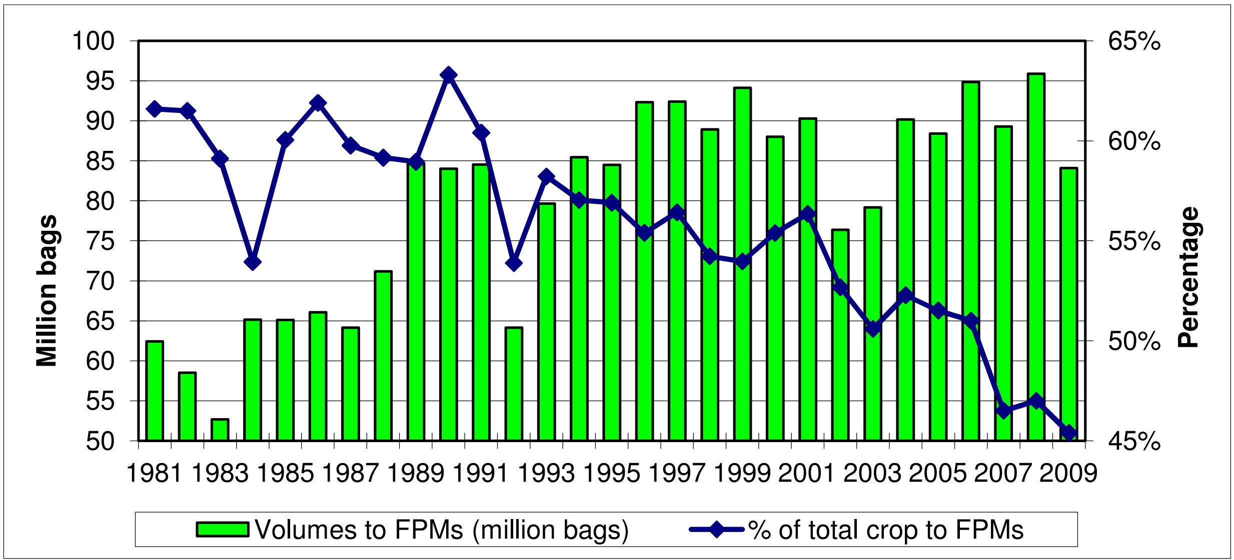

Figure 2-13: Volume and percentage of total crop send to FPM (1981-2009)
Source: PSA, 2010

Figure 2-14 indicates the distribution of the total crop to the various outlets. The relative size of the fresh produce markets, at 35%, can be compared to the other outlets. The other outlets include informal markets, processing, seed and exports. The FPMs are still the biggest sector (35%), but is followed closely by the growing informal market (29%).

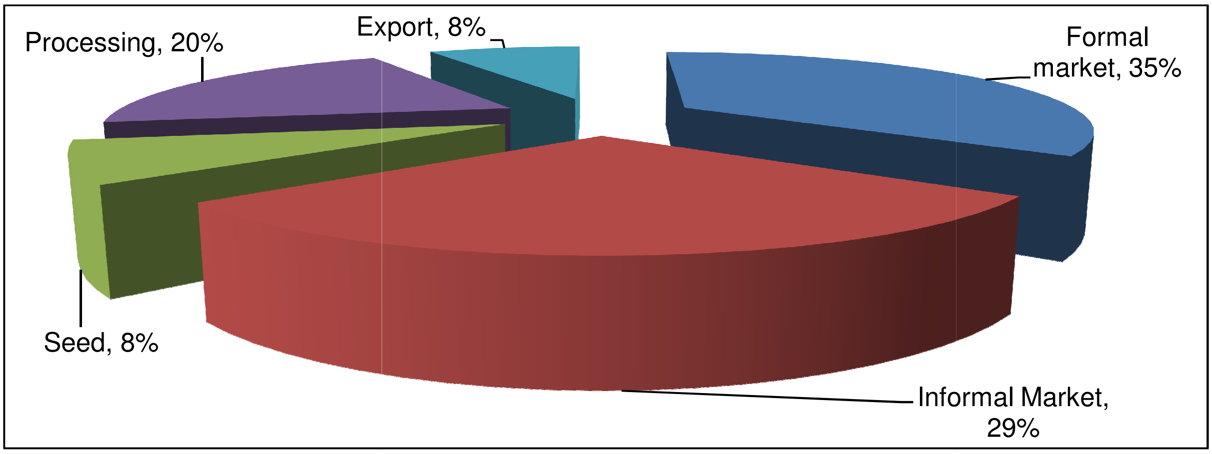

Figure 2-14: Distribution of total potato crop - 2009 crop year
Source: PSA, 2010

Figure 2-15 indicates the buyers on the fresh produce markets. The biggest buyer of potatoes is the informal market at 52%. Formal trades represent 34% of the sales with the processing industry buying only 6% of potatoes on FPMs. Hawkers on the Pretoria FPM represent between 27% and 29% of monthly turnover and 50% of sales on the Johannesburg FPM (Louw *et al.*, 2004).

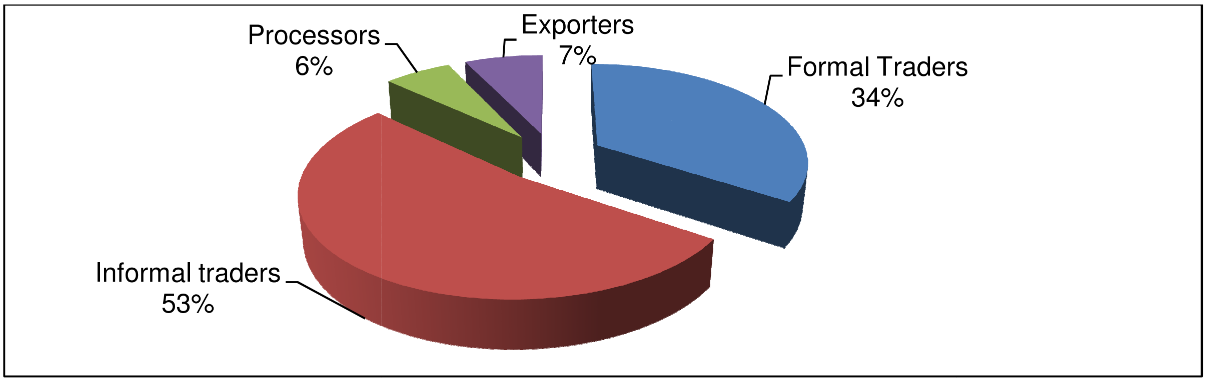

Figure 2-15: Buyers of potatoes on the FPM (2009)
Source: PSA, 2010

Figure 2-16 indicates movement in the sales volume of the four largest markets from 1997 to 2008. These four markets all moved downwards and close to each other from 1997 up to 2002/2003 and then started to increase and also move apart from then on. The Pretoria market has shown the greatest growth in volumes sold on the market from the year 2002. Three of the four markets showed growth with regards to volumes sold from the year 2003 up to the year 2008. The Durban market showed a decline in market share from 2004 onwards.

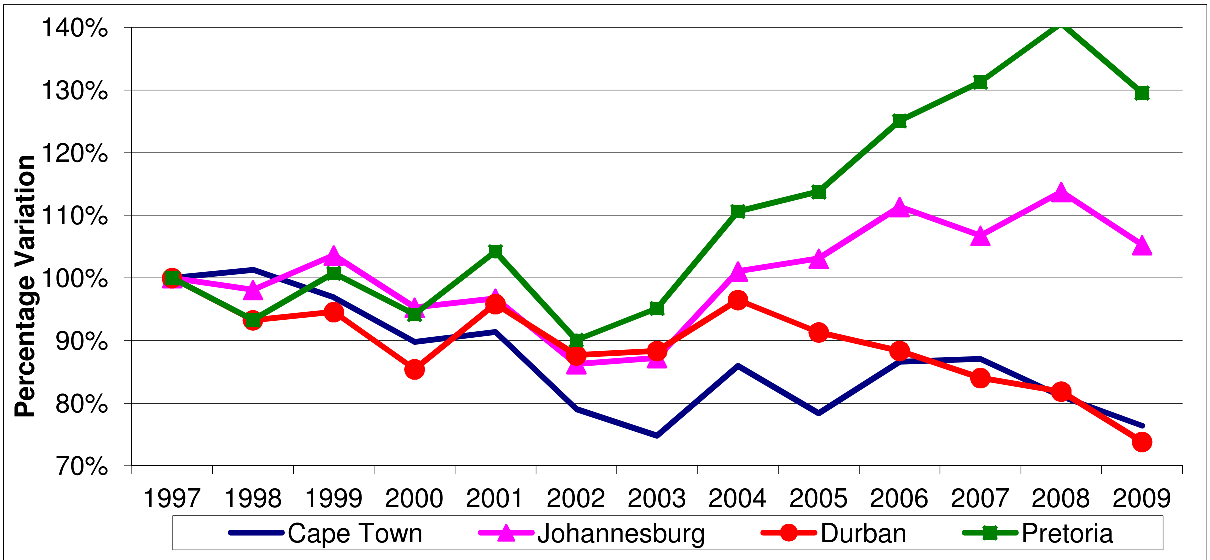

Figure 2-16: Percentage variation in sales volumes for the 4 largest FPMs (1997 2009)
Source: PSA, 2010

There is a negative relationship between price and quantity supplied. Volume control is thus of great importance. The end price of potatoes on the market is also dependent upon product grading. Potatoes are still officially graded on the market (NAMC & Commark Trust, 2006). The potatoes need to be in a good condition to be graded as such and to receive good prices. The quality of the produce on the markets is mainly influenced by degrading factors like mechanical damage, greening and other disease related factors. Figure 2-17 shows the major contributors to degradation on the fresh produce markets.

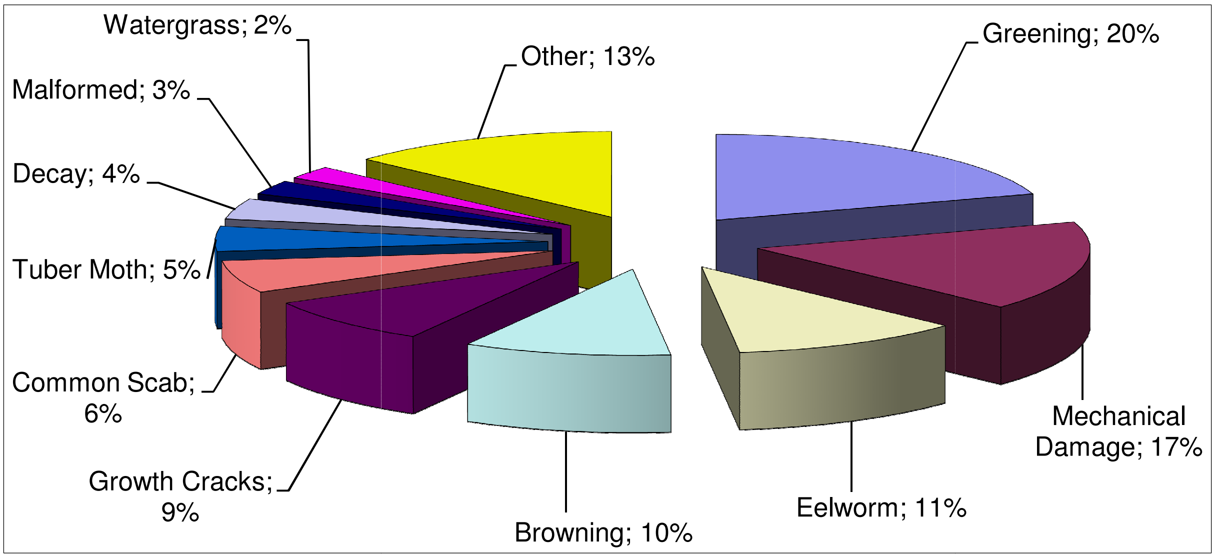

Figure 2-17: Major reasons for degradation of potatoes on the FPM (2009)
Source: PSA, 2010

2.8 Trade

South Africa contributes less than 1% to the potato export market of countries outside the South African Customs Union (SACU), and is thus not considered to be a major exporter of potatoes in world terms. South Africa is ranked 31st on the list of global potato production, supplying a mere 0.5% of the world's total production. In Africa on the other hand South Africa is one of only two exporting countries and the only exporter in Southern Africa. The majority of South African potatoes are exported to neighbouring SACU countries and to Angola, Mozambique and Mauritius (NAMC & Commark Trust, 2006).

Potatoes are mainly exported to Botswana, Namibia, Zimbabwe, Lesotho, Swaziland, Ivory Coast, Ghana, Senegal, Mauritius and the DRC (Tukkies, 2010). Angola, Mozambique and Zambia are South Africa's most prominent export destinations, accounting for 83% of all potato exports (NAMC & Commark Trust, 2006). Continentally South Africa is home to 5% of the African potato acreage and produces 14% of Africa's potatoes (Louw *et al.,* 2004). The export market for potatoes is also exhibiting growth and grew by 28% in the period between 1995 and 2005. The export of potatoes is expensive due to the bulkiness of potatoes, causing higher transport costs. The higher transaction costs are the main reason why South Africa's primary export markets are located in Southern Africa. South Africa exports both seed and table potatoes to neighbouring and nearby countries (NAMC & Commark Trust, 2006).

As African leaders in potato breeding, a major proportion of these exports are in the form of seed potatoes (Louw *et al.,* 2004). The total value of potatoes or potato products imported into South Africa amounted to about R51 million during 2005. The value of some of these imported products is negligible for all practical purposes. Frozen fries and starch are the most significant imported potato or potato related products. The two jointly constitute some 94% of all imports (NAMC & Commark Trust, 2006).

2.9 Consumption

The per capita consumption of potatoes in South Africa is about 32kg per person per annum. The per capita consumption of potatoes in developing countries is estimated at 14kg per capita per annum, while that of Europe is 86kg and North America 63kg per capita per annum respectively.

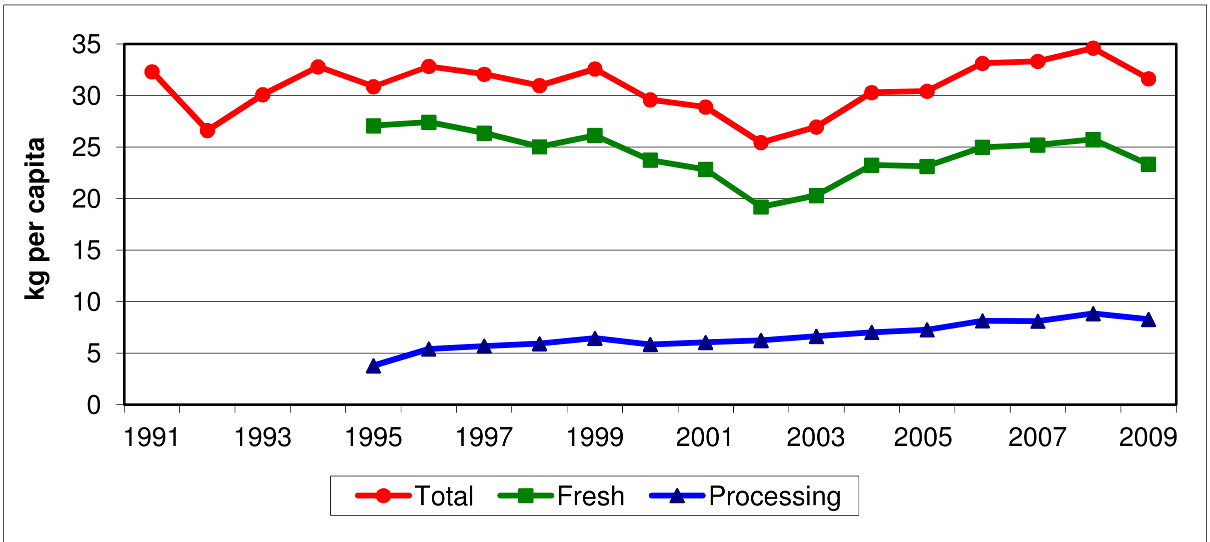

Figure 2-18: Per capita consumption of potatoes in SA
Source: PSA, 2010

It is therefore suggested that developing countries and countries like South Africa have ample room to expand per capita consumption of potatoes (NAMC & Commark Trust, 2006).

Figure 2-18 shows the per capita consumption of fresh and processed potatoes from 1991 up to 2007 for South Africa. The per capita consumption of both fresh and processed potatoes showed growth over the time period in consideration.

Table 2-4 shows the producers share in the consumer price for the various packaging available. The producers share is the highest on the informally repacked bags and the 10kg bags and the lowest on crisps. The value of the producers share showed an increase from the 2006/2007 year to the 2009/2010 year.

Table 2-4: Producer share in consumer price per retail packaging (Gauteng)

Retail Packaging	2006/2007	2007/2008	2008/2009	2009/2010	Average
	Percentage (%)				
10kg	49	50	48	55	51
7kg	41	42	42	49	43
2kg	21	24	23	27	24
1kg	22	25	25	30	26
Informal: repackaged	32	43	43	55	43
Informal: 10kg	51	56	50	58	54
Crisps: 125g	11	12	10	12	11
Frozen French fries: 1kg	16	17	21	24	20

Source: PSA, 2010

2.10 Inputs

The potato industry has a number of inputs which include seed, fertiliser, fuel, farm feed, dips and sprays, pesticides, land labour, packing material and maintenance costs. The industry suffers from relatively high and increasing input costs which make the production of potatoes relatively risky. The industry suffers from a price/cost squeeze, with stagnant producer prices and escalating input prices (NAMC & Commark Trust, 2006).

The industry currently relies on two suppliers of paper for the packaging of potatoes. The local producer of paper, namely Sappi, supplies the bulk of the paper, with Gerber Paper Products importing the balance mostly from Scandinavian countries and from Brazil. The prices of potato packaging change from year to year due to the dramatic variation of the international pulp price. Over the past few years the pulp price experienced a lot of changes which in turn, caused the price of potato pockets to change (PSA, 2010).

2.11 Organisation

Based upon research by NAMC and Commark Trust (2006) the South African potato industry has a number of organisational structures that support the potato industry in various ways. The organisational structure is set out diagrammatically in Figure 2-19.

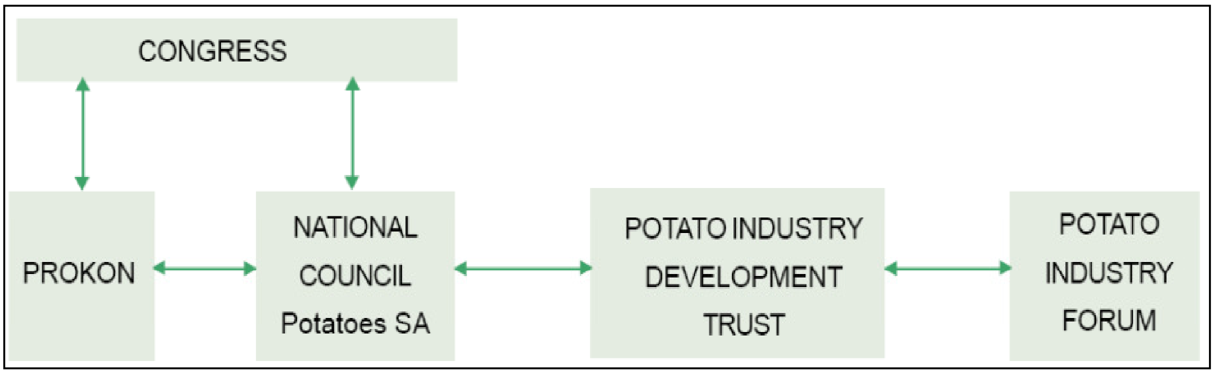

Figure 2-19: The organisational structures of the potato industry
Source: NAMC & Commark Trust, 2006

Congress is the annual meeting of all stakeholders in the potato industry. Product Control for Agriculture (PROKON) is an independent quality assurance body that ensures that consumers have access to quality fresh fruit and vegetables by providing guidelines on how to comply with consumer needs in terms of quality, size, packaging and cultivars. Potatoes South Africa (PSA) is an industry related organisation that supports the potato industry to perform optimally by rendering services such as organisational functions, product and market development, product promotion, communication, advertising, research and information. The Potato Development Trust is required to fund basic as well as applied research. The Potato Certification Service ensures that high quality planting material is locally available by supervising and administering registrations to ensure that seed potato growers meet requirements with regard to certain bacterial diseases and viruses. The Potato Exporters Forum oversees the export of potatoes and implements a code of conduct for the export of potatoes from South Africa (NAMC & Commark Trust, 2006).

2.12 Policies

South Africa has undergone vast social and economic change over the last 20 years. These changes include the abolition of apartheid, and fundamental reforms intended to create a more open and market oriented economy. Partial reforms were implemented during the 1980s and early 1990s, with their main concern being domestic markets (OECD, 2006).

Other changes included de-regulation of the marketing of agricultural products, the abolishment of certain tax concessions favouring the agricultural sector, reductions in budgetary expenditure on the sector, land reform and trade policy reform (OECD, 2006). Since 1994, the strategic direction of the agricultural sector has been shaped by three main policy documents: the White Paper on Agricultural Policy, the Agricultural Policy in South Africa discussion document and the Strategic Plan for South African Agriculture (Vink & Van Rooyen, 2009).

Policies that currently have an impact on the potato industry are the general monetary and fiscal policy of South Africa, AgriBEE framework, land restitution and redistribution and agricultural credit. A large proportion of potatoes are grown under irrigation and the fact that South Africa's water resources are scarce and limited is seen as a potential problem due to the availability of water for irrigating potatoes (NAMC & Commark Trust, 2006). Currently the South African government does not provide any direct support to the South African potato industry. The only support includes sanitary and phytosanitary measures, the maintenance of fresh produce markets, the institution of tariffs to protect against dumping, and a National Agricultural Marketing Council (NAMC) to mainly oversee the marketing of agricultural products (NAMC & Commark Trust, 2006).

Three issues within the sector are that sanitary and phytosanitary measures are not always adequate in ensuring the protection of the industry, pressure from imports of processed potatoes, and the commission sales marketing system on fresh produce markets that remains the most important price setting mechanism. The potato industry feels that ongoing efforts should be made to improve this public price setting mechanism (NAMC & Commark Trust, 2006). This public price setting mechanism is used throughout the industry to set prices for potatoes, which emphasises the efficient functioning of these markets within the potato industry.

CHAPTER 3
LITERATURE REVIEW

3.1 Defining market integration

Before one can examine market integration it is important to define the meaning of market integration. Available literature provides a vast number of definitions, yet fails to reach a standard definition. The concepts underlying market integration include prices, markets, arbitrage and the Law of One Price (LOP). The following section is aimed at stressing the various definitions of market integration, which will commence with the explanation of the concepts underlying market integration.

3.1.1 Prices

Serra and Goodwin (2002a) state that prices are the principal mechanism by which different levels of the market are linked. Prices are also used by economist to indentify markets, since price is formed by the collective activities of buyers and sellers in the market (Vollrath, 2003). Prices are repeatedly used as effective signals for allocating scarce resources and in effect stimulate agricultural productivity and economic growth (Barrett, 1996). The popularity of prices in analyses is due to the fact that prices are often the most reliable and readily available information that can be obtained (Vollrath, 2003; Goletti *et al.*, 1995). Other usable information like quantities produced or the value of trade often do not exist or is difficult to obtain (Goletti *et al.*, 1995). This is especially the case in developing countries, where data collection is often neglected.

Future prices of planted crops determine farmers anticipated profits and thus affect their planting decisions. Prices are therefore an important tool in the economic analyses of markets (Oladapo & Momoh, 2008). The overall functioning of the market can be better understood by analysing the vertical and/or spatial price transmissions between markets. The level of competitiveness in the market can also be determined by studying the extent and speed with which shocks in prices are transmitted within the marketing chain (Serra & Goodwin, 2002a).

3.1.2 Markets

Markets are complex institutions that have to simultaneously consider hierarchies and interlinked transactions of various commodities occurring in the market (Goletti *et al.*, 1995). Almost all microeconomic analysis is based on some definition of a market, therefore yielding it of great economic importance (Asche *et al.,* 2004). Most studies in market integration consider two types of markets: goods markets and financial or capital markets (Qin, Cagas, Magtibay-Ramos & Quising, 2007). Microeconomics assumes that there exists a market defined over any group of commodities (Asche *et al.,* 2004). Agricultural markets are normally characterised by a large number of producers (sellers) and relatively fewer consumers (buyers) spread over geographic regions (Franken & Parcell, 2003).

The term market does not refer specifically to any particular market place where things are bought and sold. A market rather refers to any area in which buyers and sellers move freely so that the prices of the same good will move to equality relatively easy and quickly (Boisseleau & Hewicker, 2002). A market can thus be defined as an area where the price of a good move to equality after taking the transportation costs or quality differences of the good into account (Boisseleau & Hewicker, 2002; Asche *et al.*, 2004; Asche, Gjølberg & Völker, 2003). Price of similar commodities in a market may move apart in the short run but will equilibrate in the long run due to arbitrage and substitutability (Norman-López & Bjørndal, 2009).

A good or commodity that can be transported between markets must move from a market where its value is less to a market where its value is more. The movement must continue until the difference in value between the two markets is no more than transportation costs or the difference in quality (Asche *et al.*, 2004; Norman-López & Bjørndal, 2009). The equilibrium between two markets is represented graphically in Figure 3-1.

Initially the prices in both markets are at p. If there were to be a supply shock in Market 1 that shifts the supply schedule to S1', then the new price and quantity would be given by p' and q1'. In Market 1 the price thus decreased and the quantity increased. The degree of substitution between the two markets determines the effect realised in Market 2. Price and quantity will remain unaffected in Market 2 if there are no substitution possibilities between the two markets. If the goods on the markets are perfect substitutes then consumers will substitute the goods in Market 1 for the goods of Market 2. This shift will move the demand schedule down to D2' causing the price to fall just enough to bring prices to equilibrium in both markets at P'. The demand curve will move down only a little, say to D2'', if the goods are not perfect substitutes which will not be good enough to take price to the equilibrium level (Asche *et al.*, 2004).

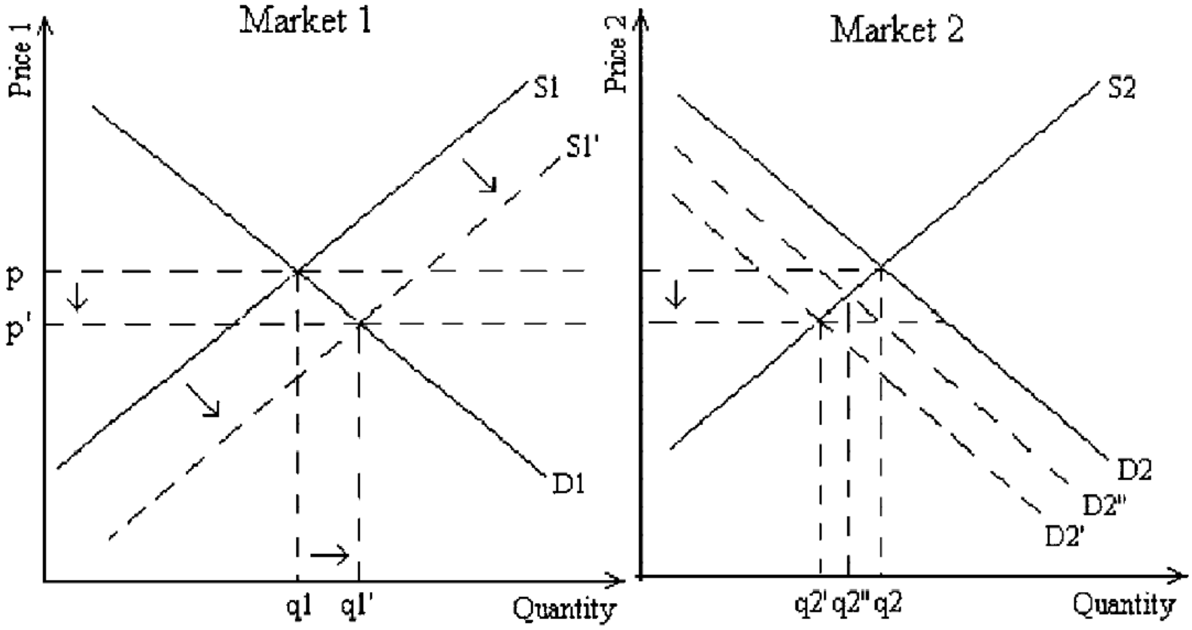

Figure 3-1: Potential Market Interaction between Two Markets
Source: Asche et al., 2004

The analysis of price relationships on markets can provide information on: (i) whether the goods on the two markets compete or not and (ii) whether the goods are perfect substitutes or not (Asche *et al.*, 2004).

3.1.3 Arbitrage

Prices between markets should tend to equality, allowance being made for small deviations in prices due to transaction costs, capital constraint, interest rate and execution risk which will discourage trading if the profit potential is small (Tsay, 1998). The price between the two markets should only differ because of transmission constraints. Arbitrage will be the force that safeguards the movement of prices on the markets in tandem (Boisseleau & Hewicker, 2002). Arbitrage can be defined as the error-correction mechanism that moves the prices of a homogenous good on two markets towards equilibrium (McNew & Fackler, 1997).

Traders buy a good in a low priced market transfer it to a high priced market and then sell the purchased good until price equalization occurs, this underlies the basic concept behind arbitrage. Spatial arbitrage is the reason why prices of a homogeneous good on markets in different geographical areas will tend to equality and thus move together (Vollrath, 2003).

Arbitrage will only occur when there is a large deviation in the prices so that the potential profit is more than the cost of trading (Tsay, 1998; Trenkler & Wolf, 2003). Therefore, prices of related products may deviate from each other in the short run, but in the long run, arbitrage will be the force that guarantees that these prices on the different markets form an equilibrium relationship (Norman-López & Bjørndal, 2009).

3.1.4 The Law of One Price (LOP)

The strict version of the LOP states that the prices of the same good or commodity should not differ between two spatially separated markets. If the prices do differ the force of arbitrage will move the prices towards equilibrium, taking the transaction cost of arbitrage into account (Trenkler & Wolf, 2003). Pede and McKenzie (2005) states that arbitrage activities will guarantee that prices in spatially separated markets equalise once adjusted for transportation costs. Vollrath (2003) extends the theory to international markets stating that prices will equalise across freely trading areas and that homogeneous goods will sell for the same prices in different countries taking the exchange rate into account. Short term price misalignments should quickly disappear over time as consumers and firms can arbitrage away the differences in price (Ratfai, 2003).

In agricultural markets, the LOP presents an interest at both the national and international level. Firstly, there is an interest in measuring the efficiency of arbitrage and in defining the boundaries of the market. Secondly the existence of a single price is important in international trade and exchange rate determination theories. The bulkiness and perish ability of agricultural products along with the separation between the production and consumption areas enhances the interest in the LOP (Zanias, 1999). In Figure 3-1 the LOP will hold if there is a substitution effect and if the price in Market 2 shifts by the same percentage as the price in Market 1. The substitution effect will cause the demand schedule in Market 2 to shift down moving the price in the same direction as the price in Market 1. The demand schedule will not shift and there will be no movement in price in Market 2 if there is no substitution effect (Asche *et al.,* 2004).

Under certain conditions there could be a failure in the Law of One Price. Ratfai (2003) indentifies the main reasons behind possible failure in the LOP as transportation costs, different currencies with sticky prices, labour market segmentation, tariff and non-tariff barriers to trade, fluctuations in nominal exchange rates, productivity differentials, pricing to market and aggregation bias, amongst others. Non-continuous trade flows, pricing to market, exchange rate risk, and geographical separation of markets can also cause failure in the LOP (Padilla-Bernal *et al.,* 2003). Obstfeld and Taylor (1997), states that the LOP fails dramatically in the short run and therefore research needs to focus on the LOP in the long run. Taking all this into consideration the LOP plays an important role in defining the extent of the market and in measuring market integration (Ghoshray & Lloyd, 2003).

3.2 Market integration

However market integration is measured, it is still dependent on a vast number of external factors. Market integration is a result of the action of the traders and the environment where the operations takes place, which is determined by the available infrastructure for trading and the policies that could affect price transmission (Goletti *et al.*, 1995). Trade flow between the markets is a sufficient but not a necessary condition for some degree of spatial market integration (Negassa *et al.*, 2003). For the markets to be integrated they need to share the same traded good and the same long run information. The information does not have to be processed simultaneously but the markets need to be connected by trade and long run information either directly or indirectly (González-Rivera & Helfand, 2001).

Markets are said to be integrated if they are connected by the process of arbitrage (Van Campenhout, 2007). The term integration means that the LOP holds (Padilla-Bernal *et al.*, 2003; Trenkler & Wolf, 2003; Pede & McKenzie, 2005). Spatial market integration can also be defined as the co-movement of prices or the smooth transmission of price signals and information across spatially separated markets (Goletti *et al.*, 1995; Barrett, 1996; Boisseleau & Hewicker, 2002; Vollrath, 2003; Meyer, 2004; Balke & Fomby, 1997; Elston *et al.*, 1999; Mushtaq *et al.*, 2008; Oladapo & Momoh, 2008; Basu, 2006; Serra, Gil & Goodwin, 2006; Fackler & Tastan, 2008).

Therefore, if two markets are integrated a shock in any of the markets in either demand or supply, and ultimately price, should be transmitted to the other market (Boisseleau & Hewicker, 2002; McNew & Fackler, 1997 ; Mushtaq *et al.*, 2008; Negassa *et al.*, 2003; Barrett, 1996). Markets that are integrated normally exhibit a long run relationship between their prices (Vollrath, 2003; Balke & Fomby, 1997; Negassa *et al.*, 2003). Spatial prices can thus deviate from each other in the short run and still be considered as integrated (Vollrath, 2003).

Other terms used to describe market integration includes the interconnectedness of markets or the interdependence of price changes across spatially separated locations in a market (McNew & Fackler, 1997; Goletti *et al.*, 1995). Market integration between two markets, as in Figure 2.1, can also be described by means of an illustration. Given two markets Market 1 and Market 2, suppose that Market 1 suffered a bad harvest and Market 2 did not. The bad harvest will cause the price to increase in Market 1. Given integration there will be a flow of goods from Market 2 to Market 1 to adjust for the bad harvest. The additional goods in Market 1 will cause the prices in Market 1 to go down while the reduced amount of goods in Market 2 will cause the price to rise in Market 2. If the markets are not integrated and there is a lack of communication flows between the two markets, then the price in Market 2 will not change (Mushtaq *et al.*, 2008; Goletti *et al.*, 1995; Goletti & Babu, 1994).

In the extreme case if the response is identical the markets will be perfectly integrated, while if there is no response the markets will be completely segmented (Vollrath, 2003; Padilla-Bernal *et al.,* 2003; Goletti & Babu, 1994). Perfect market integration implies that a single price is representative of an entire group of prices. A single stochastic trend would thus exist among the prices (Ghoshray & Lloyd, 2003). Perfectly segmented market prices will be independent (Barrett, 1996).

In the process of defining market integration it is also important to take transactions costs into account. Efficient commodity arbitrage will lead to equilibrium between two markets where prices will differ only by transaction costs (Baulch, 1997; Ismet, Barkley & Llewelyn, 1998; Zanias, 1999; Padilla-Bernal *et al.,* 2003). Rational traders will stop trading if the price difference between two markets is lower than the transaction costs (Van Campenhout, 2007). Trade flows will continue under competitive equilibrium until potential profits are exhausted (Padilla-Bernal *et al.,* 2003). When the markets move independently where price difference is less than transaction costs, one cannot conclude that the markets are not integrated (Van Campenhout, 2007). In the same sense one cannot conclude that markets are competitive when they are integrated (Ismet *et al.,* 1998; Baulch, 1997).

Some authors make a distinction between market integration and market efficiency while others take them to be an identical concept. Negassa *et al.* (2003) states that it is all the more realised that these concepts are related but not equivalent and that it is necessary to distinguish between them. Market integration is often used by economist as a proxy or as an inferential tool for efficiency (Meyer, 2004; Basu, 2006). McNew and Fackler (1997) as well as Serra *et al.* (2006) make a distinction and relate efficiency to a situation where no arbitrage opportunities have been left unexploited. Market efficiency often refers to an equilibrium relationship between prices at different levels of the marketing chain (Serra & Goodwin, 2002a). Barrett (1996) state that market integration entails the free flow of goods and information, and thus also price, over form, space and time and that this is closely related to the concept of efficiency.

Shrestha and Frechette (2003) and Thompson *et al.* (2002) calls market integration a flow-based indicator of tradability and refer to pricing efficiency as a price-based notion of tradability. Efficiency is where equilibrium is reached due to the process of arbitrage and where the marginal benefits from trade are zero (Shrestha & Frechette, 2003; Negassa *et al.*, 2003). Market integration is usually used as a measure of the degree of price transmission between spatially separated markets (Serra *et al.,* 2006). Spatial market integration is not a necessary or sufficient condition for efficiency, therefore market integration tests may result in wrongful conclusions about market efficiency (Negassa *et al.*, 2003). Markets may thus be integrated but not necessarily efficient since market integration may indicate the correct flow of information or goods, but will only be efficient once price information is correct and determined by the market mechanism.

3.3 Factors that shaped methodological progression

Since the start of market integration studies there has been a major interest in the findings and the choice of methods used. Over the years the methods used has undergone critical evaluation and has progressed in order to incorporate all relevant and available information. The rest of this section will look into the factors that shaped method selection. There have been major innovations in the methods used in testing for market integration. Innovation was primarily fuelled by increasing interest, data availability and a larger knowledge pool. Within the pool of knowledge emphasis has been placed on factors that affect the choice of method used and the reliability of inferences drawn. The factors primarily responsible for shaping methodological progression are: the non-stationarity of data, acknowledgement of transaction cost, non-linearity of models used, possibility of asymmetry in price transmission and causality and exogeneity relationship between variables. These will be discussed below.

3.3.1 Non-stationarity

Historically most studies have ignored important time series properties of the data (Goodwin & Harper, 2000). The prices of agricultural commodities are often non-stationary and therefore market integration studies based on price data should be based on appropriate methods which allow for non-stationary variables (Meyer, 2004). Where price series show non-stationary probability characteristics, traditional econometric approaches are no longer valid (Asche *et al.,* 2004).

In the 1980s economists acknowledged that most economic time series are non-stationary. For non-stationary data normal statistical inference for linear regressions will no longer be valid, which casts doubt on the reliability of results obtained earlier that did not take this into account (Asche *et al.,* 2004). Early analyses have been criticised for not recognising the usual non-stationary nature of price data (Serra *et al.,* 2006).

It is now recognised that conventional methodologies that ignore non-stationarity may suffer from specification errors and inferential biases (Serra & Goodwin, 2002a). Most recent studies take into account that price data used in analysis are often non-stationary and could lead to spurious regression and thus inferential problems (Goodwin & Piggott, 2001; Ghoshray & Lloyd, 2003; Serra *et al.,* 2006). An extensive literature is now applied that take non-stationarity into account and use the appropriate methods in determining market integration (see: Goodwin & Piggott, 2001 Ghoshray & Lloyd, 2003; Serra *et al.,* 2006; Franken & Parcell, 2003; Mushtaq *et al.,* 2008; Norman-López & Bjørndal, 2009; Xia *et al.,* 2007, amongst others).

Recognising the fact that data may be non-stationary necessitates a test for the presence of non-stationarity in the data before further analysis can be performed. The test can also be described as testing for the presence of unit roots within the time series data being used. The method most widely used to test for the presence of unit roots is known as the Augmented Dickey-Fuller (ADF) test. The test could be performed with and without the inclusion of deterministic (a constant term and time trend) variables. The reason behind the inclusion of a trend variable is that most time series data are trended over time, and it is thus important to test for unit roots having a stochastic trend against the alternative of trend stationarity (Mushtaq *et al.,* 2008). If the price data in levels is found to be non-stationary, this series does not have a constant mean, variance or co-variance and a regression including this data, will result in a spurious regression (Norman-López & Bjørndal, 2009). A stationary time series will be denoted as I(0). The ADF test is discussed in more detail in the methodology chapter.

3.3.2 Transaction cost

A wide array of literature has evaluated the relationship between prices in spatially separated markets. Most of this literature has ignored the important role of transaction costs in spatial price relationships (Piggott & Goodwin, 2002). Most conventional tests rely on price data alone and do not recognise the pivotal role played by transaction costs (Baulch, 1997; Pede & McKenzie, 2005; Shrestha & Frechette, 2003; Meyer, 2004; Goodwin & Piggott, 2001). The omission of transaction costs could cause a well functioning market to be misdiagnosed as having incomplete and/or lagged price adjustment (Baulch, 1997).

Transaction costs may inhibit price adjustments and affect tests of market integration (Goodwin & Piggott, 2001). McNew and Fackler (1997) show that stochastic transaction rates can cause market integration not to be perfect and that this problem becomes worse as transaction rates become more volatile and increase in proportion to the value of the delivered good. Transaction costs may also inhibit price adjustments that will affect test results and the inferences drawn about market integration could be misleading (Pede & McKenzie, 2005; Goodwin & Piggott, 2001).

Lately however, researchers focus on the implicit or explicit modelling of the transaction costs that influence spatial trade (Piggott & Goodwin, 2002). The recognition of the important role of transaction costs has led to the application of new empirical approaches which explicitly recognise the influences of transaction costs on spatial market linkages (Goodwin & Piggott, 2001). Recent literature take into account the influence of transaction costs, seasonality and threshold effect on tests for integration (Pede & McKenzie, 2005; Thompson *et al.,* 2002). These days the importance of transaction costs in spatial analysis is well recognised, but the main reason for not incorporating it into analysis is the lack of available data on transaction costs (Shrestha & Frechette, 2003; Zanias, 1999; Piggott & Goodwin, 2002). When such data are available, the data are usually not of the same periodicity as the available food price data (Baulch, 1997).

Little empirical estimation of transaction costs can be found in the current literature, even more so in the case of developing countries. The problem with the introduction of transaction costs into analysis is that it is difficult to measure in the real world (Maltsoglou & Tanyeri-Abur, 2005). Acknowledging the existence of transaction costs alters the way in which market integration is viewed (Van Campenhout, 2007). The existence of time varying transaction costs may seriously affect market integration tests. Preferably transaction costs should be subtracted from the price data before market integration tests are performed. Proxy variables for transaction costs or links between price differentials and transaction costs have been used in market integration analysis as a measure of transaction costs (Zanias, 1999).

Baulch (1997) advises that it is not recommended to estimate transfer costs based on inter-market price differentials when trade flows between two markets are infrequent but occur regularly between each of the two and a third market. When this is the case, price differentials between the first two markets will not reflect the costs of moving produce between them. Inter-market price spreads may also reflect factors other than just transaction costs. The presence of transaction costs will lead to a neutral band where prices are not linked to each other. Price differences will then need to exceed the neutral band for arbitrage to take place and equilibrate prices (Goodwin & Piggott, 2001).

The cost of all factors associated with spatial trade and arbitrage are covered by transaction costs. Transaction costs could include transportation charges, risk premia, information-gathering costs, negotiation costs, spoilage, theft, storage and the costs of staying in the market, amongst others (Serra *et al.,* 2006; Padilla-Bernal *et al.*, 2003). Transaction costs can be defined as the cost of running the economic system and can be classified as information, negotiation and monitoring and enforcement costs. Information costs are the cost obtained by gathering information prior to the transaction. Negotiation costs are all the costs associated with setting up the transaction and monitoring cost are associated with monitoring and enforcing the agreed upon transaction. When a detailed understanding of the transaction costs is available, it can shed light on policy actions aimed at reducing these costs (Maltsoglou & Tanyeri-Abur, 2005).

Maltsoglou and Tanyeri-Abur (2005), found that lower transaction costs could be related to:

- Better knowledge of price in the market.
- No quality conflict with the merchant.
- Higher confidence in the merchant.
- Previously agreed contracts.
- Good road access.
- Timely price information.
- Membership in an institution.
- Little damage during transport.
- Selling an improved variety.
- Coordination of transportation with other producers.

Given the acknowledged importance of transaction costs and its potential affect it could have on market integration analysis, it is of great importance to take transaction costs into account when measuring market integration. The method chosen should be able to incorporate transaction costs.

3.3.3 Non-linearity

Linear time series methods have been dominating macroeconomics since its introduction into economic studies. The popularity stemmed partially from being the only statistical method available and partially from the fact that economic theories are usually tested in a linear form (Potter, 1995). Standard time series models assume linearity in their analysis (Enders & Granger, 1998; Enders & Siklos, 2001). Even though empirical modelling of time series is dominated by linear autoregressions, there is no compelling a priori reason to assume that the true dynamic structure is linear. The primary argument behind linearity is simplicity in estimation, interpretation and forecasting; but recent research is showing that the analysis of non-linear models is reasonably straightforward. There is also no compelling theoretical reason to focus exclusively on linear models (Hansen, 1999).

Linear methods can hide much interesting economic structure in a time series model (Potter, 1995). The introduction of non-linearity in economic analysis prompted the search for more suitable models (Van Campenhout, 2007). Non-linearity becomes especially important where there are asymmetric costs of adjustment, irreversibilities, transactions costs, liquidity constraints, and other forms of rigidities (Hansen, 1999). Non-linearity is often attributed to a lack of perfect arbitrage resulting from transactions costs and uncertainty. Non-linearities appear whenever price dynamics differ across regimes. That will be when prices adjust differently depending on whether spatial price differentials are above, equal or below transaction costs (Serra *et al.,* 2006). The question arises whether the non-linear specification is superior to a linear model. In other words, whether you can reject the hypothesis of linearity in favour of non-linearity. The testing problem is algebraically quite similar to the issue of testing for structural change of unknown timing (Hansen, 1999).

The examination of non-linear adjustment mechanisms have been an important development in recent time series literature. A natural extension to examining the univariate findings is to examine the possibility of non-linear adjustments in a multivariate context (Enders & Siklos, 2001). Several recent papers have presented verification revealing threshold-type non-linearity in real exchange rate data. Analysis of threshold behaviour in the bivariate model allows one to uncover potential non-linearities in the adjustment of individual prices and provides more information regarding the dynamics of the data (Lo & Zivot, 2001). Threshold effects occur when large shocks cause different responses than smaller shocks. The resulting dynamic responses may be non-linear due to the fact that they involve various combinations of adjustments from alternative regimes defined by the thresholds. A shock may have to be of a particular size before a significant response is provoked (Goodwin & Harper, 2000).

Several econometric procedures have been proposed to capture non-linear price relationships. These procedures include an extended error-correction model (ECM), TAR models and TVECM models (Serra *et al.,* 2006). Tsay (1998) proposed a test statistic for detecting threshold non-linearity in a vector time series and a procedure for building multivariate threshold models. Threshold co-integration generalises standard linear co-integration to allow adjustment toward long run equilibrium to be non-linear and/or discontinuous. Two testing issues arise; 1) testing for the presence of co-integration and, 2) testing for linearity (Seo, 2006). Balke and Fomby (1997) proposed a two step approach; 1) examine the linear no co-integration null hypothesis against the linear co-integration alternative, and 2) examine the linear co-integration null hypothesis against the threshold co-integration alternative. The four possible hypotheses in threshold co-integration models are: 1) linear no co-integration, 2) threshold no co-integration, 3) linear co-integration, and 4) threshold co-integration (Seo, 2006). These hypotheses' are presented in Table 3-1.

Table 3-1: Four hypotheses in threshold co-integration models

Hypothesis	**Linearity versus Threshold Behaviour**	
No co-integration versus co-integration	Linear, no co-integration	Thresholds, no co-integration
	Linear co-integration	Threshold co-integration

Source: Balke & Fomby, 1997

In order to correctly measure market integration it is therefore important to correctly specify the model as a non-linear model if evidence suggest the possible existence of non-linearities in the price data, otherwise incorrect inferences may be drawn about integration within the market.

3.3.4 Asymmetry in price transmission

Price transmission can be defined as the proportion of an input price change that is passed on to the output price. Price transmission is especially important in the analysis of welfare effects of changes in agricultural policies, like elimination of farm price support programs or the introduction of support mechanisms. It is also of importance in the analysis of economic effects of new technologies. Of particular importance is the issue of asymmetric manufacturer or processor price responses to exogenous changes in input costs (Revoredo, Nadolnyak & Fletcher, 2004).

Non-linear price responses are symmetric when a shock to a certain price elicits the same response to other prices regardless of the direction of the shock, or asymmetric if the response is not the same (Serra *et al.,* 2006). It is frequently observed that increases in input prices are almost immediately reflected in the output prices. Input price decreases on the other hand, are usually followed by delayed and partial drops in the output prices (Revoredo *et al.*, 2004; Serra & Goodwin, 2002a; Goodwin & Harper, 2000; Enders & Granger, 1998; Goletti & Babu, 1994). Traders would thus be able to exploit price movements to the detriment of farmers and consumers (Goletti & Babu, 1994).

Standard time series models of co-integrated variables use to assume symmetry (Enders & Siklos, 2001; Enders & Granger, 1998). Later on authors started to hypothesise that the long run relationship between prices may be asymmetric (Serra & Goodwin, 2002a; Goodwin & Harper, 2000). These days it is well known that many important economic variables display asymmetry (Enders & Granger, 1998). It is of importance because co-integration tests and their extensions are miss-specified, or may lack power if adjustments are asymmetric (Enders & Siklos, 2001; Goodwin & Harper, 2000).

Asymmetry has attracted a great deal of attention and raised a few issues in economics. One reason is that even though asymmetry has been frequently observed it has not been fully incorporated into economic theory. Another reason is that economic policies fail to account for consumer effects of asymmetry (Revoredo *et al.*, 2004). Analysis of threshold behaviour allows one to uncover potential asymmetries in the adjustment of individual prices and provides more information regarding the dynamics of the data (Lo & Zivot, 2001). Studies investigating the presence of asymmetry have focused mainly on the agricultural and food processing sectors, the gasoline and fuel markets and on financial markets. A comprehensive study on several hundred producer and consumer goods found evidence of asymmetry in more than two thirds of the markets studied, implying that asymmetry is more a rule than an exception (Revoredo *et al.*, 2004).

Literature does not clarify what the exact causes of these asymmetries are. Studies present a variety of possible arguments but no evidence to support it (Agüero, 2004). The lack of differentiating among the possible causes of asymmetry is perhaps the most significant problem that has prevented the direct incorporation of asymmetry into economic theory and policies (Revoredo *et al.*, 2004). Even so, several theoretical and institutional reasons that may be the cause of asymmetries have been presented. One possibility is that owners or traders of perishable goods may not increase prices to avoid the risk of being left with spoiled product (Goodwin & Harper, 2000; Agüero, 2004). Imperfect competition or market power, for example monopolies, can also cause asymmetries (Goodwin & Harper, 2000; Alemu & Woraka, 2011; Revoredo *et al.*, 2004). The difference in adjustment that depends on whether prices rise or fall can be another cause. Different price elasticities at different levels of the marketing chain can also be a reason behind asymmetry, as well as government intervention in the form of producer price support (Goodwin & Harper, 2000).

Apart from these arguments asymmetry has also been ascribed to the cost of adjustment rigidities, like menu costs or sticky wages, where input price shifts is large enough to cause production volume or capacity adjustment (Revoredo *et al.*, 2004).The major problem is that when evidence of asymmetry is found without the possibility of identifying the cause(s) of such behaviour, then there is no room for policies to correct these asymmetries (Agüero, 2004).

Excluding the reasons behind asymmetry, there have been several econometric methods used to test it. One method that has been used is a variable splitting technique for detecting irreversible supply reactions. Another method showed that an asymmetric ECM can be more applicable if the price data are co-integrated. Later the threshold autoregressive test for unit roots was used and argued to be superior to the ECM (Revoredo *et al.*, 2004). Asymmetric threshold error-correction models have also been used in literature (Goodwin & Harper, 2000). The traditional studies used were not applicable because they did not take into account the co-integration or long run relations between prices (Goodwin & Harper, 2000; Agüero, 2004). Threshold co-integration methods are believed to be superior to the traditional methods. Asymmetry is so well recognised that asymmetric studies attention has shifted in recent years from trying to determine the existence of asymmetry, to the determination of the specific type of asymmetry (Enders & Granger, 1998). The framework of market integration can be extended by incorporating asymmetric price responses (Goletti & Babu, 1994).

3.3.5 Causality and exogeneity

Given two co-integrated markets, Market one and Market two, there must be some sort of causality running from one market to the other. When the past movements of prices, or lagged values of prices in one market can be used to forecast the price movements in the other market, it is referred to as Granger Causality. If the value of the lagged prices in

Market one can be used to forecast the values in Market two, then Market one's prices are said to Granger cause Market two's prices, i.e. a unidirectional relationship. If Market one cause Market two, and Market two causes Market one, then there is feedback relation between the two markets, i.e. they are bidirectional. If there is no relation between the markets they are independent. Only unidirectional relationships can be used in forecasting. If Market one causes Market two and/or other market prices without being caused by them, then Market one can be interpreted as a central market (Goletti & Babu, 1994). Market one can also be referred to as the market leader (Asche *et al.,* 2004). Stated in another way, a central market is one that causes all other markets unidirectionally but is not caused by any of them (Goletti & Babu, 1994).

Most studies assume a market setup where one market is indisputably a net-exporter and the other a net-importer, implying that trade will always flow in the same direction. In agricultural commodities it is found that it is not unusual for trade flows to reverse at certain times during the year. This can be ascribed to the fact that agricultural commodities are both a major staple and cash crop with a high trade volume. Variation in geographical regions may also cause harvest seasons to differ between locations. The price in the local market may also fall below the price in the central market, which could cause stock flows to reverse (Van Campenhout, 2007). Variables that do not respond to disequilibrium in the system of which they are a part of, may be considered weakly exogenous to that system (Ghoshray & Lloyd, 2003).

When estimating price relationships in, for example, a co-integration analysis in single equation specifications, one implicitly assumes that the right hand side variables are exogenous. Researchers therefore need to make exogeneity assumptions or run the regressions in both directions. In multivariate models it is required to make an exogeneity assumption. Analysis is thus difficult and inference can be incorrect, especially since single equation specifications cannot in general capture all the relevant information (Asche *et al.,* 2003). Modelling the prices of Market one as exogenous to Market two implies that the prices of Market one determines the price of Market two, and that changes in Market one will map directly to Market two, whilst changes in Market two are not thought to be feeding back to the prices of Market one. The problem that arises is that even though some market structures or available information may support the assumption, there is no a priori reason for this assumption to always hold. Economic theory does not provide any guidance as to what market should be chosen as exogenous. The assumption could just as well be reversed or the relationship could be bidirectional. If the assumed unidirectional relationship could be confirmed it could facilitate forecasting models (Asche *et al.,* 2003).

3.4 Models of market integration

This section will discuss most of the methods currently available and indicate where these methods have been used in studying market integration. The analysis of markets depends on the available data. Prices, trade flows, and transactions costs are the only variables that are normally observable to some extent. The availability of these data establishes a hierarchy of methods (Barrett, 1996). Past research has governed the development of methods and has identified various measures of market integration. These include amongst others correlation coefficients, short-term tests of integration, long-term tests of integration, long-term multipliers and times to adjust, co-integration coefficients, causality and centrality tests (Goletti *et al.,* 1995). Market integration has also been measured by the degree to which supply and demand shocks are transmitted from one region to another (Vollrath, 2003).

The most widely used measure of market integration use to be correlation analysis (Boisseleau & Hewicker, 2002). Price series correlation is regarded as a convenient indicator of market integration (Basu, 2006). Two variables are correlated if a change in one variable brings about a change in the other. They will be perfectly positively correlated if they have a correlation coefficient of one and perfectly negatively correlated if they have a correlation coefficient of negative one. They will not be correlated if the correlation is close to zero (Boisseleau & Hewicker, 2002). Despite its vast application and its simplicity in literature this method was found to have involved methodological flaws. These include: failure to recognise common exogenous trend, seasonality or autocorrelated and heteroskedastic residuals in the regression with non-stationary price data (Basu, 2006). Another problem associated with correlation is that it cannot account for many real world complexities (Vollrath, 2003).

In the mid-1980s several attempts were made to improve earlier methods (Basu, 2006). Since the introduction of the idea of co-integration several methods have been proposed to estimate co-integrating vectors. Other methods that have been developed include: Ordinary Least Squares (OLS), Non-linear Least Squares, Principle Components (PC), Canonical Correlations, Maximum Likelihood (ML) in a fully specified ECM, instrumental variables and spectral regression. The simplest procedure to estimate is a fully specified Error Correction Model by Maximum Likelihood (Gonzalo, 1994). Alternative methods include Delgado's variance decomposition approach and Ravallion's model (Negassa *et al.,* 2003). Both these methods have been used extensively but not without critique. Delgado's approach is based on a test of simultaneous price relationships and does not allow for dynamic relationships between prices in different markets. The Ravallion model's assumption of radial market structure does not always hold. The assumption of constant inter-market transfer costs will lead to bias against market integration if the transfer costs are time varying, and the method does not distinguish market integration due to non-competitive behaviour such as collusion (Negassa *et al.,* 2003).

Ravallion's (1986) method was one of the most significant contributions to measuring market integration. He proposed a dynamic model of spatial price differentials. The model mitigates the major limitations of the bivariate correlation method (Basu, 2006). The dynamic model allows differentiation between short run and long run market integration and market segmentation. The model incorporates the fact that arbitrage takes time, and can be reformulated as an ECM if evidence for long run market integration is found. The Ravallion model and the acknowledgement of non-stationary price series was the beginning of a vast amount of studies that used co-integration techniques to test for long run market integration. When evidence of long run market integration is found, error-correction specifications are used to investigate the short run dynamics that are consistent with this long run relationship (Van Campenhout, 2007).

The methods used in testing for market integration have come a long way over the years. Progress is especially evident in accounting for non-stationarity, common trend and even endogeneity of prices (Baulch, 1997). Market integration is complete when the LOP holds, but this requires quite severe market restrictions. Therefore, measures that attempt to measure market integration can be easily violated (Asche *et al.,* 2004). Three levels of methods that can be used in the analysis of market integration have been defined. Level one's methods are where the methods rely on price data only. Level two's methods rely on both price and transaction costs data, and Level three's methods rely on trade flow and price data (Barrett, 1996; Van Campenhout, 2007). In the end the method chosen should try to incorporate as many information as possible without violating too many restrictions.

Gonzalo (1994) asks that the method used have three characteristics: 1) it must incorporate a prior knowledge about the presence of unit roots, 2) it must be a full system estimation, and 3) it must be flexible enough to capture the dynamics of the system. In this study, an attempt will be made to account for all the factors that shaped the methodological development process as discussed in the previous section of this chapter. The next section will discuss some of the methods that are applied most in recent literature to test market integration. Even though there are a vast number of methods available our focus will be on co-integration methods, the PBM, TAR models and TVECM models.

3.4.1 Co-integration

Co-integration techniques have been regularly applied to the analysis of spatial price relationships to test the LOP and to examine the degree to which different regions are mutually integrated (McNew & Fackler, 1997). Co-integration tests are used in investigating market relationships (Asche *et al.,* 2004). The fear of spurious regression initiated the concept of co-integration. Spurious regression will be realised when time series exhibit long-term trends or important seasonal components (Boisseleau & Hewicker, 2002). The concept of co-integration was first introduced in economic literature by Granger in 1981.

Engle and Granger (1987) define co-integration as follows: "*If each element of a vector of time series x, first achieves stationarity after differencing, but a linear combination $\alpha'x$, is already stationary, the time series x, are said to be co-integrated with co-integrating vector α. There may be several such co-integrating vectors so that α becomes a matrix. Interpreting $\alpha'x = 0$ as a long run equilibrium, co-integration implies that deviations from equilibrium are stationary, with finite variance, even though the series themselves are non-stationary and have infinite variance".*

Engle and Granger (1987) stated that two markets will be considered as integrated if the error term of the regression between the two markets is stationary. Short run instability is thus allowed in the marketing margins which only need to be stable in the long run. Co-integrated prices are then interpreted as indicating market integration (Barrett, 1996). In other words, if the data series have common stochastic trends, then the linear combination of two non-stationary data series can be stationary, and the data series are said to be co-integrated (Asche *et al.,* 2004; Goodwin & Harper, 2000; McNew & Fackler, 1997; Norman-López & Bjørndal, 2009).

A linear combination of two *I(1)* (integrated of order one) series that generate a stationary, I(0) series implies the existence of a co-integration relationship between the series (Norman-López & Bjørndal, 2009). The concept underlies the idea that even though economic time series exhibit non-stationary behaviour, a linear combination between trending variables can remove the trend component and cause the time series to be co-integrated. There is thus an equilibrium price relationship which prices gravitate towards. Co-integration spurred interest due to the fact that it allows the search for an equilibrium relationship among time series even when individual series are non-stationary (Boisseleau & Hewicker, 2002).

Engle and Granger (1987) developed a two-step procedure to test for co-integration and this test is one of the most used methods in testing for co-integration. The two steps are: 1) estimate a co-integrating regression by applying OLS on the levels of the variables included, and 2) test for stationarity of the residuals using ADF tests. If the series are stationary, OLS regression can be used, and if the series are non-stationary co-integration should be used (Boisseleau & Hewicker, 2002). This approach have two problems associated with it, one, it is subject to the same normalisation problem in setting the dependent variable as with stationary data, and two, normal statistical inference and tests for the LOP are not valid. Since this approach does not have well defined limiting distributions, direct testing for the LOP is not possible. Another approach was then developed that allows the direct testing of the LOP hypothesis, the Johansen (1988) method (Asche *et al.,* 2004).

The Johansen's method models the price relationships in a VAR format and performs better than the two step approach of Engle and Granger. The use of a system of equations prevents the simultaneous equation bias that may be present if both price series in a regression are endogenous. Normalisation of prices is no longer necessary since estimation and testing is carried out within a system format. Likelihood-ratio tests can be used to look into hypotheses on the parameters, and thus test for the LOP. The VAR model is also dynamic allowing one to test hypotheses with respect to the adjustment process and to test price leadership. Co-integration can serve as evidence of causality and the information on the direction of causality is contained in the adjustment parameters. Bivariate models are preferred in initial analysis since they contain all the relevant structural information and mostly also the information about exogeneity. Multivariate models can then be estimated for interest sake (Asche *et al.,* 2004).

Despite the popularity of co-integration analysis it does not meet all the requirements of a fully incorporative model. Barrett (1996) states that co-integration is neither necessary nor sufficient for market integration, and that it is insufficient for four reasons: 1) a negative estimate of β (co-integrating vector of coefficients) implies prices move in an opposite direction rather than together, 2) the size of the co-integration coefficient is revealing about the relative rates of change, and many reported coefficients have magnitudes doubtfully far from unity, 3) market segmentation can result either from inter-market margins greater than transfer costs or from margins less than transfer costs, both implying an absence of efficient exchange between markets, yet co-integration tests identify only the previous selection, and 4) trade flows are often temporally discontinuous because of perturbations and seasonal shifts in underlying demand and supply patterns or in transactions costs. Co-integration imposes a linear approximation where it should be non-linear if there are discontinuities in the data (Barrett, 1996).

McNew and Fackler (1997) showed that prices in a well-integrated and efficient market do not need to be co-integrated. In addition, the number of co-integrating relationships among prices is not a good indicator of the degree to which a market is integrated. They go on to say that "*co-integration does not imply integration*" and argue that arbitrage alone is not a powerful enough error-correcting mechanism to produce co-integrated spatial prices. They also give three situations in which the relationship between co-integration and arbitrage conditions are not consistent. The first is when transaction costs between regions are non-stationary, the second if autarky prices are not co-integrated, creating periods in which regions are not linked by trade, and third where other forces than arbitrage cause autarky prices to be co-integrated. A major limitation of co-integration techniques is the ignorance of transaction cost, which may inhibit price transmission across spatially separated markets (Goodwin & Piggott, 2001; McNew & Fackler, 1997).

Simulation tests performed by McNew and Fackler (1997) indicate that efficiency and market integration does not necessarily lead to linearly related prices. Arbitrage is found to be an insufficient force to ensure a simple linear relationship among spatial prices. One reason is that if the forces that affect demand and supply in the different regions are not co-integrated, arbitrage will not guarantee co-integration among the prices. Another reason is that when the demand and supply forces are co-integrated across regions it may lead to the conclusion of integrated prices, regardless of whether or not there are interregional commodities flows and associated binding arbitrage conditions. It all leads to the conclusion that the degree on co-integration among prices is not a useful measure of the strength of interregional market integration (McNew & Fackler, 1997).

3.4.2 Parity bound model (PBM)

The first model that explicitly accounted for transaction costs was essentially a switching regressions model that returned estimates for the transaction costs and the probabilities of being in a state of too little, too much, or efficient arbitrage between two markets. This model became known as the Parity Bound Model (Van Campenhout, 2007; Baulch, 1997). The PBM explicitly accounts for the possibility of discontinuous trade between markets, the coincident determination of prices, and for the statistical problems brought about by common trends such as non-stationary and co-integrated time series. The model allows transfer costs to vary between periods and makes no implicit assumptions about the nature of the marketing margins. The model can also be estimated by using time series data that are incomplete (Baulch, 1997).

The parity bounds within which the prices of a homogeneous good in two geographically distinct markets can vary independently are determined by transfer costs. When the transfer costs are equal to the price difference between the markets, and there are no impediments to trade, then trade will cause prices in the two markets to move together and the spatial arbitrage conditions are binding. Transfer costs greater than the inter-market spread will inhibit trade and the spatial arbitrage conditions will not be binding. Spreads that are greater than transfer cost will violate the spatial arbitrage condition irrespective of trade occurrence. When arbitrage conditions are violated it is indicative of the existence of impediments to trade and can be seen as first evidence of a lack of market integration (Baulch, 1997).

The PBM examines the extent of market integration by distinguishing among three possible trade regimes. Regime one is at the parity bounds where spatial price differences are equal to transfer costs. Regime two is inside the parity bounds and is where the price differences are less than transfer costs. Regime three is outside the parity bounds and is where price differences exceed transfer costs. Regime one is consistent with market integration when production and consumption is specialised. When production and consumption is not specialised then Regime one and Regime two are consistent with market integration. Regime three is inconsistent with integration and a high number of observations falling in Regime three are indicative of low levels of market integration (Baulch, 1997). The PBM compares the observed regional price differentials against exogenously predicted transaction costs. Spatial price differentials that are equal, above or below transaction costs are used to estimate the probability of being in each regime (Serra *et al.,* 2006).

The PBM allows transaction cost, trade reversals, and autarky. The PBM can indicate whether markets are efficient and also the extent to which markets are efficient. When data on prices, transaction costs and trade flow are available over the same period and at the same time, the PBM allows a clear distinction between spatial market efficiency and spatial market integration (Negassa *et al.,* 2003). The PBM copes well with trade discontinuities, and complex and time-varying transactions costs. The PBM also offers more informative results by providing a continuous measure of the frequency of profitable trade opportunities rather than just a binary hypothesis test of market integration (Barrett, 1996). The PBM can distinguish between integrated and independent markets rather successfully. The PBM is also shown to be statistically reliable and can detect violations of the spatial arbitrage conditions with a high degree of accuracy (Baulch, 1997).

Given the unobservable nature of some transfer costs and the limited information available on it the PBM allows the establishment of probabilistic limits within which the spatial arbitrage conditions are likely to hold (Moser *et al.,* 2009). The underestimation of transaction costs poses a problem since it can cause bias in the PBM results away from finding market segmentation (Barrett, 1996). The PBM is complemented by the extended PBM that incorporates information of prices and transaction costs as well as on trade flows. The extended version allows the distinction between market integration and market equilibrium. In addition the extended PBM allows for the estimation of additional transaction costs that are not public information (Padilla-Bernal *et al.*, 2003).

Unfortunately the PBM also have problems associated with it. The PBM can firstly be criticised based on its underlying distributional assumptions and secondly on the fact that it is static in nature (Van Campenhout, 2007; Serra *et al,* 2006). Baulch (1997) identified three limitations of the PBM: 1) it is hard for the model to take account of the type of lagged price adjustment since only simultaneous spreads are used in estimation, 2) the models' estimates of regime probabilities are only as good as the estimate of the mean transfer costs and 3) the model may indicate a lack of market integration but do not give an idea as to its causes. Negassa *et al., (*2003) also criticise the PBM on three grounds: 1) there is no link between economic theory and the underlying distributional assumption used in the model, 2) the model handles only a limited number of markets, and 3) the approach considers short run deviations from equilibrium as inefficiencies when it may actually be due to traders rational responses to lags in information and shipment flows. Other shortcomings include the inherently arbitrary half-normality and normality assumption on which the estimators rely and that unobservable transfer costs are assumed constant across space and time. Fixed transfer costs is a very strong assumption considering that markets vary geographically and inter-temporally in terms of factors like size, access to credit, risk and transportation infrastructure (Moser *et al.,* 2009).

3.4.3 Threshold Autoregression Models (TAR)

The Threshold Autoregressive (TAR) model is better than the PBM in the analysis of market integration. This is mainly because it allows the researcher to differentiate between transaction costs and the speed of adjustment of market prices in the different markets (Van Campenhout, 2007). TAR models are quite popular in the non-linear time series literature, primarily due to the fact that they are simple to specify, estimate and interpret (Hansen, 1997). The analysis of threshold behaviour allows the discovering of non-linearities and asymmetries in the adjustment of individual prices and provides more information on the dynamics of the data (Lo & Zivot, 2001). In addition to capturing the essence of non-linearities the model allows the use of many of the tools developed for the traditional models of co-integration (Balke & Fomby, 1997). One key advantage of the TAR model is that it does not require the often incorrect observations on transaction costs (Negassa *et al.,* 2003; Serra *et al.,* 2006).

Threshold co-integration is based on the idea that the presence of transaction costs creates a neutral band. Within the neutral band there are weak or even non-existent links between spatial prices, and spatial arbitrage is unprofitable. Equilibrium is restored when shocks cause price differentials that exceed the neutral band and is driven by the profit seeking activities of spatial trade (Negassa *et al.,* 2003; Serra *et al.,* 2006; Goodwin & Piggott, 2001; Piggott & Goodwin, 2002). Threshold effects occur when larger shocks cause a different response than smaller shocks do (Goodwin & Piggott, 2001; Piggott & Goodwin, 2002). This non-linear pattern of price adjustment is represented through a combination of different regimes (Serra *et al.,* 2006; Goodwin & Piggott, 2001; Piggott & Goodwin, 2002). A regime switch is triggered when a forcing variable crosses a threshold (Piggott & Goodwin, 2002). Once the system exceeds a certain threshold, co-integration becomes active (Balke & Fomby, 1997). In threshold models regimes are defined by the past values of the time series itself (Potter, 1999).

TAR models have also been used to address the shortcoming in other models acknowledging the potential non-stationarity of data (Piggott & Goodwin, 2002). TAR models are perhaps the simplest generalisation of linear auto regressions. They were introduced to time series literature by Howell Tong (Potter, 1999; Goodwin & Piggott, 2001; Hansen, 1997; Serra *et al.,* 2006). The TAR model is only one of the non-linear models available in literature (Tsay, 1989). Various other threshold models have also been successfully applied (Potter, 1999). But the simplicity of TAR models was enhanced by Tsay (1989) who developed a simple test statistic to test for threshold non-linearity. Tsay's test can test for threshold effects and model threshold autoregressive processes (Goodwin & Harper, 2000; Goodwin & Piggott, 2001; Serra *et al.,* 2006). Two generalisations of the TAR model are the Smooth Transition Autoregressive (STAR) model and the Self-Exciting Threshold Autoregressive (SETAR) models. If the discontinuity of the threshold is replaced by a smooth transition function then the TAR model can become a STAR model (Hansen, 1997). SETAR models are TAR models where the transition depends on a lag of the process itself. The SETAR model should not be confused with the STAR model. The SETAR model describes the adjustment of price differences between two markets over time. This adjustment process can differ according to the price difference being below or above the transaction cost (Van Campenhout, 2007).

The TAR was not always widely used in application due to the fact that it was hard to identify the threshold variable and to estimate the associated threshold values, along with no available simple modelling procedure (Tsay, 1989). This is no longer the case with the availability of models that allows simple estimation. Still the TAR model has its shortcomings. The first issue is with regards to the assumption of fixed transaction costs (Piggott & Goodwin, 2002; Van Campenhout, 2007; Negassa *et al.,* 2003). The problem with the assumption of fixed or stationary transaction costs is that it may have important implications for the validity of empirical tests of spatial price parity (Piggott & Goodwin, 2002). A second critique is that the model is still highly parameterised (Negassa *et al.,* 2003). The last concern is about the inference on the threshold since the asymptotic distribution of the threshold parameter is neither normal nor nuisance parameter free, preventing the possibility to obtain standard errors and confidence intervals, thus complicating the test of the null hypothesis of no co-integration against the alternative hypothesis of threshold co-integration (Van Campenhout, 2007; Lo & Zivot, 2001).

3.4.4 Threshold Vector Error Correction Models (TVECM)

The TAR models was extended by Balke and Fomby who noted the connection between autoregressive models of an error correction term and error-correction models representing co-integration relationships. They also show that standard tests for unit root and co-integration work reasonably well in the presence of threshold co-integration. For estimation they propose a simple two step approach where threshold parameters are chosen through a grid search that minimises a sum of squared errors criterion (Serra *et al.,* 2006; Goodwin & Harper, 2000; Goodwin & Piggott, 2001; Serra & Goodwin, 2002a; Serra & Goodwin, 2002b; Hansen & Seo, 2002; Lo & Zivot, 2001). Threshold co-integration is a feasible means to combine non-linearity and co-integration, and the model allows non-linear adjustment to long run equilibrium (Hansen & Seo, 2002; Serra & Goodwin, 2002b).

Variables that are co-integrated within systems can be characterized by an ECM. An ECM describes how variables respond to deviations from equilibrium or the adjustment process through which the long run equilibrium is maintained (Balke & Fomby, 1997). An ECM accounts for both short run and long run adjustments to disequilibrium in the markets and the time it takes to eliminate disequilibrium (Mushtaq *et al.,* 2008) .The ECM specification has gained popularity in market integration literature because of its naturally appealing interpretation (Serra & Goodwin, 2002a). To account for transaction costs in the models of price transmission, Threshold Error Correction Models (TECM) have been developed. On spatially integrated markets where the direction of causality is not known, the use of a Vector Error Correction Model (VECM) is appropriate (Meyer, 2004).

The recently introduced TVECM takes into account the potential for non-linear and threshold-type adjustments in error correction models. The TVECM model is a multivariate version of TAR models (Serra & Goodwin, 2002a). The multi-location nature of markets suggests that a multivariate approach is necessary for estimating market integration (González-Rivera & Helfand, 2001). TVECM models provide information on the short run dynamics of prices and allow the investigation into the adjustment of individual prices (Serra & Goodwin, 2002a). TVECM models occur when the size of the (lagged) error correction term allows one to distinguish between different regimes and the variables in the model exhibit different types of behaviour in each regime (Serra & Goodwin, 2002b). Figure 3-2 represents price adjustment from long-term equilibrium (ECT). The solid line represents a linear ECM, the dashed line represents a one threshold TECM, and the dotted line represents a two threshold TECM (Meyer, 2004).

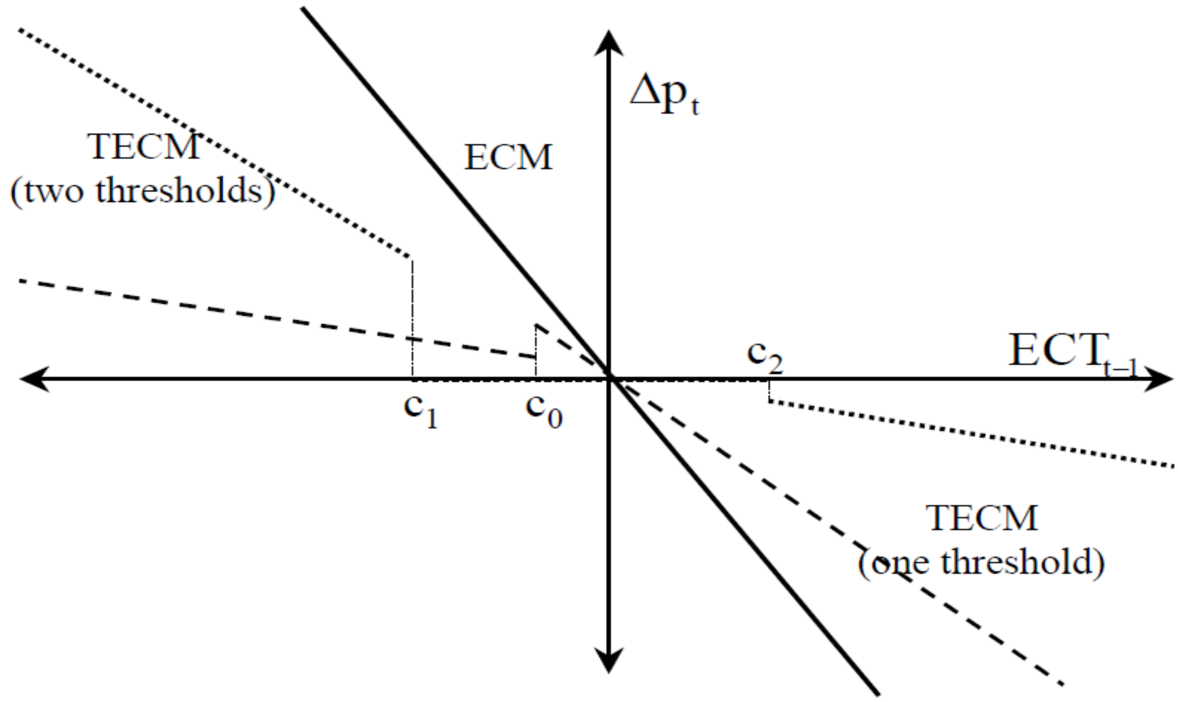

Figure 3-2: Impact of the error correction term on the price adjustment
Source: Meyer, 2004

The number of thresholds (c) in the model determines the number of different regimes (c+1) of price adjustment that the model contains. Past studies have used one threshold (c0), yielding two regimes, or two thresholds (c1 and c2), yielding three regimes to separate the adjustment process (Meyer, 2004). A two-regime TVECM allows the characterisation of a trading environment where trade between spatially separated markets occurs only when price differences exceed a certain level of transaction costs (Pede & McKenzie, 2005). A price adjustment model with three regimes makes more economic sense than a two-regime model. The band between the two thresholds of the three regime model can be interpreted as those deviations from the long-term equilibrium which are so small that they will not lead to a long-term adjustment process in the prices (Meyer, 2004). "*Within that band there is no error correction force at work, because there is no error to correct*" (Obstfeld & Taylor, 1997).

Even though a three regime model is easy to interpret a potential problem lay in the fact that no adequate test has been developed that tests for the significance of two thresholds. This fact has led Meyer (2004) to estimate an essentially restricted version of the two threshold model. They assume one regime of price adjustment defined by absolute deviations from the long-term equilibrium that are below the threshold γ (regime 1) and another defined by deviations that are above the threshold γ in absolute values (regime 2). Because of their regime definition they yield a TVECM that is based on only one threshold (γ) that can be tested for threshold significance. They also allow for the band of non-adjustment (regime 1) inside a regime of price adjustment to greater deviations from the long-term equilibrium (regime 2). The model's restriction unfortunately does not allow for asymmetric responses. Figure 3-3 illustrates the impact of the error correction term on the price adjustment, showing the neutral band.

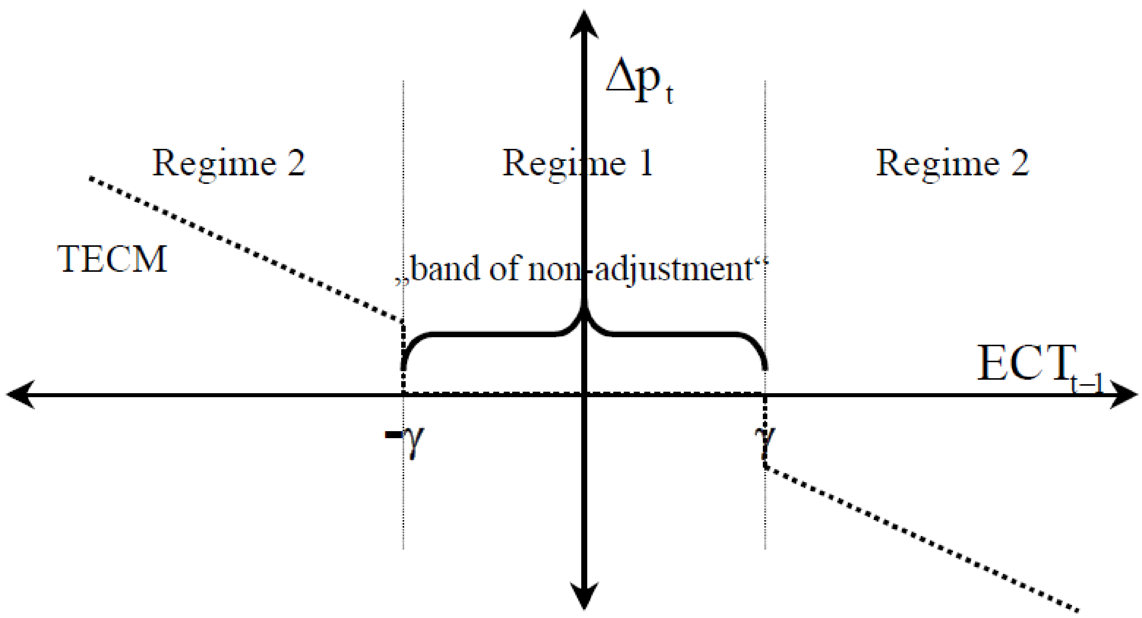

Figure 3-3: Impact of the error correction term on the price adjustment
Source: Meyer, 2004

TVECM is used in this study to study market integration. Not only does it account for all the factors that have shaped the methodological evolution of market integration tests, but it is also applied more often in recent studies. The factors that the model accounts for include time series properties, transaction costs, non-linearity, asymmetry and causality. The model applied in this study is an improvement on some models since it does not assume a two or a three regime model a priori but rather tests what will fit the data best. The model also explicitly tests for the presence of heteroskedasticity instead of just assuming its existence.

For the purpose of this study prices will refer to the price of potatoes on the market. The market is the various fresh produce markets situated in South Africa. Arbitrage refers to the force that move market prices to equilibrium, while the law of price is assumed to hold and imposed into the calculations. Market integration refers to the long run relationship between prices in the markets taking transaction costs into account. The next section provides a summary of where all the various models have been applied in market integration history.

3.5 Application history

The application of most of the methods discussed above is briefly discussed within the following section. The section shows the various ways in which the study of market integration can be applied to different commodities, regions and countries in order to provide helpful information on the transmission of prices and the efficient functioning of markets.

3.5.1 Correlation

Various authors initially used correlation analysis to study market integration until extended studies identified numerous shortcomings to this method of estimation. Even though not solely used in recent studies this method still provides helpful information and is often used as a preliminary test of market integration. Boisseleau and Hewicker (2002) used price correlation analysis followed by co-integration and regression analysis to estimate the level of wholesale electricity market integration in the European electricity market. Moser *et al.* (2009) also used correlation analysis as a preliminary study before using the PBM to study spatial market integration on rice markets in Madagascar.

3.5.2 Co-integration

Correlation analysis was followed by co-integration analysis with the Johansen method probably being the method applied the most in recent studies. The Johansen's method is also used as a preliminary test in recent studies of market integration. Norman-López and Bjørdal (2009) uses the Johansen method to test the LOP before developing their model to a VECM. Mushtaq *et al.* (2008) examined the degree of spatial market integration in the regional apple markets of Pakistan using co-integration analysis and monthly wholesale price data from January 1996 to December 2005. Their results indicate that apple markets are perfectly integrated and Quetta is the dominating market.

Asche *et al.* (2004) use the Johansen method as a direct test for the LOP hypothesis in the market for whitefish in France, they also provide a list of 16 authors that have made use of this method in different applications. Basu (2006) examine market integration on the prices of potatoes of the Hooghly district in West Bengal with the aid of Johansen's test on wholesale and retail markets. Their results showed that price signals and information were transmitted smoothly across the markets and motivate that the results have important policy implications. Johansen and Juselius (1992) developed some tests for structural hypotheses on the co-integrating relations in a Multivariate Error Correction Model.

Ismet *et al.* (1998) used multivariate co-integration tests to evaluate long run spatial price relationships in Indonesian rice markets and the factors affecting the degree of market integration with weekly price data for the 1982±1993 period. González-Rivera and Helfand (2001) analyse the extent, pattern and degree of integration in a multivariate system with co-integrating restrictions. Their methodology is applied to the Brazilian rice market. Xia *et al.* (2007) examined the integration between U.S. and Mexican cantaloupe and watermelon prices using the co-integration and error correction model approach.

Pede and McKenzie (2005) used a multivariate threshold co-integration model to characterise integration between selected maize markets in Benin over the period of market liberalisation. Observed transaction costs for market pairs are compared with the estimated thresholds obtained from the multivariate model. They find mixed evidence with respect to threshold co-integration. Balke and Fomby (1997) showed that the concept of threshold co-integration captures the essence of the non-linear adjustment process envisioned to hold for many economic phenomena and allows the use many of the tools developed for more traditional models of co-integration.

Trenkler and Wolf (2003) studied the issue of economic integration in Poland between 1924 and 1937 by means of threshold co-integration analysis of the Law of One Price. They found that the interwar economy can be regarded as integrated but with obvious restrictions which refer to the existence of relevant transaction costs for arbitrage and differences in the level of prices between cities. Qin *et al.* (2007) examines the dynamic process of regional market integration in twelve Asian economies using a new modelling approach combining DF with ECM. This approach enables them to obtain latent regional dynamic factors. The power of the DF-ECM approach is illustrated in its application to measuring market integration in the developing Asian region using monthly data.

Enders and Siklos (2001) extent the Engle-Granger test by permitting asymmetry in the adjustment. They test whether there is co-integration among interest rates for instruments with different maturities. With the empirical tests they use on U.S. yields they confirm the asymmetric nature of error correction among interest rates of different maturities. They developed an explicit test for co-integration with asymmetric error correction. They generalised the Enders and Granger (1998) TAR and momentum-TAR (M-TAR) tests for unit roots to a multivariate context. Their study point towards eight authors that supported asymmetric adjustment and they also identify three others that showed that tests for unit root and co-integration have low power in the presence of asymmetric adjustment.

3.5.3 Parity Bound model

McNew and Fackler (1997) stated that co-integration is not a good indicator of the degree of market integration. Baulch (1997) showed that the PBM detects efficient arbitrage when other tests do not. He applied the PBM to the Philippine rice markets. Negassa *et al.* (2003) extends and improves the standard PBM of spatial market efficiency by analysing the dynamic effects of marketing policy changes in the analyses of grain market efficiency in developing countries. Padilla-Bernal *et al.* (2003) used the extended PBM to analyse market integration and efficiency for U.S. fresh tomato markets. The PBM was also used by Moser *et al.* (2009) to study the spatial market integration on rice markets in Madagascar and also by other authors not mention here.

3.5.4 Autoregressive models

Autoregressive models came as another development on historic methods and also developed as a method over the years. Piggott and Goodwin (2002) used a TAR model that allowed variable transaction cost in the regional soybean markets of the US. Van Campenhout (2007) used TAR for modelling trends in food market integration in the Tanzanian maize markets. Jooste *et al.* (2006) applied a TVAR model to determine market integration in selected Fresh Produce Markets in South Africa.

Obstfeld and Taylor (1997) devised an econometric method for estimating commodity points and the speed of relative price adjustment outside the bands they define. Price adjustment was treated as a non-linear process. Using TAR methods they identify both thresholds and adjustment speeds by maximum-likelihood methods. Asche *et al.* (2003) investigates the relationships between crude oil and refined product prices in a multivariate framework. They note that this is an example of supply driven market integration and producers will change the output mix in response to price changes.

Martens, Kofman and Vorst (1998) estimate the band around the theoretical futures price within which arbitrage is not profitable for most arbitragers, using a Threshold Autoregression Model. Combining these thresholds with an Error-Correction Model, they show that the impact of the mispricing error is increasing with the magnitude of that error and that the information effect of lagged futures returns, on index returns is significantly larger when the mispricing error is negative. Goodwin and Piggott (2001) utilised Threshold Autoregression and Co-integration models to account for a neutral band representing transactions costs. They evaluate daily price linkages among four corn and four soybean markets in North Carolina. They use non-linear impulse response functions to investigate dynamic patterns of adjustments to shocks.

3.5.5 Error correction models

The last type of method in this discussion is the various Error Correction Models used in applications to date. Autoregressive and TAR models were developed to take into account factors such as asymmetry and non-linearity of data. Potter (1995) show that linear methods can hide interesting economic structure in the most examined of all univariate time series, US GNP. He also names five other authors that found similar additional asymmetries to those examined in his paper. Serra *et al.* (2006) tested for the presence of asymmetries in spatial price relationships in the EU pork markets. They contribute to the literature, in the sense that no previously published study has made an allowance for asymmetries or for non-linearities in regional food price transmission processes within the EU.

Agüero (2004) used three agricultural products with different perishable rates and rejected the null hypothesis of symmetric adjustments in the most perishable product but fail to reject for the less perishable products. He tested asymmetric price adjustment and the behaviour under risk studying Peruvian agricultural markets. Lohano and Mari (2006) analysed spatial market integration using monthly wholesale real price of onion in four regional markets located in each of the four provinces of Pakistan. Their error correction model results show that the regional markets of onion have strong price linkages, and thus are spatially integrated.

Hansen and Seo (2002) examined a two-regime Vector Error Correction Model with a single co-integrating vector and a threshold effect in the error correction term. They propose the use of a SupLM test for the presence of a threshold. They derive the null asymptotic distribution, show how to simulate asymptotic critical values and present a bootstrap approximation. They apply their methods to the term structure model of interest rates and find strong evidence for a threshold effect. They also provide a list of 11 authors that have shown applied interest in threshold co-integration testing. Lo and Zivot (2001) utilised a bivariate Threshold Vector Error Correction Model of co-integration for log price differences and developed a systematic testing, estimation, and specification strategy for investigating non-linear adjustment to the LOP. They also provide a summary of available literature on this subject.

Seo (2006) developed a co-integration test in a TVECM with a pre-specified co-integrating vector, in which the linear no co-integration null hypothesis were examined. Their method is illustrated with used car price indexes. They develop a test for the linear no co-integration null hypothesis in a Threshold Vector Error Correction Model. They adopt a sup-Wald type test and derive its null asymptotic distribution. A residual-based bootstrap is proposed, and the first-order consistency of the bootstrap is established. With a set of Monte Carlo simulations they show that the bootstrap corrects size distortion of asymptotic distribution in finite samples, and that its power against the threshold co-integration alternative is significantly greater than that of conventional co-integration tests.

Serra and Goodwin (2002a) evaluated vertical price transmission patterns in Spanish milk markets. They concentrated on the relationships between producer and retail prices. They use three regime Threshold Vector Error Correction Models that allow asymmetric price adjustments and reflect vertical price dynamics. They introduce an econometric procedure to estimate the threshold parameters that accounts for the relationship between markets at different levels of the marketing chain. To determine the threshold parameters, they used a grid search that minimised the logarithm of the determinant of the variance-covariance matrix, which is analogous to maximising a conventional Likelihood Ratio (LR) Chow test. They compare their results to those derived from the most common methodology based on the minimisation of the trace of the variance-covariance.

Goodwin and Harper (2000) used a threshold co-integration model that permits asymmetric adjustment to positive and negative price shocks. Their results revealed important asymmetries. Their results are consistent with existing literature which has determined that price adjustment patterns are unidirectional and that information tends to flow from farm, to wholesale, to retail markets. They used the threshold co-integration methods recently introduced by Balke and Fomby. In particular, a Threshold Error Correction Model allowing asymmetric adjustments were estimated and used to evaluate the dynamic time paths of price adjustments to shocks at each level in the US pork sector.

Engle and Granger (1987) extended the relationship between co-integration and error correction models and developed estimation procedures, tests and empirical examples by applying a two-step estimator. Thompson *et al.* (2002) used an ECM to measure market integration in the wheat markets of France, Germany and the UK. Meyer (2004) developed a two threshold model where the significance of the threshold could be tested and used a VECM to estimate market integration on the European pig market. Uchezuba (2005) used a TVECM to measure market integration for apples on the South African Fresh Produce markets. And Alemu and Woraka (2011) applied a TVECM and extended recent developments in time series econometrics to test for the presence of heteroskedasticity in error variances and to test whether a two or a three regime model best fits the data.

Methods not explicitly covered above that also played a vital role in market integration history include amongst other the Ravallion model. Ravallion (1986) proposed a model of price differentials to avoid the dangers of previous models price data. Oladapo and Momoh (2008) used the Ravallion model to tests the market integration of the main staple agricultural commodities in Oyo State using monthly prices over a period of 8 years, 1994–2001. With the Ravallion model they seek to determine whether a change in the price of a product in a local market is influenced by the change in the central market. Franken and Parcell (2003) used flexible least squares analysis, impulse response function and price relationships to investigate the Missouri grain oilseed markets. Ghoshray and Lloyed (2003) used a concept of irreducible co-integration vectors to study price linkages in the international wheat market.

The list of applications is endless. The important thing to note is that the methods used in analysing market integration have been applied and developed to a great extends over the last two decades. This study attempts to incorporate the critique against historical methods and attempts to acknowledge all factors that could potentially hamper the findings and inferences drawn.

3.6 Summary

Prices are the principle mechanism by which markets are linked and can be used as an effective signal to indicate market efficiency. The market is where buyers and sellers meet to determine price through the process of trade. Given the difference in transaction costs between markets the price difference between two markets should equalise in the long run. Arbitrage will assure that equilibrium between markets is reached through trade and will cause the LOP to hold. If the markets are connected in the sense that trade is driven by arbitrage and that the LOP holds, then it can be concluded that the markets are integrated. The efficient functioning of markets is important at producer and consumer level and is vital for government programs, interventions and/or policy formulations. Any policy aimed at food security needs to know how information, deficiencies/surpluses and prices will be transmitted across markets to be able to determine the effect throughout the chain.

Before any model on time series data can be estimated it is important to take the time series properties of the data into account. There are some pre-tests that need to be performed to make sure that reliable results are obtained. The most significant of these is to test whether data are stationary or non stationary, and the Augmented Dickey-Fuller (ADF) test is used to determine this. The methods used in market integration studies have a long and significant history. Market integration started off with simple correlation analysis and was followed by different co-integration techniques. Some of the well-known models include Engle and Granger's (1987) two step procedure and Johansen's methodology.

The Parity Bound Model also received a significant amount of attention especially due to the fact that it takes transaction costs into account. The problem with the PBM is that it relies on actual data on transaction costs, which is often difficult to obtain. Factors that shaped the methods used today include, as mentioned above, time series properties and transaction costs, and also the non-linearity of data along with the possible existence of asymmetric responses. Causality and exogeneity are terms of importance and is used to determine the direction of flow of goods and information, and will identify the market leader.

The presence of transaction costs yields threshold values that must be exceeded before adjustments will take place. The number of thresholds in turn yields the number of different regimes in the model. TAR and TVECM have been used in recent years and take transaction costs, non-linearity and asymmetry into account. TVECM models also allow the estimation of dynamic relationships between markets using causality and impulse response functions. For this reason these models are used in this study and are developed to a greater extend in the methodology chapter that follows.

CHAPTER 4
DATA AND METHODOLOGY

4.1 Introduction

This Chapter aims to discuss the data used as well as the methodologies to achieve the main objectives of this study. The methodologies applied in this study are adopted from Alemu & Woraka (2011). The chapter is organised as follow: First I discuss the data used in the study. Then under methodology I discuss the methods used in determining the time series properties of the data. This is followed by a discussion on the Threshold Vector Error Correction Model.

4.2 Data

The data used in this study ranged from January 1999 up to June 2009. The data is weekly data, and for consistency the price of the last week in each month was used as the monthly data point. The Fresh Produce Markets (FPM) that were chosen for the analysis include: Johannesburg (JHB), Pretoria (PTA), Cape Town (CTN), Bloemfontein (BFN), Pietermaritzburg (PMB), Durban (DBN), Port Elizabeth (PE), and Kimberly (KBY) market. The data was provided by Potatoes South Africa (PSA). The markets were selected by PSA based on their relative size, importance and geographical position.

4.3 Methodology

As is the case with any econometric study that uses time series data, market integration studies too need to be preceded by a proper investigation of the statistical properties of the time series variables used in the study. Failure to take cognisance of this could results in spurious regression. A range of tests were done to determine the statistical properties of the variables. After the statistical properties of the variables were determined, a Threshold Vector Error Correction Model (TVECM) was estimated to determine the presence or lack thereof of market integration in selected spatially separated Fresh Produce Markets. The reader is referred to the literature chapter of this thesis for details about the TVECM and its advantage over other competing models.

4.3.1 Stationary versus non Stationary variable

Non-stationary time series data is characterised by time varying mean and variance, which unless converted to stationary processes could result in spurious regression. In this study the Augmented Dickey-Fuller (ADF) procedure is applied to test for stationarity of price variables. The ADF takes the form given by 4.1

$$\mathbf{\Delta P_t = \alpha_0 + \alpha_1 t + \alpha_2 P_{t-1} + \sum_{i=1}^{k} \vartheta_{t-i} \Delta P_{t-i} + \mu_t} \quad (4.1)$$

Where, Δ stands for change of first operator, P_t is potato price at time *t* in a FPM, and $\Delta P_t = P_t - P_{t-1}$, α_i and ∂_{t-i} are parameter estimates, *k* is maximum lag order to be determined by examining the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC) or the Hannan-Quinn Information Criterion (HQC), and μ_t is an $i.i.d. \sim N(0, \sigma^2)$ error term.

Non stationarity is said to be confirmed if the null hypothesis that $\alpha_2 = 0$ is rejected against its alternative of $\alpha_2 < 0$; by computing the value from the test statistic given by $\hat{\alpha}_2 / S.E\ (\hat{\alpha}_2)$ and comparing it with the relevant critical value for the Dickey-Fuller test. On the basis of this the order of integration of the potato price under consideration could be determined. A variable is said to be integrated of order one i.e. *I*(*1*) if it is non stationary and differencing it only once is sufficient to make it stationary. A stationary variable is integrated of order zero i.e. I(0).

4.3.2 Co-integration

In this section, the techniques used to test for a long run relationship between any two potato prices of two spatially separated markets are shown. Two approaches are commonly followed, namely the residual based Engle-Granger two-step and the Johansen procedure.

The Engle and Granger (1987) procedure test for a long run relationship between two potato prices in two steps. This is discussed at some length in the paragraphs that follow.

$$P_t^1 = \alpha_0 + \alpha_1 P_t^2 + z_t \quad (4.2)$$

$$\Delta z_t = \theta_0 + \theta_1 t + \theta_2 z_{t-1} + \sum_{i=1}^{k} \pi\, \Delta z_{t-i} + \varepsilon_t \quad (4.3)$$

Where, P_t^1 is the market price in a given market and P_t^2 is the market price in the central market and θ, π, k are defined similarly as in 4.1. A test for stationarity is conducted using 4.3. To be stationary $|\theta_2|$ must be less than one and negative otherwise the P series will be explosive and integrated of I(d) where d > 1 (Gujarati & Porter, 2009). The addition of the lagged differences given by the term in 4.3 as $\sum_{i=1}^{k} \pi \, \Delta z_{t-i}$ ensures that the ε_t series are not serially correlated (Engel & Granger, 1987).

The Johansen test takes into account the number of co-integrating relationships amongst co-integrating variables. The test is based on the notion that economic variables are much more likely to be endogenously interdependent. Determining the number of co-integrating vectors will give an insight into the number of equations to be estimated. At least the presence of one co-integration relationship is necessary for the analysis of long run relationships of the prices to be plausible, even though more than one co-integrating relationship might exist.

The Johansen test utilises two test statistics formulations, namely the Eigen statistic and the Trace statistic. It is a maximum likelihood ratio test involving a reduced rank regression between two variables, say I(1) and I(0), providing n Eigen statistics $\hat{\lambda}_1 > \hat{\lambda}_2 > \ldots > \hat{\lambda}_n$ and corresponding eigenvectors $\hat{V} = (\hat{v}_1 \ldots \hat{v}_2)$, where the r elements of $\hat{V}$ are the co-integration vectors. The magnitude of λ_i is a measure of the strength of correlation between the co-integrating relations for $i = 1 \ldots r$. The test of the null hypothesis that there are r co-integrating vectors present can be stated as:

$$H_0: \lambda_i = 0 \qquad\qquad i = r + 1 \ldots \ldots n$$

The Maximal-Eigen Statistic is given by:

$$\lambda_{max} = -T \log\left(1 - \hat{\lambda}_{r+1}\right) \qquad\qquad r = 0, 1, 2, \ldots \ldots, n - 1 \tag{4.6}$$

Where T is the sample size and $\left(1 - \hat{\lambda}_{r+1}\right)$ is the Max-Eigen Statistic estimate.

The trace statistic is computed as:

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} \log\left(1 - \hat{\lambda}_i\right) \quad r = 0, 1, 2, \ldots \ldots, n - 1 \tag{4.7}$$

Testing the null hypothesis of r co-integrating vectors against the alternative of $r + 1$.

4.3.3 The Model

Let P_t^m be a two dimensional *I(1)* time series variable $P_t^m = (P_t^1, P_t^2)$ where P_t^1 is the price of potatoes in market one at time t, and P_t^2 is the potato price in the central market at time t. The linear form of the vector autoregressive (VAR) model, is given by:

$$P_t^m = \hat{\lambda}_0 + \hat{\lambda}_1 P_{t-1}^m + \hat{\lambda}_2 P_{t-2}^m + \dots + \hat{\lambda}_k P_{t-k}^m + \varepsilon_t \tag{4.8}$$

Where $t = 1, 2, 3, \dots T, k$ is the lag length. It is assumed unknown and is determined by using the available lag length selection criteria.

Over the years the approaches used to determine market integration has changed notably. Detailed discussion about the historical evolution of methods used to measure market integration is made in the literature review section of this study.

The Threshold Vector Error Correction version of (4.8), i.e. TVECM$_1$, is given by:

$$\Delta P_t^m = \lambda_0 + \widehat{\Pi} P_{t-1}^m + \sum_{i=1}^{k-1} \hat{\rho}_i \, \Delta P_{t-i}^m + v_t^{(j)} \tag{4.9}$$

Where $\widehat{\Pi} = \sum_{i=1}^{k} \lambda_i - I_2 = \nabla\beta = \begin{pmatrix} \nabla_1 \\ \nabla_2 \end{pmatrix} (1, \alpha_1, \alpha_2)$, $\beta = (1, \alpha_1, \alpha_2)$ is a co-integrating vector,

$\nabla = \begin{pmatrix} \nabla_1 \\ \nabla_2 \end{pmatrix}$ is a vector of adjustment coefficients, and $\rho_i = -\sum_{l=i+1}^{k} \lambda_i$. In this study the Law of One Price is assumed to hold. This means that a co-integrating vector of the form (1, -1) will be tested and imposed.

A Threshold Vector Error Correction Model (TVECM$_3$) is given by:

$$\Delta P_t^m = \hat{\varphi}_0^j + \widehat{\Pi}^j P_{t-1}^m + \sum_{i=1}^{k-1} \theta_i^{(j)} \, \Delta \hat{P}_{t-i}^m + \varepsilon_t^j, \quad for \quad \gamma(j-1) \le z_{t-d} \le \gamma(j) \tag{4.10}$$

Where $\widehat{\Pi^j} = \sum_{i=1}^{k} \lambda_i^j - I_2 = \nabla^j\beta = \begin{pmatrix} \nabla_1^j \\ \nabla_2^j \end{pmatrix} (1, \alpha_1, \alpha_2)$ and $\theta_i^j = -\sum_{l=i+1}^{k} \vartheta_l^j$ and j is defined as before, t is defined as before, $j = 1,2,3; -\infty = \gamma(0) < \gamma(1) < \gamma(2) < \gamma(3) = \infty; \varepsilon_t^j \sim IIN(0, \Sigma^j)$, for a three regime $\gamma = (\gamma_1, \gamma_2)$ is the threshold value, Z_{t-d} is the threshold variable and d is the delay parameter. The threshold variable is assumed known but the threshold values $\gamma = (\gamma_1, \gamma_2)$, the delay parameter d and the lag length k are assumed unknown.

From equation (4.10) a two-regime threshold vector error correction model $TVECM_2$ could be derived by allowing j to take values $j = 1{,}2$ and making $\gamma_{(2)} = \infty$.

The parameters $\varphi_0^{(j)}$, ∇^j, and θ_i^j are estimated after a two dimensional grid search is applied to determine γ by selecting those values of γ which minimise the log determinant of the variance covariance matrix of residuals $\hat{\Sigma}_m(\hat{\gamma}, \hat{d})$. The search was restricted to a minimum of 20 observations in each regime.

4.3.4 Issue of non-linearity

Market integration studies that take into account transaction costs are based on the concept of non-linearity. It is a concept that is used to establish if markets respond differently when faced with different types of shocks. Linear models implicitly assume that adjustments to equilibrium are symmetric. This is a case where actors react similarly to both negative and positive shocks.

For example, in situations where bidirectional causality between two markets is confirmed, actors in these different markets could face varying transaction costs depending on their location. This could be attributed to the presence of established routes from one market to the other. Such differences in transaction costs could be one of the causes for nonlinear or asymmetric responses. Recent studies have taken into account the fact that responses could be non-linear (Goodwin & Harper, 2000).

If the assumption of linearity is made in situations where they are in fact non-linear, it could result in errors which could affect market integration decisions. All these have led to the development of techniques that accounts for the possibility of nonlinear adjustments. Non-linearities become especially important in the presence of asymmetric costs of adjustments, irreversibilities, transaction costs, liquidity constraints and other forms of rigidities (Hansen, 1999). An extension to Hansen's (1999) approach was applied to test for linearity, i.e. the null hypothesis of $TVECM_1$ against its alternative hypothesis of $TVECM_m$ for $m = 2, 3$.

The test for non-linearity was made side by side with the identification of the number of regimes that best fits the data. This was made by extending the methodology initially proposed by Hansen's (1999) for Threshold Autoregressive Models. The methodology applied to test the null hypothesis of a linear VECM (equation 4.9) against its alternative hypothesis of a two or three regime TVECM$_m$ (for example equation 4.10) for m = 2, 3 is given by 4.11.

$$LR_{lm} = T^* \left(\ln\left(\left|\hat{\Sigma}\right|\right) - \ln\left(\left|\hat{\Sigma}_m(\hat{\gamma}, \hat{d})\right|\right)\right) \text{ for } m = 2,3, \dots \quad (4.11)$$

Where LR_{lm} represents the test statistic, the subscripts l and m stands for linear and non-linear representations and $\hat{\Sigma}$ and $\hat{\Sigma}_m(\hat{\gamma}, \hat{d})$ respectively represents the variance covariance matrix of residuals obtained from the linear VECM (equation 4.9) and TVECM$_m$ (equation 4.10).

Because the parameters needed to test linearity are identified only in the alternative hypothesis, but not in the null hypothesis, a non-standard procedure will be applied. To do this a Monte Carlo type of simulation experiment is required. The experiment is done in seven steps using algorithm developed by Alemu as indicated in Alemu & Woraka (2011) as follows:

Step 1	Estimate equation 4.11 using actual values of $\hat{\Sigma}$ and $\hat{\Sigma}_m(\hat{\gamma}, \hat{d})$.
Step 2	Generate random samples (with replacement) from residuals obtained from equation 4.9
Step 3	Using parameters from equation 4.9, and the random samples generated in step two simulate the dependent variable in 4.9
Step 4	Fit two and three regime models using the results in step three.
Step 5	Calculate $\hat{\Sigma}$ and $\hat{\Sigma}_m(\hat{\gamma}, \hat{d})$ using simulated values in steps 3 and 4.
Step 6	Estimate equation 4.11
Step 7	Repeat steps two to six 2 000 times.

In order to assess the sensitivity to sample size the experiment are repeated 2 000 times. The decision for or against linearity will be made on the basis of the *p*-values calculated as the number of times the simulated LR_{lm} exceeded the calculated LR_{lm}. The procedure outlined above can also be used at the same time to decide whether a two or a three regime model best fits the data.

After these results were obtained a non-linear impulse response function was calculated based on the function developed by Potter (1995). The estimates give information about the dynamic interrelationships between prices in different markets and also provide additional information on the asymmetric nature of the price relationships. Potter (1995) gives the following function to determine the responses:

$$IRF_{t+j}(\varepsilon, Z_{t-1}, Z_{t-2}, \dots) = E\left[{Z_{t+k}}/{Z_t} = z_t + \varepsilon, Z_{t-1} = z_{t-1,\dots}\right] - E\left[{Z_{t+k}}/{Z_t} = z_t, Z_{t-1} = z_{t-1,\dots}\right] \quad (4.12)$$

Where the responses are defined on the basis of the actual $(z_t, z_{t-1,\dots})$data and a shock (ε). The shock is calculated by multiplying the standard deviation of the time series data per specific market by one half.

CHAPTER 5
RESULTS

5.1 Introduction

This chapter is divided into four sections. Non-stationarity and co-integration tests were performed where the time series properties of the data are determined. To determine non-stationarity the ADF test was applied, while Engle and Granger's two step procedure and Johansen's test was used to determine co-integration. The Johansen's method models the price relationships in a VAR context. The VAR model determines the existence of a long run relationship between variables. Prior to the estimation of the VAR model the lag length has to be determined. Thereafter the TVECM is determined and the number of thresholds estimated to determine the number of regimes in the model. The test for the number of regimes coincides with the test for non-linearity. Hansen's (1999) methodology was applied and Monte Carlo simulations were performed in order to obtain these results. The methodologies applied determine whether a two or a three regime model should be estimated. The chapter is then concluded with a brief summary.

5.2 Time series properties

5.2.1 Non-Stationarity

If price data are non-stationary, long run relationships between price variables estimated using Ordinary Least Square regression techniques could be invalid, as a result a static representation of the LOP could be spurious. Therefore, before further analysis on the data is made, a test on the data generating process of the price series needs to be conducted. In other words, the presence of a unit root in the price series need to be checked and appropriate action taken to convert the series to a stationary process. The presence of unit root is done usually using ADF tests. JHB market is initially taken as market leader based on market indications that were later confirmed through causality testing.

5.2.2 Co-integration

The linear combination of two non-stationary data series can be stationary, and the data series are then said to be co-integrated. A linear combination of two I(1), integrated of order one, series that generate a stationary I(0) series implies the existence of a co-integration relationship between the series. The concept underlies the idea that even though economic time series exhibit non-stationary behaviour, a linear combination between trending variables can remove the trend component and cause the time series to be co-integrated.

Co-integration techniques have been regularly applied to the analysis of spatial price relationships to test the LOP and to examine the degree to which markets in different regions are integrated. Two markets will be considered integrated if the error term of the regression between the two markets is stationary. Short run instability is thus allowed in the marketing margins which only need to be stable in the long run. Co-integrated prices are then interpreted as indicating market integration.

Engle and Granger's two step approach

Engle and Granger (1987) developed a two-step procedure to test for co-integration and this test is one of the most used methods in testing for co-integration. This is termed in the literature as a residual based test. The two steps are; 1) estimate a co-integrating regression by applying OLS on the levels of the variables included, and 2) test for stationarity of the residuals using ADF tests. The method checks the presence or lack thereof of co-integration relationships.

Results are shown in Table 5-1. From the table it can be seen that the null hypothesis of unit root was rejected for all the market pairs since the p-value for all market pairs are less than 0.05. The calculated ADF statistic is less than the critical test statistic at 95% level of significance. The trend was found insignificant in all of the market pairs except for the BFN-JHB pair, where the trend p-value was the only value below 0.05 at 0.0015. All other market pairs yielded p-values greater than 0.05. The intercept was found to be significant in all but three market pairs with only BFN-JHB, CTN-JHB and PE-JHB market yielding p-values greater than 0.05.

Next, the ADF test was again performed on the price differences, taking the significance of the trend and intercept term into account. If a trend was insignificant, it was estimated with the intercept term only, thus removing the insignificant trend value from estimation. All markets except BFN-JHB market pair, where both intercept and trend is significant, were thus estimated again. Where trend and intercept were insignificant, both were excluded in the second estimation, as is the case for CTN-JHB and PE-JHB market. For the other market pairs the intercept was found significant and therefore included in the regression.

Table 5-1: Test for the stationarity of price differences

Markets	ADF-statistic	Critical Value 95%	P-value	Trend P-value	Intercept P-value
Pretoria (PTA) – Johannesburg	-9.6752	-4.0331	0.0000	0.2559	0.0007
Bloemfontein (BFN)– Johannesburg	-8.6232	-4.0331	0.0000	0.0015	0.000
Cape Town (CTN) - Johannesburg	-7.9191	-4.0337	0.0000	-0.7979	0.4265
Durban (DBN) – Johannesburg	-10.1428	-4.0331	0.0000	0.5473	0.0200
Pietermaritzburg (PMB) - Johannesburg	-7.9422	-4.0331	0.0000	0.6445	0.000
Port Elizabeth (PE) – Johannesburg	-7.0738	-4.0331	0.0000	0.5357	0.6174
Kimberly (KBY) – Johannesburg	-8.9644	-4.0331	0.0000	0.3513	0.0044

Note: Johannesburg is used as central market
Source: authors' computation

The results for these are shown in Table 5-2. In general, test results using the Engle-Granger methodology indicated that all the market combinations considered in this study have long run relationships i.e. they are co-integrated.

Table 5-2: Test for the stationarity of price differences, trend removed

Markets	ADF-statistic	Critical Value 95%	P-value	Trend P-value	Intercept P-value
Pretoria (PTA) – Johannesburg (JHB)	-9.6012	-3.4833	0.0000	NA	0.0000
Bloemfontein (BFN) – Johannesburg (JHB)	NA	NA	NA	NA	NA
Cape Town (CTN) – Johannesburg (JHB)	-8.3762	-2.5836	0.0000	NA	NA
Durban (DBN) – Johannesburg	-10.1560	-3.4833	0.0000	NA	0.0000
Pietermaritzburg (PMB) - Johannesburg (JHB)	-7.9581	-3.4833	0.0000	NA	0.0000
Port Elizabeth (PE) – Johannesburg (JHB)	-7.0957	-2.5836	0.0000	NA	NA
Kimberly (KBY) – Johannesburg (JHB)	-8.9202	-3.4833	0.0000	NA	0.0001

Note: Johannesburg is used as central market
Source: authors' computation

The decision is based on the fact that all probability values are less than 0.05, one can thus reject the null hypothesis of unit root at 95% level of significance. All ADF statistics are less than the critical values estimated after taking trend and intercept significance into account.

The significance of the ADF test on the market pairs is evidence of a long run relationship between variables.

Johansen's method

Another approach widely used in the literature is the residual based approach is the one by Johansen (1988). The Johansen method checks long run relationships within a VAR framework and can be used to determine the number of co-integration relationships present in the data. In this study tests for long run relationships (co-integration) between any two spatially separated markets are done by imposing the LOP, which requires stating the co-integrating vector as [1 -1] and practically meant applying ADF tests on price differences between any two spatially related markets.

Additional test for long run relationship was performed using the Johansen's procedure, which was preceded by tests for lag-length. The lag length results are provided in Table 5-3. The tests for lag length were conducted by means of various criterions. These criterions include: Final Predictor Error (FPE), Akaike Information Criterion (AIC), Schwartz Information Criterion (SIC) and the Hannan-Quinn (HQC) Information Criterion. From the lag length results provided in Table 5-3, the majority of the test statistics identified a VAR of order one (PTA, BFN, DBN, PMB and KBY market).

The decision per criterion is based upon the identification of the test statistic that yields the lowest value. The lag length in which most test criterion are minimum is chosen as the order of VAR to be estimated. Therefore a VAR model with one lag was fitted in order to determine the long run relationship among the variables. For PE and CTN market a VAR model with three and two lags were fitted respectively. In the CTN market, the test statistics identified one and three lags with two statistics each and then two lags with one statistic, it was then decided to estimate a VAR of order two. Although KBY market identified a VAR of order one, further calculations experienced near singularity problem and this was accounted for by increasing the VAR of KBY market to a VAR of order two. Table 5-3 below shows the results of the lag length criterion of the various FPM.

The VAR is a dynamic model allowing one to test hypotheses with respect to the adjustment process and to test price leadership. Co-integration can serve as evidence of causality and the information on the direction of causality is contained in the adjustment parameters. After lag lengths were determined, the long run relationship between the price variables was established by fitting a VAR model with the respective lag lengths.

Table 5-3: Lag Length Order Selection

Pretoria – Johannesburg				
Lag	**FPE**	**AIC**	**SIC**	**HQC**
0	0.000347	-2.291793	-2.244832	-2.272725
1	0.000232*	-2.694415*	-2.553532*	-2.637212*
2	0.000235	-2.681276	-2.446472	-2.585938
3	0.000237	-2.672538	-2.343812	-2.539065
Bloemfontein – Johannesburg				
Lag	**FPE**	**AIC**	**SIC**	**HQC**
0	0.001583	-0.772435	-0.725475	-0.753368
1	0.000938	-1.295503	-1.154621*	-1.238301*
2	0.000924*	-1.310904*	-1.0761	-1.215566
3	0.000935	-1.299552	-0.970827	-1.16608
Cape Town – Johannesburg				
Lag	**FPE**	**AIC**	**SIC**	**HQC**
0	0.004402	0.250094	0.297055	0.269162
1	0.002207	-0.440605	-0.299722*	-0.383402*
2	0.002159	-0.462301	-0.227497	-0.366963
3	0.002156*	-0.464050*	-0.135325	-0.330578
Durban – Johannesburg				
Lag	**FPE**	**AIC**	**SIC**	**HQC**
0	0.001218	-1.034531	-0.98757	-1.015463
1	0.000757*	-1.509797*	-1.368914*	-1.452594*
2	0.000761	-1.505835	-1.271031	-1.410498
3	0.000771	-1.492964	-1.164239	-1.359492
Pietermaritzburg – Johannesburg				
Lag	**FPE**	**AIC**	**SIC**	**HQC**
0	0.002111	-0.485028	-0.438068	-0.465961
1	0.001258*	-1.002290*	-0.861408*	-0.945088*
2	0.001269	-0.993581	-0.758777	-0.898244
3	0.001298	-0.971141	-0.642416	-0.837669
Port Elizabeth – Johannesburg				
Lag	**FPE**	**AIC**	**SIC**	**HQC**
0	0.00218	-0.452666	-0.405705	-0.433598
1	0.001105	-1.132153	-0.991271*	-1.074951*
2	0.001089	-1.147091	-0.912287	-1.051753
3	0.001040*	-1.193464*	-0.864739	-1.059992
Kimberly – Johannesburg				
Lag	**FPE**	**AIC**	**SIC**	**HQC**
0	0.003833	0.11153	0.158491	0.130597
1	0.002264*	-0.414892*	-0.274010*	-0.357690*
2	0.002306	-0.396657	-0.161853	-0.30132
3	0.002346	-0.379477	-0.050752	-0.246005

*stands for the lag-order selected
Source: Authors' computation

In all of the market pairs, the results indicated the presence of one co-integrating relationship among the price variables. These results are indicated in Table 5-4. Johansen's VAR method is based upon two statistics, the Max-Eigen Statistic and the Trace statistic. The identification of a co-integrating relationship is based on these two statistics and the rejection on the null hypothesis of no deterministic trend would imply that a co-integration relationship exists. The acceptance of the null would imply that there is no co-integrating variable and that there exists no long run relationship between variables.

Table 5-4: Co-integration testing results

Pretoria - Johannesburg		
Rank	**Max-Eigen Statistic**	**Critical Value**
None*	68.0126	11.2248
At most 1	0.1224	4.1299
Trace Statistic		
None*	68.1350	12.3209
At most 1	0.1224	4.1299

Pietermaritzburg - Johannesburg		
Rank	**Max-Eigen Statistic**	**Critical Value**
None*	49.7980	11.2248
At most 1	0.1165	4.1299
Trace Statistic		
None*	49.9145	12.3209
At most 1	0.1165	4.1299

Bloemfontein - Johannesburg		
Rank	**Max-Eigen Statistic**	**Critical Value**
None*	47.7457	11.2248
At most 1	0.1438	4.1299
Trace Statistic		
None*	47.8895	12.3209
At most 1	0.1438	4.1299

Port Elizabeth - Johannesburg		
Rank	**Max-Eigen Statistic**	**Critical Value**
None*	40.1298	11.2248
At most 1	0.0466	4.1299
Trace Statistic		
None*	40.1765	12.3209
At most 1	0.0466	4.1299

Cape Town - Johannesburg		
Rank	**Max-Eigen Statistic**	**Critical Value**
None*	55.8338	11.2248
At most 1	0.0109	4.1299
Trace Statistic		
None*	55.8447	12.3209
At most 1	0.0109	4.1299

Kimberley – Johannesburg		
Rank	**Max-Eigen Statistic**	**Critical Value**
None*	62.1655	11.2248
At most 1	0.1117	4.1299
Trace Statistic		
None*	62.2772	12.3209
At most 1	0.1117	4.1299

Durban - Johannesburg		
Rank	**Max-Eigen Statistic**	**Critical Value**
None*	82.1608	11.2248
At most 1	0.1137	4.1299
Trace Statistic		
None*	82.2746	12.3209
At most 1	0.1138	4.1299

Trend assumption: No deterministic trend.
* denotes rejection of the hypothesis at the 0.05 level
Trace test indicates 1 co-integrating eqn(s) at the 0.05 level.
Max-Eigen value test indicates 1 cointegrating eqn(s) at the 0.05 level

Source: Authors' computation

One co-integrating relationship was identified, based on both test statistics, for each market pair considered below. In all market pairs the test statistics were less than the critical value at 95% level of significance and the model identified at most one co-integrating relationship per market pair. A major limitation of co-integration techniques is the ignorance of transaction cost and the imposition of a linear approximation where it could be non-linear. The degree of co-integration among prices is not a useful measure of the strength of interregional market integration, but it does provide helpful information and serves as a pre-test for market integration.

5.3 The model

After long run relationships are confirmed, as shown in the previous section, tests for linearity were conducted. This was done using Hansen's (1999) procedure. The procedure could also serve to decide on the number of regimes (one, two, or three) that best fit the data. A decision on the number of regimes is crucial as it helps decide on the direction of trade flow – one versus two directional flows. Since the parameters needed to test for linearity are indentified only in the alternative hypothesis, a standard test procedure can't be applied. This is handled in this study by conducting a Monte Carlo type experiment. The experiment was repeated 2 000 times. It helped calculate p-values by counting the number of times that the simulated SupLR statistic is higher than the calculated SupLR statistic. These values are shown in Table 5-5. See Hansen (1999) for details on the procedures followed.

Three types of $TVECM_i$ are estimated. Each model is identified by the value its subscript i takes, 1or 2 or 3. A value i=1 represents a linear VECM model. A value i=2 or 3 on the other hand represents a two and three regime nonlinear TVECM respectively. Table 5-5 presents results from the linearity test and the number of regimes that best fits the data. This test was conducted by: firstly testing for linearity and secondly if non-linearity is confirmed, we decide whether a two regime or a three regime model best fits the data. The linearity null was rejected at the 1% level of significance for all market pairs. A linear model would have no threshold variable and LR12 from the table below would be accepted, i.e. p-value greater than 0.05.

Table 5-5: Test for linearity and the number of regimes

Hypothesis	Likelihood ratio	Bootstrap p-values
Pretoria – Johannesburg		
Hypothesis	Likelihood ratio	Bootstrap p-values
		Heteroscedastic
LR12	63.1077	0.0000
LR13	0.4004	1
LR23	62.7073	0.0080
Bloemfontein - Johannesburg		
Hypothesis	Likelihood ratio	Bootstrap p-values
		Heteroscedastic
LR12	59.8622	0.0000
LR13	2.9156	0.8340
LR23	62.7778	0.0010
Cape town - Johannesburg		
Hypothesis	Likelihood ratio	Bootstrap p-values
		Heteroscedastic
LR12	125.9733	0.0000
LR13	197.8954	0.0000
LR23	71.9221	0.0030
Durban - Johannesburg		
Hypothesis	Likelihood ratio	Bootstrap p-values
		Heteroscedastic
LR12	117.7018	0.0000
LR13	147.5636	0.0000
LR23	29.8618	0.0280
Pietermaritzburg- Johannesburg		
Hypothesis	Likelihood ratio	Bootstrap p-values
		Heteroscedastic
LR12	49.7631	0.0000
LR13	21.2465	0.0740
LR23	28.5165	0.0210
Port Elizabeth - Johannesburg		
Hypothesis	Likelihood ratio	Bootstrap p-values
		Heteroscedastic
LR12	135.9843	0.0000
LR13	215.9266	0.0000
LR23	79.9423	0.0020
Kimberley - Johannesburg		
Hypothesis	Likelihood ratio	Bootstrap p-values
		Heteroscedastic
LR12	155.3236	0.0000
LR13	233.7746	0.0000
LR23	78.4510	0.0090

Source: Authors' computation

After non-linearity was confirmed (Table 5-5), the number of regimes were next identified to decide on the direction of flow of potatoes. Results (provided in Table 5-6, columns 3 and 6) identified one directional flow, Johannesburg FPM being the destination market. This was detected in the four out of the seven market combinations considered, the others were found to be independent. Overall, results attest to a priori expectation that Johannesburg is the leading FPM in South Africa. The distance between spatially separated markets are of importance as markets separated by greater distance are less likely to be integrated or ought to yield higher threshold values due to higher transaction costs. Results found are in line with a priori expectation, as most market combinations separated by greater distance yielded higher threshold values.

Furthermore, Table 5-6 gives results on the status of market pairs in terms of satisfying the Law of One Price in the short run. The LOP is satisfied when price differences between any two spatially separated market pairs are smaller than transaction costs, restricting arbitrage possibilities. The threshold values in column 5-6 represent transaction costs, which should be exceeded for equilibrating activities to take place. Here, this was checked by checking the number of times deviations from equilibrium fall within the neutral band, the band within which price differences are less than transaction costs. According to the results found, the law doesn't hold for the majority of market combinations (Table 5-6, column 4). In other words no evidence of market integration is found. Threshold values can be interpreted as follows: a single threshold variable, as is the case for BFN-JHB market would imply that the price difference would have to be 22% different to exceed the threshold and trigger adjustment. For a two threshold variable, as in KBY-JHB, the threshold values indicate that transaction costs is higher when moving from KBY to JHB market, at 12%, than vice versa at 1.4%. A possible explanation for this could be due to the lack of backhauling when returning from JHB to KBY market.

Table 5-6: Summary of TVECM results

Market Pair	Distance (km)	Regime	Market integration	Thresholds		Direction of Causality
				c1	c2	
PTA – JHB	85	2R	Not	-0.1406	NA	Independent
BFN - JHB	417	2R	Not	-0.2165	NA	JHB to BFN
CTN- JHB	1405	2R	Yes	-0.0103	NA	JHB to CTN
PMB - JHB	520	2R	Yes	-0.1357	NA	Independent
DBN - JHB	598	3R	Not	-0.0417	0.022	JHB to DBN
KBY- JHB	514	3R	Not	-0.1177	0.014	JHB to KBY
PE – JHB	1062	3R	Not	0.0199	-0.124	Independent

Source: Authors' computation

Figures 5-1 to 5-3 investigate the degree to which deviations from equilibrium fall persistently within and outside the equilibrium band for the three regime models. These figures also give information about the time of switches between regimes which might assist in identifying the underlying causes. If a market pair of a $TVECM_3$ is in equilibrium state, then most of the observation would fall within the neutral band. This is not the case in any of the $TVECM_3$ estimated, with most observations falling within regime I for KBY and DBN market, and within regime III for PE market. If this is the case it implies that these market pairs are not in a state of equilibrium and thus not integrated.

In addition, Figures 5-1 to 5-3 give the time of switches between regimes. Results show no discernible pattern on the time of switches. The movement from Figure 5-1 is: one observation falls in regime one, then moves to regime two, moves back down to regime one, then up to regime two, three and then regime one again. The up and down movements continue with no distinct pattern identifiable. All figures are interpreted in the same way.

A final step used in this study was to determine the dynamic interrelationships of price between different markets with the aid of impulse response functions. The impulse response function was estimated for the three regime models. The results of the KBY-JHB market pair are shown in Appendix A. From these results one can identify asymmetric behaviour and confirm no integration as found. In response to the shock introduced, the market does not stabilise in the short run as expected from an integrated market.

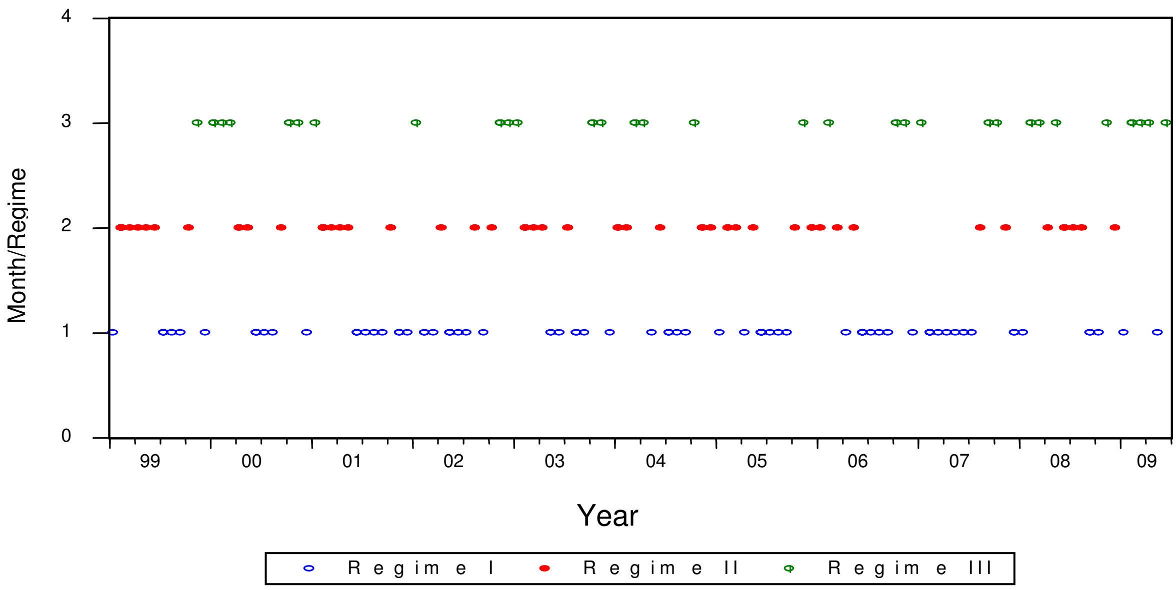

Figure 5-1: Regime Switching Estimates for KBY & JHB Market pairs
Source: Authors' computation

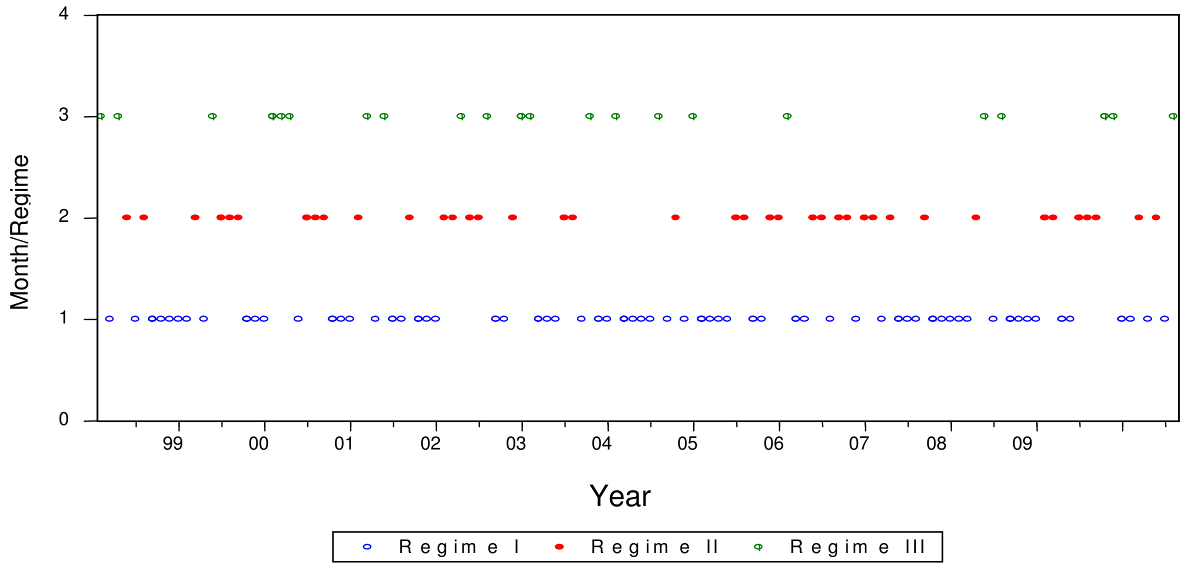

Figure 5-2: Regime Switching estimates for DBN & JHB market Pairs
Source: Authors' computation

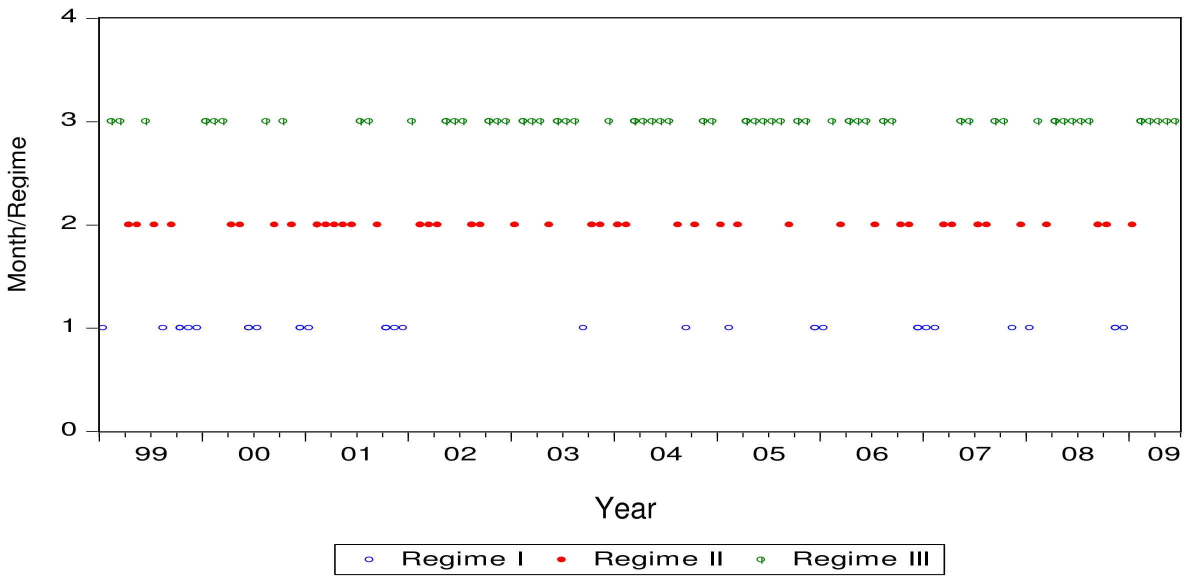

Figure 5-3: Regime Switching Estimates for PE and JHB Market Pairs
Source: Authors' computation

5.4 Summary

In this chapter the results of market integration in the potato market are represented after applying the methodologies discussed in Chapter 4. Co-integration tests were done by imposing the LOP. Test results based on the Engle-Granger methodology indicated that all market combinations are co-integrated. Additional test for co-integration was performed by using Johansen's co-integration test. This test was preceded by selecting the appropriate lag length. After lag lengths were determine a VAR was fitted and all the results indicated the presence of one co-integrating relationship among prices.

To test for non-linearity Hansen's procedure was used and the method also indicated the number of regimes that best fit the data used. Non-linearity was confirmed for all the market pairs considered. Four market pairs were found to be two regime models while the other three pairs were found to be three regime models. The method also allowed the determination of flow and indicated Johannesburg market as the destination market, i.e. the market leader. The LOP were found to not hold for the majority of the market pairs considered. Only CTN and JHB indicates market integration, which could be due to adequate information flows between these markets, rather than the physical flow of goods, since these to markets are separated by the most distance. Finally regime switching and impulse response functions were graphically analysed and also indicated no integration since most observations were not in the neutral band and there were also no discernible pattern on the time of switches, and the data showed irresponsiveness to shocks.

CHAPTER 6
SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

6.1.1 Background and motivation

Potatoes are the most important vegetable product in South Africa, the third most important food crop in the world and yields more nutritious food more quickly on less land and in harsher climates than any other major crop. Potato production provides employment opportunities and livelihoods and has notable multiplier effects throughout the supply chain. Potatoes are planted in all the regions of South Africa and sold on all of the Fresh Produce Markets, which serve as the price setter for the industry (PSA, 2010; FAO, 2008; CIP, 2009).

Market integration studies are often used to understand markets and has important policy implications and aids in policy formulation, implementation and recommendations and may also affect the effectiveness of policies and be used to measures the impact thereof. The cost of incorrect policies can be immense (Negassa *et al.,* 2003; Goletti *et al.,* 1995). Market connectedness can contribute greatly to rural households escape from poverty and plays a crucial role in lessening the effects of shocks and in reducing food insecurity by ensuring a food balance between surplus and deficit regions (Kose *et al.,* 2003; Goletti *et al.,* 2003).

Market integration will also reveal the performance of agricultural markets and will clarify market conditions. When markets are integrated traders cannot exploit the market to their benefit and farmers will be able to specialise and realise gains from trade. Farmers will specialise in production, the consumer will benefit from effective prices and society as a whole will be better off (Lohano & Mari, 2006).

6.1.1 Problem statement and objectives

Potato producers of South Africa are not sure about the movement of and the fairness of prices on the fresh produce markets. Producers can not accurately determine their marketing strategy based on the prices they receive. Information on the actual flow of goods and information is not available to the producer. Producers are thus not able to specialise and benefit from gains of trade and may make incorrect marketing decisions.

Market integration studies have a wide application over the last few decades. In agriculture it has been used to determine the overall performance of the market and various authors have applied various methods and techniques in studying market integration. Correlation and co-integration analysis led the way and are of the most used methods to date but failed to account for transaction costs and non-linearity (Moser *et al.,* 209). The PBM was another method with a wide application in agricultural studies but relies on actual transaction cost and this makes it difficult to use in the absence of such data. The models that followed are the TAR, VAR and TVECM. The TVECM is the model used more often in later studies as it accounts for shortcomings in other models. The TVECM accounts for non-linearity, asymmetry and transaction costs.

The only market integration study that has been done on potatoes has been in West Bengal. Studies done in South Africa included a study done on the apple industry and another done on the Fresh Produce Markets for a range of produce. The study focuses on the potato industry of South Africa and is better than the other models in the sense that it allows non-linearity and asymmetry in the variables and transaction costs are taken into account. The model also allows one to test for the presence of heteroskedasticity without assuming its existence. The model tests the alternative of a two and a three regime model and does not impose the use of a specific regime. The performance of other markets, other commodities and markets in other countries can be studied with the model developed in this study. The primary objective of the study is to analyse market integration within the potato industry of South Africa.

6.2 Industry Background

Potatoes are the most important vegetable product in South Africa and contribute to three percent of total South African agriculture. The top four producers of potatoes are China, the Russian Federation, India and the United States of America (FAO, 2008). Africa now supplies eight percent of the world's potato production and South Africa produces 14% of Africa's potatoes. The top producers in Africa are Egypt, Malawi, South Africa and Algeria (FAO, 2008; PSA, 2010). The potato is a vital part of the global food system being the most important root and tuber crop in the world, and the third most important food crop in the world it is seen as a highly recommended food security crop (FAO, 2008; CIP, 2009).

Table potatoes are produced for consumption purposes while seed potatoes are produced for regenerative purposes. Potato production rose by 23% from 1991 to 2005 (NAMC & Commark Trust, 2006; Louw *et al.,* 2004, PSA, 2010). All provinces of South Africa produce potatoes, and produce all year round. The four largest production regions are Limpopo province, the Western Free State, the Sandveld region and the Eastern Free State, accounting for 62% of volumes. The three largest cultivars are Mondial, BP1, and Up-to-date accounting to 84% of total volumes and representing almost 80% of potatoes sold on the FPM's (PSA, 2010). The processing industry of South Africa has doubled over the past five years and now represents 19% of the total South African crop. The potato cultivar that is selected depends on the end use of the product (Louw *et al.,* 2004, PSA, 2010).

The potato industry operates in a free market environment with the FPM's the preferred marketing channel where supply and demand determine prices (NAMC & Commark Trust, 2006; Louw *et al.,* 2004, PSA, 2010). South Africa has 19 markets and these markets form a R8 billion industry. The four largest markets are Johannesburg, Pretoria, Cape Town and Durban and represent 70% of total market share. Most of the potatoes sold on the markets are Class 1 potatoes, 72%, and 45% of these are medium sized potatoes. Johannesburg market is labelled as the price setter (PSA, 2010).

6.3 Literature Review

A literature review was performed in order to understand the concepts underlying market integration and to investigate the factors that have shaped method development and selection over the years. The models that have been historically used to determine market integration were discussed in detail and critiques against the models were considered. Thereafter the applications of the different models by various authors were discussed.

6.3.1 Defining market integration

Various concepts are involved in the definition of market integration. The concepts are prices, markets, arbitrage and the LOP. The collective action of buyers and sellers in the market forms prices and these prices can be used as signals for resource allocation (Vollrath, 2003; Goletti *et al.,* 1995). A market can be defined as the area where buyers and sellers move freely so that the prices of the same good will move to equality. Arbitrage can be defined as the force that ensures the equal movement of prices on the markets or the error-correction mechanism that moves the prices of the same good on two markets towards equilibrium (Boisseleau & Hewicker, 2002). Even though prices may differ in the short run, arbitrage will warrant that the prices on different markets move to equilibrium in the long run (Norman-López & Bjørndal, 2009).

The strict version of the LOP states that prices of the same good will not differ between two spatially separated markets, taking transaction costs into account. If prices do differ the force of arbitrage will move the prices towards equilibrium (Trenkler & Wolf, 2003). The LOP plays an important role in defining the market and in measuring market integration (Ghoshray & Lloyd, 2003). For markets to be integrated they need to share the same long run information and they need to share the same traded group (González-Rivera & Helfand, 2001). Markets are integrated if they are connected by the process of arbitrage and if the LOP holds. Spatial market integration refers to the co-movement of prices or the spread of price signals and information across spatially separated markets (Goletti *et al.,* 1995).

6.3.2 Factors that shaped method selection

The models used in market integration studies today were developed based upon certain developments and findings in studies from various authors. The most important factors that influenced market integration models used today include non-stationarity, the presence of transaction costs and the non-linear and asymmetric properties of data and the concepts behind causality and exogeneity. Most prices for agricultural commodities are non-stationary and methods used to measure market integration should take this into account (Meyer, 2004).

Nowadays an extensive literature takes non-stationarity into account and uses the correct methods to determine market integration. Another important factor to consider is transaction costs, and most conventional tests do not take the important role played by transaction costs into account. The importance of transaction costs have led to new models that explicitly or implicitly account for transaction cost in modelling (Piggott & Goodwin, 2002). Transaction costs will lead to a neutral band within which prices are not linked to each other and for arbitrage to take place price differences would have to exceed the neutral band (Goodwin & Piggott, 2001).

The existence of non-linear data and non-linear models, as well as asymmetry within data has led to the development of a range of new models that account for non-linearity and asymmetry. Linear methods used on non-linear data can hide a lot of important information (Potter, 1995; Hansen, 1999). The procedures that have been developed to capture the non-linearity of data include an extended ECM, TAR models and TVECM models (Serra *et al.,* 2006). Tsay (1998) developed a test that can be used to test for the presence of threshold non-linearity. Symmetry of variables was always assumed, but later it became known that most economic variables exhibit asymmetry. Asymmetry is when prices respond differently to shocks in a given price and can yield older methods ineffective (Enders & Granger, 1998).

The direction of flow of goods and information is also important in market integration analysis. When two markets are co-integrated there must be some relationship between them. Markets can have either unidirectional, bidirectional or independent relationships. When there exists a relationship where the price in one market causes the price in the other market, that market is said to Granger cause the price of the other market. When the relationship is unidirectional, where one market causes the other markets price, but is itself not affected by that markets price, then that market is referred to as the central market or market leader (Asche *et al.,* 2004).

6.3.3 Models of market integration

Correlation analysis use to be used most often in market integration studies. If a change in the one market brings about a change in the other market, these markets would be correlated and thus interpreted as integrated (Boisseleau & Hewicker, 2002). After the introduction of the concept of integration and the acknowledgment of the flaws of correlation analysis several methods have been used in market integration studies Methods that have been used include OLS, Non-linear Least Squares, PC, canonical correlations, ML, Delgado's variance decomposition approach, and most significantly Ravallion's model (Negassa *et al.,* 2003). Ravallion's model combined with the acknowledgement of non-stationarity started a series of studies that used co-integration techniques to test for long run market integration (Van Campenhout, 2007).

Engle and Granger (1987) developed a two step procedure to test for co-integration. They stated that markets are integrated if the error term of the regression between the two markets is stationary. The two steps of the model are to regress the variables on each other by applying OLS and then test for stationarity of the residuals. The approach was followed by the Johansen's method in 1988, which models the relationship between prices in a Vector Autoregressive (VAR) format (Boisseleau & Hewicker, 2002; Asche *et al.,* 2004). Co-integration techniques ignore transactions costs and do not account for non-linear variables, but can serve as a valuable pre-test and give an indication of the direction of causality (Barrett, 1996; Asche *et al.,* 2004; Goodwin & Piggott, 2001; McNew & Fackler, 1997).

The Parity Bound Model was the first model that explicitly accounted for transaction costs and also allowed for the possibility of irregular trade between markets. The model examines market integration by differentiating between three regimes, where the three regimes are defined by the parity bounds that are in turn determined by transaction costs (Baulch, 1997). The main problem associated with the PBM is the assumption of fixed transaction costs, which is highly unlikely given the immense variation between markets (Moser *et al.,* 2009).

TAR models came as an alternative to the PBM and takes non-linearities and asymmetries into account. TAR models grew in popularity due to ease of specification, estimation and interpretation and it does not depend on the often incorrect data on transaction costs (Hansen, 1997; Lo & Zivot, 2001; Negassa *et al.,* 2003; Serra *et al.,* 2006). The TAR model was extended to TECM and VECM. On spatially integrated markets where the direction of causality is not known the use of a VECM is appropriate (Meyer, 2004).

Balke and Fomby proposed a simple two-step procedure where threshold parameters are chosen through a grid search that minimises sum of squared errors criterion. The number of thresholds determines the number of regimes in the model (Meyer, 2004). The TVECM accounts for potential non-linearities and threshold-type adjustments in Error Correction Models and is a multivariate model (Serra *et al.,* 2006; González-Rivera & Helfand, 2001). Due to the improvements of the TVECM on other models and its recent popularity in application, it was concluded as the best model to apply to test spatial market integration within the potato industry.

6.4 Data and Methodology

The data used in the study is weekly data ranging from January 1999 to June 2009. For consistency the last week in every month was used as the monthly data point. The study was done on eight selected Fresh Produce Markets and included JHB, PTA, CTN, BFN, PMB, DBN, PE and KBY markets. Data was provided by PSA and the selection of market based upon their relative size, importance and location.

Any time series study need to first consider the time series properties of the data before any further test can be performed. A range of tests were done to determine the statistical properties of the variables. The first was to test for the stationarity of price variables, and this was done by making use of the ADF procedure. If a variable is non-stationary and differencing it only once makes it stationary, then it is said to be integrated of order one *I(1),* and integrated of order zero, I(0), if it is stationary.

In order to determine the long run relationship between market prices two methods have been commonly used. The first is the two step procedure proposed by Engle and Granger and the second is Johansen's procedure. Before the VAR model is estimated it is necessary to determine the lag length by means of various criterions. The price of market one is regressed upon the price of the central market in the VAR model. After the VAR model has identified the existence of a long run relationship, the TVECM is estimated for each possible regime. In this study the LOP is assumed to hold, implying that a co-integrating vector of the form (1, -1) will be tested and imposed. The parameters of the model are estimated by applying a two dimensional grid search and selecting the values of the thresholds as those which minimise the log determinant of the variance covariance matrix of residuals. The search was restricted to a minimum of 20 observations in each regime.

Non-linearity was tested for by applying an extension to Hansen's (1999) approach, and testing the null hypothesis of a one regime TVECM model against a two- and a three regime model. The test for non-linearity is done along with the test that determines the number of regimes that best fit the data. This is done by testing the null hypothesis of a linear VECM against the alternative hypothesis of a two or three regime $TVECM_{m.}$ The parameters needed to test linearity are not indentified in the null hypothesis; therefore a non-standard test procedure was applied. For this a Monte Carlo type of simulation was done in five steps. The decision about linearity is then based upon the number of time the simulated statistic exceeds the calculated statistic.

6.5 Results

Before any tests are performed it is important to analyse the time series properties of the data. In this study the presence of a unit root in the price series was checked and appropriate action taken to convert the series to a stationary process where necessary. Unit root tests were performed by applying an ADF test on the variables. Data series are said to be co-integrated when the linear combination of two non-stationary data series are stationary. A linear combination between trending variables can remove the trend component and cause the time series to be co-integrated.

If the error term of the regression between the two markets is stationary the two markets will be considered integrated. Co-integrated prices are then interpreted as indicating market integration. Engle and Granger (1987) developed a two-step procedure to test for co-integration and was the method used in testing for co-integration. This method is termed as a residual based test in the literature and checks the presence or lack of co-integration relationships.

The null hypothesis of unit root was rejected for all the market pairs. The trend was found insignificant in all of the market pairs except for the BFN-JHB pair that also yielded a significant intercept value. The ADF test was again performed on the price differences taking trend and intercept significance into account. Where the trend and intercept were insignificant, both were excluded in the second estimation, as is the case for CTN-JHB and PE-JHB market. For the rest the intercept value was found significant and included in the second regression. Test results based on the Engle-Granger methodology indicated that all the market combinations considered in this study have long run relationships i.e. they are co-integrated

After applying the residual based test, the Johansen's method was applied next. The Johansen method checks long run relationships within a VAR framework and can be used to determine the number of co-integration relationships present in the data. In this study tests for co-integration between two spatially separated markets were done by imposing the LOP, which required stating the co-integrating vector as [1 -1] and practically meant applying ADF tests on price differences between any two spatially related markets.

The Johansen's procedure was preceded by tests for lag-length and was done using certain criterions that included the FPE, AIC, SIC and the HQC information criterion. From the lag length results, the PTA, BFN, DBN, PMB and KBY market's test statistics identified a VAR of order one. For CTN and KBY market a VAR model with two lags were identified, while a VAR model with three lags were identified for PE market.

After lag lengths were determined, the long run relationship between the price variables was established by fitting a VAR model with the respective lag lengths. The results indicated the presence of one co-integrating relationship among the price variables in all of the market pairs. This was based upon two statistics the Max-Eigen Statistic and the Trace statistic. The ignorance of transaction cost and the imposition of a linear approximation where it could be non-linear is a major limitation of co-integration techniques. But it does provide helpful information and serves as a valuable pre-test for market integration.

After the confirmation of long run relationships, tests for linearity were conducted using Hansen's (1999) procedure. The procedure also served to decide on the number of regimes that best fit the data. The number of regimes helps decide on the direction of trade flow – one versus two directional flows. For this a Monte Carlo type experiment was performed and repeated 1 000 times. It helped calculate p-values by counting the number of times that the simulated SupLR statistic is higher than the calculated SupLR statistic.

Three types of $TVECM_i$ are estimated as identified by the value its subscript i takes. A value i=1 represents a linear VECM model, while a value i=2 or 3 represents a two and three regime nonlinear TVECM respectively. Where non-linearity was confirmed we decided whether a two regime or a three regime model would best fit the data. The linearity null was rejected for all market pairs at the 1% level of significance.

Thereafter the number of regimes was identified to decide on the direction of the flow of potatoes. Results identified one directional flow and overall results confirmed a priori expectation that Johannesburg is the leading FPM in South Africa. This was found to be the case in four out of the seven market combinations considered. Furthermore, the LOP was checked by checking the number of times deviations from equilibrium fall within the neutral band. The neutral band is determined by threshold values.

Four of the market combinations yielded a two-regime model, whilst the other four yielded a three regime model. The LOP were found to not hold for the majority of the market combinations, and it was concluded that no evidence of market integration in the short run could be found. The LOP is satisfied when price differences between any two spatially separated market pairs are smaller than transaction costs, restricting arbitrage possibilities. The threshold values should be exceeded for equilibrating activities to take place.

In addition the study graphically investigated the degree to which deviations from equilibrium fall persistently within and outside the equilibrium band for the three regime models. The figures also gave information on the time of switches between regimes, but no discernible pattern was identified. The market pairs were found not to be in a state of equilibrium and thus not integrated. Finally the impulse response function results attested to results found and showed no response to shocks introduced.

6.6 Conclusion

Potatoes are the most important vegetable product in South Africa and are of great importance in food security and poverty alleviation. Results indicate that the prices of potatoes on the selected fresh produce markets are integrated in the long run. There is however lack of evidence to support the existence of a spatial relationship in the short run. In other words the markets are not integrated in the short term. Johannesburg market was found to be the market leader and the other market will follow in price changes.

When the LOP does not hold it implies that riskless profit opportunities exist in the markets and that arbitrage possibilities are not present. Policies implemented in the potato industry would be more costly and could be ineffective with the lack of market integration. Given the importance of the potato as a product and the significance of the industry it is of great importance for the markets, as price setting mechanism, to function properly. Otherwise, farmers may not receive fair prices for their produce and consumers will pay more.

Due caution is however still advised in interpreting these findings since this study is purely based on performance in prices on the markets and no investigation into the structure and the conduct of the market was considered. It would be inadvisable for example to make policy related decisions based on these findings since this study does not incorporate all the aspects to consider to base such a decision upon. The study is however vital as a forerunner in determining whether South African fresh produce markets are integrated and whether they are efficient in their important task of price determination. The study could be used in conjunction with other conduct and structure analysis to investigate the functioning of the Fresh Produce Markets.

6.7 Recommendations for future research

The development of the methods used to determine market integration has come a long way over the last two decades. There is however still some shortcomings that could be addressed through future research. More and more studies indentify factors that should be taken into account when measuring market integration. This study accounted for most factors indentified and took into account non-stationarity, transaction costs, asymmetries and non-linearity. There is however still some shortcomings to this model such as its consideration of transaction costs as constant that could be addressed through future research.

Future research could include other vegetables in analysis, specifically competitors of potatoes like cauliflowers and onions. The inclusion of other vegetables could strengthen the study by providing additional information on the functioning of the fresh produce markets and could also allow a distinction to be made between commodities on the same markets. In this study the price data of eight markets were used and after Johannesburg was identified as the market leader seven market pairs were formed that were used in further analysis. Future research could extend this model to test all markets pairs that would result in a total of 56 pairs or equations to be estimated. This could be extended even further by using price information on not only the eight chosen markets but on all 19 Fresh Produce Markets of South Africa.

Another possible addition could be to test the prices of all potatoes, all sizes and all classes separately. This study used average prices for potatoes per 10 kg. Potatoes are divided into classes (Class 1 to Class 4) and per size (large, medium, small & baby) that all realise different prices on the market and the aggregation of these prices could have weakened the data. To test them separately could yield interesting results based on stronger price data. This study used price data after 1999 to account for the deregulation of the markets, a future study could compare the period before and after 1999. A weekly data is used in this study. But a future study could determine market integration based on daily price information.

Given that this study is only performance based and based only upon price data a survey within the potato industry could enrich the results obtained. The survey could include farmers and market agents in order to gather useful information from both sides. Additional information on all inter-market movements, in- and outflows on the markets and imports and exports could also be essential when drawing conclusions from these results. Lastly, a possible limitation could be the estimation of transaction costs, where a model that includes actual transaction costs would be a stronger model. The problem is that there is no such data available which should emphasise the importance of data gathering for future research.

The inclusion of transaction costs in spatial market analysis is essential but data limitations could lead to measurement error. These limitations point out the need for richer data on transaction costs. Still this research gives vital information on the relationships that exist on the market for potatoes in South Africa. These findings cannot be the sole evidence used in discussions on spatial trade behaviour among potato marketers, but should be used in conjunction with other analyses in describing the effects of various suppliers' marketing strategies on prices and the overall functioning of the market.

The study of market integration is important and it is recommended that the markets are investigated to a greater extend to determine the functioning of the market in full. This would have great policy implications and could save large sums of money in the long run. Any possibility of misconduct should be investigated and all segments of the market chain, along with the various role players should be examined. After careful analysis, due action ought to be taken to correct any misalignments within the industry.

REFERENCES

AGÜERO, J.M. (2004). Asymmetric Price Adjustments and Behaviour Under Risk: Evidence from Peruvian Agricultural Markets, *Presented at the American Agricultural Economics Association Annual Meeting,* Denver, Colorado.

ALEMU, Z.G. AND WORAKA, T.K. (2011). Price Transmission and Adjustment in the Ethiopian Coffee market, *Agrekon, Vol. 50 (2)*

ASCHE, F., GJØLBERG, O. AND VÖLKER, T. (2003). Price Relationships in the Petroleum Market: An Analysis of Crude Oil and Refined Product Prices, *Energy Economics,* Vol. 25: 289-301.

ASCHE, F., GORDON, D.V. AND HANNESSON, R. (2004). Tests for Market Integration and the Law of One Price: The Market for Whitefish in France, *Marine Resource Economics,* Vol. 19: 195-210.

BALKE, N.S. AND FOMBY, T.B. (1997). Threshold Co-integration, *International Economic Review,* Vol. 38 (3): 627–645.

BARRETT, C.B. (1996). Markets Analysis Methods: Are our Enriched Tool Kits well suited to Enlivened Markets? *American Journal of Agricultural Economics*, Vol. 78: 825-829.

BASU, J.P. (2006). Co-integration and Market Integration: An application to the Potato Markets in Rural West Bengal, India, *Presented at the International Association of Agricultural Economist conference,* Gold Coast, Australia.

BAULCH, B. (1997). Transfer Costs, Spatial Arbitrage, and Testing for Food Market Integration, *American Journal of Agricultural Economics,* Vol. 79: 477-487.

BOISSELEAU, F. AND HEWICKER, C. (2002). European Electricity and its Impact on Market Integration, *KEMA Consulting,* Germany.

CERVANTES-GODOY, D. AND DEWBRE, J. (2010). Economic Importance of Agriculture for Poverty Reduction, *OECD Food, Agriculture and Fisheries Working Papers,* No. 23.

ELSTON, J.A., HASTIE, J.D. AND SQUIRES, D. (1999). Market Linkages between U.S. and Japan an Application to the Fisheries Industry, *Japan and the World Economy,* Vol. 11: 517-530.

ENDERS, W. AND GRANGER, C.W.J. (1998). Unit-root Tests and Asymmetric Adjustment with an Example Using the Term Structure of Interest Rates, *Journal of Business & Economic Statistics,* Vol. 16 (3): 304-311.

ENDERS, W. AND SIKLOS, P.L. (2001). Co-integration and Threshold Adjustment, *Journal of Business & Economic Statistics,* Vol. 19 (3): 166-176.

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

FACKLER, P.L. AND TASTAN, H. (2008). Estimating the Degree of Market Integration, *American Journal of Agricultural Economics,* Vol. 90(1): 69-85.

FAFCHAMPS, M. (1992). Cash Crop Production, Food Price Volatility, and Rural Market Integration in the Third World, *American Journal of Agricultural Economics,* Vol. 74 (1): 90-99.

FRANKEN, J.R.V. AND PARCELL, J.L. (2003). Market Integration: Case Studies of Structural Change, *Paper presented at the NCR-134 Conference on Applied Commodity Price Analysis, Forecasting and Market Risk Management.*

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO). (2008). New Light on a Hidden Treasure. An end-of-year review. International year of the potato. ISBN 978-92-5-306142-8.

GHOSHRAY, A. AND LLOYD, T. (2003). Price Linkages in the International Wheat Market, *Presented to the International Association of Agricultural Economists Triennial Conference,* Durban, South Africa.

GOLETTI, F., AHMED, R. AND FARID, N. (1995). Structural Determinants of Market Integration: The case study of Rice in Bangladesh, *The Development Economics*, Vol. XXXIII-2.

GOLETTI, F. AND BABU, S. (1994). Market Liberalization and Integration of Maize Markets in Malawi, *Agricultural Economics,* Vol. 11: 311-324.

GONZÁLEZ-RIVERA, G. AND HELFAND, S.M. (2001). The Extent, Pattern, and Degree of Market Integration: A Multivariate Approach for the Brazilian rice market, *American Journal of Agricultural Economics*, Vol.83: 576-592.

GONZALO, J. (1994). Five Alternative Methods of Estimating Long run Equilibrium Relationships, *Journal of Econometrics,* Vol. 60: 203-233.

GOODWIN, B.K. AND HARPER, D.C. (2000). Price Transmission, Threshold behavior, and Asymmetric Adjustment in the U.S. Pork Sector, *Journal of Agricultural and Applied Economics,* Vol. 32: 543-553.

GOODWIN, B.K. AND PIGGOTT, N. (2001). Spatial Market Integration in the Presence of Threshold Effects, *American Journal of Agricultural Economics,* Vol. 83(2): 302-317.

GUJARATI, D.N. AND PORTER, D.C. (2009). Basic Econometrics. Fifth Edition, *McGraw-Hill Higher Education*, International Edition, ISBN: 978-007-127625-2.

HANSEN, B.E. (1997). Inference in TAR models, *Studies in Non-linear Dynamics Econometrics,* Vol. 2(1): 1-14.

HANSEN, B.E. (1999). Testing for Linearity, *Journal of Economic Surveys,* Vol. 13 (5).

HANSEN, B.E. AND SEO, B. (2002). Testing for two-regime Threshold Co-integration in Vector Error-Correction Models, *Journal of Econometrics,* Vol. 110: 293–318.

INTERNATIONAL POTATO CENTRE (CIP). (2009). Available at http://www.cipotato.org/pressroom/facts/figures/2008internationalyearofthepotato.asp [Date of access: 10 July 2010].

ISMET, M., BARKLEY, A.P. AND LLEWELYN, R.V. (1998). Government Intervention and Market Integration in Indonesian Rice Markets, *Agricultural Economics,* Vol. 19: 283-295.

JOHANSEN, S. (1988). Statistical Analysis of co-integration vectors, *Journal of Economic Dynamics and Control,* Vol. 12: 231-254.

JOHANSEN, S. AND JUSELIUS, K. (1992). Testing structural hypotheses in a multivariate co-integration analysis of the PPP and the UIP for UK, *Journal of Econometrics,* Vol. 53: 211-244.

JOOSTE, A., JORDAAN, H., ALEMU, Z.G. AND SPIES, D. (2006). Investigation into Price Trends and Market Integration in selected Fresh Produce Markets in South Africa, *Report prepared for the National Agricultural Marketing Council,* University of the Free State.

KIPLE, K. F. AND ORNELAS, K. C. (2000). The Cambridge World History of Food. ISBN: 9780521402163.

KOSE, M.A., PRASAD, E.S. AND TERRONES, M.E. (2003). Financial Integration and Macroeconomic Volatility, *IMF Staff Papers,* Vol. 50: 119-142.

LO, M.C. AND ZIVOT, E. (2001). Threshold Co-integration and Nonlinear Adjustment to the Law of One Price, *Macroeconomic Dynamics,* Vol. 5: 533-576.

LOHANO, H.D. AND MARI, F.M. (2006). Testing Market Integration in Regional Onion Markets of Pakistan: Application of Error correction Model in the Presence of Stationarity, *International Research Journal of Finance and Economics,* Issue 1, ISSN 1450-2887.

LOUW, A., MADEVU, H., JORDAAN, D. AND VERMEULEN, H. (2004). Securing Small Scale Producer Participation in Restructured National and Regional Agri-food Systems. RSA Country Report, *International institute for Environment and Development (IIED),* London, University of Pretoria.

MALTSOGLOU, I. AND TANYERI-ABUR, A. (2005). Transaction Costs, Institutions and Smallholder Market Integration: Potato Producers in Peru, *ESA Working Paper No 05-04.* Agricultural and Development Economics Division. The Food and Agriculture Organization of the United Nations.

MARTENS, M., KOFMAN, P. AND VORST, T.C.F. (1998). A Threshold Error-Correction Model for Intraday Futures and Index Returns, *Journal of Applied Economics,* Vol.13: 245-263.

MCNEW, K. AND FACKLER, P.L. (1997). Testing Market Equilibrium: Is Co-integration Informative? *Journal of Agricultural and Resource Economics,* Vol. 22 (2): 191-207.

MEYER, J. (2004). Measuring Market Integration in the Presence of Transaction Costs – A Threshold Vector Error Correction Approach, *Agricultural Economics,* Vol. 31: 327–334.

MOSER, C., BARRETT, C. AND MINTEN, B. (2009). Spatial Integration at Multiple Scales: Rice Markets in Madagascar, *Agricultural Economics,* Vol. 40: 281-294.

MUSHTAQ, K., GAFOOR, A. AND DAD, M. (2008). Apple Market Integration: Implications for Sustainable Agricultural Development, *The Lahore Journal of Economics,* Vol. 13: 129-138.

NATIONAL AGRICULTURAL MARKETING COUNCIL (NAMC) AND COMMARK TRUST. (2006). A Diagnostic Study of the Potato Subsector: Unlocking the potential for contribution towards ASGI-SA, *Commissioned by the Department of Agriculture.*

NEGASSA, A., MYERS, R. AND GABRE-MADHIN, E. (2003). Analyzing the Grain Market Efficiency in Developing Countries: Review of Existing Methods and Extensions to the Parity Bound Model, *Market trade and institutions division,* Discussion paper, No. 63.

NORMAN-LÓPEZ, A. AND BJØRNDAL, T. (2009). Is Tilapia the same product Worldwide or are Markets Segmented? *Aquaculture Economics & Management,* Vol. 13: 138-154. ISSN 1365-7305.

OBSTFELD, M. AND TAYLOR, A.M. (1997). Nonlinear Aspects of Goods-Market Arbitrage and Adjustment: Heckscher's Commodity Points Revisited, *Journal of the Japanese and International Economies,* Vol. 11: 441-479, Article No. JJ970385.

OLADAPO, M.O. AND MOMOH. S. (2008). Price Transmission and Market Integration in Oyo State, Nigeria, *The Authors Journal compilation, African Development Bank.*

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD). (2006). Agricultural Policy Reform in South Africa, *Policy Brief,* April 2006.

PADILLA-BERNAL, L., THILMANY, D.D. AND LOUREIRO, M.L. (2003). An Empirical Analysis of Market Integration and Efficiency for U.S. Fresh Tomato Markets, *Journal of Agricultural and Resource Economics,* Vol. 28: 435-450.

PEDE, V.O. AND MCKENZIE, A.M. (2005). Integration in Benin Maize Market: An Application of Threshold Co-integration Analysis, *Presented at the American Agricultural Economics Association Annual Meeting,* Providence, Rhode Island.

PIGGOTT, N.E. AND GOODWIN, B.K. (2002). Spatial Market Linkages With Variable Transactions Costs: Regional Soybean Markets and Repeal of the Jones Act.

POTATOES SOUTH AFRICA (PSA), (2010). Available at http://www.potatoes.co.za, [Date of access: 10 July 2010].

POTTER, S.M. (1995). A Nonlinear Approach to US GNP, *Journal of Applied Econometrics,* Vol. 10: 109–125.

POTTER, S.M. (1999). Nonlinear Time Series Modelling: An Introduction, *Journal of Economic Surveys,* Vol. 13 (5): 505-528.

QIN, D., CAGAS, M.A., MAGTIBAY-RAMOS, N. AND QUISING, P.F. (2007). Measuring Regional Market Integration in Developing Asia: A Dynamic Factor Error Correction Model (DF-ECM) Approach, *Working Paper Series on Regional Economic Integration,* No. 8.

RATFAI, A. (2003). How fast is Convergence to the Law of One Price? Very (When Price Differential are Properly Measured), *Central European University.*

RAVALLION, M. (1986). Testing Market Integration, *American Journal of Agricultural Economics*, Vol. 68: 102-109.

REVOREDO, C.L., NADOLNYAK, D.A. AND FLETCHER, S.M. (2004). Explaining Price Transmission Asymmetry in the US Peanut Marketing Chain, *Presented at the Annual Meetings of the American Agricultural Economics Association,* Denver, Colorado.

SEO, M. (2006). Bootstrap Testing for the Null of No Co-integration in a Threshold Vector Error Correction Model, *Journal of Econometrics,* Vol. 134: 129-150.

SERRA, T., GIL, J.M. AND GOODWIN, B.K. (2006). Local Polynomial Fitting and Spatial Price Relationships: Price Transmission in EU pork markets, *European Review of Agricultural Economics,* Vol. 33 (3): 415-436.

SERRA, T. AND GOODWIN, B.K. (2002a). Price Transmission and Asymmetric Adjustment in the Spanish Dairy Sector, *2002 AAEA-WAEA Annual Meeting.*

SERRA, T. AND GOODWIN, B.K. (2002b). Specification selection issues in Multivariate Threshold and Switching Models, *2002 AAEA-WAEA Annual Meeting.*

SHRESTHA, S.S. AND FRECHETTE, D. (2003). Transfer Costs and Spatial Price Efficiency in the Nepalese Tomato Markets, *Presented at the American Agricultural Economics Association Annual Meeting,* Montreal, Canada.

THOMPSON, S.R., SUL, D. AND BOHL, M.T. (2002). Spatial Market Efficiency and Policy Regime Change: Seemingly Unrelated Error Correction Model Estimation. *American Journal of Agricultural Economics,* Vol. 84 (4): 1042-1053.

TRENKLER, C. AND WOLF, N. (2003). Economic Integration in Interwar Poland – A Threshold Co-integration Analysis of the Law of One Price for Poland (1924-1937), *EUI Working Paper ECO.* No. 2003/5.

TSAY, R.S. (1989). Testing and Modelling Threshold Autoregressive Processes, *Journal of the American Statistical Association,* Vol. 84 (405): 231-240.

TSAY, R.S. (1998). Testing and Modelling Multivariate Threshold Models, *Journal of the American Statistical Association,* Vol. 93 (443): 1188-1202.

TUKKIES. (2010). Supply Chain Management in the South African Potato Industry. Report on Fresh Potatoes. *Department of Agricultural Economics, Extension and Rural Development. University of Pretoria.*

UCHEZUBA, D. I. (2005). Measuring Market Integration for Apples on the South African Fresh Produce Market: a Threshold Error Correction Model, *M.Sc. (Agric). University of the Free State,* Bloemfontein.

VAN CAMPENHOUT, B. (2007). Modelling Trends in Food Market Integration: Method and an Application to Tanzanian Maize Markets, *Food policy,* Vol. 32: 112-127.

VINK, N. AND VAN ROOYEN, J. (2009). The Economic Performance of Agriculture in South Africa since 1994: Implications for Food Security, *Development Planning Division Working Paper Series,* No. 17, DBSA, Midrand.

VOLLRATH, T.L. (2003). North American Agricultural Market Integration and Its Impact on the Food and Fiber System, *Agriculture Information Bulletin* No. 784, Washington, DC.

XIA, Y., SUSANTO, D. AND ROSSON, P. (2007). Testing the Market Integration in Regional Cantaloupe and Melon Markets between the U.S. and Mexico: An Application of Error Correction Model, *Presented at the Southern Agricultural Economics Association Annual Meeting,* Mobile, Alabama.

ZANIAS, G.P. (1999). Seasonality and Spatial Integration in Agricultural (product) Markets, *Agricultural Economics,* Vol. 20: 253-262.

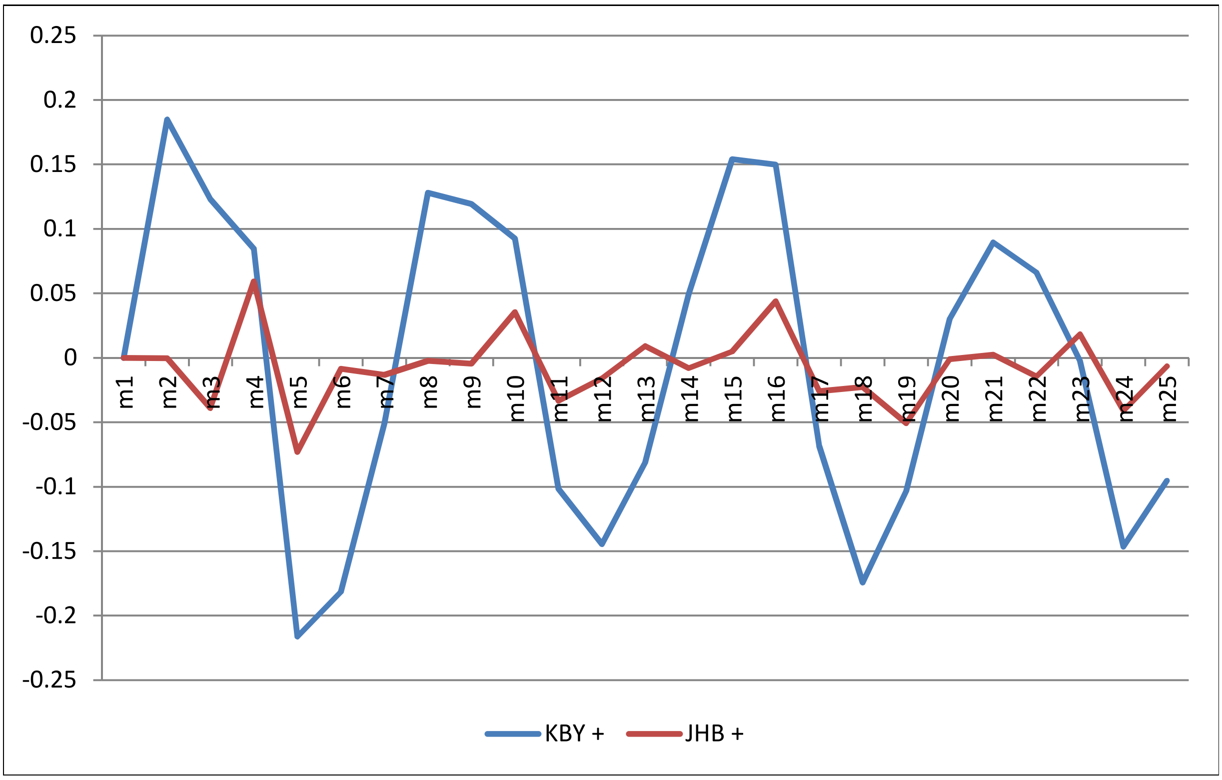

Figure A-1: Impulse Response function for KBY-JHB market pair
Source: Author's computation