An econometric analysis of spatial market integration and price formation in the Namibian sheep industry

by

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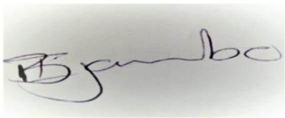
DECLARATION

I, Bertha Deshimona Ijambo, hereby declare that this dissertation submitted at the University of Pretoria in partial fulfilment for the degree of Master of Science in Agricultural Economics, is solely my own work. This dissertation has not been previously in its entirety or in part submitted at this or any other tertiary institution.

Signature: 

Date: 12 December 2017

DEDICATION

Primarily, I dedicate this dissertation to my late grandmother. Kuku, your departure left a big empty space that nobody will ever be able to fill. I dearly miss you, your jokes, and laughter. Secondly, I dedicate this dissertation to my mother, Eweline Ijambo, a lovely, hardworking, courageous, and prayerful woman whose words of encouragement gave me strength to push each day with persistence. Not to forget, Bertha Kapia my second mother, my godmother and namesake. She taught me that where you come from does not matter, what matters is your humility towards others, perseverance, tenacity and your desire to achieve success. I thank God for these prominent women in my life.

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ABSTRACT

The Namibian government introduced the Small Stock Marketing Scheme (SSMS) for the sheep market in 2004. The SSMS is a quantitative export restriction. Quantitative export restriction policies decrease the tradable quantity of a commodity, and increases domestic supply of a commodity, causing a lack of equilibrium in spatial markets. This, therefore, has the capacity to hinder market integration. Moreover, a quantitative export restriction disrupts the domestic supply and demand, and ultimately the equilibrium prices. A policy such as the quantitative export restriction therefore determines the domestic price levels. The effect of the SSMS on spatial market integration and price formation remains unclear. A lack of empirical evidence on spatial sheep market integration and domestic price levels can create challenges for policy makers. This is because a lack of evidence could prevent policy makers from implementing evidence-based policies, which might buffer poor consumers and producers from adverse price shocks, and lead to improved resource allocation.

This study hypothesises that the SSMS policy negatively affected the long-run equilibrium relationship and short-run dynamics between the Namibian and South African markets. The study further hypothesises that the policy negatively influenced the level of equilibrium prices. As a result, this study hence observes spatial price integration in the presence of the SSMS, by defining the long-run equilibrium and short-run dynamics. The spatial price integration analysis is evaluated by subdividing price series data into pre-

SSMS (1999M01-2003M12) and post-SSMS (2004M01-2015M12). The long-run equilibrium relationship is conducted with the Engle and Granger (1987) method and the Johansen (1988) cointegration approach. Short-run dynamics are, in turn, determined with an error correction model (ECM) and vector error correction model (VECM). The study also examined the impact of the SSMS on domestic price levels. This was done by recognising the reaction of the domestic supply, demand, and price functions to the SSMS. The analysis is conducted within the partial equilibrium framework (PEF). Additionally, the synthesis generated a simulation with the PEF to determine the impact on price changes were the SSMS to be removed.

The analyses acknowledged a long-run equilibrium relationship between the spatial markets. As predicted, the long-run equilibrium relationship is not the same, pre- and post-SSMS. The price transmission elasticity (0.94) post-SSMS is marginally higher than pre-SSMS (0.88) is, which contradicts *a priori* expectation that quantitative export restrictions weaken price transmission. The pre-SSMS evaluation indicated a presence of short-run dynamics. Post-SSMS, the VECM revealed no bidirectional effect. The VECM also specified that the Namibian prices are effecting the adjustments in the short run to return to the long-run equilibrium position. This implies that if there is a shock that disturbs the equilibrium between the two spatial prices, Namibian prices would move to restore equilibrium. Likewise, the study appraised the response of the supply and demand functions to the policy in the PEF, incorporating the SSMS as an export ratio variable. The PEF results displayed that the SSMS influenced the supply function negatively, because of the negative elasticity of 0.013. This denotes that in the presences of the SSMS a 10 per cent increase in the quantitative export ratio decreases supply by 0.13 per cent, in which the response is slow. A negative effect is bound to decrease supply, and increase domestic price levels. Furthermore, the SSMS had a positive influence on the demand function, with an elasticity of 0.03 for the export abattoir demand, and 0.93 for the non-export abattoir demand. A positive impact on demand means a decrease in the producer price increases demanded for live sheep. The price equation outcome revealed that the SSMS had an insignificant effect of -0.0044 on the domestic producer prices. The price equation result is attributed to the low elasticity of the SSMS in the domestic supply and demand equation; the continued increase in producer prices post-SSMS due to the drought; and finally, because the SSMS is allowed to vary. Based on the simulation results, the removal of the SSMS policy would increase domestic producer prices by 4 per cent and 6 per cent, in

2017 and 2018, respectively. The percentage increase is considered low, as a result, this suggests that other dynamic factors, such as drought and market structure, affecting prices.

This study therefore rejects the hypothesis stating that the long-run equilibrium relationship and short-run dynamic forces had reduced post-SSMS price transmission. The price transmission and speed of adjustment improved, post-SSMS. The study concludes that the SSMS policy did not have a detrimental effect, which was contrary to what was anticipated. The synthesis further fails to reject the hypothesis stating that the SSMS influenced domestic price levels, but the influence was very minimal and negligible. Both the spatial price integration and price formation analyses conclude that the SSMS had no detrimental effect on the sheep market. As a result, the study indicates that a quantitative export restriction policy, which varies, is better than an export control policy that does not allow any variation.

Keywords: Market integration, price formation, government intervention, quantitative export restrictions, Namibia’s sheep market

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LIST OF ACRONYMS

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
BoN	Bank of Namibia
CPI	Consumer Price Index
ECM	Error Correction Model
ECT	Error Correction Term
EGARCH	Exponential Generalised Autoregressive Conditional Heteroscedasticity
EPP	Export Parity Price
EU	European Union
GDP	Gross Domestic Product
IPP	Import Parity Price
Kg	Kilogram
LOP	Law of One Price
NAD	Namibian Dollar
NAM	Namibia
NamCo.	Namibia Allied Meat Company
NAP	Namibia Agricultural Policy
NCP	Northern Cape Province
OLS	Ordinary Least Squares
PBM	Parity Bound Model
PEF	Partial Equilibrium Framework
PWC	PricewaterhouseCoopers
R	Rand (South African currency)
SA	South Africa
SACU	Southern African Customs Union
SSMS	Small Stock Marketing Scheme
TAR	Threshold Auto Regressive Model
TIC	Threshold Cointegration Model
VAR	Vector Autoregressive model
VECM	Vector Error Correction Model

CHAPTER 1:
INTRODUCTION TO THE RESEARCH STUDY

1.1 Introduction

Numerous African governments adopted market liberalisation policies in the early 1990s. Researchers support the idea of market liberalisation because market liberalisation allows free trade, encourages market competition, and improves price transmission. Ghosh (2011) concurs that liberalisation can strengthen spatial market integration because liberalisation policies remove barriers on product movement, and allow price signals to transmit swiftly. Amikuzuno (2010) adds that trade liberalisation policies have the ability to expand domestic markets, and improve market integration by creating incentives for producers and consumers. Nonetheless, countries implementing full market liberalisation face challenges, such as competition, product dumping, fluctuating prices, and poor infrastructure. Baquedano and Liefert (2014) add that open economies are exposed to a type of food insecurity, which probably comes from importing world price shocks into domestic economies. In such instances, government intervention is required to improve infrastructural facilities, such as roads, communication, and market institutions, and so create price stabilisation policies.

Policies such as price stabilisation interventions contribute towards improving the speed of price transmission among spatially integrated markets (Goletti *et al.*, 1995). Yet, Goletti *et al.* (1995) note that certain other government interventions affect market integration, as interventions prevent the effective flow of price information. Ghosh (2011) further argues that government policies act as barriers to spatial price transmission, as some policies insulate the domestic markets from external markets, and prevent price convergence. The quantitative export restriction is an example in this regard, as it creates barriers between spatial markets. Baltzer (2013) motivates this statement by stating that quantitative export restrictions reduce, and disrupt the relationship between the domestic and international prices, especially when trade already exists between the two countries. Once a negative effect on market integration occurs, which may be a result of poor flow of price signals between spatial regions (Ghosh, 2011), government ought to re-visit or re-evaluate the policy.

The Namibian government introduced a quantitative export restriction, that is, the Small Stock Marketing Scheme (SSMS) for the sheep market in 2004. Quantitative export restriction policies decrease the quantity of a commodity that can be exported, and increase domestic supply of that commodity, causing a lack of equilibrium in spatial markets. Quantitative export restrictions disrupt the domestic supply and demand, and ultimately the equilibrium prices. Therefore, a quantitative export restriction such as the SSMS has the capacity to hinder spatial market integration, and determine domestic price levels.

Namibia and South Africa belong to the Southern African Customs Union (SACU), and the two countries are bound by similar reciprocal trade agreements. When economic integration and trade connect countries, market integration exists (Fackler & Goodwin, 2001). Gonzalez-Rivera and Helfand (2001) and Minot (2011) state that markets can be considered as integrated when they trade a homogeneous commodity, as is the case with Namibia and South Africa. However, it has been shown that market integration can occur in the absence of trade due to information being shared between markets (Fackler & Goodwin, 2001; Negassa *et al.*, 2003). Taljaard *et al*. (2009) affirm the existence of market integration between the Namibian and South African sheep markets. In view of the market integration concept, this means that a long-run equilibrium relationship exists between the Namibian and South African sheep prices.

Spatial market integration determines how prices in spatially separate regions with a homogenous good move together over the long run. Concisely, well-integrated markets contribute toward resource optimisation, market expansion, food accessibility, and price stabilisation. According to Van Campenhout (2012), integrated markets attract greater numbers of traders, and prices decrease because of an increased supply of a commodity in the market, which leads to exports. An increased supply of a commodity results in the commodity moving from a low-price region to a high-price region. This consequently allows for a price risk spread across a large geographical area (Van Campenhout, 2012). Price mechanisms in well-functioning markets permit market efficiency, which leads to Pareto optimality (Amikuzuno *et al*., 2015).

Spatial market integration can allow for an efficient transmission of price signals. These benefit agents, especially producers, who require accurate price signals in the market to make informed decisions. Producers rely on accurate producer prices to determine whether to increase or decrease supply. If spatial market integration does not prevail, price signals may not transmit between markets, which can result in misinformed decisions being made, and highly volatile prices. A lack of market integration hampers food reallocation from a food surplus country to a food deficit country, and thus has implications for food security.

Nevertheless, factors such as government interventions, market failure, high transaction costs, and poor infrastructure compromise spatial market integration. These issues cause structural problems, which in turn hinder the long-run equilibrium relationship. As noted by Myers and Jayne (2011), government interventions affect domestic price formation, and disturb spatial price transmission. Therefore, the quantitative export restriction (SSMS) introduced on the exportation of live sheep by the Namibian government is believed to have had an effect on spatial market integration and price formation. Given the dependency of Namibia's small stock industry on the South African market, it is therefore imperative to assess the effect of the quantitative export restriction on the Namibian sheep market.

1.2 Statement of the problem

Namibia and South Africa are trading partners, and the two countries are economically integrated because they belong to SACU. This means that market integration exists (Fackler & Goodwin, 2001), as mentioned earlier. Market integration benefits countries because it permits a smooth price transmission, resulting in the transfer of commodities from a surplus-producing country to a deficit-producing country (Amikuzuno *et al*., 2015). However, factors such as government interventions (for example the SSMS) affect market integration by disrupting the efficient flow of price signals, and this causes an interim move from the equilibrium position. A deviation from the equilibrium position then results in a change in the equilibrium pricing condition. A change in the equilibrium pricing condition consequently leads to changes in the domestic supply and demand within the market. This result in a possible market distortion, and an effect on trade relations between the countries involved.

Hence, it is possible to argue that the SSMS may have had a negative effect on spatial market integration and price formation. Primarily, because the policy is a quantitative export restriction, it buffers the domestic market from price shocks transmitting from the international market (Baltzer, 2013). An export restriction policy reduces the exportation of a commodity, which increases the domestic supply of that commodity and cause disequilibrium (Djuric *et al*., 2009). The SSMS policy thus demonstrates a probable direct effect on the effectiveness of market integration between Namibia and South Africa. Therefore, the policy gives grounds to question the influence of the SSMS on spatial price transmission in Namibia, pre- and post-SSMS, as it is anticipated to have changed. The researcher can reason that the SSMS changed the degree of market integration, and the speed of price adjustment between the two countries' sheep markets.

Trade occurs between Namibia and South Africa because spatial arbitrage opportunities exist for arbitrageurs in the two markets. Arbitrage is the mechanism behind the law of one price (LOP), which occurs in the presence of disproportional pricing conditions (Pippenger & Phillips, 2007). Similarly, arbitrage is an equilibrium concept (Mohanty *et al*., 1996); thus, any intervention such as the quantitative export restriction (for example the SSMS) affects domestic supply and demand, and equilibrium prices. Tentatively, quantitative export restriction policies play a role in determining domestic price levels (Djuric *et al*., 2015). Meyer *et al.* (2006) mention that trade volumes and policies define domestic prices in a country, and govern how the domestic market integrates with the rest of the world.

In considering this, it needs to be noted that Namibia is an open economy, and a net exporter of live sheep, particularly to South Africa. Sheep producers in Namibia operate under the export parity price (EPP). The price formation of sheep producer prices is a function of world producer prices, as well as exchange rates and trade policies. Considering the heavy reliance of the Namibian sheep producers on the South African market, fluctuations in South African prices are bound to reflect in the Namibian prices. In that view, the SSMS is not only expected to have an impact on market integration, but also on the domestic price levels. It is therefore imperative to not only establish the impact of the SSMS on spatial market integration, but to also determine the effect of the SSMS on domestic price levels.

A review of relevant literature reveals that only two studies have been conducted on the effect of the SSMS on prices between the Namibian and South African markets. These are studies by Sarker and Oyewumi (2015) and Taljaard *et al. (*2009). Firstly, the study by Taljaard *et al.* (2009) partially looks at price transmission between South Africa and

Namibia. The key objective of that analysis is to give an approximation of the socio-economic impact of the SSMS on the sheep market in the Northern Cape Province (NCP), in South Africa. Secondly, the study by Sarker and Oyewumi (2015) examined price volatility between Namibia's sheep market and South Africa's sheep market. Both these studies focus on the impact of the SSMS on the South African market. Furthermore, the researcher is unaware of any studies done on market integration and domestic price levels in the Namibian sheep market. Hence, this suggests the importance of assessing spatial market integration and domestic price formation in the presence of the SSMS.

1.3 Purpose of the study

The vital role that the sheep sector plays in Namibia's economic growth necessitates the assessment of the impact of the SSMS on spatial market integration and domestic price formation, especially because South Africa is Namibia's main trading market. Henceforth, it is crucial to determine the market relationship between the two countries. This is because well-connected markets are essential sources of food security, since the persistence of food scarcity in one country is determined by the integration of one country with other countries (Van Campenhout, 2012). Understanding the relationship between international prices and domestic prices is central in designing policies and appraising how exposed the domestic market is to fluctuations in international prices (Abidoye & Labuschagne, 2014).

Namibia operates under the EPP, which renders South African producer prices as key determinants of Namibian producer prices. Any change in the SSMS policy can govern the formation of domestic prices. Examining the domestic price formation complements the market integration analysis by providing a holistic evaluation of the SSMS on the sheep market. This is because the analysis of domestic price formation looks at the domestic market, while market integration observes the sheep market at a regional level. Analysing the impact of the SSMS on spatial price transmission, and understanding the determination of price levels, can assist in policy analysis. This, in due course, can serve as a starting point for analysing the performance of the Namibian sheep market. It is important to analyse the performance of an industry as this helps in making policy recommendations, and provides a suggested optimal environment for efficient price transmission. By doing that, the study aims to provide a better understanding of how the implemented policy has influenced price determination and market integration in the Namibian sheep market.

1.4 Research objectives

The overall objective of the analysis is to evaluate the effect of the SSMS on the sheep market. The study is divided into two parts. The first part evaluates the spatial price transmission, before and after the policy intervention. This is done in order to identify whether the SSMS changed the market integration between Namibia and South Africa. Secondly, the SSMS policy may have altered domestic producer price levels of the sheep sector. The second section therefore assesses the domestic supply, demand, and price blocks. This will inform the understanding of how the interactions of supply, demand, and price with the SSMS influence domestic price levels. Observing spatial market integration and domestic price formation, combined, will give an overview of how the sheep market functions.

The study aims to address the subsequent specific objectives:

- to examine the spatial price transmission in Namibia with reference to South Africa, that is, before and after the SSMS:
    - by determining the long-run equilibrium relationship, which indicates spatial price transmission and market integration between the Namibian and South African sheep markets; and
    - by determining the short-run dynamics causing co-movement of prices in the identified long-run equilibrium relationship, which indicates the speed of price adjustment.
- to determine the impact of the SSMS on domestic price levels.

1.5 Hypotheses

The purpose of the study is to evaluate the implications of the SSMS on market integration and the formation of domestic price levels in the sheep market. Quantitative export restrictions such as the SSMS act as barriers to price transmission, as these policies reduce and disrupt spatial price integration in the presence of trade (Ghosh, 2011; Baltzer, 2013). Moreover, the SSMS policy has reduced the trade volume of live sheep to South Africa. Because Namibia is a net exporter of live sheep and meat, price shocks in the South

African market are likely to influence domestic prices. There is a possibility that the SSMS affected domestic price levels. Given these circumstances, the present study hypothesises:

Hypothesis 1:
The long-run equilibrium relationship and short-run dynamics reduced between the Namibia and South African markets, post-SSMS.

Hypothesis 2:
The SSMS negatively influenced the level of local equilibrium pricing.

1.6 Methodology

Spatial market integration analysis examines the long-run equilibrium relationship and short-run dynamics. The long-run equilibrium relationship is estimated with cointegration techniques, which include the Engle and Granger (1987) and the Johansen cointegration approaches. Before determining the long-run equilibrium relationships, the univariate properties of individual prices series are tested. Specifically, the presences of non-stationarity price series are tested, using the Augmented Dickey-Fuller (ADF) test and Kwiatkowski-Philips-Schmidt-Shin (KPSS) test. Then, the short-run dynamics are determined with the estimation of the error correction model (ECM), and the vector error correction model (VECM).

In terms of domestic price levels, the response of the domestic supply, demand, and price blocks to policy changes can further affect the domestic producer price levels. Henceforward, for the price formation analysis, the partial equilibrium framework (PEF) is used to appraise the effect of the SSMS on domestic supply, demand, and price equations. The PEF is developed to serve as a policy tool that analyses the effect of policy changes on the sheep sector’s price levels.

1.6.1 Data sources

The study uses time series data obtained from the Meat Board of Namibia and other complementary secondary sources (such as World Bank database, Bank of Namibia (BoN), and Namibia Weather Bureau) to address the research objectives stated above.

Data such as gross domestic product (GDP) per capita, GDP deflator and Namibia’s total population are collected from the World Bank database; exchange rates and interest rates from Bank of Namibia; rainfall data from the Namibia Weather Bureau, and trade flow data and price series used in the PEF from the Meat Board of Namibia.

1.7 Organisation of the study

This study is organised in the following manner. Chapter 1 provides the introduction, moves into the problem statement, purpose of the study and a brief description of the methodologies used. Chapter 2 gives an overview of the Namibian agricultural sector and background to the SSMS, and looks at literature on market integration, price formation, possible analytical methods, and empirical evidence, thus giving an overview of the theoretical concepts underpinning the study. Chapter 3 addresses the methodological part of the study, and hence outlines the theoretical framework. Chapter 4 discusses the results from the analyses. Finally, the study ends with a summary and conclusion in Chapter 5.

CHAPTER 2:
NAMIBIAN AGRICULTURAL SECTOR, SSMS, MARKET INTEGRATION, PRICE FORMATION, AND GOVERNMENT INTERVENTIONS: AN OVERVIEW OF KEY CONCEPTS

2.1 Introduction

The Small Stock Marketing Scheme (SSMS) is a quantitative export restriction. A quantitative export restriction policy possibly insulates the domestic market from external market forces, and impedes market integration. Poor market integration hinders the flow of commodities and price information between two regions. A disruption of a commodity flow from one region to another is likely to affect market performance and efficiency. Literature agrees that a partial or a lack of market integration influences resource distribution and market efficiency, and this, in turn, has welfare implications for various market agents (Baltzer, 2013; Ghosh, 2011; Goletti *et al.*, 1995; Minot, 2011; Myers & Jayne, 2011). Secondly, the SSMS introduced in the sheep sector reduced the exportation of live sheep to South Africa. The export restriction increased the domestic supply of a commodity and this in turn influenced domestic prices (Djuric *et al.*, 2015). In that light, the SSMS could have affected the domestic price levels.

This chapter provides an overview of the Namibian agricultural sector, gives background information on the SSMS, and considers key concepts necessary for analysing market integration and price formation. In addition, this chapter discusses the different methods in market integration analysis to help identify the appropriate method to implement in the study, as well as provide empirical evidence. The chapter ends by reviewing the method capable of assessing the impact of the SSMS on domestic price levels.

2.2 Overview of the Namibian agricultural sector

Namibia is a semi-arid country characterised by low rainfall, limited arable land with poor soil, and poor vegetation. These factors contribute to poor farming conditions, and low productivity. As noted by Van Wyk and Treurnicht (2012), half of the country is not suitable for farming, and is prone to the occurrence of droughts. Apart from climatic challenges, Namibia's economy faces macroeconomic challenges such as fluctuations of the exchange rate, currency devaluation, slow gross domestic product (GDP) growth, high unemployment rates, mounting risk of input costs due to inflation, and unstable fiscal policies. Despite these, Namibia relies on the agricultural export market to stimulate and sustain economic growth (Schutz, 2009). The agricultural export market contributes to employment creation and foreign exchange earnings, through production and trade. That being the case, the agricultural sector is one of the most significant sectors in the country, contributing greatly towards economic growth. Farming contributes about 6.07 per cent to GDP, and roughly, 70 per cent of the population depends on agriculture for sustainable living (Van Wyk & Treurnicht, 2012).

The agricultural sector comprises of crops and livestock. Livestock is the leading sub-sector, due to the sector's adaptability to the climatic and physiological conditions. The Namibian livestock industry consists of cattle and small stock animals (sheep and goats). The small stock industry is second to the cattle industry, in terms of performance and revenue contribution to Namibia's livestock and meat industry. According to industry data sourced from the Meat Board of Namibia, between 1999 and 2015 the small stock industry, on average, contributed about 0.422 billion Namibian dollars (NAD),[1] and the cattle industry contributed 1.10 billion NAD. Namibia exports a large number of small stock animals to various countries such as South Africa and Botswana (Schutz, 2009). This is because of the proximity of the South African and Botswana markets to the western and southern parts of Namibia, where most of the small stock farming occurs.

According to Kahuika *et al.* (2006), approximately 68 per cent of small stock farming takes place in the drier, southern part of Namibia, in the Hardap and Karas regions. In these two regions, a high concentration of commercial small stock and small-scale farming exists. In particular, producers in these two regions farm with Karakul, the indigenous Damara, Van Rooi, Blackhead Persian, Mutton Merino, Dorper, Dorper crossbreed, and other crossbreeds (Spears & BFAP, 2014). The productivity of these breeds permits Namibia to export high quality and wholesome lamb and mutton produce. The commodities are then exported to Australia, New Zealand, the United Kingdom, Ireland, South Africa, Japan, the Middle East, North America, and the European Union (Van Wyk & Treurnicht, 2012). Out of all the export markets, the European Union market is

1 1 US dollar=8.14 NAD, on average, between 1999 and2015.

Namibia's most lucrative market for boneless sheep meat. South Africa is Namibia's main trading partner in terms of live sheep[2] and meat because of the economic integration and geographical orientation between Namibia and South Africa. Therefore, spatial market integration exits between the Namibian and South African market, which means that a government intervention can affect domestic price integration and price formation.

2.3 Background to the Small Stock Marketing Scheme (SSMS)

Before 2004, Namibian small stock farmers had marketed large numbers of high-grade and off-grade sheep to South African abattoirs and feedlots. High-grade animals are animals with good meat palatability, often A,[3] AB and B grade animals, and off-grade animals are matured C grade animals with the least palatable meat. The high number of sheep marketed by Namibian producers led to high export volumes, especially of live sheep, to South Africa. The increase in the number of live sheep exports resulted in an underutilisation of Namibia's export abattoirs (Schutz, 2009).

The government's aim is to promote and improve development and efficiency in the agricultural sector. Thus, the government documented a wide range of policy instruments under the National Agricultural Policy (NAP). The NAP is based on various objectives, including government's contribution towards economic growth, employment creation, income inequality reduction, and poverty alleviation (MAWF, 1995). In addition to the NAP, there is a need to push for the utilisation of local export abattoirs and processing plants, driven by Namibia's aim to promote value-addition in Namibia, as well as to advance development and efficiency, so as to become an industrialised country by 2030 (Eita *et al*., 2002). The need for government to attain economic development led to the government introducing the SSMS, which promotes a redirection of livestock (mainly sheep) to the local slaughtering and processing plants (Schutz, 2009).

The government, through the Ministry of Agriculture, Water and Forestry (MAWF), gazetted the SSMS under section 20 of the Meat Industry Act, 1981 (Act No. 12 of 1981), in June 2004. The scheme was introduced as an alternative to the previously proposed 15

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2 Sheep producers market both sheep and lamb, but market mainly lamb because of a high price incentive obtained when marketing lambs. The study refers to marketable lamb and sheep as slaughter sheep or simply sheep, due to a lack of accurate data.

3 A grade = youngest and C grade = oldest carcasses.

per cent export levy on live sheep (PWC, 2007). The SSMS was expected to be in place for a period of four years (from 2004 to 2007) (Schutz, 2009). During the four-year period, sheep producers had to redirect live sheep to export abattoirs in order to increase the utilisation of export abattoirs and contribute to value addition in the small stock industry. Moreover, the scheme comprises the placing of a quantitative export restriction on the exportation of live sheep by using a quantitative export ratio (export to slaughter).

The quantitative export ratio requires farmers to sell sheep for slaughter to an export abattoir of the farmer's choice and convenience. For example, a 1:1 ratio means that for every one sheep exported, one must be slaughtered domestically. This 1:1 ratio is the ratio that the SSMS initially started with. For the past 12 years, the quantitative export ratio has been fluctuating between 1:6, 1:3, and 1:1, with the current year's (2016) ratio standing at 1:1. The quantitative export ratio amendments were made to accommodate the increased slaughter demand, especially during times of drought when sheep producers are destocking. Another reason would be the increase in the number of export abattoirs from two to four, which caused an increase in total slaughter capacity from 612 150 to 1 258 950 head of sheep (Schutz, 2009). The rise in total slaughter capacity necessitated frequent amendments to the quantitative export ratio to ensure the proper utilisation of Namibia's slaughter facilities.

Essentially, the scheme was implemented to decrease the export of live sheep, and increase the utilisation of export abattoirs by 100 per cent by 2007 (PWC, 2007). Resultantly, capacity utilisation stood at a record of 57 per cent utilisation in 2004, and increased to 75 per cent in 2007. Job creation was considered during the implementation process of the SSMS. The SSMS facilitated the creation of more than 300 jobs in the export abattoir and processing plants, but some individuals in the auctioneering and transport businesses lost employment as a result (Schutz, 2009). The scheme was implemented to create value addition; however, value addition has not improved beyond slaughtering and exportation of carcasses, and de-boning represented 0.42 per cent of total export (Schutz, 2009). The scheme makes provision for both sheep and goats, but due to the lack of a formal goat market in Namibia, the scheme has not been applicable to the goat sector. Figure 2.1 below depicts the number of small stock marketed (sheep), before and after the introduction of the SSMS. The non-export approved abattoirs supply sheep meat mainly to the domestic market, and the export approved abattoirs supply to the international and domestic markets. Figure 2.2 below illustrates how the increased throughput to export abattoirs increased mutton exports and decreased mutton imports.

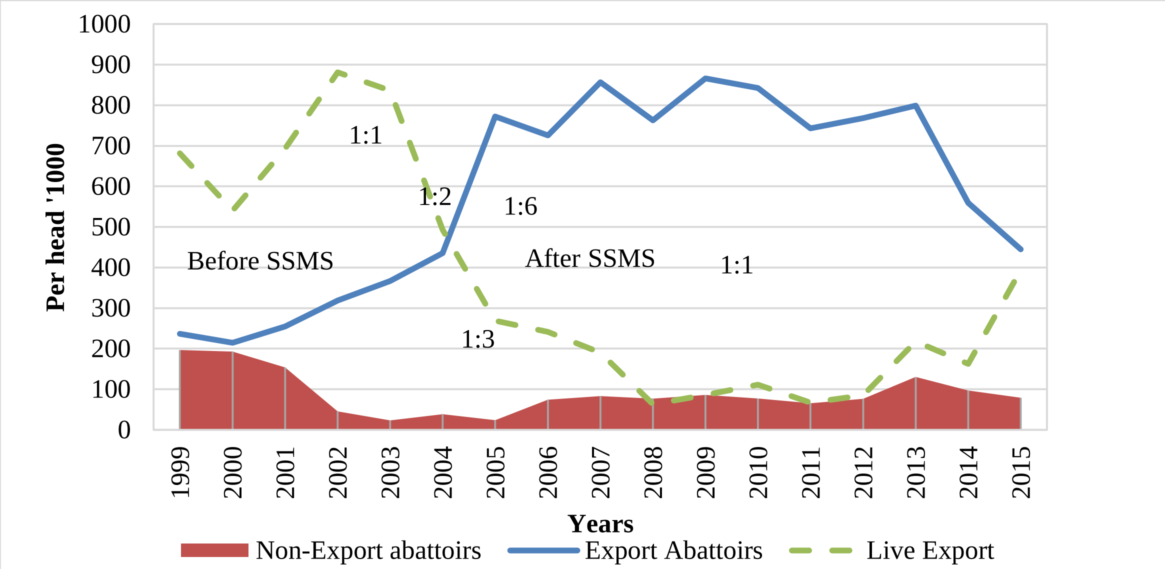

Figure 2.1: Small stock marketing (Sheep)
Source: Meat Board of Namibia, 2015

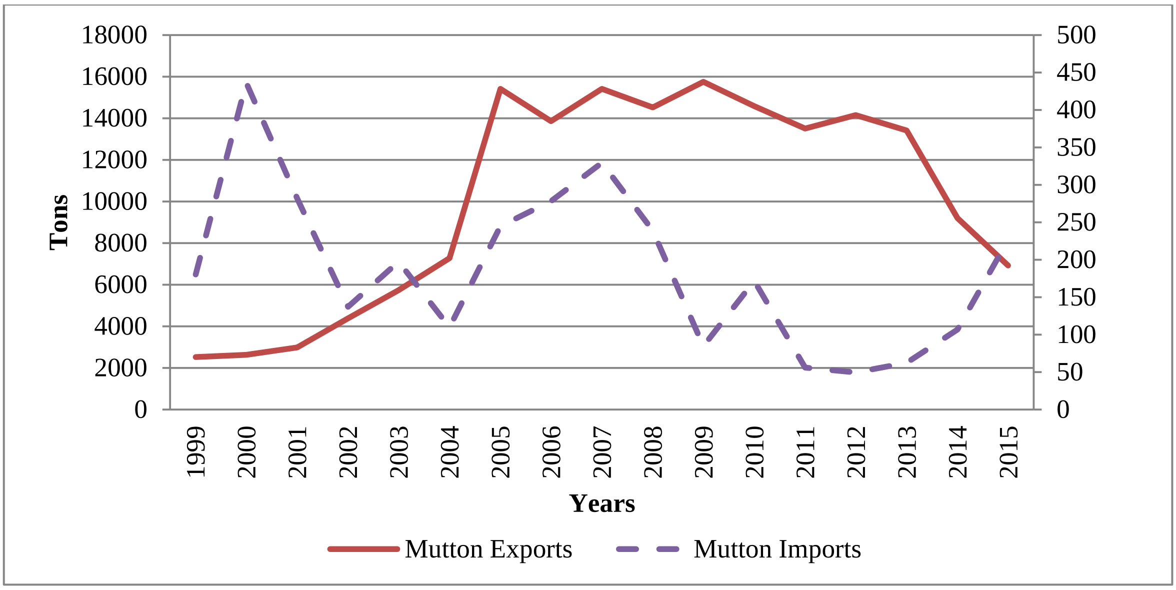

Figure 2.2: Mutton exports and imports
Source: Meat Board of Namibia, 2015

Deducing from Figure 2.1 above, it can be seen that from 2004, the export of live sheep decreased, while the slaughter of sheep increased at domestic export abattoirs and non-export abattoirs, *ceteris paribus*. The drought that persisted from the end of 2012 through to 2015 caused a large reduction in the number of live sheep marketed to export abattoirs, non-export abattoirs, and in the exportation of live sheep to South Africa (Figure 2.1

above). An important insight is that at the onset of drought (at the end of 2012), farmers sold large quantities of sheep as a drought management practice. This led to a reduced availability of live sheep on the market in 2013, which eventually reduced sheep throughput to export abattoirs, non-export abattoirs and the live sheep trade. A decrease in throughput to export abattoirs in 2013 further led the closure of one of the export-approved abattoirs, Namibia Allied Company (NamCo). The closure of NamCo led to a decrease in total slaughter capacity at export abattoirs, and an increase in the exportation of live sheep towards end of 2013, through to 2015 (Figure 2.1 above). An increase in live sheep exports has been attributed to the amendment of the quantitative export ratio to a 1:1 ratio, which defeats the purpose of the policy.

From 2015, the slaughtering at export abattoirs continued to decrease, whereas, the export of live sheep increased, such that the two figures can be seen to be drawing close. A decrease in throughput at export abattoirs could possibly be attributed to poor body weight, making some sheep unsuitable to slaughter. The average carcass mass dropped from 19.97 kilogram (Kg) in 2014 to 18.73 Kg in 2015. Nevertheless, as shown in Figure 2.2 above, an increase in the slaughter numbers at domestic export abattoirs increased the export of mutton, and decreased mutton imports. When throughput to export abattoirs started decreasing, the mutton supply also reduced, resulting in an increasing mutton import again from 2013 to 2015. Furthermore, Figure 2.3 below shows the drastic percentage changes in livestock marketed to South Africa.

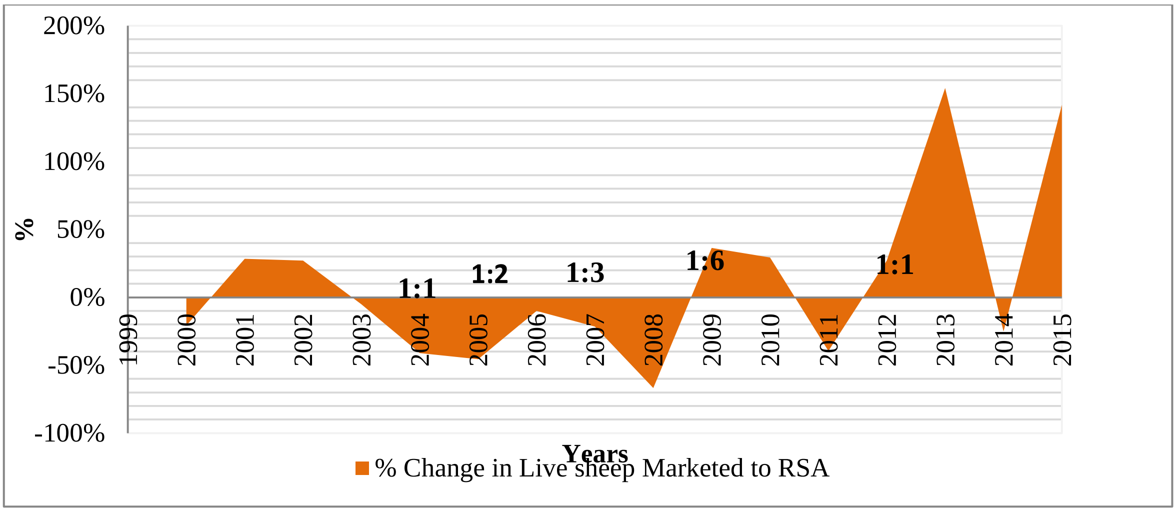

Figure 2.3: Percentage change in Namibian live sheep marketed to South Africa
Source: Meat Board of Namibia, Monthly Statistics, 2015

From Figure 2.3, it evident that in 2004, the introduction of the SSMS caused the export of live sheep to South Africa to drop by 33 per cent. An interesting fact to note from Figure 2.3 (above) is the high decrease in live sheep marketed in 2008, resulting from an increase in the quantitative export ratio from 1:3 in 2007 to 1:6 in 2008. The incidence of higher average prices in the South African market, compared with prices in the Namibian market, caused a high increase in the exportation of live sheep to South Africa between 2009 and 2010, post-SSMS. An increase in producer prices in both the Namibian and South African markets constituted a mechanism to incentivise producers, after a drastic drop in the live sheep marketed in 2008. Increases between 2012 and 2015 are attributable to drought. As mentioned earlier, the drought affected sheep productivity and production, and reduced throughput to export abattoirs, which caused the closure of the NamCo abattoir. In the end, the drought and closure of NamCo led to an oversupply of sheep to other existing export abattoirs. The oversupply triggered an increase in the exportation of live sheep to the South African market. Hypothetically, an increase in the supply of a commodity can decrease prices (Ferris, 2005). Therefore, the SSMS not only reduced the exportation of live sheep, holding other factors constant, but also affected producers negatively.

Unfortunately, the policy negatively affected small-scale farmers by excluding producers from marketing sheep to export abattoirs. This is because small-scale farmers sell off-grade (mainly C-grade) animals with a low carcass weight, which ultimately fetch low prices per kilogram-carcass. Commercial farmers produce sheep that fetch reasonable prices. However, because they have very little bargaining power (Van Wyk & Treurnicht, 2012), commercial producers are also deprived of attaining high prices. Both small-scale and commercial producers are affected negatively (Schutz, 2009). This is expected because export restrictions increase domestic supply and this consequently causes a decrease in domestic prices (Djuric *et al*., 2015). The decrease in producer prices violates one of the scheme's principles, as the SSMS promised to ensure competitive prices to producers, abattoirs and tanneries (Kahuika *et al*., 2006). Van Wyk and Treurnicht (2012) argue that the policy intervention left sheep producers with little revenue, and some producers resorted to other profitable ventures such as game and cattle farming. Therefore, the introduction of the SSMS is seen as one of the reasons why the sheep industry has seen a decrease in sheep production (Figure 2.4 below).

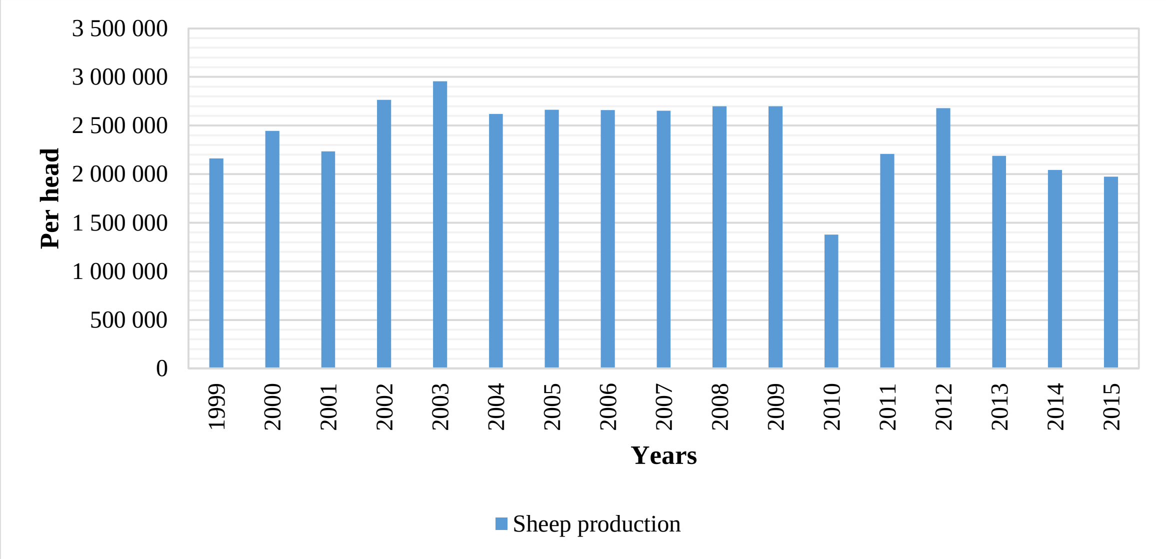

Figure 2.4: Sheep production
Source: Meat Board of Namibia, 2015

The government established the SSMS on the following principles: promotion of domestic slaughter; enabling price monitoring to ensure price competitiveness; and accommodating producers' local slaughter demands (PWC, 2007). In reality, many of these principles have not been adhered to. The SSMS created a high dependence of sheep producers on a few export abattoirs and limited producers' bargaining power (Schutz, 2009). The sudden increase in supply to export abattoirs and relative constant demand of sheep by export abattoirs pushed producer prices down. Figure 2.5 below illustrates the fluctuations in Namibia's average producer prices, as well as South African average producer prices.

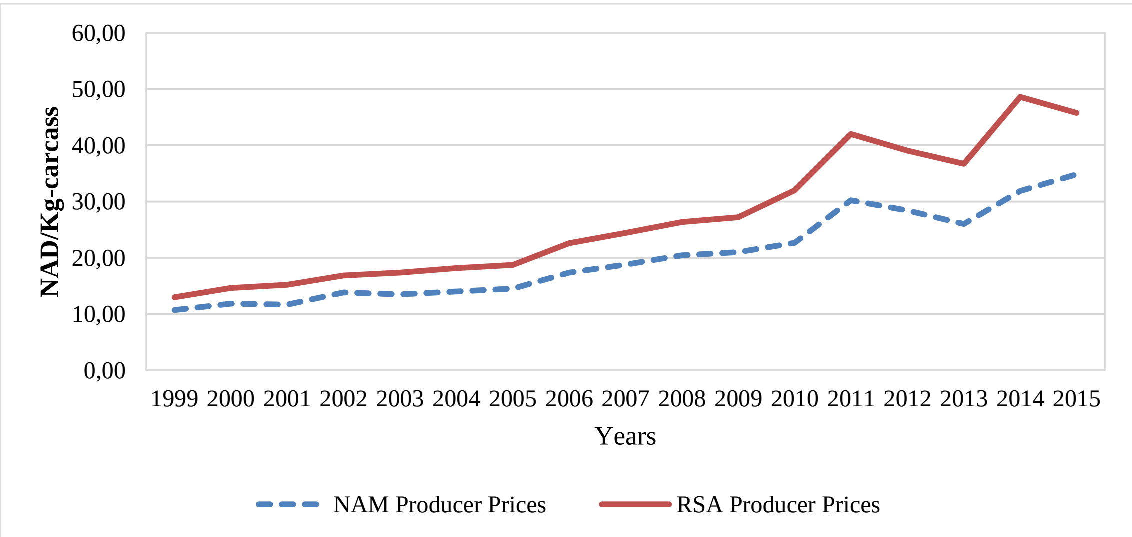

Figure 2.5: Average producer prices for Namibia and South Africa
Source: Meat Board of Namibia, 2015

According to Morris and Mare (2013), the South African market has always been the best-price market for Namibian producers. Namibian producers prefer selling sheep to the South African market because of the high, average sheep producer prices (NAD/kg carcass weight) offered in the South African market. As presented in Figure 2.5 above, the average price difference was 3.09 NAD[4]/kg prior to 2004, while the average price difference increased to 8.22 NAD/kg after the introduction of the scheme. The price gap has widened between the Namibian and South African producer prices, over time (Schutz, 2009; Taljaard *et al.*, 2009; Van Wyk & Treurnicht, 2012). This is expected because a quantitative export restriction policy can drive a wedge between the international and domestic markets (Taljaard *et al.*, 2009). Bonarriva *et al.* (2009) confirm that a quantitative export restriction policy results in domestic prices being lower than the international prices are, due to an increased supply of a commodity on the market (Bonarriva *et al.*, 2009). On average, producer prices have increased by 8.08 per cent in Namibia over the past 12 years, whereas in South Africa, producer prices increased by 9.74 per cent. Taljaard *et al.* (2009) state that pre-SSMS, Namibian export abattoirs offered a slightly higher price for A2 grade (young sheep with less fatness) carcass, as compared with the same A2 grade carcass offered in South Africa. Nevertheless, the A2 grade carcass price changed after the introduction of the scheme.

In summary, the types of government policies in place affect producers' decisions (Happe *et al*., 2006), for example on whether to reduce or increase a commodity's supply. On occasion, farmers might decide to withdraw from producing, or reduce production of a commodity. The decision made influences the supply of a commodity, and the tradable quantity between markets. This eventually affects equilibrium supply and demand, and hence the equilibrium in domestic prices. Babiker and Abdalla (2009) conclude that price transmission analysis considers two markets, each with their own supply and demand, and this equilibrium in supply and demand recognises domestic equilibrium prices. The introduction of a policy in any of the two markets can move prices away from the autarky price, and disturb the product flow from a surplus-producing country to a country with a commodity deficit. The policy thus could have affected spatial market integration and price formation.

4 Producer prices are measured in Namibian dollar per kilogram (NAD/kg).

The SSMS reduced the number of live sheep exported to South Africa; it also influenced domestic prices and distorted the sheep market by creating a market in which producers are highly dependent on export abattoirs. A restrictive policy, such as the quantitative export restriction, can influence the domestic equilibrium pricing condition. The SSMS also negatively influenced trade between Namibia and South Africa because it reduced the live sheep supply to some abattoirs in the northern regions (Sarker & Oyewumi, 2015; Taljaard *et al.*, 2009). Based on these points, the researcher questions the impact of the SSMS on spatial price integration and domestic price levels, as these concepts are not well researched in Namibia.

2.4 Theory on market integration

Baulch (1997) mentions that market integration has been an important topic because of its central connection to policy interventions, such as price stabilisation policies and market liberalisation policies. Measuring market integration is the foundation for understanding how certain markets work (Ravallion, 1986). As a result, the theory noted below helps to form expectations on the effect of the SSMS on the sheep market integration in Namibia.

2.4.1 Relation of the law of one price to market integration

Market integration is founded on the law of one price (LOP) idea. At an appropriate level, price transmission is able to cause an efficient market arbitrage, and create well-functioning and efficient markets, which effect is known as LOP in a competitive market (Abidoye & Labuschagne, 2014). In the presence of LOP, homogenous goods ought to sell at the same price in separate regions, taking into consideration transaction costs and exchange rate conversions (Bukenya & Labys, 2005; Fackler & Goodwin, 2001; Sexton *et al.*, 1991). The notion of LOP indicates that the price differential in spatially integrated agricultural commodity markets should not exceed transaction costs (Baltzer, 2013; Kurosaki, 1996). If price differentials exceed transaction costs, this creates profitable trade opportunities for arbitrage.

Arbitrageurs exploit profitable trade opportunities by transferring a commodity from a low-price market to a high-price market; that is, when market integration exists. In the process, arbitrage is an equilibrium condition behind the LOP concept (Mohanty *et al.*, 1996; Pippenger & Phillips, 2007), and this condition drives prices towards equality in spatially separate markets. Prices can converge without arbitrage, but for the strict version of LOP to hold, arbitrage must be present (Pippenger & Phillips, 2007). The strict version of LOP rarely occurs in reality because there are short-run dynamics, which cause temporary deviations from the equilibrium price. This affects arbitrage, leading to weak LOP. Accordingly, an efficient arbitrage process prevents unnecessary price movement in spatial regions by stabilising market prices and allowing prices to transmit smoothly (Kurosaki, 1996).

Fackler and Goodwin (2001) hypothesise that a single price is likely to occur in spatial markets when trade and arbitrage connect markets. In the absence of trade, and when the spatial price differential is smaller than or equal to transaction costs, the domestic market becomes unrelated to external markets (Kurosaki, 1996). Baltzer (2013) emphasises that when there is no trade between separate markets, domestic supply and demand dynamics determine domestic prices, and the domestic product becomes unconstrained by the import- and export-parity prices. Resultantly, markets become segmented the moment when there is a lack of trade, and the market segmentation notion contradicts and violates LOP. It is important to note that market integration also occurs in the absence of trade (Fackler & Goodwin, 2001), because economic integration causes price co-movement. This means that when markets share information, market integration is possible. Nevertheless, once trade exists, LOP predicts the relationship between the domestic market and international markets (Baltzer, 2013).

A situation where LOP does not hold does not automatically indicate that there is no market integration. It simply means that there is some inefficiency in the transmission process, and therefore the market integration is not perfect. Theoretically, LOP is expected to hold in free market economies, in the absence of government interventions, which is rarely the case in reality. In a free market economy, LOP prevails in spatial markets when prices converge to a single price, taking into consideration transaction costs (Fackler & Goodwin, 2001). Likewise, market integration analysis uses LOP on the basis that if price shocks transmit on a one-to-one ratio, then there is an integration of prices in spatial markets. The one-to-one transmission is plausible; firstly, after prices of a homogenous commodity in two distinct markets equilibrate; secondly, when prices originate from separate markets where arbitrage exists, and where there is a perfect co-movement of prices; and finally, when price differentials cover the relevant transaction costs (Pippenger & Phillips, 2007). A violation of these presumptions will not permit LOP to hold. This means that the long-run price transmission elasticity of one, implied by LOP, will not hold. However, the long-run price transmission elasticity of less than one implied by the weak LOP will hold. Viju *et al.* (2006) add that the costs of arbitrage, error in data, and the way in which prices are defined also contribute to the failure of LOP.

Deviations from LOP are possibly attributable to geographical location, distance between spatial regions, and policy intervention. This means that the further the distance is between separate markets, the higher the transaction costs are, and the higher is the possibility of price differential being less than the transaction costs, which causes market segmentation (Kurosaki, 1996). Policy interventions may lead to imperfect markets (monopolistic or oligopolistic markets), which can insulate the domestic market, and prevent prices from converging to a single price, even after considering transaction costs. This violates the LOP, and causes a deviation from the LOP assumption. As such, LOP is crucial in identifying spatial price transmissions, and comprehending the efficiency of a market. This study follows the principle of LOP in explaining market integration.

2.4.2 Market integration and price transmission

The terms ‘market integration’ and ‘price transmission’ are often used interchangeably. Market integration occurs when there is a co-movement of price in spatially separate markets. Two markets are integrated if they trade a homogeneous commodity, and share the same long-run information (Gonzalez-Rivera & Helfand, 2001). Gonzalez-Rivera and Helfand (2001) place great emphasis on the existence of a physical trade flow of a commodity for market integration to be present. Yet, Fackler and Goodwin (2001) recognise that trade flow is not the only factor leading to market integration, as market integration can occur even when two countries belong to a common trading network. Market integration can be direct, through trade, or indirect because of economic integration. This study uses Fackler and Goodwin (2001)’s definition of market integration as the study recognises that trade flow plays an important role in market integration but it is not a necessary condition for market integration occur. Goletti *et al*. (1995) denote market integration as the perfect, or less than perfect, transmission of price signals among separate regions.

Price transmission in spatially separate regions takes place when price shocks from one market transmit to another market. Price transmission is the long-run relationship of prices, although the speed of adjustment determines the time taken for markets to absorb changes. Price transmission is defined by concepts such as completeness, dynamics, and speed of adjustments, while these same theories assess market integration (Rapsomanikis *et al.*, 2004). Spatial price transmission is a topic widely assessed in the context of LOP (Acosta, 2012). The price transmission theory is vital in conceptualising the degree of market integration. The main idea behind market integration is to study the degree of price transmission, and speed of price adjustment, in spatially separate markets. Therefore, the concepts of market integration and price transmission are used interchangeably, because price transmission forms the substance of market integration.

2.4.3 Market integration versus market efficiency

This study also acknowledges the difference between market integration and market efficiency, because these terms are sometimes misunderstood. Market integration and market efficiency are different concepts that need to be perceived differently (Barrett, 2001; Barrett & Li, 2000; Negassa *et al.*, 2003), because differentiating between the two notions can help with the interpretation of either analysis. Barrett (2001) and Barrett (2005) define market efficiency as a condition that satisfies the zero marginal benefit of the equilibrium condition, and this concept refers to welfare efficiency and it assumes Pareto efficiency. Negassa *et al*. (2003) explain spatial market efficiency as being an equilibrium condition of the market, where no unexploited profitable trade opportunities exist for an arbitrage process. This means that market efficiency assumes perfect competitiveness in the long-run market equilibrium.

Fackler and Goodwin (2001), and Goodwin and Piggott (2001) define spatial market integration as the degree to which supply and demand shocks in one market transmit to another market. Myers and Jayne (2011) mention that spatial market integration arises from the inter-regional flows of information about supply and demand, as well as equilibrium prices. This study places emphasis on market integration, specifically spatial price integration.

2.4.4 Extreme concepts of market integration

Spatial market integration has two extreme concepts, to be precise, market integration and market segmentation. Market segmentation occurs the minute a country produces a non-tradable commodity. This results in market isolation, whereby price shocks arising in one market do not distress prices in another market (Fackler & Goodwin, 2001). Fackler and Goodwin (2001) further stipulate that if markets trade, market integration can be complete or imperfect, depending on the market structure characterising the industry. In a perfectly competitive market structure, market integration permits full transmission of price shocks from one market to another market at some time, on an equal basis. This implies the existence of the LOP, although according to Tappata (2009), partial transmission may occur in highly competitive markets due to consumers' willingness to incur costs in searching for information about market prices. The insulation of domestic markets, due to market control resulting from monopolistic or oligopolistic market behaviour, can potentially hinder price shocks from flowing between markets. Such insulation can be achieved by allowing partial transmission of price shocks between the domestic market and the rest of the world. This study aims to test market integration by following the principle of LOP, as mentioned earlier.

2.4.5 Factors affecting price transmission

Several factors that impede the complete transmission of price signals have been identified. The most-cited causes of imperfect price transmission are inadequate development of market fundamentals, market failure, government interventions, and high transport costs (Meyer & von Cramon-Taubadel, 2004). Baquedano and Liefert (2014) identified price and border policies, changes in exchange rates, market structure and conditions, transaction costs, and substitutability between domestic and foreign goods as being factors that affect price transmission. Abidoye and Labuschagne (2014) add that the level of transportation cost, lack of market information, trade barriers or uncompetitive markets influence price transmission. Minot (2011) and Myers and Jayne (2011) add that government tariffs and policies, high transaction costs, and information asymmetry disrupt market operations and performance. These create disincentives for producers and consumers in the market, and hinder effectiveness in the market chain (Minot, 2011; Myers & Jayne, 2011). For instance, high transaction costs in markets allow partial integration or no integration at all. Moreover, high tariffs insulate domestic markets and cause a lack of price shock absorption from the international to the domestic market. Government policies, such as quantitative export restrictions and exchange rate policies hinder perfect price signal transmission in spatial markets. For an accurate transmission of price signals, an appropriate level of spatial market integration is essential, because market integration potentially contributes to the effectiveness of markets.

The potential contribution of market integration to market efficiency has rendered market integration tests as significant tools in appraising the impacts of market changes and policy regimes affecting domestic prices in spatial price integration. Price transmission analyses have come to be essential in providing insight on exactly how changes in one region transmit to another region through replicating the degree of market integration (Rapsomanikis *et al.,* 2004). The degree of market integration is determined by the long-run relationship. The long-run equilibrium relationship measures the effect of a price shock in one market on prices in another market. Analysing whether spatial prices move together in the long-run period provide a better indication of price transmission (Viju *et al.,* 2006). On the other hand, a short-run dynamic analysis presents the speed of price transmission in markets in terms of days, weeks, or months (Goletti & Babu, 1994), and shows the length of time that price shocks take to transmit to another market. These are necessary because prices in the short run may temporarily deviate, converge over a long-run period, and cointegrate (Viju *et al.,* 2006). Goodwin and Piggott (2001) show, theoretically, that any price deviation from the equilibrium position between two markets corrects through spatial arbitrage condition, as prices converge. Accordingly, it is wise to look at the long-run price relationship, as it better explains the equilibrium condition (Sexton *et al.,* 1991) and the short-run adjustment dynamics in the market. Assessing the market integration components (long-run equilibrium relationship and short-run dynamics), pre- and post-SSMS, can give a clear distinction of the changes that may have occurred. This could help answer the hypotheses stated initially that the long-run equilibrium relationship and short-run dynamics deteriorated between the Namibian and South African markets, post-SSMS.

2.5 Price formation

Price transmission and price formation include the effects of arbitrage. The arbitrage condition is dependent on the supply and demand in different markets. According to

Meyer (2005), when arbitrage does not exist between two markets, domestic supply and demand forms domestic prices, known as the equilibrium-pricing condition. Once arbitrage connects regions, the equilibrium price in one region defines the equilibrium price in another region (Chisanga, 2012; Meyer, 2005). Meyer *et al*. (2006) add that there are three trade regimes; autarky, import parity price (IPP), and export parity price (EPP). These trade regimes determine domestic price formation, depending on the trade flow. IPP occurs when a country is a net importer, and here the domestic commodity price is a function of world price, exchange rates, transportation costs, and possible import tax. EPP occurs when a country is a net exporter of a commodity, and at this point, the domestic price is a function of world price, exchange rates, transportation costs and export tariffs. In the autarky trade regime, domestic price formation lies within the price band of IPP and EPP, that is, domestic supply and demand forms domestic prices. Parity prices are border prices, and these prices are often preferred in testing LOP, instead of internal prices (Meyer, 2005).

Namibia is a net exporter of live sheep, thus it operates under the EPP trade regime. As a result, sheep producers trade at, or close to, export parity price. Namibian producer prices are a function of South African producer prices (a proxy of world producer prices), the exchange rate, and policies. Consequently, the SSMS could have affected the domestic price levels, as well as spatial market integration.

Identifying and studying exogenous and endogenous variables affecting the equilibrium supply and demand of the sheep market aids in gaining an understanding of how domestic price levels form. A country's trade volumes and policies influence the level of domestic prices, and this guides how the domestic market integrates with the rest of the world (Barrett & Li, 2000; Meyer *et al*., 2006). Reviewing the formation of domestic price levels, which is also known as the equilibrium price condition, can provide a detailed explanation of how market distortions such as the SSMS affect the pricing systems.

2.6 Theory on market integration methods

2.6.1 Methods used in market integration analysis

In assessing market integration, analysts have presented different tools over the years for analysing spatial price transmission. Price transmission methods discussed include price correlation, a regression-based model, and cointegration models of the linear cointegration approaches like Engle-Granger and vector error correction model (VECM). Linear models evolved further to account for asymmetry with the threshold vector autoregressions (TAR) model, and the parity bound model (PBM). The method of choice depends on how well the model answers the research objectives and the availability of data. In some of these methods, Negassa *et al.* (2003) indicate that some analysts use prices, while others use prices and trade flow, or prices, trade flow and transaction costs, depending on the available data. Earlier studies mainly used prices because of the impression that prices in spatially separate markets are highly correlated (Fackler & Goodwin, 2001; Sexton *et al*., 1991).

Correlation and regression-based models were the earliest methods developed for market integration assessments (Fackler & Goodwin, 2001; Fackler & Tastan, 2008; Goodwin & Piggott, 2001). However, correlation and regression-based methods are heavily criticised because these methods ignore market dynamics and non-stationarity in price series. The latter can cause spurious results. Negassa *et al*. (2003) argue that the price correlation method ignores dynamic factors. Dynamic factors include inflation, transaction costs, policies, trade flow, and climatic conditions (Negassa *et al*., 2003). The price correlation method can indicate a high degree of market integration when there is no integration. This is because the co-movement of prices may well not only be a result of market integration, but might be a result of economic integration.

The regression-based model is an improvement on the correlation model. The regression-based model uses the ordinary least squares (OLS) technique. Negassa *et al*. (2003) criticise the regression-based method by stating that a unit root in the price series violates the classical OLS assumptions, and makes hypothesis testing difficult. Abdulai (2007) reasons that statistical significance in a regression-based method may be a result of common trends in variables such as population growth, inflation, or climate patterns, rather than price integration.

Fackler and Goodwin (2001), in turn, conclude by saying that price correlation and regression-based methods are similar, and the two models have some common problems. Fackler and Goodwin (2001) further add that the two models' empirical tests are developed in the same way, but interpretations differ, since the regression-based method presumes causality in the estimation and interpretation of results. The joint determination has caused researchers to adopt instrumental variables to obtain consistent estimates (Fackler & Goodwin, 2001). As a result, researchers have resorted to using other time series methods, due to shortcomings in the price correlation and regression-based methods.

The bivariate regression function is criticised on the ground of its static nature because spatial arbitrage conditions presume the coexistence of prices, but it does not recognise lags in the adjustment of prices (Fackler & Goodwin, 2001). Hence, linear logarithm models share some of the shortcomings with the correlation model, and this may lead to model misspecification due to the strict assumptions of LOP (Badiane *et al*., 2010). The stronger version of LOP requires the spatial arbitrage condition to hold as an equality, and for prices to fully transmit and integrate (Dickey & Fuller, 1979). Often, price transmission modelling requires vigorous functions that include dynamic variables of the commodity market. Since a basic regression function equation is not complete, this may lead to bias and erroneous inferences (Badiane *et al*., 2010).

Due to the dynamic nature of the agricultural industry, agricultural analyses require dynamic testing methods to capture, for example price shocks resulting from government policies. Researchers came up with dynamic time series techniques after the identification of shortcomings in the correlation coefficient, regression-based method, and linear logarithm model. Dynamic time series models assume that price transmission may not always be immediate, as transmission might take longer to complete. The incomplete price transmission in agricultural markets is attributable to the bulkiness of agricultural products, inadequate status of market infrastructure, development, and government intervention. Goodwin and Piggott (2001) argue that delivery delays and other impediments such as government interventions cause slow price transmission. Goodwin and Piggott (2001) introduced a dynamic response to price shocks, which led to price adjustments in the long run. The dynamic response to price shocks was the start of the analysis of the long-run equilibrium relationship and short-run dynamics using dynamic time series methods. The dynamic time series tests include Granger causality, the Ravallion/Timmer (1986) dynamic model, impulse response analysis of structural or non-structural vector autoregressive (VAR) models, and cointegration analysis.

The Granger causality test examines market dominance in a VAR model framework by regressing market prices in one market, on lagged prices in another market (Fackler & Goodwin, 2001). The Granger causality is tested by way of using significant coefficients, which indicates that price shocks in one market can cause price responses in another market, with a lag adjustment. The causality test addresses lead/lag relationships in markets; however, it puts less emphasis on real causality, and this causes confusion in the Granger causality concept (Fackler & Goodwin, 2001). Fackler and Goodwin (2001) add that Granger causality tests the direction of price information flow among spatial regions, which is dependent on the dominant market theory. The direction can be unidirectional, bidirectional, or non-existent. As explained further by Fackler and Goodwin (2001), a country with a large supply of a certain commodity can cause a shift in the world market supply of that commodity, and influence other countries. In the end, the Granger causality test is sensitive to omitted variables biases (Fackler & Goodwin, 2001). It fails to address the relationship existing between contemporaneous and lagged prices, yet it shows whether the two are statistically different from zero. The Granger causality model requires an additional model that can assess price behaviours before inferences on market integration can be drawn.

Ravallion (1986) proposed an advanced test, one interpreted as the VAR model. The method is a progression from the regression-based and Granger causality tests, and it considers dynamic time series. The improved test is necessary because, according to Fackler and Goodwin (2001), short-run market integration exists when price shocks transmit immediately between markets, and the long-run market integration exists once prices equalise, over time. Ravallion's (1986) work on dynamic modelling is the most prominent and progressive work in time series analyses (Worako *et al.*, 2008). The model considers dynamic time series, and recognises that price shocks take time to transmit from one market to another. McNew (1996) reveals that the Ravallion dynamic model assumes linear relationships in prices. This ignores transfer costs in the model estimation, which renders the model vulnerable to misspecification, and informs incorrect acceptance and rejection of the market integration hypothesis (McNew, 1996).

Like those of his predecessors, the Ravallion (1986) dynamic test fails to adhere to statistical properties such as stationarity. To account for these issues, Granger (1986) and Engle and Granger (1987) introduced the cointegration test, which builds on the Ravallion dynamic model. The Engle and Granger (1987) method is a two-step procedure consisting of a cointegration test and an error correction model (ECM). The cointegration test allows for price transmission to be less than one and for prices to be assessed endogenously (Ismet *et al*., 1998). Cointegration may occur in the absence of LOP in spatial markets because in reality, the strict price behaviour assumed by LOP is not always possible (Viju *et al.,* 2006). The cointegration test builds on the spatial arbitrage concept of the stronger assumption of LOP. The cointegration technique evaluates the long-run equilibria and addresses long-run tendencies of the dynamic systems (Fackler & Goodwin, 2001).

The cointegration test recognises the time-series property of the error term (Fackler & Goodwin, 2001). This means that if spatial prices are non-stationary, estimations could be inconsistent, and hence result in non-stationary residuals; but when residuals are stationary, prices equilibrate in the long-run (Fackler & Goodwin, 2001). Once price series are stationary, a standard OLS estimation is valid, and inference regarding causality and impulse response is obtainable. According to McNew (1996), the cointegration test ought to show that prices in spatial markets exhibit long-run statistical equilibrium. The presence of cointegration permits the use of the second step in the Engle and Granger (1987) procedure. The second step of the Engle and Granger (1987) approach uses the error correction model (ECM). The ECM tests the short-run dynamics, in line with the long-run relationship (Van Campenhout, 2007). The ECM represents the arbitrage process. Balke and Fomby (1997) mention that the ECM describes how variables respond to deviations from the equilibrium position. The ECM is an adjustment process through which the long-run equilibrium is maintained. Policy interventions, imperfect competition, price risks, and uncertainty dynamics determine the speed of adjustment.

Overall, the cointegration test and ECM are reputable in specifying and estimating dynamic models (Worako *et al.*, 2008). The reputation is a result of the two components' ability to capture the long-run equilibrium relationship and the short-run dynamics

(Worako *et al.*, 2008). This gives the Engle and Granger (1987) method the capacity to assume a joint parametric treatment of the long-run relationship and short-run dynamics (Boswijk, 1995).

Despite the breakthrough, the Engle and Granger (1987) method has drawbacks. The Engle and Granger (1987) method is a single equation method, appropriate for the estimation of two or more variables. Brooks (2008) argues that the Engle and Granger (1987) method is more appropriate for the estimation of two variables because, for an analysis of more than two variables, it gives only one cointegrating vector. That is why the Johansen (1988) approach is preferable during multivariate variable analysis, as discussed below. Negassa *et al*. (2003) infer that cointegration tests "assume stationary spatial marketing margins, stationary transaction costs, and/or those markets are linked by a constant trade pattern." However, in actual sense, transaction costs vary and trade is not always continuous. Ismet *et al*. (1998) reason that the cointegration approach ignores transaction cost variations and assumes a linear relationship between market prices. Ismet *et al*. (1998) add that cointegration tests lack the ability to distinguish between integrated markets and independent markets, when subjected to common exogenous inflationary processes.

Additionally, the Engle and Granger (1987) model suffers from simultaneous equation bias, because the system assumes unidirectional behaviour (Asche *et al*., 2012; Brooks, 2008). Simultaneity problems arise when the relationship between two variables is bidirectional. Asche *et al.* (2012) reason that simultaneous equation bias can be controlled by assuming that one price is exogenous in the Engle and Granger model. Otherwise, the simultaneity problem can be contained by estimating equations using the maximum likelihood vector error correction model (VECM), introduced by Johansen (1988) and Johansen and Juselius (1990). The method is called the Johansen (1988) cointegration approach.

The Johansen (1988) cointegration approach is a multivariate and unrestricted vector autoregressive (VAR) model. The Johansen (1988) model contains no exogenous variables, as exogeneity is a testable hypothesis in the model (Asche *et al*., 2012). The model addresses endogeneity and simultaneity problems in bivariate and multivariate models (Acquah & Owusu, 2012). The Johansen (1988) approach estimates price series using the maximum likelihood ratio, and it determines all possible cointegrating vectors available in the model. Chirwa (2001) claims that the model allows for numerous testing of cointegrating vectors in bivariate and multivariate systems. When there is a bidirectional relationship, more than one cointegrating vector is possible (Brooks, 2008). If the Johansen model identifies cointegrating vectors, the estimation proceeds with a VECM. The VECM estimates the short-run dynamic relationship, and it links the long-run relationship and the short-run relationship. Acquah and Owusu (2012) note that the VECM links the long-run and short-run relationships by introducing the error correction term (ECT). The ECT captures the speed of price adjustments toward the long-run equilibrium.

Even so, the Johansen (1988) method suffers, as it relies on asymptotic properties, which renders the system vulnerable to error specifications in limited samples (Sjo, 2008). Analysing a bivariate integration using a multivariate approach possibly leads to misspecification and results in inconsistent estimates, because of an omission of important variables (Gonzalez-Rivera & Helfand, 2001). The Johansen (1988) cointegration approach also ignores the effect of transaction costs on market integrations. Like the Engle and Granger (1987) method, the Johansen model assumes any price deviations between integrated markets as being transaction costs. The model also assumes that any deviations from the long-run equilibrium positions trigger arbitrage operations. In reality, this might not be accurate.

In recent literature, researchers have realised the essence of accounting for transaction costs, policies, exchange rates and other dynamic factors, and have additionally realised that price data are non-stationary. To account for some of these factors, specifically transaction costs, the TAR and PBM models have become important tools in market integration analysis. Goodwin and Piggott (2001) assert that there is a need for mechanisms that recognise the presence of transaction costs. This is because the ignoring of the incidence of transaction costs can lead to a "neutral band", which causes a lack of price linkage (Goodwin & Piggott, 2001). As stated by Fackler and Goodwin (2001), the TAR uses fixed, but unknown, transaction costs that act as a threshold. A price spread greater than the threshold reverts to the threshold point; and one within the transaction cost band behaves in a serially independent manner. The TAR model accounts for nonlinearity and non-symmetrical adjustment in prices and provides information on the dynamics of the data (Abdulai, 2007). As a result, the TAR method of analysis has become useful in identifying thresholds caused by transaction costs (Goodwin & Piggott, 2001). Nonetheless, the TAR model has weaknesses. The TAR model uses price data, and assumes constant transaction costs over time because the model is unable to measure transaction costs. Barrett (2001) mentions that, aside from the usage of price data and assumption of constant transaction costs, the TAR model assumes continuous trade flows. Resultantly, recent studies such as Myers & Jayne (2011) tried to relax the assumption by using trade flows. Instead of setting transaction costs as the threshold variable, Myers and Jayne (2011) set the trade flow variable as a threshold, and allow multiple threshold and price regimes to exist. This advancement has allowed price transmission to differ, depending on the trade flow magnitudes between markets, and rapid price adjustments to occur when the threshold quantity goes beyond the anticipated threshold (Myers & Jayne, 2011).

The PBM includes prices and transaction costs. Transaction costs are included to determine the parity bounds within which prices of a commodity vary independently. Abdulai (2007) explains the PBM as follows: *In the first regime, spatial price differential equals transaction costs, and trade may be absent or present. In the second regime, spatial price differential is less than transaction costs, and arbitrage opportunities may not be profitable. Finally, in the third regime, spatial price differential is greater than transaction costs, and trade may be present or absent, however the third regime violates the arbitrage condition*. Baulch (1997) developed the PBM, and Barrett and Li (2000) extended the model by including actual trade flows in the analysis. Negassa *et al*. (2003) used the PBM to quantify the effects of agricultural policy changes on spatial grain market efficiency in developing countries; this extended and improved on the standards of the PBM. The PBM tackled the issue of discontinuous trade flows between markets, non-linearity in price adjustment, and the statistical problems posed by common trends. Moser *et al.* (2006) criticise the PBM by arguing that the PBM establishes probabilistic limits within which spatial arbitrage are conditioned to hold, and assumes constant transfer costs across markets and quarters. Van Campenhout (2007) adds that the distributional assumption on the switching regression model creates a concern. The system models regime one as a constant plus an error term; regime two adds an additional error; and regime 3 subtracts an additional error, which additional errors are half normally distributed and truncated from below at zero (Van Campenhout, 2007). Van Campenhout (2007) further indicates that since the PBM is static, it does not show how far off the parity bound is from the equilibrium prices, yet it shows the probabilities of being off the parity bounds. According to Barrett (2001), the PBM does not permit analysis of intertemporal adjustment to short-run deviation from long-run equilibrium, and they assume serial independence of prices and transaction costs. The PBM is difficult to adopt as a favourable model, because of the criticisms mentioned and the model's requirement for transaction costs data.

In brief, this section reviews market integration methods, which started as static models and advanced to methods capable of assessing dynamic responses. Most static models primarily only use price data; however, over the years, the models have advanced to the inclusion of price, trade, and transaction costs data, which improve inferences. Furthermore, researchers realise the importance of dynamic factors to the impediment of market integration. This means that researchers recognise the fact that the strict LOP concept, on which market integration is found, might not hold in reality. This is because, for example, high transaction costs and government intervention limit price transmission. In consequence, this led to the advancement of methods that provide better inferences regarding market integration. Often, these methods are limited by the availability of data. Van Campenhout (2007) mentions that price data are more readily available than other factors that affect market integration are, hence the increased use of price data in market integration analysis. Therefore, the present study used price data in the market integration analysis because of the availability of price data.

As previously mentioned, the correlation and regression-based methods ignore dynamic factors such as government intervention and non-stationarity in price series resulting in spurious results. Linear logarithm models are no different from the correlation and regression-based methods, as they share similar shortcoming, and hence likely to cause misspecification due to the strict assumption of LOP (Badiane *et al*., 2010). The Granger causality test requires an additional model to examine price relationship before inferences can be made about price transmission. The TAR model is data intensive as it requires price, trade volume and transaction costs data. The PBM requires transaction costs data, which are rarely available. Barrett (2001) argues that the PBM does not permit analysis of intertemporal adjustment to short-run deviation from long-run equilibrium, and the PBM assumes serial independence of prices and transaction costs. Because of the shortcomings of these models, the study uses the Engle and Granger (1987) and Johansen (1988) methods (Goychuk & Meyers, 2011) to assess market integration.

The two models are used because the study aims to evaluate whether the long-run relationship and short-run dynamics changed after the introduction of the SSMS, and the two models are sufficient to address that. According to Worako *et al*. (2008), the cointegration test and ECM's ability to capture the long-run equilibrium relationship and short-run dynamics have made the techniques reputable in specifying and estimating dynamic models. In addition, cointegration tests allow price transmission to be less than one, and the presence of cointegration assumes causality at least in one direction. Whereas, the Johansen (1988) cointegration method exogeniety is a testable hypothesis.

The Engle and Granger (1987) method has weaknesses. However, the study overcomes the Engle and Granger (1987) method's shortcomings by assuming constant transaction costs, continuous trade and using the Johansen (1988) cointegration approach. The Johansen (1988) is mainly used to test exogeniety post-SSMS, as the policy is anticipated to have caused a bidirectional relationship between the Namibian and South African sheep markets.

2.6.2 Empirical evidence of market integration in the presence of a government intervention

The studies by Babiker and Abdalla (2009), Babiker and Bushara (2006), and Nigussie *et al*. (2014) all contribute to the analysis of market integration. These studies use either the Engle and Granger (1987) or the Johansen (1988) cointegration approach. Babiker and Abdalla (2009) and Babiker and Bushara (2006) subdivided the price series to evaluate market integration effectively. Nonetheless, these studies do not analyse market integration in the presence of a government intervention. There has, however been a growing interest in analysing market integration in the presence of government interventions, especially in Africa. Yet, little or no empirical evidence exists in Namibia on the effect of a policy on price behaviour. This is especially so for the case of the SSMS, which is a quantitative export restriction policy. Studies by Sarker and Oyewumi (2015) and Taljaard *et al.* (2009) have attempted to study the impact of the SSMS on markets, but the authors' focus is mainly on the effect of the SSMS on the South African market, as mentioned earlier.

In the Malawian market, Goletti and Babu (1994) observed the possible effect of market liberalisation on the degree of market integration, using the cointegration test. After conducting the study using monthly retail prices of eight different sites, the study indicated an increase in market integration after the liberalisation of the market. Considering the results, Goletti and Babu (1994) suggest that market liberalisation, alone, cannot accomplish structural change in integrated markets, as investment in infrastructure is required.

Ismet *et al*. (1998) employed the multivariate cointegration test and a bootstrapped regression analysis to evaluate the effects of government interventions on market integration in the rice market. The test was conducted using weekly price data from 1982 to 1992. The analysis indicated a smaller degree of market integration during the post-self-sufficient period than during the pre-self-sufficiency period. Despite the geographical dispersion and spatial segmentation, the rice market had a stable, long-run relationship. Accordingly, government intervention positively influenced market integration, post-self-sufficiency period (1985–1993).

Amikuzuno (2010) and Subervie (2009) both used the threshold autoregressive (TAR) model to evaluate price transmission in the presence of policy regimes. Amikuzuno (2010) aimed at determining whether the price transmission and the factors responsible for market integration improved adequately under high and reduced periods of agricultural import tariffs in Ghana. In this study, price transmission changed and speed of price adjustments improved. In conclusion, trade liberalisation could not have affected market integration. Factors such as seasonality, wholesalers' market power, road barriers, and risk associated with tomato trading may have affected price transmission. Hence, the study recommends that the effects of these factors be minimised. Subervie (2009) appraised the impact of the coffee sector reforms on shocks transmitted to producers that allow asymmetric adjustment towards the long-run equilibrium relationship. The findings indicated a close cointegration of spatial prices after the reform, and an increase in price variation between producer prices and world producer prices.

Ghosh (2011) used the maximum likelihood method of cointegration to assess the impact of agricultural policy reforms on spatial market integration in the grain markets in India. In this study, Ghosh (2011) divided the monthly wholesale prices into sub-sample, pre-reform (1984-March to 1991-July) and post-reform (1991-August to 2006-March). By subdividing the data, the study found improved market integration post-reform in markets that were previously poorly integrated or segmented. The study suggests that government needs to promote growth in production and ensure price stability, since effects and incentives are transmitted efficiently in all regional markets. Secondly, the region could avoid famine by designing agricultural policies and rationalising government intervention into the food economy. Finally, the government could work on promoting agricultural growth and ensuring stability in food grain prices by preventing direct intervention. This is so simply because the agricultural policy reforms and transaction costs determine the degree of market integration.

Badiane and Shively (1997) examined the response of a local market to structural and macroeconomic policies, using a dynamic model. The outcome of the analysis showed that the degree of price transmission between the dominant market and the concurrent markets determined price adjustment. Therefore, the results point out that a reduction in prices, which took place because of the economic reform in 1983, could be traced back to the dominant and concurrent markets. The distinctness in the extent of market integration has implications on the long-run changes of the arbitrage costs and the formation of market prices.

Baffes and Gardner (2003) evaluated the commodity price transmission from world to domestic prices in the presence of a policy reform. In this study, the results revealed that Argentina, Chile, and Mexico were well integrated with the world markets. Krivonos (2004) looked at the effect of the coffee sector reform on coffee growers during the late 1980s and early 1990s. The study outcome indicated an increase in the long-term producer price shares after liberalisation, suggesting a close cointegration between the world prices and domestic prices. The results from the error correction model showed improved short-run dynamics from the world prices to the domestic prices. Baffes and Gardner (2003) and Krivonos (2004) both used the cointegration analysis.

There are studies specifically addressing the influence of the export restriction policies on spatial market integration. Djuric *et al*. (2009) and Djuric *et al.* (2015) assessed the impact of an export restriction on the local market using the Markov-switching vector error correction model (MSVECM). The studies used weekly prices to determine the price transmission between Serbian wheat growers and the world prices. Both studies indicated an existence of a constant long-run equilibrium relationship. However, the speed of price adjustments differed. Djuric *et al*. (2009) disclosed a decrease in the speed of adjustment after the introduction of the export restriction, which is expected. On the other hand, Djuric *et al*. (2015) displayed an increase in the speed of adjustment, attributing the outcome to intensive arbitrage activities in the Serbian wheat market induced by world market price changes. The increase in the speed of adjustment result suggests that export restrictions are susceptible to policy failure.

Götz *et al*. (2013) and Goychuk and Meyers (2011) looked at the influence of export control on spatial price transmission between Russia and Ukraine. Götz *et al*. (2013) analysed the study using the Markov-switching vector error-correction model. Goychuk and Meyers (2011) used the Johansen maximum likelihood test and the Engle and Granger procedure. The export restriction temporarily decreased the extent of market integration between the Russian and Ukrainian markets, which caused disequilibrium, and an increase in market instability (Götz *et al*., 2013). The study by Goychuk and Meyers (2011) found that the Russian prices were cointegrated with the European Union prices, but not with the Canadian or US wheat prices. The Ukrainian prices were not cointegrated with other prices. The results from the error correction model showed a presence of the short-run dynamics between Russia and EU, with a fast merging rate.

The studies mentioned above address spatial market integration in the presence of a government intervention, with some being more specific to an export restriction policy. This study follows a similar approach by Goychuk and Meyers (2011) that used the Johansen (1988) maximum likelihood test and the Engle and Granger (1987) procedure. The studies previously mentioned provide a mixed empirical evidence for spatial market integration. Nevertheless, to the best of the researcher’s knowledge, no such studies have been conducted on the Namibian sheep sector. Therefore, the study under analysis contributes to literature by evaluating the impact of the SSMS (quantitative export restriction) on spatial market integration, using monthly producer prices. To carefully evaluate the impact of a policy instrument such as the SSMS, the study divides the price series into sub-samples, to see the before and after effects of the policy on spatial price transmission (Yang *et al*., 2015; Babiker & Abdalla, 2009; Babiker & Bushara, 2006; Ismet *et al*., 1998; Ghosh, 2011).

2.7 Partial equilibrium framework (PEF)

The choice of model is often determined by the aim of the study and factors such as data availability (Binfield *et al*., 1999). This current study adopts the Food and Agricultural Policy Research Institute (FAPRI) model to analyse the domestic price formation in Namibia. According to Binfield *et al*. (1999), the FAPRI is a standard, recursive, and dynamic PEF. The PEF permits researchers to determine changes in the supply, demand, and price equations caused by changes in a policy. As a result, elasticities form an important part of the PEF results, because it measures the responsiveness of one variable to another.

Elasticity of supply is the responsiveness of the quantity supplied to changes in a variable (for example price). Demand elasticity measures for instance the responsiveness of quantity demanded to changes in price and income. Therefore, elasticity measures the percentage change in one variable with respect to the percentage change in another (Binger & Hoffman, 1998). Elasticity value can be unitary, elastic, or inelastic. Unitary occurs when the percentage change in the dependent variable is equal to the percentage change in the independent variable (Meyer, 2005). A variable is considered elastic (inelastic) when the elasticity value is greater (less) than one. Four types of elasticities exists, namely own price elasticity, cross price elasticity, input price elasticity, and income elasticity.

Own price elasticity refers to the negative or positive impact of price on quantity. Calculated as follow (Meyer, 2005):

$$\in_{op}= \frac{\%\Delta \text{ in } Q_w}{\%\Delta \text{ in } P_w} = \frac{\Delta Q_w}{\Delta P_w}\frac{P_w}{Q_w} = \frac{dQ_w}{dP_w}\frac{P_w}{xQ_w} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2.1)$$

Cross price elasticity, determines gross substitutes or gross complements of products (De Beer, 2009). Henceforth, changes in price and quantity of sheep in a given period determines changes in the demand of other commodities such as beef and in turn alters the price and supply of the other commodity (Wahl *et al*., 1991). Mathematically expressed as follow (Meyer, 2005):

$$\in_{cp}= \frac{\%\Delta\ in\ Q_w}{\%\Delta\ in\ P_p} = \frac{\Delta Q_w}{\Delta P_p}\frac{P_p}{Q_w} = \frac{dQ_w}{dP_p}\frac{P_p}{xQ_w} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2.2)$$

Input price elasticity measures the percentage change in output relative to a percentage change in input price, expressed as follow:

$$\in_I = \frac{\%\Delta \; in \; Q_w}{\%\Delta \; in \; P_I} = \frac{\Delta Q_w}{\Delta P_I}\frac{P_I}{Q_w} = \frac{dQ_w}{dP_I}\frac{P_I}{xQ_w} \text{.................................}(2.3)$$

Income elasticity of demand is the responsiveness of supply or demand to a change in income. For instance, consumers or markets' responsiveness to changes in price, taking into consideration constraints such as income, determines the demand for sheep.

$$\in_{cp} = \frac{\%\Delta \; in \; Q_w}{\%\Delta \; in \; I} = \frac{\Delta Q_w}{\Delta I}\frac{I}{Q_w} = \frac{dQ_w}{dI}\frac{I}{xQ_w} \text{.................................}(2.4)$$

The concept of elasticity helps in understanding the components of the supply, demand, and price equations in the PEF (Meyer, 2005).

Westhoff *et al.* (2004) acknowledge that the PEF is appropriate for estimating a directional impact of dynamic factors on supply and demand. Modelling the supply and demand of an agricultural commodity with the PEF has become a standard approach in policy impact studies (Kotevska *et al.*, 2013). The PEF regards the agricultural sector as a closed system, and other domestic sectors and the world economy as exogenous components (Meyer, 2005). The PEF is directed to a specific sector, rather than the economy (Prišenk *et al*., 2015), and efficiently examines the impact of policies on industries, over time (Mapila, 2011). The PEF provides considerable and current details on the dynamic factors influencing a specific commodity (Westhoff *et al.*, 2004). Likewise, these attributes make the PEF a suitable model to use in this study.

The PEF is a convenient and efficient methodology, developed by the FAPRI to analyse policies (Meyer, 2005). Meyer (2005) adopted the FAPRI in modelling the market outlook and the impact of policy options on the wheat industry. The framework is currently used at the Bureau for Food and Agricultural Policy (BFAP) at the University of Pretoria for generating baseline projections and scenario analyses (De Beer, 2009). Mapila (2011) assessed the macro–micro linkages between rural livelihoods, agricultural research innovation systems, and agricultural policy changes in Malawi. Gebrehiwet (2010) modelled agricultural input expenditure in a multi-market modelling framework. Another study that uses the PEF is one by Barrett (1999), which considers the effects of real exchange rate depreciation on stochastic agricultural producer prices in low-income agriculture. Most, if not all, of these studies analyse the impact of a policy or another variable, such as the exchange rate, affecting a sector. This validates the use of a PEF in assessing the impact of the SSMS on domestic price levels.

The PEF falls short because the model assumes perfect substitution of commodities (such as sheep), which means that domestic prices of exportable products ought to be equivalent to its domestic-currency border price (Bautista *et al*., 1998). Technically, this is not true in practice as policy interventions drive a wedge in spatially separate regions' prices (Bautista *et al*., 1998). The framework has proven to be suitable in analysing policy changes, as shown in the FAPRI and BFAP models. Accordingly, the PEF is an appropriate tool for identifying the impact of policy changes on the sheep sector at the domestic level. Since no policy tool exists that allows analysts to analyse the effect of policy changes on the Namibian sheep sector, the PEF serves as the first step to enable this analysis.

2.8 Summary of the literature review

This chapter described the Namibian agricultural sector, gave a background overview to the SSMS, and outlined the theoretical and empirical literature review on spatial price integration and price formation. The livestock industry is the dominant agricultural sector, and the sheep sector is second in terms of performance to the cattle industry. This gives basis to assess the impact of the SSMS on spatial price transmission and domestic price formation. This is because it is important to understand how exposed the domestic market is to fluctuations in international prices (Abidoye & Labuschagne, 2014), and how domestic producer prices react to policy changes.

Literature identifies the point that LOP forms the base of market integration. Market integration benefits spatially connected markets by contributing to the accurate flow of price information and price signals. Beside the benefits, there are factors such as government interventions that affect market integration. Studies noted here have shown that government interventions have an effect on market integration (Goletti & Babu, 1994;

Ghosh, 2011; Ismet *et al.*, 1998; Babiker & Abdalla, 2009; Babiker & Bushara, 2006; Nigussie *et al.*, 2014). Studies that examined the impact of a government intervention such as an export restriction displayed a constant or decrease in market integration, and a decrease or increase in the speed of adjustment (Djuric *et al.*, 2009; Djuric *et al.*, 2015; Götz *et al.*, 2013, Goychuk & Meyers, 2011). Some studies used the cointegration methods, TAR, and others used the MSVECM. This study uses the Engle and Granger, and the Johansen's cointegration techniques followed by Goychuk and Meyers (2011) to assess price transmission in the presence of a government intervention.

Asche *et al*. (2012) disclose that arbitrage works in both directions in spatial markets. Once there is a dominant market governing another market's price, the concurrent market will not have an influence on the dominant market's prices. For this study, Namibia is considered as a price taker, and South Africa as the dominant market. Hence, pre-SSMS, the price transmission is assumed unidirectional. During the post-SSMS period, owing to the impact the policy had on the South African market, there is a possibility that price transmission is bidirectional. Therefore, the study uses both the Engle and Granger (1987) method and the Johansen (1988) cointegration approach. The maximum likelihood (VECM) is used to verify the bidirectionality assumption, post-SSMS, by checking the significance of the ECT. The Johansen (1988) cointegration method then tests the exogeniety assumption.

Namibian sheep producers operate under the EPP, which means that Namibian producer prices are a function of world producer prices, policies and other factors (e.g. exchange rates and transaction costs). Since there is arbitrage between Namibia and South Africa, a decrease in exports leads to an increase in supply on the domestic market, which further results in reduced prices. Consequently, the SSMS could have had an effect on the domestic price level dynamics. There are no known studies, which incorporate the assessment of the effect of government intervention on domestic price levels in the Namibian sheep sector. Therefore, this study employs the PEF to assess the domestic price formation. This is done by assessing the responsiveness of the domestic supply, demand and price equation to the SSMS variable, and simulating the PEF. The PEF is used because it is a suitable model used by prominent institutions such as FAPRI and BFAP to analyse policy changes, and it will efficiently answer the price formation objective.

CHAPTER 3:
MARKET INTEGRATION AND PRICE FORMATION ANALYSIS: A METHODOLOGICAL OVERVIEW

3.1 Introduction

This chapter outlines the methodological approach of analysing spatial market integration and price formation. As explained earlier, spatial market integration techniques look at price signal transmission across spatial markets by assessing price behaviour and performance in spatially separate markets (Ismet *et al*., 1998). On the other hand, appraising the impact of a policy intervention such as SSMS on domestic supply and demand ultimately informs policy makers about the likely influence of the introduced intervention on domestic producer prices. The methodologies are selected to identify the degree of price transmission and speed of price adjustment, as well as to determine the domestic price levels. Beside discussion on methodological approaches, this chapter also provides a detailed description of data.

3.2 Data description

3.2.1 Data used in spatial market integration

The analysis focuses on the price relationship between Namibia and South Africa, pre- and post-SSMS. The price series used are monthly average producer prices, from January 1999 to December 2015, sub-divided into pre-SSMS 1999M01[5]-2003M12,[6] and post-SSMS 2004M01-2015M12. Several studies have employed sub-samples in a cointegration approach to examine the impact of agricultural policy reform on food market integration (Ismet *et al*., 1998; Ghosh, 2011; Yang *et al*., 2015). Therefore, to assess the impact efficiently, the monthly prices are divided into pre-SSMS 1999M01-2003M12, being the time during which the SSMS was non-existent, and post-SSMS 2004M01-2015M12, when the policy became effective. In most cases, capturing policy interventions using cut-off periods, especially when using monthly observations, is problematic. This is because policy interventions take time to reflect in price behaviour. However, it is believed that the

5 M01 stands for the first month, which is January.
6 M12 stands for the twelfth month, which is December.

pre- and post-SSMS price ranges used in this study are large enough to capture the influence of policy changes on the price transmission between Namibia and South Africa. Additionally, the producer prices used are secondary nominal prices, obtained from the Meat Board of Namibia. The Meat Board of Namibia assists the meat and livestock industry in Namibia by providing relevant technical and administrative information, and support. Price information dissemination is one of the supporting functions provided to producers.

Average producer prices are the prices offered to producers by abattoirs. Abattoirs determine prices, based on the quality of carcasses, so, poor carcass quality translates into low prices being paid to producers. Abattoirs set producer prices according to the following classifications: A0, A2, A5, AB0, AB2, AB5; B0, B2, B5; and C0, C2, C5, which are carcass grades. The classifications of A, AB, B, and C show the age of sheep, and the numbers 0–5 indicate the fatness and quality of carcasses (Van Wyk & Treurnicht, 2012). A-grades are young sheep (lamb) with no teeth that produce tender meat, and AB-grades are sheep with one to two teeth. B-grades are sheep with three to six teeth, which have outgrown the AB-grade stage, and have medium-tender meat. C-grades are matured sheep with more than six teeth and the least-tender meat. Carcass grades determine the quality of lamb and mutton, by predicting the palatability and amount of meat derived from carcasses suitable for human consumption. Producer prices are the average prices that abattoirs offer to sheep producers for slaughter sheep.

3.2.2 Price formation data

The study used secondary annual data for the price formation analysis, dated from 1999 to 2015. The time series is very short, and this could limit the study; however, there is very limited data dating backwards from 1999. The variables incorporated in the PEF include real gross domestic product (GDP) per capita, population, rainfall, tariffs, drought dummies, shift caused by the closure of an export abattoir in 2013, real producer prices, export parity, live sheep quantities, and the SSMS policy. The PEF regards these variables as either endogenous or exogenous variables. Endogenous variables are variables controlled within a system. Exogenous variables are variables determined outside of a system. Exogenous variables include macroeconomic variables, such as population, real gross domestic product (GDP), the consumer price index (CPI), and a policy (such as the SSMS).

It is worth noting that although Namibia exports live lambs and meat, the quantitative export restriction is only applicable to the exportation of live sheep and lambs. Due to a lack of disaggregated export data, the synthesis collectively classifies live sheep and lambs as slaughter sheep.

3.3 Methodological approach for the spatial price transmission

This section outlines the theoretical framework of the Engle and Granger (1987) cointegration approach, as the Johansen (1988) cointegration approach builds on the Engle and Granger (1987) system. The primary step in assessing price transmission is testing the univariate properties of the price data; secondly comes the testing of the long-run equilibrium relationship (cointegration); and then thirdly, follows examining the short-run dynamics using the ECM and the VECM.

3.3.1 Univariate properties

The initial step in the analysis includes testing individual price series (pre- and post-SSMS) for stationarity. When the price series are stationary, an estimation of the price series with the ordinary least squares (OLS) is possible, and inference is acceptable (Fackler & Goodwin, 2001). This is because a stationary time series has statistical properties, such as mean, variance, and autocorrelation that are all constant over time (Babiker & Abdalla, 2009). This is not the case for a non-stationary time series. Non-stationary time series are common in macroeconomic and financial series, and these variables in most instances do not return to the mean value, and the variance goes to infinity, as it is time dependent (Babiker & Abdalla, 2009). Consequently, the moment price series are non-stationary, standard inference and procedure become invalid. Chirwa (2001) affirms that when price series are non-stationary, normal inferences invalidate parameters, and cause spurious regression. Hence, statistical properties, such as non-stationarity of price series, invalidate econometric tests and produce misleading results about the degree of market integration (Baffes & Gardner, 2003). Acquah and Owusu (2012) mention that stationary time series have finite variance, and temporary changing means allowing for price series to revert to the mean value. For that reason, stationarity has become a pre-condition for time series analysis (Acquah & Owusu, 2012).

This analysis employed the Augmented Dickey-Fuller (ADF) unit root test and Kwiatkowski-Philips-Schmidt-Shin (KPSS) approach to test the order of integration, I(d), of the price series. The order of integration is the number of times the price series are differenced before prices come to be stationary (Badiane *et al.*, 2010). The order of integration is determined by comparing the t-statistics of the estimated coefficients to the critical value, in order to reject or fail to reject the null hypothesis (Babiker & Abdalla, 2009). The ADF examines the null hypothesis of a unit root against the alternative hypothesis of stationarity. Rejecting the null hypothesis means that price series are integrated of order I(0), and are stationary. If the variables under investigation are non-stationary at levels, and stationary at first difference, they are I(1). The study additionally used the KPSS to test the stationarity of price series. The KPSS' null hypothesis states that price series are stationary, and rejecting the null hypothesis means that prices are non-stationary. Evidently, the ADF and KPSS are opposites of each other, and the KPSS is used to validate the ADF results. The moment stationarity is proved in both tests, the assessment proceeds to the cointegration analysis to evaluate the presence of a long-run relationship between spatial markets.

3.3.2 Cointegration test

After identifying I(1) in individual prices series, the analysis advanced to testing the stationarity of the error term, which determines the existence of cointegration between price series. In any econometric analysis, the error term should be stationary and free of serial autocorrelation, as this ensures temporary deviation of prices from the equilibrium (Engle & Granger, 1987). As soon as two price series are stationary, the error term is likely to be stationary, and this shows the presence of a long-run equilibrium relationship in price series (Baffes & Gardner, 2003). The manifestation of a long-run equilibrium relationship indicates that prices cannot move too far from the equilibrium, as market dynamics work to eliminate the deviation. In other words, the presence of cointegration allows price signals to deviate for a short period. However, market forces (arbitrage operations) work in the long run to bring price differences back to equilibrium.

The study established cointegration between Namibian and South African sheep producer prices using the Engle and Granger (1987) cointegration approach. The cointegration test was conducted on both the pre-SSMS and post-SSMS subsamples. The Engle and Granger (1987) method is a residual unit root test, which uses the ADF test to support the null hypothesis by examining the error terms. The null hypothesis states that there is no cointegration. The Johansen (1988) approach was also applied to test the number of cointegrating vectors, using the two likelihood test statistics, namely the trace test and maximum eigenvalue. Since the study includes two price series, at most one cointegrating vector ought to exist in the Johansen (1988) system. Equation (3.1) is the original regression function, while Equation (3.2) is the basic logarithmic regression function used to test the relationship between two spatial markets.

$$P_t^{NAM} = \beta_0 + \beta_1 P_t^{SA} + Z_t \qquad (3.1)$$

$$lnP_t^{NAM} = \beta_0 + \beta_1 lnP_t^{SA} + Z_t \qquad (3.2)$$

The P_t^{NAM} signifies domestic producer prices, β_0 represents the intercept, β_1 characterises the slope, P_t^{SA} denotes South African producer prices, and Z_t represents the error term. Rendering according to Dickey and Fuller (1979), by assumption Z_t is an independent normal random variable with zero mean, and a constant variance, thus the error term is a white noise term. $\beta_1 = 0$, means that no relationship exists between price series, and if $\beta_1 = 1$ then LOP exists and relative prices are constant. $\beta_1 \neq 1$ and $\beta_1 \neq 0$, mean that the relationship between two prices exists, but relative prices are not constant. A long-run relationship between, P_t^{NAM} and P_t^{SA} proves that the two spatial prices are cointegrated. This implies that prices move closer together in the long run, although prices can deviate from each other in the short run. During the initial step of the Engle and Granger (1987) method, the regression is estimated with the OLS.

3.3.3 Error correction model

The identification of the long-run equilibrium relationship allowed the analysis to precede to the second step of the Engle and Granger (1987) method, which is the ECM. Yet, for the Johansen cointegration approach a VECM was appraised. Prior to the introduction of the

SSMS, the price transmission is reckoned to be unidirectional, and that post-SSMS, the price transmission could possibly be bidirectional. The presence of cointegration implies Granger causality, at least in one direction. The VECM determines causality by looking at the significance associated with the error correction terms (ECT). If both ECT in the VECM are significant, it implies that a bidirectional relationship exists. Likewise, if the ECT on the South African equation is significant, it implies that causality flows from Namibia to South Africa. If ECT on the Namibian equation is significant, it means that causality flows from South Africa to Namibia. As consequence, the author opted to assess pre-SSMS with an ECM, and post-SSMS with a VECM, because of the unidirectional and bidirectional assumption, pre- and post-SSMS.

Studies by Miller (1991) and Engle and Granger (1987) state that once a long-run equilibrium relationship is present, a constrained ECM exists, which captures the short-run dynamics of cointegrated variables. Conforming to Worako *et al*. (2008) unlike the static framework, the ECM is a dynamic model with a dynamic component. The dynamic component allows the model to capture adjustments in the dependent variable caused by changes in the market (Worako *et al*., 2008). These adjustments are observed when the dependent variable deviates from its long-run equilibrium point. As such, the ECM recognises the long-run equilibrium relationship as the convergence of price series to some long-run term. Short-run dynamics, on the other hand, are classified as the speed of adjustment, which measures the correction of the past period's disequilibrium in the model.

Subsequently, the ECM defines how prices in the short run adjust to the long-run equilibrium. During this step, since all variables are stationary, statistical inference is possible from the estimated model. The study follows Badiane and Shively (1997), who examined the extent that a local market responds to policy reform. The price integration model for the Namibian sheep market is as follows:

$$P_t^{NAM} = \alpha_0 + \alpha_1 time + \beta P_t^{SA} + Z_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.3)$$

where P_t^{NAM} and P_t^{SA} represent domestic producer prices and South African producer prices, respectively. The α_0 represents an intercept, which is the fixed cost of marketing, and β denotes an arbitrage cost coefficient between spatial markets. Equation (3.3) is not complete, because price transmission modelling requires a vigorous function, which includes dynamic variables of the market.

In order to identify and apprehend dynamic natures in spatial markets, the analysis expanded Equation (3.3) to obtain:

$$P_t^{NAM} = \sum_{j=1}^{n} \alpha_j \ P_{t-j}^{NAM} + \sum_{j=0}^{n} \beta_j \ P_{t-j}^{SA} + \gamma X_t + Z_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.4)}$$

Equation (3.4) shows that P^{SA} determines P^{NAM}; j denotes lags; and X denotes a matrix consisting of an intercept and a time trend. Namibia's sheep market is small in comparison with the South African market, so the South African market is considered to be a dominant market. Important to note is that a central/dominant market exists, because of transportation and logistics, as well as transmission of information about transactions (Asche *et al.*, 2012). A possibility of $\beta_j = 0$ for all j, permits market segmentation between Namibia and South Africa, and price shocks from the South African sheep market cannot transmit to the Namibian market prices. $\beta_0 = 1$, conditions that LOP holds, and prices transmit immediately (there are no lags in price transmission because β_0 indicates the current period). However, when $\sum_{j=1}^{n} \alpha_j + \sum_{j=0}^{n} \beta_j = 1$ then the relationship exhibits a long-run relationship (as opposed to immediate price transmission).

According to the dynamic approach adapted from Baffes and Gardner (2003) and Krivonos (2004), the model includes lagged values of P^{NAM}, and P^{SA} as follows:

$$P_t^{NAM} = \alpha + \beta_1 P_t^{SA} + \beta_2 P_{t-1}^{NAM} + \beta_3 \ P_{t-1}^{SA} + Z_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.5)}$$

where α and β_js are the estimated parameters, and Z_t the error term. Banerjee *et al.* (1996) note that the explanatory variable is an exogenous variable that yields consistent and asymptotically efficient estimates in the ECM. The assumption allows the presence and estimation of lagged variables. In the VECM, P_t^{SA} , is a testable hypothesis. Baffes and Gardner (2003, following Hendry *et al*., 1984) imposed a homogenous restriction on Equation (3.5).

Rearranging Equation (3.5) yields the error specification:

$$P_t^{NAM} - P_{t-1}^{NAM} = \alpha + \delta(P_t^{SA} - P_{t-1}^{SA}) + \theta(P_{t-1}^{NAM} - \gamma P_{t-1}^{SA}) + Z_t \ldots\ldots\ldots\ldots\ldots (3.6)$$

where $\delta = \beta_1, \theta = (1 - \beta_2)$ and $\gamma = \left(\frac{\beta_1 - \beta_2}{1 - \beta_2}\right)$

Equation (3.6) describes the reaction of domestic producer prices to changes in South African producer prices, and adjustments to the long-run equilibrium. Equation (3.6) shows that P_t^{NAM} is proportional to a current change in P_t^{SA}. The δ represents the responsiveness of domestic producer prices to South African producer prices, that is, it measures short-run dynamics. The P_t^{NAM} partially correlates to domestic producer prices from the previous period, P_{t-1}^{NAM}, which deviates from the equilibrium values corresponding from a one lag period of South African producer prices, P_{t-1}^{SA}, given by the coefficient θ. The parameter θ is an error correction term (ECT) that measures the speed of adjustment of Namibian producer prices to deviations from the long-run equilibrium position, γP_t^{SA}. The parameter θ is expected to be negative and significant, creating a downward correction when P_{t-1}^{NAM} moves above γP_{t-1}^{SA}, and an upward correction when γP_{t-1}^{SA} moves above P_{t-1}^{NAM} (Krivonos, 2004). Badiane and Shively (1997) suggest that a shock in the dominant market permits the price adjustment process to include interim multipliers as initial shocks fluctuate, converge, and stabilise within the concurrent market. Once the appropriate speed of price adjustment is estimated, it is a useful insight to know the time required for the market to eliminate at least 50 per cent of the deviations from the long-run equilibrium, known as half-life. It is obtained as follow:

$$hl = \ln(0.5)/\ln(1 + \lambda) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.7)$$

where λ is the speed of adjustment value from the ECM and VECM.

3.4 Model structure of the Namibian sheep market (PEF)

This section discusses the development of the supply, demand, and price equation in the PEF for the Namibian sheep market. The PEF scrutinises the effect of the SSMS on domestic price levels, functioning as a supplementary model to market integration techniques. An assessment of the spatial price transmission and domestic price levels provides a holistic evaluation of the effect of the SSMS policy on the sheep market at a regional and domestic level.

The study aims to measure the impact of the SSMS on domestic price formation, firstly because the policy may have influenced arbitrage opportunities for sheep producers between Namibian and South African markets. An apparent change in arbitrage, which is an equilibrium condition, may have changed domestic supply and demand. Parappurathu (2007) argues that supply and demand curves are used to depict the price effect of a policy. Moreover, Namibia is a net exporter of live sheep. As a result, the Namibian producer prices are determined by the South African producer prices, which mean that the SSMS could have had an impact on the domestic price levels. It is, therefore, vital to establish the impact of the SSMS on domestic prices levels, because this is imperative in understanding the sheep market's price behaviour.

In the PEF, several behavioural equations were estimated. By specification, the sheep sector's framework consists of the supply, demand, and price equations. By formation, the model takes into account the SSMS policy. The SSMS is set as an export ratio variable in the different equations. The different behavioural equations are single dependent variables regressed on explained variables using the two stage least square method (2SLS), which is used by Meyer (2005). Meyer (2005) argues that simultaneous equation estimation methods (for example the 2SLS) are ideal in estimating econometric parameters because such methods eliminate simultaneous bias.

Single equations are estimated with the 2SLS to produce parameters used in the first stage of the analysis (Meyer, 2005). Meyer (2005) further states that the first stage determines the fitted values of the dependent variables, which are then used in the second stage to replace the original dependent variables. The second stage then uses OLS to estimate consistent and efficient parameters for predetermined variables in the supply, demand, and price equations. The framework then solves the model to obtain the estimations. The R-square and t-statistics are then used to validate equations. The R-square specifies how the independent variable(s) explains the dependent variable. Validating the model with statistical tests establishes a certain level of reliance on the estimated equations (Mapila, 2011).

Subsections 3.4.1 through to 3.4.3 below lists the variables influencing the supply, demand, and price equation in order to motivate the variables included in the different equations. Accordingly, the subsections give an overview of the supply, demand, and price dynamic factors in the Namibian sheep industry. Despite explaining the listed variables below, the focus of this study is to ultimately relate the effect of the SSMS on the domestic price by assessing the impact of the SSMS on domestic supply and demand, as well as price equation. Hence, Chapter 4 only discusses the SSMS variable and its impact on supply and demand, as well as the direct influence of the SSMS on the price equation. The rest of the results are presented in Appendix 7.

3.4.1 Supply system

The partial adjustment framework and adaptive expectation are approaches developed to model supply responses (De Beer, 2009). The partial adjustment approach models the gradual adjustments to changes in the environment. This means that the supply movement in one period to the next depends on the share of the difference between the present-day level of supply, and preferred level of supply (Meyer, 2005). The adaptive expectation approach presumes that suppliers base production decisions on relevant values of future prices (Meyer, 2005). Price expectations are important in modelling supply behaviour, but the adaptive expectation fails to capture consequences resulting from a policy change that could change a producer’s expectation (Westhoff *et al.*, 2004). Combining the partial adjustment and adaptive expectation approaches resulted in a widely known model, called the Nerlove supply model. The Nerlove supply model assumes that a desired level of supply exits, which depends on some expected price level (Meyer, 2005). Most often, since the expected price is unobserved, there is a need to formulate the Nerlove model, established on how producers form expectations, built on the actual and past prices (De Beer, 2009). Apart from prices, there are other factors, such as climatic conditions, biological restrictions, input costs and expected prices that influence the supply function.

Producers seek to maximise profit, thus seeking arbitrage opportunities subject to biological changes, input costs, and institutional constraints. Wahl *et al.* (1991) mention that biological restrictions comprise the source of new animals (reproduction) driving supply in the market. Restrictions determine future production according to the current decisions made on breeding herd size (Wahl *et al*., 1991). Van Wyk and Treurnicht (2012) argue that economic, reproduction and physical factors (climate) constrain the biological, dynamic processes of sheep production. For instance, unproductive sheep reduce sheep production, and sheep population. The sheep population determines the number of sheep suitable for slaughter at export abattoirs and non-export abattoirs, as well as for the exportation of live sheep. According to the livestock census data from the Directorate of Veterinary services in Namibia, the total population of sheep (breeding herds, rams, ewes, and lambs) in Namibia was 2.6 million head of sheep in 2012, while in 2015 the total population of sheep was about 1.9 million. Sheep marketed in 2012 increased, and in 2015, sheep marketed decreased. The drastic reduction in the total sheep population over the years is attributable to drought. The reduction in the total sheep population decreased the quantity of sheep suitable for marketing.

Sheep producers market both sheep and lamb, but mainly market lamb because of a high price incentive obtained when marketing lambs. The study refers to marketable lamb and sheep as slaughter sheep or simply sheep, due to a lack of accurate data in a dis-aggregated form. A lack of data on slaughter sheep statistics led to the approximations of statistics. The analysis approximates that 75 per cent of the total sheep population are sheep suitable for slaughter. De Lange (2008) indicates that, for a good farm setting comprising a well-managed pasture, a correct stocking rate, and good disease control, the lambing percentage should be 80 per cent, on average. To be inclusive of small-scale farmers, who most of the times experience production losses as a result of poor selection and farm management, 75 per cent is therefore an appropriate approximation. The approximated sheep population is then used as a dependent variable in the sheep supply function.

Climatic conditions such as rainfall and drought affect agricultural productivity, and disturb vegetation growth and water capacity. Namibia is a semi-arid country, characterised by deteriorating grazing land, unpredictable rainfall, drought and water scarcity, which results in less vegetation and limited fodder production (Van Wyk & Treurnicht, 2012). This study expects rainfall to have a positive effect on sheep production, because an increase in rainfall would increase vegetation growth. Over the past four years, Namibia experienced severe droughts, which decreased vegetation palatability and nutrition, reduced water levels, and ultimately reduced sheep production. Drought, therefore, ought to demonstrate a negative effect on sheep production.

Varian (1984, as quoted by Meyer, 2005) notes that production represents a firm's technical constraint, which defines the physical relationship between factor inputs and the maximum level of output for a given technology. Producers retain sheep for a number of years, and input-use in previous years often influences input-use in the current year (Binfield *et al*., 1999). The study thus considers lagged lick cost as a variable in the analysis. The lagged lick cost variable is expected to negatively affect sheep production, because a high input cost increases production costs, which then reduces sheep producers' profit. Henceforth, when input costs increase, supply decreases to cut production costs.

Lastly, institutions define the environment in which producers operate. Institutions represent the rules governing an industry to ensure coordination and compliance of key role players in the industry. For instance, according to national legislation, producers are not allowed to use growth stimulants and growth hormones in sheep production (MAWF, 2015). Another example would be the SSMS policy, which states that producers ought to market live sheep to domestic export abattoirs before considering the exportation of live sheep. Conforming to Happe *et al.* (2006), policies governing a specific market influence producers' decisions, and determine producers' actions regarding the product market. Decisions that individual producers make revolve around the institutions in place, which leads to heterogeneous farms and to the withdrawal of some farmers from a sector. A withdrawal of producers from an industry negatively affects the sector's supply of a commodity. With that said, the above-mentioned constraints are the supply dynamics influencing the supply response in the market, and in turn determine domestic prices.

Expected prices influence supply because of how production occurs (Mapila, 2011). The way production takes place can lead to time lags between the decision time and the attainment of output. Sarmiento and Allen (1998) condition that the use of inputs and output prices influence current production, and impede the process of bringing actual production to coincide with the desired production level. Sheep producers are likely to produce at predictable price levels, holding other factors constant. The previous year's sheep producer prices and input costs play a major role in the supply decisions made by sheep producers. For that reason, lagged prices and input costs allow producers to predict the expected price levels and possible returns from production. Meyer (2005) argues that agents in the supply chain base supply on their anticipation of the market outlook. Product supply in the next highest level of the market channel depends on the expected profits accumulating to the producer (Meyer, 2005). The previous year's sheep production determines the current year's production level of sheep. A convenient way of expressing the relationship between supply and price is by using elasticity. Elasticity measures supply responsiveness to changes in price. The law of supply states that an increase in price will increase supply in the market (Van Wyk & Treurnicht, 2012). The total domestic sheep supply equation is as follows:

$$SHPTOLPRO_t^{NAM} = f(SHPTOLPRO_{t-1}^{NAM}, P_{t-2}^{NAM}, P_t{}^{NAM}, INPUTP_{t-2}^{NAM}, RAIN_{t-1}^{NAM}, SSMS_t,\ HEALTH - SAFETY\ TREND) \ldots\ldots\ldots\ldots\ldots\ldots(3.8)$$

where $SHPP_t^{NAM}$ is the total supply of sheep per head in the market at time *t*, $SHPTOLPRO_{t-1}^{NAM}$ lagged sheep supply per head at time *t*. $INPUTP_{t-1}^{NAM}$, is lagged lick costs in Namibian dollars per kilogram (NAD/kg) at time *t*, the $SSMS_t$ is the policy variable, and the $HEALTH - SAFETY\ TREND$ is a variable presenting the health and safety regulations that producers adhere to. These variables affect the supply response at time *t*.

3.4.2 Demand system

The demand block illustrates the demand response of live slaughter sheep and it comprises the demand in the domestic market by export abattoirs and non-export abattoirs. Export abattoirs and non-export abattoirs seek to demand ideally more live sheep from producers at lower prices to increase profitability. This is because a decrease (increase) in price leads to an increase (decrease) in demand. The law of demand states that high prices reduce the demand for a specific commodity, and this causes a negative relationship to exist between a commodity and its own price (Meyer, 2005). In consequence, any changes in sheep prices are bound to affect live sheep demand. Therefore, due to the impact the prices could have on demand, it is essential to measure the responsiveness of demand to changes in price when deriving the demand function of markets (De Beer, 2009). This is called elasticity of demand (Varian, 1987).

Institutions and government interventions are important determinants in the demand function, because institutions and policies regulate the demand side. For instance, the Namibian government implemented the SSMS. The policy mandated sheep producers to offer sheep for slaughter to a few export-approved abattoirs. The proposed action led to export abattoirs gaining more market power, so this makes the SSMS variable an important variable to consider in the demand function. The study therefore expects a positive effect of the SSMS variable on the export abattoirs. A positive effect of the SSMS variable on non-export abattoirs is also expected because slaughter capacity at export abattoirs is limited; hence, a high supply of live sheep at export abattoirs could result in a positive spill over effect to non-export abattoirs.

Another form of regulation is that of the international markets' standards, which include the International Organization for Standardization (ISO) and HACCP (Hazard, Analysis, and Critical Control Points) standards. Export abattoirs export to the international market under these strict international standards, specifically those of the European Union (EU). For exporting to the EU, market producers are prohibited from using growth stimulants and growth hormones in sheep production (MAWF, 2015). Conformation of export-approved abattoirs to international standards requires the implementation of stringent health and safety requirements, as well as a set of standards that producers should adhere to. This renders the health and safety trend variable an important variable in the demand function because compliance by producers with the requirements and standards prescribed translates into abattoirs demanding more sheep from producers.

Namibia is prone to the occurrence of drought. Drought has made farming, particularly extensive farming, and unpredictable in Namibia. The severe drought experienced in Namibia from 2012 until 2016 has affected sheep production and the carcass weights of sheep. Decreased production, coupled with poor body condition of sheep, results in abattoirs, especially export abattoirs, demanding fewer live sheep, which thus negatively affects the demand function. Hence, average carcass weight is a vital variable to consider in the equation.

Another variable to consider is the shift variable, which is caused by the closure of one of the export abattoirs in 2013. The closure was attributable to a reduction in suitable sheep throughput to export abattoirs, due to the drought. The closure of the export abattoir caused a major shift in the domestic market, because the shift resulted in a decreased total slaughter capacity of export abattoirs. This means that, as opposed to four export abattoirs, there were now three export abattoirs available, thus making the shift variable an essential variable in the demand function. As a result, the domestic demand function is as follows:

$$EXP\_ABATTOIRS_t^{NAM} = f\,(P_t^{NAM}, P_t^{SA}, \text{SSMS}, SHIFT13,\ HEALTH - SAFETY\ TREND, SHPACMS, DRGHT\_Dummy) \ldots\ldots..(3.9)$$

$$NON - EXP\_ABATTOIRS_t^{NAM} = f\,(P_t^{NAM}, P_t^{Goat}, \text{SSMS}, SHIFT13,\ HEALTH - SAFETY\ TREND, DRGHT\_Dummy) \ldots\ldots..(3.10)$$

where $EXP\_ABATTOIRS_t^{NAM}$ is slaughter at export abattoirs per head at time *t*, P_t^{NAM} average sheep producer prices at time *t*, P_t^{SA} South African average sheep producer prices at time *t*, SSMS is the policy variable, *SHIFT13* represents the closure of the NamCo abattoir at time *t*, *HEALTH-SAFETY TREND*, $SHPACMS$ is the sheep average carcass mass at time *t*, and DRGHT Dummy represents the drought dummy at time *t*. $NON - EXP_ABATTOIRS_t^{NAM}$is slaughter at non-export abattoirs per heard at time *t*, and P_t^{Goat} is average goat auction prices at time *t*.

3.4.3 Price equation

The price equation is set to determine the direct impact of the SSMS on domestic producer prices. Depending on the country's production level and consumption patterns, domestic price formation takes on any of the three trade regimes: autarky, import parity price (IPP) or export parity price (EPP). Namibia is a net exporter of live sheep, and thus operates on or close to the EPP regime. A country switches to the EPP when that country is a net exporter of a commodity. The EPP assumes a high degree of transmission of price shocks from the world to the domestic market.

Under the EPP trade regime, domestic price is exogenously determined as a function of world price, export tariffs, and policies. South Africa is Namibia's major export destination for live sheep; as a result, South African producer prices are set as a proxy of world producer prices. A positive relationship between the Namibian and South African producer prices is possible because of the integration, which exists between the two spatial markets.

Prices of substitute products influence prices of other products, most certain a product which competes for the same resources. In the price equation, beef is a substitute good for sheep, so changes in beef producer prices affect sheep producer prices. Policies in place such as the SSMS can influence domestic producer prices, therefore the SSMS is considered a variable in the price equation, and it is expected to have negatively affected domestic prices. The average carcass mass determines incentive producers receive, hence also an important variable to consider. The PEF closes on trade (exports), and thus the study considers the export variable as the excess supply of live sheep.

$$P_t^{NAM} = f\,(P_t^{SA}, P_t^{BEEF}, \frac{D_{CONSUMPTION}}{TOLPRO} RATIO_t, SHPACM, SSMS_t) \ldots\ldots\ldots \; (3.11)$$

P_t^{SA} represents South African producer prices at time t, $BEEFP_t^{NAM}$ represents beef producer prices at time t, $\frac{D_{CONSUMPTION}}{TOLPRO} RATIO_t$ represents the excess supply of live sheep to South Africa, *SHPACM* is the average carcass of sheep, and $SSMS_t$ is the policy intervention.

3.5 Summary of the Methodological overview

This chapter discussed the data used in the study, the methodological approach to price transmission analysis, and the model structure of the PEF. The study sub-divided monthly average producer prices into pre-SSMS 1999M01-2003M12, and post-SSMS 2004M01-2015M12 for the price transmission analysis. For the price formation analysis, the study used secondary annual data dated from 1999-2015, which is very short as there is a lack of data dating backwards from 1999, and this is likely to limit the study. The PEF included variables such as the real gross domestic product (GDP) per capita, population, rainfall, tariffs, drought dummies, shift caused by the closure of an export abattoir in 2013, real producer prices, export parity, live sheep quantities, and the SSMS policy.

The price series data pre-SSMS 1999M01-2003M12, and post-SSMS 2004M01-2015M12 for the price transmission analysis is analysed with the Engle and Granger (1987) and Johansen (1988) cointegration model structures. The estimation began with testing the univariate properties, cointegration tests, and then the ECM. The results are reported in the following chapter. In the PEF, behavioural equations are estimated using the 2SLS, and the SSMS is set as an export ratio variable. After estimating behavioural equations using the 2SLS, the following step was to simulate the model. The model is simulated to determine the likely outcome if the SSMS policy is removed.

CHAPTER 4:
PRICE TRANSMISSION AND PRICE FORMATION – RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter outlines the empirical findings for the spatial sheep market integration between Namibia and South Africa, and domestic price formation, according to the theoretical methods discussed in Chapter 3. As mentioned before, in the spatial price transmission examination, monthly prices are divided into subsamples, 1999M01-2003M12, and 2004M01-2015M12. The price series are sub-divided to represent the pre- and post-effects of the SSMS on price transmission. The long-run equilibrium relationship and short-run dynamics results are summarised in tables as pre- and post-SSMS to illustrate the changes that occurred. Furthermore, logarithmic specification is used in the spatial price transmission analysis because of the intuitive interpretation of the coefficients as elasticities.

In the price formation analysis, the researcher is particularly interested in assessing the impact of the SSMS on domestic price levels. This is done by relating findings associated with the effect of the SSMS policy on domestic supply, demand, and price systems, by means of a partial equilibrium framework (PEF). The PEF consists of endogenous and exogenous variables, representing dynamic factors in the Namibian sheep market. The SSMS, which is an exogenous and a variable of interest, is set as an export ratio variable in the PEF to determine the impact of the SSMS on the domestic supply, demand, and price equations. The study only aims to determine the response of the domestic supply, demand, and price to the SSMS; thus, this chapter only reports and discusses the results of the responsiveness of the supply and demand equations to the SSMS variable. Results of other variables from the supply and demand blocks can be found in Appendix 7, for interested readers. The study additionally estimated the price equation to assess the direct effect of the SSMS variable on domestic price levels, and also conducted a simulation to determine what the price might be if the policy is removed.

4.2 Spatial price transmission discussion and results

4.2.1 Descriptive statistics

Table 4.1 below reports on the descriptive statistics of nominal prices for Namibian and South African producer prices for the sheep market.

Table 4.1: Data summary statistics

	NAM_Prices_	SA_Prices_
Pre_SSMS		
Mean	12.32	15.35
Median	11.93	15.14
Maximum	16.10	19.69
Minimum	9.74	11.96
Std. Dev.	1.59	1.94
Observations	60	60
Post_SSMS		
Mean	23.36	31.35
Median	22.13	29.02
Maximum	37.72	50.05
Minimum	12.94	16.39
Std. Dev.	6.88	9.53
Observations	144	144

Source: Based on data collected from the Meat Board of Namibia, 2015

Looking at the mean producer prices during the pre- and post-SSMS period in Namibia, it appears that during the post-SSMS period, producer prices increased by almost two-fold, suggesting that the SSMS led to an increase in producer income. The increase in price can additionally be attributed to the general inflation trends, since the prices are not adjusted to account for inflation. The price series are nominal prices, and unadjusted, due to a lack of monthly consumer price index (food) data unavailable to the author. In reference to Subsection 2.3, and Figure 2.5, average producer prices did increase, but the prices increased at a lower rate, compared with South African prices. The nominal producer price observed in the South African sheep market ranges from a minimum of 11.96 Namibian dollars per kilogram (NAD[7]/kg) carcass to 19.69 NAD/kg-carcass, pre-SSMS. Post-SSMS, the South African nominal producer prices range between 16.39 NAD/kg-carcass and

7 1US-dollar=8.14NAD, on average, between 1999 and 2015.

50.05 NAD/kg-carcass. As explained in Subsection 2.3, the average price difference between Namibia and South Africa was 3.09 NAD/kg prior to 2004, while after the introduction of the scheme, the average price difference increased to 8.22 NAD/kg-carcass. To supplement the description of price series in Table 4.1 above, graphical representations of individual price behaviour of producer prices are shown in Figure 2.5. It is evident that a spatial price variation exists.

4.2.2 Univariate properties of price series

As explained in Chapter 3, the statistical properties of stationary time series have become a precondition in time series analysis. This is because the properties of constant mean, constant variance, and autocorrelation over time, allow the mean value to return to equilibrium. On the other hand, non-stationary time series invalidate estimated results, and cause spurious regression, as mentioned in Subsection 3.3.1. Accordingly, the procedure requires a stationarity test of price series. The study employed the Augmented Dickey-Fuller (ADF) unit root test, and Kwiatkowski-Philips-Schmidt-Shin (KPSS) test. Table 4.2 below reports the stationarity test outcomes of individual price series in levels and in first difference. Detailed results are shown in Appendix 2.

Table 4.2: Stationarity test

	Pre_SSMS		**Post_SSMS**	
	In Levels	1st Difference	In Levels	1st Difference
		ADF Test		
NAM_Prices	-1.86	-5.55***	-1.43	-8.84***
SA_Prices	-1.30	-5.75***	-1.06	-9.53***
	Pre_SSMS		**Post_SSMS**	
	In Level	1st Difference	In Level	1st Difference
		KPSS Test		
NAM_Prices	0.68**	0.05	1.33***	0.05
SA_Prices	0.83***	0.05	1.34***	0.06

** SSMS stands for Small Stock Marketing Scheme*
**NAM and SA stand for Namibia and South Africa*
The null hypothesis is rejected at 1%*, 5%**, 10%* level of significance*

The null hypothesis of the ADF test conditions that price series are non-stationary, and the alternative states that price series are stationary. The KPSS null hypothesis states that price series are stationary. In levels, the ADF test fails to reject the null hypothesis that price series have a unit root, and the KPSS rejects the null hypothesis stating price series are stationary (Appendices 2.i and 2.iii) . The ADF and KPSS outcomes mean that price series are non-stationary, for both pre- and post-SSMS. Differencing price series once, the ADF rejects the null hypothesis and the KPSS fails to reject the null hypothesis (Appendices 2.ii and 2.iv). This means that Namibian and South African price series are stationary, pre- and post-SSMS. Price series are stationary in first difference, and integrated of order 1, $I(1)$. To augment the price series in Table 4.2, correlograms in Appendix 1 indicate that the autocorrelation functions converge towards zero and price series in first differences are stationary. Based on the evidence of stationary price series at $I(1)$, the study proceeded to the assessment of spatial price cointegration using the Engle and Granger (1987) two-stage approach, as well as the Johansen (1988) cointegration approach.

4.2.3 Cointegration test of the Engle and Granger (1987), and Johansen (1988) approach

The cointegration test determines the existence of a long-run equilibrium relationship between spatial prices. The analysis turned to the Engle and Granger (1987) and the Johansen cointegration (1988) approaches to test for cointegration. The Engle and Granger (1987) method tests whether residuals are stationary and the Johansen (1988) approach establishes the number of cointegrating vectors. Tables 4.3 (a) and (b) below report the cointegration results. The full analysis results are presented in Appendix 4.i.

Table 4.3(a): Engle and Granger cointegration test

Variable	Coefficient	Std. Error	t-Statistic
OLS Regression:			
Pre_SSMS			
C	0.105	0.17	0.61
LSA_Prices_Before	0.88	0.06	13.92***
Post_SSMS			
C	-0.08	0.04	-2.07**
LSA_Prices_After	0.94	0.01	81.17***
ADF Test Of Residuals (in levels):			
Pre_SSMS			
C	-0.003	0.005	-0.54
Resid_Log(-1)	-0.27	0.08	-3.20***
Post_SSMS			
C	0.0001	0.002	0.07
Resid_Log(-1)	-0.263	0.06	-4.58***
ADF stands for augmented Dickey-Fuller* **The null hypothesis is rejected at 1%*, 5%**, 10%* level of significance*			

The co-movement of prices in spatial markets justifies the essence of determining whether two (or more) price series have a long-run equilibrium relationship. The null hypothesis of the cointegration test conditions that there is no cointegration. Rejecting the null hypothesis means that the residuals of the cointegrating function are stationary, and spatial prices have a long-run equilibrium relationship. The results of the Engle and Granger (1987) cointegration test display test statistics that are larger in absolute values than the critical values and residuals are stationary (Table 4.3(a) above). The stationarity of residuals suggests the existence of a cointegration between the two separate market prices, and results are consistent with *a priori* expectation. This point to the rejection of the null hypothesis of no cointegration, concluding that Namibian producer prices follow South African producer price signals, pre- and post-SSMS. This means that over a long-run period, for example an increase in South African producer prices will increase Namibian producer prices. The presence of the cointegration proves that there is a long-run equilibrium relationship between the Namibian and South African producer prices, because of the trade flow between the two markets.

In Section 1.7, this study hypothesised that price transmission is lower, post-SSMS. However, Table 4.3(a) indicates that the long-run equilibrium relationship during the post-SSMS period, 0.94, demonstrates a slightly higher elasticity than does the transmission elasticity pre-SSMS, 0.88. High price transmission elasticities of 0.94 and 0.88 are expected because South Africa is Namibia's main trading partner when it comes to the exportation of live sheep. The improvement of the price transmission elasticity, post-SSMS, contradicts *a priori* expectation because quantitative export restrictions such as the SSMS ought to impede spatial price transmission. Quantitative export restrictions reduce exports and increase supply, causing an interim lack of equilibrium (Djuric *et al*., 2009). Baltzer (2013) affirms that quantitative export restrictions reduce and impede spatial market integration. Götz *et al*. (2013) found a decrease in price transmission because of an export restriction. Notwithstanding this, the increased price transmission could be a result of drought, in the sense that at the onset of drought, export volumes of live sheep to South Africa increased (refer to Figures 2.1 and 2.3 in Chapter 2). This proves Meyer's (2005) statement that trade volumes affect price transmissions. Sheep producers destock during drought, as a risk management practice. The destocking by farms at the onset of the drought, which occurred at the end of 2012 in Namibia, led to the increased marketing of live sheep. The increased marketing of live sheep further led to increased throughput to export abattoirs, which resulted in an over-utilisation of export abattoirs. Since export abattoirs were over-utilised, the trade volume of live sheep to South Africa increased. During this time, the government relaxed the quantitative ratio to control the oversupply of slaughter sheep at export abattoirs, thereby rendering the SSMS policy inefficient. For example, the export ratio reduced from 1:6 to 1:1, leading to large numbers of live sheep leaving the country for the South African market. In addition, an increase in live sheep being marketed results in a drop in producer prices. This is seen in both the Namibian and South African market prices in Figure 2.5, especially from 2012 to 2013 at the onset of the drought. Babiker and Bushara (2006) attribute increases in price transmission in recent years to improved information technology, whereby price changes in one market are expected to transmit immediately to another market's price. This may have been the case between Namibia and South African sheep prices. The study also conducted a Johansen (1988) cointegration test for the pre- and post-SSMS periods, as reported in Table 4.3(b) below with reference to Appendix 5.i.

Table 4.3(b): Johansen's cointegration test

Variable	**Coefficient**	**Std. Error**	
Regression:			
LSA_Prices_Before	-0.89	0.14	
LSA_Prices_After	-0.92	0.03	
Co-integrated Vectors:			
Pre_SSMS			
Trace			
Hypothesised No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value
None	0.17	12.38	15.49
At most 1	0.03	2.00	3.84
Maximum Eigenvalue			
Hypothesised No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value
None	0.17	10.38	14.26
At most 1	0.03	2.00	3.84
Post_SSMS			
Trace			
Hypothesised No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value
None	0.13	20.46	15.49***
At most 1	0.01	1.46	3.84
Maximum Eigenvalue			
Hypothesised No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value
None	0.13	19.00	14.26***
At most 1	0.01	1.46	3.84
The null hypothesis is rejected at 1 %*, 5 %**, 10 %* level of significance*			

The Johansen (1988) multivariate approach estimates two likelihood tests, the trace and eigenvalue tests. Hjalmarsson and Österholm (2007) illustrate the point that the trace test tests the null hypothesis of *r* (the number of cointegrating relationships) cointegrating vectors against the general alternative hypothesis of more than *r* cointegrating vectors. The maximum eigenvalue test tests the null hypothesis of *r* cointegrating vectors against the alternative hypothesis of *r* +1 cointegrating vectors (Hjalmarsson, & Österholm, 2007). The Johansen (1988) method therefore depends on the association between the rank of matrices, and their characteristics. In reference to Table 4.3(b) above, the trace and maximum eigenvalue tests show that, pre-SSMS, there are no cointegrating vector and no cointegration. Given this evidence, the cointegration test results imply that spatial producer price series have no long-run equilibrium relationship during the pre-SSMS period, while during the post-SSMS, the trace and maximum eigenvalue tests exhibit one cointegrating vector. This suggests cointegration in spatial prices, and a long-run equilibrium relationship between Namibia and South Africa, post-SSMS.

For the pre-SSMS period, the trace and maximum eigenvalue results in Table 4.3(b), above, are insignificant and show that there are no cointegrating vectors, thus no cointegration. The pre-SSMS results of no cointegration, in the Johansen test, contradict a *priori* expectation. This is because spatial market integration exists when two markets trade with each other and are economically integrated, which is the case between Namibia and South Africa. The study attributes the outcome primarily to the small sample used, which comprises 60 observations pre-SSMS, as compared to 144 observations post-SSMS. Sjo (2008) argues that the Johansen (1988) cointegration approach suffers from error specifications in small samples, due to its reliance on asymptotic properties.

The post-SSMS period’s trace and maximum eigenvalue results, which indicate cointegration, are as expected. This suggests that, despite the quantitative export restriction, producers are likely to pay more attention to the South African producer prices in the post-SSMS period than in the pre-SSMS period. For instance, an increase in producer prices in the South African market permits sheep producers to increase throughput of live sheep to export abattoirs. This, in turn, increases producers’ export quotas, and the number of live sheep available for export. Monitoring prices helps farmers to determine profit margins, and this can lead to an increase in the price transmission process. However, the increase in price transmission does not mean that the price signals are rapid, as the speed of price adjustment is justified by the ECM. Note, observing Tables 4.3(a) and 4.3(b) above that a marginal difference in the price transmission in both tables exists, and the results in both tables show that price transmission improved after the introduction of the SSMS.

In addition, it was mentioned in Subsection 3.2.1 that both the Engle and Granger (1987) and Johansen (1988) methods were used because it is believed that during the pre-SSMS period, the price transmission is unidirectional, although post-SSMS, the price transmission may be bidirectional. The reason behind the anticipation of a unidirectional transmission is that South Africa is a dominant market, compared with Namibia, because of its large sheep market. The dominancy in the South African market is because of improved transportation, logistics, and efficient flow of information (Asche *et al*., 2012), as compared with Namibia. Therefore, a unidirectional effect presumes that price shocks in South African producer prices transmit to Namibian producer prices. The expected unidirectional relationship between the two markets, pre-SSMS, is the motivation for opting to use the Engle and Granger (1987) method for the pre-SSMS analysis, especially in the ECM analysis. In spite of this, it is also believed that the impact of the SSMS on South African abattoirs and feedlots was large, such that it resulted in a possible bidirectional effect, and hence constitutes a motivation to use the VECM, post-SSMS. The VECM ascertains causality by examining whether the error correction terms (ECT) are significant or not. If both ECT are significant, then bidirectionality exists.

The study therefore endeavoured to test cointegration for both pre- and post-SSMS with the Engle and Granger (1987) method, as well as the Johansen (1988) cointegration approach, to ensure a comprehensive analysis. Based on the results given by the cointegration test, and the bidirectional assumption post-SSMS, the researcher opted to assess short-run dynamics during the pre-SSMS period with the Engle and Granger (1987) method, that is, the ECM. For the short-run dynamics analysis, post-SSMS, the researcher opted to use the VECM. Despite the long-run cointegration results, the cointegration test does not include short-run dynamics observations. Thus, the analysis proceeded to estimate the ECM and VECM, which observe short-run dynamics.

4.2.4 Error correction model

An ECM is the second step in the Engle and Granger (1987) cointegration approach. The VECM is a form of a vector autoregressive (VAR) model, used when variables have one or more cointegrating vectors. The ECM captures short-run dynamics in the recognised long-run equilibrium relationship, and identifies the speed of price adjustment back to the long-run equilibrium once a price shock occurs. Clearly, the ECM links the long-run equilibrium relationship, established by the cointegration test, with the short-run dynamics. The ECM is sensitive to lag structures in the model, and to ensure reliable estimates, accurate optimal lags are required to capture dynamic effects on prices (Gonzalez-Rivera & Helfand, 2001). For that reason, the analysis used the Akaike Information Criterion (AIC) value to select optimal lags. The AIC indicated the use of two lags in the ECM estimation (indicated in Appendix 3). Tables 4.4(a) and (b) below present results from the ECM and VECM analyses. Detailed results are shown in Appendix 4.ii and Appendix 5.ii.

Table 4.4 (a): Error correction model (Pre-SSMS)

Variable	Coefficient	Std. Error	t-Statistic
Pre_SSMS			
C	-0.000008	0.005	0.02
D(LNAM_Prices_Before(-1))	0.27	0.13	2.06**
D(LNAM_Prices_Before(-2)	0.10	0.13	0.77
D(LSA_Prices_Before)	0.55	0.13	4.09***
D(LSA_Prices_Before(-1))	-0.05	0.16	-0.32
D(LSA_prices_Before(-2))	0.02	0.16	0.10
ECT	-0.30	0.10	-3.16**
*Optimum lag lengths were chosen using AIC *The null hypothesis is rejected at 1%***, 5%**, 10%*			

Expectations are that the error correction term (ECT) should be negative and significant. The negative sign on the adjustment parameter denotes that when positive (negative) deviations transpire in the long-run equilibrium, a correction occurs by decreasing (increasing) producer prices. As anticipated and presented in Table 4.4(a) above, the ECT is negative and significant during the pre-SSMS period. According to the half-life calculation, it takes 2.3 months to eliminate at least 50 per cent of the deviation from the long-run equilibrium. This means for instance that a shock to the South African producer prices perhaps due to a policy intervention can drive a wedge between the South African and Namibian producer prices; as a result, it can take 2.3 months for Namibian producer prices to eliminate the shock. The time it takes for Namibian producer prices to restore equilibrium is moderately short. This is possibly attributable to price risks and uncertainty in the sheep market, and drought periods making sheep supply unreliable, as these dynamic factors determine the speed of price adjustment. The short-run coefficient on D(LSA_Prices_Before) (contemporaneous prices in SA) is 0.55, prior to the introduction of the SSMS. This means that a 10 per cent increase in South African producer prices generates a 5.5 per cent increase in monthly variation of Namibian producer prices. Clearly, the short-run variable is positive and significant, which establishes the existence of short-run dynamics, as anticipated.

Table 4.4(b): Vector Error Correction Model (Post-SSMS)

Variable	Coefficient	Std. Error	t-Statistic
Post_SSMS			
C	0.005	0.004	1.31
D(LNAM_Prices_After(-1))	0.37	0.13	2.93***
D(LNAM_Prices_After(-2))	0.18	0.13	1.45
D(LSA_Prices_After(-1))	-0.05	0.14	-0.36
D(LSA_Prices_After(-2))	-0.17	0.13	-1.25
ECT_NAM	-0.33	0.09	-3.57***
C	0.006	0.003	1.72*
D(LNAM_Prices_After(-1))	0.42	0.12	3.64***
D(LNAM_Prices_After(-2))	0.13	0.12	1.08
D(LSA_Prices_After(-1))	-0.15	0.13	-1.13
D(LSA_Prices_After(-2))	-0.19	0.12	-1.60
ECT_SA	-0.07	0.08	-0.79
** Optimum lag lengths were chosen using AIC* **The null hypothesis is rejected at 1%***, 5%**, 10%**			

The expectation of a negative and significant coefficient of the ECT in the VECM is no different from that of the ECM. The ECT_NAM, which is the speed of price adjustment of Namibian producer prices' deviation from the long-run equilibrium position, shown in Table 4.4(b) above, is negative and significant, as predicted. The post-SSMS result suggests that a period of 2.1 months is needed to eliminate 50 per cent of the deviation. Again, what this means for example is that a shock to the South African producer prices due to decreased production can drive a wedge between the South African and Namibian producer prices, hence, it will take 2.1 months for Namibian producer prices to eliminate the shock. The post-SSMS period's speed of price adjustment is an improvement from the pre-SSMS period's speed of adjustment.

The speed of price adjustment during the post-SSMS period is marginally faster than during the pre-SSMS period, because it takes fewer months to eliminate price shock post-

SSMS, compared with the pre-SSMS period. This outcome disputes the initial expectation, because quantitative export restrictions, imperfect competition (oligopolistic market), price risks, and uncertainty can govern the speed of price adjustments in markets, that is, how fast or slow prices adjust back to the long-run equilibrium. Hence, the speed of price adjustment during the post-SSMS period is expected to be less than during the pre-SSMS period. Djuric *et al*. (2015) and Goychuk and Meyers (2011) found an increased speed of price adjustment after the introduction of an export restriction policy. Djuric *et al*. (2015) attribute the increased speed of adjustment to intensive arbitrage activities prompted by changes in the world market prices, which could be the case in Namibia. Despite the higher speed of price adjustment during the post-SSMS period than during the pre-SSMS period, the speed of price adjustment could be still low, post-SSMS. The high speed of price adjustment does not necessarily mean that adequate signals are being transmitted to domestic producer prices. The reason is that a quantitative export restriction policy decreases trade and increases the domestic supply of a commodity, causing a temporary disequilibrium, which could buffer the domestic market (Djuric *et al*., 2009).

The ECT_SA coefficient, which is a magnitude that measures the amount by which South African prices are below or above the long-run equilibrium in the previous period, is negative but not significant. The result indicates that there is no response in South African producer prices' deviation back to the long-run equilibrium. This means that there is no bidirectional effect, according to *a priori* expectation. The outcome could be a result of the dominance of the South African sheep market. The South African sheep market is a major player in the sheep market in terms of supply and demand, in comparison with Namibia. For that reason, price shocks from the Namibian market may not affect the South African market prices in a long-run period.

4.2.5 Diagnostic tests of residuals

The study conducted diagnostic tests to validate the accuracy of the models. The diagnostic tests consist of the serial correlation test and the normality test for the ECM, as shown in Table 4.5(a) below, as well as the Portmanteau tests for autocorrelations and the Cholesky normality test for the VECM, as shown in Table 4.5(b) below. Serial correlation tests test the assumption of no serial correlation. The assumption states that, conditional on the independent variables, residuals in two different periods are uncorrelated (Wooldridge, 2013). Serial correlation tests are employed in the study because the presence of serial correlation does not affect the consistency of estimators, although it does affect the efficiency of estimators, thus leading to biased standard errors. Likewise, the study assessed the normality assumption, which states that residuals are independent of explanatory variables, and residuals are independently and identically distributed (Wooldridge, 2013). A violation of the normality assumption leads to bias or misleading results. For that purpose, it is of utmost importance to diagnose residuals to validate models, and ensure that inferences are accurate.

Table 4.5 (a): Diagnostic tests (ECM) (see Appendix 6.i)

Serial correlation test				
	Observed R-Square		Probability test (Chi-Square)	
Pre_SSMS	0.16		0.92	
Post_SSMS	2.47		0.29	
Normality test				
	Jarque-Bera	Probability test	Skewness	Kurtosis
Pre_SSMS	30.63	0.00	-0.87	6.14
Post_SSMS	3.14	0.21	0.04	3.73
The null hypothesis is rejected at 1 %*, 5 %**, 10 %* level of significance*				

The study tested serial correlation using the Breusch-Godfrey serial correlation LM test. Looking at the observed R-square and the probability test, pre-SSMS, the model accepts the null hypothesis of no serial correlation. Yet, the analysis rejects the normality test hypothesis, during the pre-SSMS period. Since the non-normality arises due to kurtosis, it does not affect the analysis (Paruolo, 1997).

The Portmanteau tests for autocorrelations test serial correlation in the VECM. The null hypothesis conditions that there is no serial correlation up to the chosen lag h. Table 4.5(b) below shows that there is no serial correlation in the multivariable model, because the analysis fails to reject the null hypothesis. Additionally, the normality test (post-SSMS) fails to reject the normality test hypothesis, and in that, the residuals are normally distributed. In conclusion, on statistical grounds, the results generated from the ECM and VECM are valid.

Table 4.5(b): Diagnostic tests (VECM) (see Appendix 6.ii)

Portmanteau Tests for Autocorrelations		
Lags	Q-Statistics	Probability test
1	0.13	1.00
2	0.75	1.00
3	5.70	0.93
4	15.06	0.52
5	18.11	0.58
6	25.15	0.40
7	30.84	0.32
8	39.03	0.18
9	40.89	0.26
10	43.52	0.32
11	44.17	0.46
12	82.54	0.00***

Normality test: Cholesky (Lutkepohl)			
	Components	Chi-square	Probability test
Skewness	Joint	2.99	0.22
Kurtosis	Joint	3.43	0.18

Jarque-Bera	Components	Probability test
6.425701	Joint	0.17
The null hypothesis is rejected at 1%*, 5%**, 10%* level of significance*		

4.3 Price formation: PEF results and discussions

The PEF entails the estimation of several behavioural equations. Table 4.6 below shows how the results in Subsections 4.3.1 through to 4.3.4 are obtained. In this section, emphasis is placed on the responses of supply and demand equations to the SSMS variable, and on how the variable affects the domestic price levels. The study additionally tested the SSMS variable for the price equation, since it is anticipated that the price would have been affected. The study also simulated the PEF to identify the possibility of the removal of the SSMS variable. As a result, the study only reports on the SSMS variable in the supply, demand, and price equation because it is the variable of interest. For interested readers, the rest of the supply, demand, and the price equation results are found in Appendix 7. It is recommended that the results in Appendix 7 be used with caution because of a lack of statistically significant coefficients in Appendix 7, Tables 7.1, 7.2, 7.3, and 7.4. The lack of statistically significant coefficients can be attributed to the small sample used dated from 1999-2015, and perhaps due to the selection of the instrumental variables essential for the 2SLS estimation. Nevertheless, elasticities play an important role in the PEF and are calculated at mean values of the corresponding variables.

Table 4.6: PEF baseline and outlook analysis steps

Step1	Identify the appropriate trade regime in which the Namibian sheep market operates.
Step 2	Estimate a system of equations to understand the relationship of exogenous variables on endogenous equations**.**
Step 3	Then use coefficients from the estimated systems of equations to generate baseline results.
Step 4	Test model accuracy of the estimated models using a graphical approach.
Step 5	**Model closure:** The PEF closes on net trade because Namibia is a net exporter of live sheep (operates under the export parity price (EPP)).
Step 6	**Estimate the outlook period (2016-2021)** • Make assumptions of policy and price variables. • Forecast or project macroeconomics variables.
Step 7	**Introduction of policy shocks into the model** • Compare the simulated outcomes with the baseline values. • Examine the introduction of a policy shock on the systems of equations, with special emphasis on the equilibrium prices.

4.3.1 Supply response

Table 4.7 below presents the findings from the supply response equation. The supply response equation is estimated as a function of lagged sheep production, lagged sheep prices, current sheep prices, lagged lick prices, lagged rainfall, SSMS, and the health-safety trend variable. The full model specifications and results are reported in Appendix 7.i.

Table 4.7: Response of the supply function to the SSMS policy

Supply Function				
	Variables	**Coefficient**	**t-Statistics**	**Elasticity**
Production equation	SSMS	-9.64	-0.28	-0.013
Level of significance: 1%*, 5%**, 10%**				

Looking at Table 4.7, the supply equation is influenced negatively by the SSMS variable, and it has an elasticity of -0.013. This means that during the SSMS period, an increase in the quantitative export ratio (for example changing the ratio from 1:1 to 1:3) reduces sheep production by an elasticity of 0.013. A decrease in supply due to a negative response of the SSMS is likely to shift the supply function to the left, and this in turn increases domestic producer price levels. The outcome is plausible because, theoretically, a decrease in the quantity supplied would increase producer prices.

The responsiveness of sheep production to the policy change is relatively small. This can be attributed to the biological nature of the sheep production, because it takes some time to examine the effect of a policy change on the sheep production due to lagged production. The results are also probable because supply is often based on expected input costs and output prices. For that reason, the slow response of the supply function to changes in the SSMS can ultimately be attributed to other dynamic factors such as drought in the sheep market.

4.3.2 Demand response

Table 4.8 below reports findings from the demand response equation. The demand response comprises the export abattoir equation and non-export abattoir equation. The export abattoir equation is a function of domestic producer prices, South African producer prices, drought dummy, shift variable, average carcass mass, SSMS, and the health-safety trend variable. The non-export abattoir equation is a function of domestic producer prices, goat prices, drought, shift variable, SSMS, and the health-safety trend variable. The full model specifications and results are reported in Appendix 7.ii.

Table 4.8: Response of the demand function to the SSMS policy

Demand Functions				
	Variables	**Coefficient**	**t-Statistics**	**Elasticity**
Slaughter at export abattoir equation (per head)	SSMS	6.99	0.12	0.03
Slaughter at non-export abattoirs (per head)	SSMS	34.56	1.92*	0.93
Level of significance: 1%*, 5%**, 10%**				

The SSMS variable has a positive effect on both slaughter at export abattoirs and non-export abattoirs variables, as indicated in Table 4.8. The positive effect of the SSMS variable on export abattoirs and non-export abattoirs means that an increase in the quantitative export restriction policy increases throughput to abattoirs, as expected. The positive response of the non-export abattoirs equation to a change in the SSMS is moderately higher than that of export abattoirs, with an elasticity of 0.93 and 0.03, respectively. The SSMS has a moderately high positive impact on slaughter at non-export abattoirs because an increase in the export ratio means sheep producers supply more live sheep for slaughter to export abattoirs. Export abattoirs have a limited slaughter capacity, and thus cannot absorb all live sheep offered, this result in a spill over to non-export abattoirs. This explains the moderately high responsiveness of non-export abattoirs to changes in SSMS policy.

According to Schutz (2009), after the introduction of the SSMS, export abattoirs increased in number from two to four, which increased the total slaughter capacity from 612 150 to 1 258 950 head of sheep. The increase in total slaughter capacity increased the demand for live sheep. Nevertheless, the drought that occurred from 2012 to 2016 reduced the number of sheep produced. Due to the reduction in sheep production, one of the export abattoirs from the total of four closed down, and this decreased total slaughter capacity again. Resultantly, when there is a high slaughter demand, especially during a drought, export abattoirs are unlikely to respond to sheep producers' high demands, which cause inefficiency in the SSMS policy. The high slaughter demand also led to large numbers of live sheep being exported to the South African market, and an increased throughput to non-export abattoirs. The increased slaughter at non-export abattoirs explains the positive elasticity on the SSMS variable.

4.3.3 Price equation

The study tested the responsiveness of prices to the SSMS variable, because export restriction policies are expected to influence domestic price levels (Table 4.9). The price equation is set as a function of South African producer prices, excess supply (define by the ratio of domestic consumption relative to total production), beef producer prices (substitute commodity), average carcass mass, and the SSMS variable (see Appendix 7.iii).

Table 4.9: Response of the price equation to the SSMS policy

Price equation				
	Variables	**Coefficient**	**t-Statistics**	**Elasticity**
Domestic Prices	SSMS	-0.052	-0.463	-0.0044
** Level of significance: 1%***, 5%**, 10%**				

The result from the price equation showed a negative sign on the SSMS variable. This means that an increase in the quantitative export ratio decreases domestic producer prices. Theory states that a quantitative export restriction policy decreases prices because of an increased supply of a commodity on the domestic market (Djuric *et al.*, 2009). The SSMS reduced live sheep exports to South Africa and increased the domestic supply of live sheep, and this could explain the negative sign on the SSMS variable in the price equation. The elasticity of the SSMS variable is -0.0044, which is close to zero and negligible. Overall, the supply and demand results demonstrate that the SSMS policy had an effect on the supply and demand blocks. Yet, the effect on domestic supply and demand is not manifested in the domestic producer prices.

The lack of significance of the SSMS in the price equation can be attributed to three things. Firstly, the magnitudes of the effect of the SSMS on the domestic supply and demand equations are relatively small. The supply equation had a responsiveness of -0.013, and the demand response mainly the export abattoirs equation indicated an elasticity of 0.03. Therefore, a very small or insignificant effect of the SSMS on prices is expected. Secondly, prices continued to increase post-SSMS (due to drought), although at a minimal rate. The increase in domestic producer prices opposes what is expected of a quantitative export restriction policy, because export restriction policies ought to reduce domestic producer prices. Thirdly, the SSMS policy is allowed to vary to accommodate factors such as drought and oversupply to export abattoirs. Altogether, the price equation affirms that the SSMS has little to negligible effect on domestic price levels. This is plausible because the spatial price transmission results also confirm that the SSMS had no detrimental effect on price behaviour. This suggests that there are other factors determining domestic producer prices. Since the Namibian producer prices are determined by the export parity price, the South African producer prices may be the main drivers of the domestic producer prices. This is proven by the high elasticity and significance of the South African producer price variable in the price equation (see Appendix 7.iii).

4.3.4 Model Simulation

This section demonstrates the stimulation of the impact of the SSMS on domestic supply, demand, and price within the market. Illustrations in this section allow readers to gain an understanding on how supply, demand, and price dynamics respond to different shocks in the market (De Beer, 2009). Before, the PEF model can be simulated there are assumptions required to facilitate the simulation. The assumptions make it easy to build a baseline, which is then used to create scenario analysis.

4.3.4.1 Baseline Projections

The study generated the baseline of the sheep industry based on future assumptions on exogenous and endogenous variables. To forecast endogenous variables, precise forecasts of exogenous variables are essential, because endogenous variables are only as good as the predicted exogenous forecasts. In this study, the exogenous variables are held constant at the 2015-year level. According to De Beer (2009), the baseline is best deliberated as a commodity market outlook, rather than forecasts, due to the assumptions employed on the model about forecasted values. The assumptions include agricultural policies, the macroeconomic environment, and weather condition (Meyer, 2005).

The study assumed that the SSMS policy remained the same, at a 1:1 ratio, over the projected years, 2016-2021. The World Bank projected a GDP per capita growth rate of 4.2 per cent and 5.39 per cent in 2016 and 2017, that is, 45 877.17 NAD and 48 349.94 NAD, respectively. There is an expected economic instability in South Africa because of a slow growth and credit rating, which might increase exchange rate volatility (BON, 2016). Depreciation of the South African currency (Rand) is anticipated to influence the NAD because the two currencies are pegged. Therefore, it was projected that exchange rate could increase by 5.8 per cent, resulting in 14.86 NAD/US dollar and 15.64 NAD/US dollar in 2017 and 2018, respectively.

An expected increase in exchange rate can have a multiplier effect on inflation rate, which can influence the consumer price index of food, CPI: food, leading to increased CPI: food projection, as indicated in Table 4.10. High inflation rate additionally affect lick costs, causing an increase in lick prices. According to the Bank of Namibia economic outlook (2016), the agricultural sector ought to only recovery in 2017 from the persisting drought and adverse conditions, which could lead to increased investment in agricultural activities, and allow growth in the sector. Table 4.10 shows the baseline assumption from 2016-2021.

Table 4.10: Baseline Assumptions for Namibia's Sheep Market

Variables	Units	2016	2017	2018	2019	2020	2021
GDP per capita	NAD	45 877.17	48 349.94	50 989.85	53 416.97	55 959.62	58 623.29
CPI: Food	Index	122.19	129.40	135.98	142.03	147.91	154.43
Exchange rate	NAD/US dollar	14.11	14.86	15.64	16.47	17.33	18.25
Interest rate	%	10.75	11.46	12.06	12.68	13.34	14.04
Population	million	2 515 383	2 573 237	2 632 421	2 692 967	2 754 905	2 818 268.
SSMS	Export Restriction	1	1	1	1	1	1
Lick prices	NAD/kg	3.67	3.86	4.03	4.22	4.42	4.65
Rainfall	mm	286.93	295.50	301.15	302.16	299.45	301.26
Drought	Drought_dummy	1	1	1	1	0	0
NamCo. Abattoir Closure	Shift2013	1	1	1	1	1	1

4.3.4.2 Scenario analysis

The study section is established by asking the "What if Question", to gain an understanding on the model's responds to a shock on the market (De Beer, 2009). The question asked in this study is "what if the SSMS policy is removed?" As a result, the SSMS was removed during the year 2018 and 2019, and the results are shown in Table 4.11 below.

Table 4.11: Impact of a removal of the SSMS

	2016	2017	2018	2019	2020	2021
Baseline						
Sheep production	1 157.57	197.60	870.15	602.50	560.53	433.87
Export abattoirs	321.41	698.54	375.35	462.45	498.88	565.69
Non-export abattoirs	68.74	45.88	95.08	70.95	62.09	49.92
Sheep producer price	29.40	11.30	21.91	1946	18.33	16.26
Scenario						
Sheep production	1 157.57	197.60	879.39	611.06	563.26	437.98
Export abattoirs	321.41	698.54	342.32	419.21	498.16	563.91
Non-export abattoirs	68.74	45.88	65.73	43.64	62.23	50.28
Sheep producer price	29.40	11.30	22.74	20.61	18.36	16.31
Absolute change						
Sheep production	0.00	0.00	9.23	8.56	2.73	4.11
Export abattoirs	0.00	0.00	-33.10	-43.47	-0.73	-1.77
Non-export abattoirs	0.00	0.00	-29.33	-27.26	0.15	0.36
Sheep producer price	0.00	0.00	0.83	1.16	0.02	0.06
% Change						
Sheep production	0%	0%	1%	1%	0.49%	1%
Export abattoirs	0%	0%	-9%	-9%	-0.1%	-0.3%
Non-export abattoirs	0%	0%	-31%	-38%	0.2%	1%
Sheep producer price	0%	0%	4%	6%	0.1%	0.3%

Table 4.11 above shows that if the SSMS policy is removed, throughput to export abattoirs and non-export abattoirs can reduce. Throughput to export abattoirs would drop by approximately 9 per cent for both the years 2018 and 2019. For the years, 2020 and 2021 a decrease is expected but at a low rate of 0.1 and 0.3 per cent, respectively. Throughput to non-export abattoirs would drastically decrease by 31 per cent and 38 per cent, in 2018 and 2019, respectively. In 2020 and 2021, throughput to non-export abattoirs is anticipated to increase. Sheep production is expected to increase by approximately one per cent for the years 2018, 2019, and 2021, with the exception in 2020 that indicates an increase of less than one per cent (0.48 per cent). The removal of the SSMS policy is likely to have a positive impact on domestic sheep producer prices. However, the increase is expected to be at a rate of about 4 and 6 per cent for the years 2018 and 2019, respectively. For the years, 2020 and 2021, prices are anticipated to increase but at an extremely low percentage change of 0.1 and 0.3, respectively. The simulation model shows that the removal of the SSMS would lead to an increase in domestic producer prices; however the increase could be low. Therefore, it is evident that there are other dynamics factors, such as drought, and the type of market structure affecting domestic price levels, and in turn market integration.

4.4 Summary of the results and discussions

This summary section summarises the results and discussions of the spatial price integration and price formation analysis. Initially, on the spatial price transmission, Chapter 2 defined the law of one price (LOP) as a condition in the market that requires spatial markets with a homogenous good to have the same price, taking into consideration transaction costs. The study analysed market integration by testing LOP. The study proved that the strict price behaviour implied by LOP does not exist in the case considered above. The strong LOP fails to prevail in the analysis, possibly due to the distance between the two spatial regions and policy intervention. Secondly, the study found spatial market integration, which implies a weak LOP. The price transmission is incomplete (no full transmission), and the probable reason could be due to the government intervention, and other dynamic factors such as transaction costs. Table 4.12 below displays a summary of the results.

Table 4.12: Summary of the outcomes

	Engle & Granger Method		Johansen's Approach/VECM	
	Pre-SSMS	**Post-SSMS**	**Pre-SSMS**	**Post-SSMS**
Cointegration	Present	Present	Absent	Present
Short-run adjustment	Present		Absent	No short-run from SA to NAM prices, But present short-run from NAM to SA prices
Speed of adjustment	-0.301			-0.327
Half-life	2.3 months			2.1 months

A long-run equilibrium relationship exists between the Namibian and South African sheep markets, pre- and post-SSMS. The trade flow and common economic policies have been efficient in leading spatial prices toward a long-run equilibrium. More importantly, the price transmission is not the same, before and after the introduction of the SSMS, that is, spatial price integration changed in the sheep market. The cointegration tests results from the Engle and Granger (1987) method indicate that spatial price transmission during the post-SSMS is marginally higher than during pre-SSMS, at 0.94 and 0.88, respectively. The SSMS, which is a quantitative export restriction policy, ought to impede price transmissions, but the analysis found an opposing outcome. The outcome can be attributed to periods of drought in Namibia over the past four years. During the drought, trade increased between the two markets because of a reduced quantitative export ratio. This in turn affected the price transmission mechanism. Mokumako and Baliyan (2016) suggest that trade results in a high price transmission elasticity, this coming from an analysis of a long-run price transmission from South Africa to Botswana. Meyer (2005) mentions that trade affects price transmission. Obviously, the lack of trade leads to market segmentation, but an increase in trade leads to increased market integration.

The synthesis used the ECM, during the pre-SSMS period, and the VECM, during the post-SSMS period. The pre-SSMS analysis found short-run dynamics, causing co-movement of prices in the identified long-run equilibrium relationship. Post-SSMS, the study found that there were no short-run dynamics from the Namibian market to the South African market. The speed of price adjustment, before and after the implementation of the SSMS, changed. The study found a speed of adjustment, post-SSMS, of 2.1 months, which is marginally faster than pre-SSMS price adjustment of 2.3 months. Considering how economically integrated the Namibian and South African markets are, the speeds of price adjustments are moderately low, due to the possible inefficient transmission of price signals because of market insulation resulting from quantitative export restrictions, and drought periods, which affect the live sheep supply. In conclusion, the study rejects the hypothesis, which states that the long-run equilibrium and short-run dynamics, post-SSMS, reduced between Namibia and South Africa, as both increased.

Regarding the impact of the SSMS on the level of domestic prices, the study found a negative elasticity of the SSMS in the supply equation. The elasticity is -0.013, which is an indication of a slow response to the SSMS policy change. A positive elasticity of the SSMS in the demand function (slaughter at export abattoirs and slaughter at non-export abattoirs) exists. These outcomes indicate that the SSMS had an effect on the domestic supply and demand equations. However, the price equation suggests that the SSMS had minimal to no effect on the domestic producer prices. The study attributes the lack of impact of the SSMS on domestic prices to the low responsiveness of the supply and demand to the SSMS policy (mainly the export abattoir equation); the continued increase in producer prices post-SSMS due to the drought; and finally, because the SSMS is allowed to vary. The simulation done on the PEF affirmed that the SSMS might have a limited effect on domestic prices levels, if the policy is removed.

In summary, after the introduction of the policy, prices continued to increase, although at a minimal rate, when compared with South African prices. This decreased the chance of producers reducing sheep production at a faster rate. Furthermore, PWC (2007) found that although the policy promised a levelled playing field where both producers and export abattoirs benefit from the policy, this was not the case. The existence of a few export-abattoirs and a large number of sheep producers, and a mandatory requirement of producers to slaughter sheep locally before exporting, created a dependence of producers on export abattoirs. Hypothetically, an oversupply of a commodity in the market results in decreased price levels in the market. However, the SSMS policy resulted in minimal increasing producer prices, when compared with the South African prices. The minimal increasing producer prices led to low profits accruing to sheep producers. Since sheep producers seek to maximise profit, they are most likely to monitor prices in the Namibian and South African markets. This is so that sheep producers can take advantage of favourable prices, in order to benefit from high prices. This ultimately increases the price transmission process, hence increasing spatial market integration. The spatial market integration and price formation results exhibit no detrimental effect of the SMSS policy.

Resultantly, the SSMS policy seems to have a limited distortive effect on the sheep market.

CHAPTER 5:
SUMMARY AND CONCLUSION

This chapter summarises the synthesis of, and makes comments on, the objectives and hypothesis. The study then proceeds to describe the methods used and reports on the major findings of the study, and hence, make conclusions.

The Namibian government introduced a quantitative export restriction policy, the Small Stock Marketing Scheme (SSMS) for the sheep market, in 2004. The policy was implemented to reduce the exportation of live sheep to the South African market, and additionally increase sheep throughput to Namibian export abattoirs. Quantitative export restriction policies reduce exports and increase domestic supply of a commodity (Djuric *et al*., 2009). This causes a lack of equilibrium in the market.

Government interventions, such as quantitative export restrictions, buffer the domestic market from external price shocks from foreign markets (Baltzer, 2013). This affects spatial market integration. Spatial market integration occurs when countries trade a homogenous good. South Africa is Namibia's main sheep trading partner, which means that market integration between the two countries exists (Taljaard *et al*., 2009). Considering how dependent Namibian producers are on the South African sheep market, it is vital to evaluate spatial market integration.

Namibia is a net exporter of live sheep to South African, and as a result, operates under the export price parity (EPP) trade regime. This means that Namibian producer prices are explained by factors such as South African producer prices, policies and other factors. The SSMS reduced the live sheep trade between Namibia and South Africa, thus disturbing spatial arbitrage opportunities. Arbitrage is an equilibrium condition. Therefore, any shocks such as a government intervention are likely to affect supply and demand, which governs the domestic price levels. Djuric *et al*. (2015) confirm that export restrictions have effects on domestic price levels. This is because export restriction policies reduce exports, and increase the domestic supply of the affected commodity. The increase in the supply of a commodity in the domestic market then negatively affects domestic prices. Evidently, the policy might not only have influenced spatial market integration, as the SSMS policy may also have affected the domestic producer price levels. This nurtures a reason to question the effect of the SSMS on domestic price levels. The objective of this study was therefore to determine the long-run equilibrium relationship, and the short-run dynamics, in spatial markets, and to determine the price formation in the domestic market. It is vital to assess the effect of the SSMS on spatial price transmission and price formation because policy makers need to understand how a quantitative export restriction policy might affect price behaviour and market integration. Markets that are not well integrated affect a country’s food security, as they prevent an efficient flow of commodities from a surplus-producing country to a deficit-producing country.

This research endeavoured to assess spatial price integration and price formation in the presence of the SSMS on the Namibian sheep market. The analysis evaluated the SSMS by identifying spatial price transmission in the sheep market, before 1999M01-2003M12 and after 2004M01-2015M12. The price ranges were divided into subsamples to recognise the possible changes in the long-run equilibrium relationship and short-run dynamics between the Namibian and South African sheep producer prices. The price formation analysis examined the impact of SSMS on domestic price levels. This evaluation was done by appraising the responsiveness of the domestic supply, demand, and price functions to the SSMS policy, and how these eventually dictated domestic price levels.

In order to answer the long-run equilibrium relationship objective, the synthesis used the Engle and Granger (1987) method and the Johansen (1988) cointegration approach. Before the cointegration test, the study performed the univariate properties tests on individual price series, with an Augmented Dickey-Fuller (ADF) unit root test and Kwiatkowski-Philips-Schmidt-Shin (KPSS) test. A unidirectional modelling approach, in the form of an Engle-Granger test for cointegration with its associated ECM, was conducted, pre-SSMS. This approach can be motivated by the size of the respective markets and the associated trade flows. The South African sheep market is much larger in comparison with its Namibian counterpart, and as such, live sheep were exported from Namibia to South Africa before the implementation of the SSMS. Post-SSMS, trade flows to South Africa reduced and the assumption of a unidirectional price relationship between South African and Namibia could have been affected. As a result, the possibility of a bidirectional relationship was evaluated through the Johansen (1988) procedure, with the estimation of an associated VECM. Next, the study used the partial equilibrium framework (PEF) to assess and simulate the domestic price formation.

After a careful evaluation of the univariate properties, the study found that the price series are non-stationary in levels, but stationary in first difference, $I(1)$, having used the ADF and KPSS tests. The confirmation of stationary price series at $I(1)$ led to the testing of producer prices for cointegration. The empirical evidence from the Engle and Granger (1987) cointegration method exhibits cointegration in spatial markets, which implies that the two markets were integrated in the long run, during the pre- and post-SSMS periods. The Johansen (1988) cointegration approach specified that there is no long-run equilibrium relationship between the Namibian and South African markets, during the pre-SSMS period. This implies that there was no co-movement of prices, nor any spatial price transmission, pre-SSMS. The possible reason for this discrepancy is the small sample used, pre-SSMS, the reason being that the Johansen (1988) cointegration approach suffers from error specifications in small samples, due to its reliance on asymptotic properties (Sjo, 2008).

During the post-SSMS period, the Johansen (1988) method indicates the presence of a long-run equilibrium relationship. The study attributes this to the high prices that prompted Namibian sheep producers to observe South African producer prices carefully, which in turn increased price transmission. The study further reveals an unexpected result about the long-run equilibrium relationship. The long-run equilibrium results state that the price transmission elasticity of 0.94, post-SSMS, is moderately higher than the price transmission elasticity of 0.88 revealed during the pre-SSMS period. This outcome contrast with *a priori* expectation, as quantitative export restrictions such as the SSMS likely impede price transmission (Baltzer, 2013). However, the study attributes the high price transmission elasticity during the post-SSMS period to drought. During drought periods, the export ratio decreased, for instance, from a 1:6 to 1:1, thus increasing the exportation of live sheep to the South African market. This additionally renders the SSMS inefficient, and increases market integration through increased trade.

In terms of the short-run dynamics, the pre-SSMS results show the existence of short-run dynamics, with a disequilibrium being corrected after 2.3 months. During the post-SSMS period, the analysis indicates that the Namibian market corrected disequilibrium after 2.1 months. This contradicts *priori* expectations because quantitative export restrictions are anticipated to hinder price transmission. According to the estimated results of the VECM, there was no bidirectional price transmission during the post-SSMS period. This means that directionality flows from the South African market to the Namibian market. The outcome indicates that the Namibian producer prices are doing the adjustments in the short run to return to the long-run equilibrium position. Based on the findings noted above, there is a high price transmission elasticity of 0.94, post-SSMS, and the speeds of adjustment periods do not differ significantly. For those reasons, the study concludes that the SSMS did not have a detrimental effect on market integration. This is contrary to a *priori* expectation that the SSMS affected market integration negatively.

The spatial market integration results contrast with outcomes reported by Djuric *et al*. (2009), Djuric *et al.* (2015), Götz *et al*. (2013), and Goychuk and Meyers (2011). Djuric *et al*. (2009) and Djuric *et al.* (2015) found a constant price transmission after the introduction of the export restriction in question. Götz *et al*. (2013) revealed a decrease in the degree of market integration after the implementation of the export restriction. Goychuk and Meyers (2011) established a mixture of results, because the Russian wheat prices were cointegrated with the European Union prices, but not with the Canadian or US wheat prices. The Ukrainian prices were not cointegrated with other prices. Djuric *et al*. (2009) also found a decrease in the speed of adjustment after the restriction period, which opposes the results from the synthesis presently under study. Nonetheless, Djuric *et al.* (2015) and Goychuk and Meyers (2011) identified an increased speed of adjustment after the introduction of the export restriction policies they studied. These results are similar to the outcomes of this present study. Djuric *et al.* (2015) attribute the increased speed of adjustment to the demanding arbitrage activities of wheat traders in Serbia, induced by world market price changes.

Following from the results set out above, the study identified the fact that, during the pre- and post-SSMS periods, the long-run equilibrium relationship and the short-run dynamics changed. This addresses the main objective, which states that the SSMS changed the spatial price integration, pre- and post-SSMS. Accordingly, the study rejects the hypothesis that the long-run equilibrium relationship and the short-run dynamics reduced between the Namibia and South African market, post-SSMS.

The study examined domestic price levels by assessing the response of the domestic supply and demand equations to the SSMS variable. The findings revealed a negative elasticity of the SSMS on the supply equation, with an elasticity of -0.013, indicating a low response to the SSMS. The negative effect is anticipated because, since a quantitative export restriction increases domestic supply, producers are likely to decrease commodity supply to keep prices high. The low responsiveness of the supply equation can be attributed to the lagged biological production of sheep, and the fact that sheep producers possibly respond to other dynamic factors such as own prices and input costs. On the other hand, the SSMS variable showed a positive elasticity of the SSMS on the demand function (slaughter at export abattoirs and non-export abattoirs). An increase in demand could be a result of the low price levels, compared with South African producer prices that occurred due to an increase supply of live sheep in the domestic market. Therefore, because of the low prices offered on the Namibia market, abattoirs demanded more live sheep from producers. The responsiveness of the export abattoirs and non-export abattoirs equations to a change in the SSMS are 0.03 and 0.93, respectively. The positive result of the SSMS in the export abattoirs equation is attributed to the mandate of the SSMS policy. The SSMS requires sheep producers to slaughter at export abattoirs, before producers may export. The positive responsiveness of the non-export abattoirs to the SSMS is attributed to the increased throughput to non-export abattoirs. The increased throughput resulted from an oversupply at export abattoirs, caused by the drought and the closure of one of the export abattoirs.

The study further looked at the price equation because it was anticipated that the quantitative export restriction influenced domestic price levels. The analysis found a negative but negligible elasticity. The insignificant elasticity indicates that the policy had an extremely small influence on the domestic producer prices. The study attributes the insignificant impact of the SSMS on domestic producer prices to the low responsiveness of the supply and demand (especially slaughter at export abattoir) to the SSMS policy. Despite the low producer prices offered in the Namibian market, compared with the producer prices offered in the South African market, the domestic producer prices still increased, although the increase is minimal. Besides the government intervention, the drought occurred and this decreased the sheep supply and caused increases in domestic prices. To accommodate the drought, the SSMS was allowed to vary. The study further simulated the PEF model by asking the question, "what if the SSMS policy is removed during 2018 and 2019? How will the Namibian producer prices respond to the removal of the SSMS?" According to the simulation model, the removal of the SSMS would decrease throughput to export abattoirs and non-export abattoirs. Throughput to export abattoirs would decrease by 9 per cent for 2018 and 2019, and throughput to non-export abattoirs could decrease by 31 per cent and 38 per cent for 2018 and 2019, respectively. Sheep production is likely to increase by 1 per cent for both 2018 and 2019. The removal of the SSMS could increase domestic producer price levels by 4 per cent and 6 per cent in 2018 and 2019, respectively. The impact of the SSMS on domestic producer prices is extremely small, which confirms the results in the price equation that the SSMS had a minimal and negligible effect on domestic producer prices. The PEF analysis addressed the second objective, which states that the SSMS had an effect on domestic price levels. The study fails to reject the hypothesis that the SSMS negatively influenced the level of domestic prices, because the policy did affect domestic producer prices although to an extremely small and negligible extent.

Accordingly, the spatial market integration and price formation results indicate that the SSMS had no detrimental influence on domestic price levels. The study deduces that other dynamic factors could have influenced the sheep market. More importantly, a variable quantitative export restriction policy, variable in the sense that the quota ratios can be changed, is better than an export control that is strictly enforced and does not permit variation. This is because a quantitative export restriction policy that does not vary will not allow producers to export an excess in production, even when the local market is unable to take up most or all of the commodities available on the market. An invariable quantitative export restriction can thus lead to a great distortion effect on trade. On the other hand, when a quantitative export restriction policy varies, which is the case in the Namibian sheep market, the effect will not be detrimental. The policy will, for instance be able to reduce the quota ratio, which will then increase the exportation of a commodity and prevent a further drop in the domestic prices. This in turn helps to regulate domestic prices. As a result, this study positively contributes to literature by evaluating the impact of the SMSS on market integration and price formation in the Namibian sheep market.

Authors such as Schutz (2009) and Taljaard *et al.* (2009) have assumed that the SSMS resulted in an oligopolistic market structure and that the market structure had a dampening effect on producer prices, but no empirical evidence exists to support this. Oligopolistic markets are not always exploitive, and this can be tested by assessing the vertical integration between producer prices and wholesale prices. Testing this is beyond the scope of this study, hence leaving this concept for future research. There is still more to be done to improve the PEF, and this is left for future research. Moreover, the simulation model indicated that the removal of SSMS would have an extremely small effect on domestic prices. Drought seems to have had an effect on the sheep market. Drought periods are likely to have a multiplier effect on the input side (lick costs) and the slaughter-to-export ratio. In future, it would be interesting to simulate the probable impact of drought on sheep producer prices in Namibia.

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APPENDICES

Appendix 1: Price series - Correlograms

1.i Pre-SSMS

Appendix 1.1: Nominal Namibian producer prices

Date: 11/08/16 Time: 17:21
Sample: 1999M01 2003M12
Included observations: 59

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |** |	. |** |	1	0.300	0.300	5.5863	0.018
. |*. |	. | . |	2	0.086	-0.004	6.0532	0.048
. | . |	. | . |	3	0.072	0.052	6.3893	0.094
.*| . |	**| . |	4	-0.168	-0.225	8.2449	0.083
.*| . |	. | . |	5	-0.107	0.005	9.0128	0.109
**| . |	**| . |	6	-0.234	-0.227	12.742	0.047
.*| . |	. | . |	7	-0.192	-0.028	15.291	0.032
**| . |	**| . |	8	-0.221	-0.222	18.749	0.016
.*| . |	. | . |	9	-0.165	-0.021	20.709	0.014
.*| . |	.*| . |	10	-0.107	-0.163	21.555	0.018
. | . |	. |*. |	11	0.047	0.132	21.724	0.027
. |*. |	. | . |	12	0.147	-0.029	23.389	0.025
.*| . |	**| . |	13	-0.075	-0.207	23.823	0.033
.*| . |	**| . |	14	-0.079	-0.205	24.321	0.042
. | . |	. | . |	15	0.031	0.030	24.401	0.059
. | . |	.*| . |	16	0.015	-0.071	24.421	0.081
.*| . |	**| . |	17	-0.095	-0.227	25.198	0.090
. | . |	.*| . |	18	-0.025	-0.069	25.253	0.118
. | . |	. | . |	19	0.060	0.002	25.573	0.143
. | . |	.*| . |	20	0.003	-0.095	25.574	0.180
. | . |	.*| . |	21	-0.003	-0.184	25.575	0.223
. |*. |	. | . |	22	0.090	0.002	26.366	0.236
. |*. |	.*| . |	23	0.127	-0.069	27.968	0.217
. | . |	**| . |	24	-0.040	-0.258	28.130	0.255

Appendix 1.2: Nominal South African producer prices

Date: 11/08/16 Time: 17:24
Sample: 1999M01 2003M12
Included observations: 59

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |** |	. |** |	1	0.250	0.250	3.8935	0.048
. |*. |	. | . |	2	0.075	0.014	4.2531	0.119
. |*. |	. |*. |	3	0.210	0.200	7.0805	0.069
. | . |	.*| . |	4	-0.049	-0.164	7.2363	0.124
**| . |	**| . |	5	-0.290	-0.279	12.830	0.025
.*| . |	. | . |	6	-0.148	-0.064	14.322	0.026
**| . |	.*| . |	7	-0.260	-0.195	18.984	0.008
***| . |	.*| . |	8	-0.357	-0.182	27.993	0.000
.*| . |	. | . |	9	-0.149	-0.044	29.593	0.001
.*| . |	.*| . |	10	-0.102	-0.085	30.362	0.001
.*| . |	.*| . |	11	-0.145	-0.112	31.948	0.001
.*| . |	.*| . |	12	-0.078	-0.204	32.420	0.001
. |** |	. |*. |	13	0.242	0.169	36.985	0.000
. |*. |	.*| . |	14	0.095	-0.094	37.702	0.001
. |*. |	. |*. |	15	0.187	0.098	40.547	0.000
. |*. |	.*| . |	16	0.200	-0.113	43.902	0.000
. |*. |	.*| . |	17	0.078	-0.081	44.426	0.000
. | . |	.*| . |	18	-0.001	-0.075	44.426	0.001
. |*. |	. | . |	19	0.083	0.002	45.041	0.001
. | . |	. | . |	20	-0.058	-0.033	45.350	0.001
.*| . |	. | . |	21	-0.100	0.017	46.301	0.001
. | . |	. | . |	22	-0.021	-0.008	46.346	0.002
. | . |	. | . |	23	-0.063	-0.000	46.743	0.002
. | . |	. |*. |	24	-0.016	0.077	46.769	0.004

1.ii Post-SSMS

Appendix 1.3: Nominal Namibian producer prices

Date: 11/08/16 Time: 17:27
Sample: 2004M01 2015M12
Included observations: 143

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|** |	.|** |	1	0.291	0.291	12.336	0.000
.|* |	.|. |	2	0.092	0.008	13.580	0.001
*|. |	*|. |	3	-0.158	-0.204	17.255	0.001
**|. |	*|. |	4	-0.262	-0.186	27.459	0.000
*|. |	.|. |	5	-0.134	0.014	30.157	0.000
**|. |	**|. |	6	-0.227	-0.214	37.926	0.000
.|. |	.|. |	7	-0.016	0.036	37.964	0.000
*|. |	**|. |	8	-0.182	-0.266	43.030	0.000
.|. |	.|. |	9	-0.051	-0.035	43.430	0.000
.|* |	.|* |	10	0.110	0.087	45.316	0.000
.|* |	.|* |	11	0.177	0.081	50.253	0.000
.|*** |	.|** |	12	0.479	0.350	86.589	0.000
.|* |	*|. |	13	0.088	-0.161	87.832	0.000
.|. |	*|. |	14	-0.032	-0.095	88.001	0.000
*|. |	.|. |	15	-0.187	0.015	93.644	0.000
**|. |	.|. |	16	-0.233	-0.053	102.54	0.000
*|. |	.|. |	17	-0.081	0.028	103.62	0.000
*|. |	*|. |	18	-0.165	-0.083	108.16	0.000
.|. |	.|. |	19	0.019	-0.036	108.22	0.000
**|. |	**|. |	20	-0.216	-0.215	116.09	0.000
*|. |	**|. |	21	-0.183	-0.226	121.78	0.000
.|. |	*|. |	22	-0.028	-0.103	121.92	0.000
.|* |	.|* |	23	0.156	0.102	126.10	0.000
.|*** |	.|. |	24	0.363	0.005	149.11	0.000
.|* |	.|. |	25	0.103	-0.065	150.99	0.000
.|. |	.|. |	26	0.034	-0.052	151.19	0.000
.|. |	.|* |	27	-0.046	0.115	151.57	0.000
*|. |	*|. |	28	-0.183	-0.125	157.58	0.000

Appendix 1.4: Nominal South African producer prices

Date: 11/08/16 Time: 17:29
Sample: 2004M01 2015M12
Included observations: 143

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|** |	.|** |	1	0.215	0.215	6.7270	0.009
.|. |	.|. |	2	-0.001	-0.049	6.7271	0.035
*|. |	*|. |	3	-0.130	-0.125	9.2111	0.027
**|. |	**|. |	4	-0.249	-0.207	18.452	0.001
.|. |	.|. |	5	-0.036	0.059	18.647	0.002
*|. |	*|. |	6	-0.146	-0.187	21.889	0.001
.|. |	.|. |	7	0.014	0.037	21.919	0.003
.|. |	*|. |	8	-0.027	-0.107	22.034	0.005
*|. |	*|. |	9	-0.086	-0.093	23.191	0.006
.|. |	.|. |	10	0.018	-0.025	23.243	0.010
.|* |	.|* |	11	0.149	0.176	26.751	0.005
.|*** |	.|** |	12	0.423	0.344	55.046	0.000
.|* |	.|. |	13	0.143	-0.018	58.327	0.000
*|. |	*|. |	14	-0.125	-0.152	60.843	0.000
*|. |	*|. |	15	-0.198	-0.071	67.186	0.000
*|. |	.|. |	16	-0.196	0.033	73.476	0.000
.|. |	.|. |	17	-0.044	0.021	73.799	0.000
.|. |	.|. |	18	-0.051	-0.048	74.237	0.000
.|. |	*|. |	19	-0.022	-0.117	74.321	0.000
*|. |	*|. |	20	-0.107	-0.204	76.268	0.000
*|. |	*|. |	21	-0.187	-0.172	82.209	0.000
*|. |	*|. |	22	-0.084	-0.087	83.423	0.000
.|* |	.|. |	23	0.138	0.068	86.731	0.000
.|** |	.|. |	24	0.305	0.042	102.92	0.000
.|* |	.|. |	25	0.151	-0.042	106.94	0.000
*|. |	*|. |	26	-0.084	-0.088	108.19	0.000
*|. |	.|. |	27	-0.199	-0.058	115.26	0.000
*|. |	.|. |	28	-0.127	0.070	118.16	0.000

Appendix 2: Unit root test

2.i Pre-SSMS

2.i.a ADF test in levels

Appendix 2.1: Namibian producer prices

Null Hypothesis: LNAM_PRICES_BEFORE has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic – based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.864080	0.3466
Test critical values:	1 % level	-3.548208	
	5 % level	-2.912631	
	10 % level	-2.594027	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNAM_PRICES_BEFORE)
Method: Least Squares
Date: 07/16/16 Time: 13:25
Sample (adjusted): 1999M03 2003M12
Included observations: 58 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNAM_PRICES_BEFORE(-1)	-0.085927	0.046096	-1.864080	0.0677
D(LNAM_PRICES_BEFORE(-1))	0.350833	0.125811	2.788564	0.0073
C	0.219121	0.115375	1.899202	0.0628

R-squared	0.147193	Mean dependent var	0.005547
Adjusted R-squared	0.116182	S.D. dependent var	0.044786
S.E. of regression	0.042104	Akaike info criterion	-3.447013
Sum squared resid	0.097501	Schwarz criterion	-3.340439
Log likelihood	102.9634	Hannan-Quinn criter.	-3.405500
F-statistic	4.746461	Durbin-Watson stat	2.078758
Prob(F-statistic)	0.012543		

Appendix 2.2: South African producer prices

Null Hypothesis: LSA_PRICES_BEFORE has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic – based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.302796	0.6226
Test critical values:	1 % level	-3.548208	
	5 % level	-2.912631	
	10 % level	-2.594027	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LSA_PRICES_BEFORE)
Method: Least Squares
Date: 07/16/16 Time: 13:28
Sample (adjusted): 1999M03 2003M12
Included observations: 58 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LSA_PRICES_BEFORE(-1)	-0.052308	0.040151	-1.302796	0.1981
D(LSA_PRICES_BEFORE(-1))	0.277187	0.130428	2.125218	0.0381
C	0.148518	0.109284	1.359013	0.1797

R-squared	0.091444	Mean dependent var	0.008297
Adjusted R-squared	0.058406	S.D. dependent var	0.036179
S.E. of regression	0.035106	Akaike info criterion	-3.810537
Sum squared resid	0.067785	Schwarz criterion	-3.703962
Log likelihood	113.5056	Hannan-Quinn criter.	-3.769024
F-statistic	2.767826	Durbin-Watson stat	2.006790
Prob(F-statistic)	0.071559		

2.i.b KPSS test in levels

Appendix 2.3: Namibian producer prices

Null Hypothesis: LNAM_PRICES_BEFORE is stationary
Exogenous: Constant
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.678434
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.015211
HAC corrected variance (Bartlett kernel)	0.078365

KPSS Test Equation
Dependent Variable: LNAM_PRICES_BEFORE
Method: Least Squares
Date: 11/27/17 Time: 09:51
Sample: 1999M01 2003M12
Included observations: 60

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.503932	0.016057	155.9429	0.0000

R-squared	0.000000	Mean dependent var	2.503932
Adjusted R-squared	0.000000	S.D. dependent var	0.124375
S.E. of regression	0.124375	Akaike info criterion	-1.314507
Sum squared resid	0.912677	Schwarz criterion	-1.279601
Log likelihood	40.43522	2Hannan-Quinn criter.	-1.300854
Durbin-Watson stat	0.130327		

Appendix 2.4: South African producer prices

Null Hypothesis: LSA_PRICES_BEFORE is stationary
Exogenous: Constant
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.828003
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.015081
HAC corrected variance (Bartlett kernel)	0.077384

KPSS Test Equation
Dependent Variable: LSA_PRICES_BEFORE
Method: Least Squares
Date: 11/27/17 Time: 10:02
Sample: 1999M01 2003M12
Included observations: 60

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.723254	0.015988	170.3312	0.0000

R-squared	0.000000	Mean dependent var	2.723254
Adjusted R-squared	0.000000	S.D. dependent var	0.123843
S.E. of regression	0.123843	Akaike info criterion	-1.323086
Sum squared resid	0.904881	Schwarz criterion	-1.288180
Log likelihood	40.69258	Hannan-Quinn criter.	-1.309433
Durbin-Watson stat	0.087197		

2.ii Pre-SSMS

2.ii.a ADF test in first difference

Appendix 2.5: Namibian producer prices

Null Hypothesis: D(LNAM_PRICES_BEFORE) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic – based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.553288	0.0000
Test critical values:	1 % level	-3.548208	
	5 % level	-2.912631	
	10 % level	-2.594027	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNAM_PRICES_BEFORE,2)
Method: Least Squares
Date: 07/16/16 Time: 13:31
Sample (adjusted): 1999M03 2003M12
Included observations: 58 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNAM_PRICES_BEFORE(-1))	-0.698175	0.125723	-5.553288	0.0000
C	0.004301	0.005673	0.758194	0.4515

R-squared	0.355129	Mean dependent var	0.001420
Adjusted R-squared	0.343613	S.D. dependent var	0.053105
S.E. of regression	0.043024	Akaike info criterion	-3.420234
Sum squared resid	0.103661	Schwarz criterion	-3.349184
Log likelihood	101.1868	Hannan-Quinn criter.	-3.392558
F-statistic	30.83901	Durbin-Watson stat	2.025069
Prob(F-statistic)	0.000001		

Appendix 2.6: South African producer prices

Null Hypothesis: D(LSA_PRICES_BEFORE) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic – based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.751693	0.0000
Test critical values:	1 % level	-3.548208	
	5 % level	-2.912631	
	10 % level	-2.594027	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LSA_PRICES_BEFORE,2)
Method: Least Squares
Date: 07/16/16 Time: 13:32
Sample (adjusted): 1999M03 2003M12
Included observations: 58 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LSA_PRICES_BEFORE(-1))	-0.747091	0.129891	-5.751693	0.0000
C	0.006277	0.004753	1.320577	0.1920

R-squared	0.371366	Mean dependent var	0.000308
Adjusted R-squared	0.360140	S.D. dependent var	0.044160
S.E. of regression	0.035324	Akaike info criterion	-3.814627
Sum squared resid	0.069876	Schwarz criterion	-3.743577
Log likelihood	112.6242	Hannan-Quinn criter.	-3.786951
F-statistic	33.08197	Durbin-Watson stat	1.999297
Prob(F-statistic)	0.000000		

2.ii.b KPSS test in first difference

Appendix 2.7: Namibian producer prices

Null Hypothesis: D(LNAM_PRICES_BEFORE) is stationary
Exogenous: Constant
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.049399
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.001995
HAC corrected variance (Bartlett kernel)	0.003137

KPSS Test Equation
Dependent Variable: D(LNAM_PRICES_BEFORE)
Method: Least Squares
Date: 11/27/17 Time: 10:16
Sample (adjusted): 1999M02 2003M12
Included observations: 59 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.004551	0.005865	0.775914	0.4410

R-squared	0.000000	Mean dependent var	0.004551
Adjusted R-squared	0.000000	S.D. dependent var	0.045053
S.E. of regression	0.045053	Akaike info criterion	-3.345169
Sum squared resid	0.117725	Schwarz criterion	-3.309957
Log likelihood	99.68249	Hannan-Quinn criter.	-3.331423
Durbin-Watson stat	1.366435		

Appendix 2.8: South African producer prices

Null Hypothesis: D(LSA_PRICES_BEFORE) is stationary
Exogenous: Constant
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.049485
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.001266
HAC corrected variance (Bartlett kernel)	0.002076

KPSS Test Equation
Dependent Variable: D(LSA_PRICES_BEFORE)
Method: Least Squares
Date: 11/27/17 Time: 10:19
Sample (adjusted): 1999M02 2003M12
Included observations: 59 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.008452	0.004672	1.809084	0.0756

R-squared	0.000000	Mean dependent var	0.008452
Adjusted R-squared	0.000000	S.D. dependent var	0.035885
S.E. of regression	0.035885	Akaike info criterion	-3.800189
Sum squared resid	0.074689	Schwarz criterion	-3.764977
Log likelihood	113.1056	Hannan-Quinn criter.	-3.786444
Durbin-Watson stat	1.488332		

2.iii Post-SSMS

2.iii.a ADF in levels

Appendix 2.9: Namibian producer prices

Null Hypothesis: LNAM_PRICES_AFTER has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic – based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.428960	0.5665
Test critical values:	1 % level	-3.476805	
	5 % level	-2.881830	
	10 % level	-2.577668	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNAM_PRICES_AFTER)
Method: Least Squares
Date: 07/16/16 Time: 13:37
Sample (adjusted): 2004M03 2015M12
Included observations: 142 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNAM_PRICES_AFTER(-1)	-0.017619	0.012330	-1.428960	0.1553
D(LNAM_PRICES_AFTER(-1))	0.299991	0.080231	3.739081	0.0003
C	0.059475	0.038446	1.546993	0.1241

R-squared	0.098935	Mean dependent var	0.006603
Adjusted R-squared	0.085970	S.D. dependent var	0.045472
S.E. of regression	0.043473	Akaike info criterion	-3.412449
Sum squared resid	0.262697	Schwarz criterion	-3.350002
Log likelihood	245.2839	Hannan-Quinn criter.	-3.387073
F-statistic	7.630942	Durbin-Watson stat	2.030853
Prob(F-statistic)	0.000717		

Appendix 2.10: South African producer prices

Null Hypothesis: LSA_PRICES_AFTER has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic – based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.064234	0.7288
Test critical values:	1 % level	-3.476805	
	5 % level	-2.881830	
	10 % level	-2.577668	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LSA_PRICES_AFTER)
Method: Least Squares
Date: 07/16/16 Time: 13:40
Sample (adjusted): 2004M03 2015M12
Included observations: 142 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LSA_PRICES_AFTER(-1)	-0.011438	0.010748	-1.064234	0.2891
D(LSA_PRICES_AFTER(-1))	0.220263	0.082505	2.669698	0.0085
C	0.044062	0.036636	1.202700	0.2311

R-squared	0.054111	Mean dependent var	0.006569
Adjusted R-squared	0.040501	S.D. dependent var	0.040863
S.E. of regression	0.040027	Akaike info criterion	-3.577621
Sum squared resid	0.222701	Schwarz criterion	-3.515174
Log likelihood	257.0111	Hannan-Quinn criter.	-3.552245
F-statistic	3.975850	Durbin-Watson stat	1.979314
Prob(F-statistic)	0.020936		

2.iii.b KPSS in levels

Appendix 2.11: Namibian producer prices

Null Hypothesis: LNAM_PRICES_AFTER is stationary
Exogenous: Constant
Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.332864
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.089580
HAC corrected variance (Bartlett kernel)	0.868531

KPSS Test Equation
Dependent Variable: LNAM_PRICES_AFTER
Method: Least Squares
Date: 11/27/17 Time: 10:27
Sample: 2004M01 2015M12
Included observations: 144

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.107029	0.025029	124.1385	0.0000

R-squared	0.000000	Mean dependent var	3.107029
Adjusted R-squared	0.000000	S.D. dependent var	0.300345
S.E. of regression	0.300345	Akaike info criterion	0.439148
Sum squared resid	12.89959	Schwarz criterion	0.459772
Log likelihood	-30.61864	Hannan-Quinn criter.	0.447528
Durbin-Watson stat	0.023339		

Appendix 2.12: South African producer prices

Null Hypothesis: LSA_PRICES_AFTER is stationary
Exogenous: Constant
Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.337143
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.099501
HAC corrected variance (Bartlett kernel)	0.991996

KPSS Test Equation
Dependent Variable: LSA_PRICES_AFTER
Method: Least Squares
Date: 11/27/17 Time: 10:28
Sample: 2004M01 2015M12
Included observations: 144

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.396865	0.026378	128.7752	0.0000

R-squared	0.000000	Mean dependent var	3.396865
Adjusted R-squared	0.000000	S.D. dependent var	0.316539
S.E. of regression	0.316539	Akaike info criterion	0.544180
Sum squared resid	14.32817	Schwarz criterion	0.564804
Log likelihood	-38.18097	Hannan-Quinn criter.	0.552560
Durbin-Watson stat	0.016916		

2.iv Post-SSMS

2.iv.a ADF in first difference

Appendix 2.13: Namibian producer prices

Null Hypothesis: D(LNAM_PRICES_AFTER) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic – based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.835740	0.0000
Test critical values:	1 % level	-3.476805	
	5 % level	-2.881830	
	10 % level	-2.577668	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNAM_PRICES_AFTER,2)
Method: Least Squares
Date: 07/16/16 Time: 13:39
Sample (adjusted): 2004M03 2015M12
Included observations: 142 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNAM_PRICES_AFTER(-1))	-0.709230	0.080268	-8.835740	0.0000
C	0.004790	0.003696	1.296173	0.1970

R-squared	0.358005	Mean dependent var	0.000368
Adjusted R-squared	0.353420	S.D. dependent var	0.054265
S.E. of regression	0.043635	Akaike info criterion	-3.411950
Sum squared resid	0.266556	Schwarz criterion	-3.370319
Log likelihood	244.2485	Hannan-Quinn criter.	-3.395033
F-statistic	78.07030	Durbin-Watson stat	2.017980
Prob(F-statistic)	0.000000		

Appendix 2.14: South African producer prices

Null Hypothesis: D(LSA_PRICES_AFTER) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic – based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.525887	0.0000
Test critical values:	1 % level	-3.476805	
	5 % level	-2.881830	
	10 % level	-2.577668	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LSA_PRICES_AFTER,2)
Method: Least Squares
Date: 07/16/16 Time: 13:41
Sample (adjusted): 2004M03 2015M12
Included observations: 142 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LSA_PRICES_AFTER(-1))	-0.784929	0.082400	-9.525887	0.0000
C	0.005241	0.003399	1.541920	0.1254

R-squared	0.393263	Mean dependent var	0.000394
Adjusted R-squared	0.388929	S.D. dependent var	0.051229
S.E. of regression	0.040046	Akaike info criterion	-3.583590
Sum squared resid	0.224516	Schwarz criterion	-3.541959
Log likelihood	256.4349	Hannan-Quinn criter.	-3.566673
F-statistic	90.74253	Durbin-Watson stat	1.976307
Prob(F-statistic)	0.000000		

2.iv.b KPSS in first difference

Appendix 2.15: Namibian producer prices

Null Hypothesis: D(LNAM_PRICES_AFTER) is stationary
Exogenous: Constant
Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.051857
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.002067
HAC corrected variance (Bartlett kernel)	0.001356

KPSS Test Equation
Dependent Variable: D(LNAM_PRICES_AFTER)
Method: Least Squares
Date: 11/27/17 Time: 10:37
Sample (adjusted): 2004M02 2015M12
Included observations: 143 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.006154	0.003816	1.612773	0.1090

R-squared	0.000000	Mean dependent var	0.006154
Adjusted R-squared	0.000000	S.D. dependent var	0.045629
S.E. of regression	0.045629	Akaike info criterion	-3.329577
Sum squared resid	0.295645	Schwarz criterion	-3.308858
Log likelihood	239.0648	Hannan-Quinn criter.	-3.321158
Durbin-Watson stat	1.404453		

Appendix 2.16: South African producer prices

Null Hypothesis: D(LSA_PRICES_AFTER) is stationary
Exogenous: Constant
Bandwidth: 13 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.057218
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.001655
HAC corrected variance (Bartlett kernel)	0.001274

KPSS Test Equation
Dependent Variable: D(LSA_PRICES_AFTER)
Method: Least Squares
Date: 11/27/17 Time: 10:39
Sample (adjusted): 2004M02 2015M12
Included observations: 143 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.006325	0.003414	1.852794	0.0660

R-squared	0.000000	Mean dependent var	0.006325
Adjusted R-squared	0.000000	S.D. dependent var	0.040823
S.E. of regression	0.040823	Akaike info criterion	-3.552159
Sum squared resid	0.236649	Schwarz criterion	-3.531440
Log likelihood	254.9793	Hannan-Quinn criter.	-3.543739
Durbin-Watson stat	1.563751		

Appendix 3: Lag selection

Appendix 3.1: Pre-SSMS

VAR Lag Order Selection Criteria

Endogenous variables: LNAM_PRICES_BEFORE LSA_PRICES_BEFORE

Exogenous variables: C

Date: 07/24/16 Time: 10:44

Sample: 1999M01 2003M12

Included observations: 48

Lag	LogL	LR	FPE	AIC	SC	HQ
0	107.1690	NA	4.29e-05	-4.382043	-4.304076	-4.352579
1	176.9336	130.8087	2.77e-06	-7.122235	-6.888335*	-7.033844*
2	182.0454	9.158470	2.65e-06*	-7.168556*	-6.778723	-7.021238
3	182.6999	1.118123	3.05e-06	-7.029161	-6.483394	-6.822915
4	185.8940	5.190526	3.17e-06	-6.995585	-6.293884	-6.730411
5	187.2522	2.093816	3.56e-06	-6.885508	-6.027874	-6.561407
6	191.0125	5.483829	3.64e-06	-6.875522	-5.861955	-6.492493
7	191.7764	1.050332	4.23e-06	-6.740683	-5.571183	-6.298727
8	195.3113	4.565849	4.40e-06	-6.721302	-5.395868	-6.220419
9	197.8364	3.051187	4.81e-06	-6.659849	-5.178481	-6.100038
10	201.8225	4.484394	4.99e-06	-6.659271	-5.021970	-6.040532
11	207.2332	5.636096	4.92e-06	-6.718048	-4.924814	-6.040382
12	217.4841	9.823855*	4.01e-06	-6.978506	-5.029338	-6.241912

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5 % level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Appendix 3.2: Post-SSMS

VAR Lag Order Selection Criteria
Endogenous variables: LNAM_PRICES_AFTER LSA_PRICES_AFTER
Exogenous variables: C
Date: 07/24/16 Time: 10:52
Sample: 2004M01 2015M12
Included observations: 132

Lag	LogL	LR	FPE	AIC	SC	HQ
0	198.8771	NA	0.000174	-2.982986	-2.939307	-2.965237
1	514.5144	616.9275	1.54e-06	-7.704764	-7.573728	-7.651517
2	526.2025	22.49070	1.38e-06*	-7.821250*	-7.602856*	-7.732505*
3	528.1941	3.771977	1.42e-06	-7.790820	-7.485068	-7.666576
4	532.2796	7.613791	1.42e-06	-7.792115	-7.399005	-7.632373
5	535.0291	5.040746	1.44e-06	-7.773168	-7.292701	-7.577928
6	536.9149	3.400202	1.49e-06	-7.741135	-7.173310	-7.510397
7	541.8169	8.689988	1.47e-06	-7.754802	-7.099620	-7.488566
8	544.1336	4.036639	1.51e-06	-7.729297	-6.986757	-7.427563
9	551.1679	12.04360*	1.45e-06	-7.775272	-6.945374	-7.438039
10	551.7802	1.029801	1.52e-06	-7.723943	-6.806688	-7.351213
11	553.2068	2.355921	1.59e-06	-7.684951	-6.680338	-7.276722
12	557.6136	7.144498	1.58e-06	-7.691116	-6.599145	-7.247389

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5 % level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Appendix 4: Engle and Granger (1987) method

4.i Cointegration test

Appendix 4.1: Pre-SSMS

Null Hypothesis: RESID02_LOG has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic – based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.200027	0.0249
Test critical values:	1 % level	-3.546099	
	5 % level	-2.911730	
	10 % level	-2.593551	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESID02_LOG)
Method: Least Squares
Date: 07/16/16 Time: 13:52
Sample (adjusted): 1999M02 2003M12
Included observations: 59 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID02_LOG(-1)	-0.267922	0.083725	-3.200027	0.0022
C	-0.002683	0.004972	-0.539656	0.5915

R-squared	0.152292	Mean dependent var	-0.002896
Adjusted R-squared	0.137420	S.D. dependent var	0.041114
S.E. of regression	0.038185	Akaike info criterion	-3.659440
Sum squared resid	0.083111	Schwarz criterion	-3.589015
Log likelihood	109.9535	Hannan-Quinn criter.	-3.631949
F-statistic	10.24017	Durbin-Watson stat	1.473761
Prob(F-statistic)	0.002246		

Appendix 4.2: Post-SSMS

Null Hypothesis: RESID02_LOG has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic – based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.575254	0.0002
Test critical values:	1 % level	-3.476472	
	5 % level	-2.881685	
	10 % level	-2.577591	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESID02_LOG)
Method: Least Squares
Date: 07/16/16 Time: 13:58
Sample (adjusted): 2004M02 2015M12
Included observations: 143 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID02_LOG(-1)	-0.258943	0.056596	-4.575254	0.0000
C	0.000182	0.002467	0.073602	0.9414

R-squared	0.129269	Mean dependent var	0.000216
Adjusted R-squared	0.123094	S.D. dependent var	0.031509
S.E. of regression	0.029506	Akaike info criterion	-4.194561
Sum squared resid	0.122755	Schwarz criterion	-4.153122
Log likelihood	301.9111	Hannan-Quinn criter.	-4.177722
F-statistic	20.93295	Durbin-Watson stat	2.051689
Prob(F-statistic)	0.000010		

4.ii Error correction model (ECM) – Pre-SSMS

Appendix 4.3: ECM - Pre-SSMS

Dependent Variable: D(LNAM_PRICES_BEFORE)
Method: Least Squares
Date: 07/16/16 Time: 14:50
Sample (adjusted): 1999M04 2003M12
Included observations: 57 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.48E-05	0.004922	0.017235	0.9863
D(LNAM_PRICES_BEFORE(-1))	0.266721	0.129440	2.060581	0.0446
D(LNAM_PRICES_BEFORE(-2))	0.099773	0.129471	0.770623	0.4446
D(LSA_PRICES_BEFORE)	0.546291	0.133670	4.086875	0.0002
D(LSA_PRICES_BEFORE(-1))	-0.050748	0.160905	-0.315391	0.7538
D(LSA_PRICES_BEFORE(-2))	0.015772	0.158003	0.099823	0.9209
RESID02_LOG(-1)	-0.301258	0.095341	-3.159788	0.0027

R-squared	0.431545	Mean dependent var	0.006736
Adjusted R-squared	0.363330	S.D. dependent var	0.044251
S.E. of regression	0.035309	Akaike info criterion	-3.734794
Sum squared resid	0.062335	Schwarz criterion	-3.483893
Log likelihood	113.4416	Hannan-Quinn criter.	-3.637285
F-statistic	6.326283	Durbin-Watson stat	1.991574
Prob(F-statistic)	0.000053		

Appendix 5: Johansen's (1988) cointegration approach

5.i Cointegration approach

Appendix 5.1: Pre-SSMS

Date: 07/21/16 Time: 10:21
Sample (adjusted): 1999M04 2003M12
Included observations: 57 after adjustments
Trend assumption: Linear deterministic trend
Series: LNAM_PRICES_BEFORE LSA_PRICES_BEFORE
Lags interval (in first differences): 1 to 2
Unrestricted Cointegration Rank Test (Trace)

Hypothesised No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.166501	12.38287	15.49471	0.1395
At most 1	0.034510	2.001843	3.841466	0.1571

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesised No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.166501	10.38103	14.26460	0.1881
At most 1	0.034510	2.001843	3.841466	0.1571

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalised by b'*S11*b=I):

LNAM_PRICES_BEFORE	LSA_PRICES_BEFORE
-20.45245	18.20594
-3.117579	12.07204

Unrestricted Adjustment Coefficients (alpha):

D(LNAM_PRICES_BEFORE)	0.014730	-0.003597
D(LSA_PRICES_BEFORE)	-9.13E-05	-0.006499

1 Cointegrating Equation(s): Log likelihood 223.6718

Normalised cointegrating coefficients (standard error in parentheses)

LNAM_PRICES_BEFORE	LSA_PRICES_BEFORE
1.000000	-0.890160
	(0.14079)

Adjustment coefficients (standard error in parentheses)

D(LNAM_PRICES_BEFORE)	-0.301258
	(0.10947)
D(LSA_PRICES_BEFORE)	0.001867
	(0.10020)

Appendix 5.2: Post-SSMS

Date: 07/21/16 Time: 10:38
Sample (adjusted): 2004M04 2015M12
Included observations: 141 after adjustments
Trend assumption: Linear deterministic trend
Series: LNAM_PRICES_AFTER LSA_PRICES_AFTER
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesised No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.126061	20.45886	15.49471	0.0082
At most 1	0.010300	1.459838	3.841466	0.2270

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesised No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.126061	18.99902	14.26460	0.0083
At most 1	0.010300	1.459838	3.841466	0.2270

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalised by b'*S11*b=I):

LNAM_PRICES_AFTER	LSA_PRICES_AFTER
-25.92129	23.80386
-3.494770	6.466928

Unrestricted Adjustment Coefficients (alpha):

D(LNAM_PRICES_AFTER)	0.012651	-0.002466
D(LSA_PRICES_AFTER)	0.002550	-0.003750

1 Cointegrating Equation(s): Log likelihood 564.6146

Normalised cointegrating coefficients (standard error in parentheses)

LNAM_PRICES_AFTER	LSA_PRICES_AFTER
1.000000	-0.918313
	(0.02822)

Adjustment coefficients (standard error in parentheses)

D(LNAM_PRICES_AFTER)	-0.327933
	(0.09198)
D(LSA_PRICES_AFTER)	-0.066090
	(0.08378)

5.ii Vector error correction model (VECM) - Post-SSMS

Appendix 5.3: VECM - Post-SSMS

Vector Error Correction Estimates
Date: 07/24/16 Time: 12:59
Sample (adjusted): 2004M04 2015M12
Included observations: 141 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
LNAM_PRICES_AFTER(-1)	1.000000	
LSA_PRICES_AFTER(-1)	-0.918313	
	(0.02822)	
	[-32.5367]	
C	0.012032	
Error Correction:	D(LNAM_PRICES_AFTER)	D(LSA_PRICES_AFTER)
CointEq1	-0.327933	-0.066090
	(0.09198)	(0.08378)
	[-3.56536]	[-0.78883]
D(LNAM_PRICES_AFTER(-1))	0.373105	0.421552
	(0.12726)	(0.11592)
	[2.93193]	[3.63667]
D(LNAM_PRICES_AFTER(-2))	0.184527	0.125932
	(0.12770)	(0.11632)
	[1.44504]	[1.08265]
D(LSA_PRICES_AFTER(-1))	-0.051798	-0.147573
	(0.14343)	(0.13065)
	[-0.36114]	[-1.12954]
D(LSA_PRICES_AFTER(-2))	-0.167180	-0.194916
	(0.13413)	(0.12218)
	[-1.24640]	[-1.59534]
C	0.004732	0.005658
	(0.00362)	(0.00330)
	[1.30684]	[1.71553]
R-squared	0.168332	0.134776
Adj. R-squared	0.137530	0.102730
Sum sq. resids	0.239664	0.198857
S.E. equation	0.042134	0.038380
F-statistic	5.464880	4.205777
Log likelihood	249.5277	262.6866
Akaike AIC	-3.454294	-3.640944
Schwarz SC	-3.328815	-3.515465
Mean dependent	0.007014	0.007098
S.D. dependent	0.045369	0.040517
Determinant resid covariance (dof adj.)		1.24E-06
Determinant resid covariance		1.14E-06
Log likelihood		564.6146
Akaike information criterion		-7.810136
Schwarz criterion		-7.517351

5.iii System equation for the VECM - Post-SSMS

Appendix 5.4: System equation of VECM: Post-SSMS

System: UNTITLED
Estimation Method: Least Squares
Date: 07/24/16 Time: 15:21
Sample: 2004M04 2015M12
Included observations: 141
Total system (balanced) observations 282

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.327933	0.091977	-3.565358	0.0004
C(2)	0.373105	0.127256	2.931930	0.0037
C(3)	0.184527	0.127697	1.445039	0.1496
C(4)	-0.051798	0.143429	-0.361143	0.7183
C(5)	-0.167180	0.134130	-1.246404	0.2137
C(6)	0.004732	0.003621	1.306841	0.1924
C(7)	-0.066090	0.083782	-0.788827	0.4309
C(8)	0.421552	0.115917	3.636668	0.0003
C(9)	0.125932	0.116319	1.082647	0.2799
C(10)	-0.147573	0.130649	-1.129537	0.2597
C(11)	-0.194916	0.122179	-1.595339	0.1118
C(12)	0.005658	0.003298	1.715532	0.0874

Determinant residual covariance 1.14E-06

Equation: D(LNAM_PRICES_AFTER) = C(1)*(LNAM_PRICES_AFTER(-1) -
0.918313312264*LSA_PRICES_AFTER(-1) + 0.0120320025827) +
C(2)*D(LNAM_PRICES_AFTER(-1)) +
C(3)*D(LNAM_PRICES_AFTER(
-2)) + C(4)*D(LSA_PRICES_AFTER(-1)) + C(5)*D(LSA_PRICES_AFTE
R(-2)) + C(6)
Observations: 141

R-squared	0.168332	Mean dependent var	0.007014
Adjusted R-squared	0.137530	S.D. dependent var	0.045369
S.E. of regression	0.042134	Sum squared resid	0.239664
Durbin-Watson stat	2.016773		

Equation: D(LSA_PRICES_AFTER) = C(7)*(LNAM_PRICES_AFTER(-1) -
0.918313312264*LSA_PRICES_AFTER(-1) + 0.0120320025827) +
C(8)*D(LNAM_PRICES_AFTER(-1)) +
C(9)*D(LNAM_PRICES_AFTER(
-2)) + C(10)*D(LSA_PRICES_AFTER(-1)) +
C(11)*D(LSA_PRICES_AFT
ER(-2)) + C(12)
Observations: 141

R-squared	0.134776	Mean dependent var	0.007098
Adjusted R-squared	0.102730	S.D. dependent var	0.040517
S.E. of regression	0.038380	Sum squared resid	0.198857
Durbin-Watson stat	2.045417		

Appendix 6: Diagnostic tests

6.i Pre-SSMS: ECM

Appendix 6.1: Serial correlation diagnoses

Breusch-Godfrey Serial Correlation LM Test:

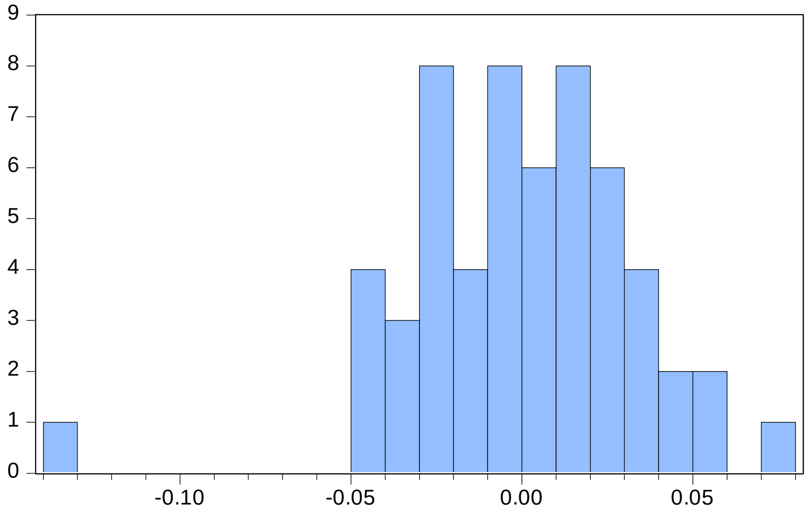
F-statistic	0.066974	Prob. F(2,48)	0.9353
Obs*R-squared	0.158622	Prob. Chi-Square(2)	0.9238

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 07/16/16 Time: 14:53
Sample: 1999M04 2003M12
Included observations: 57
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.67E-05	0.005024	0.009291	0.9926
D(LNAM_PRICES_BEFORE(-1))	-0.187546	0.810133	-0.231501	0.8179
D(LNAM_PRICES_BEFORE(-2))	0.174988	0.598702	0.292279	0.7713
D(LSA_PRICES_BEFORE)	0.001409	0.137088	0.010276	0.9918
D(LSA_PRICES_BEFORE(-1))	0.089995	0.387326	0.232349	0.8173
D(LSA_PRICES_BEFORE(-2))	-0.062647	0.250397	-0.250190	0.8035
RESID02_LOG(-1)	-0.024943	0.257893	-0.096718	0.9234
RESID(-1)	0.209704	1.042324	0.201189	0.8414
RESID(-2)	-0.176735	0.493352	-0.358233	0.7217

R-squared	0.002783	Mean dependent var	4.26E-19
Adjusted R-squared	-0.163420	S.D. dependent var	0.033364
S.E. of regression	0.035987	Akaike info criterion	-3.667405
Sum squared resid	0.062161	Schwarz criterion	-3.344818
Log likelihood	113.5210	Hannan-Quinn criter.	-3.542037
F-statistic	0.016744	Durbin-Watson stat	1.987730
Prob(F-statistic)	0.999999		

Appendix 6.2: Normality test



Series: Residuals
Sample 1999M04 2003M12
Observations 57

Mean	4.26e-19
Median	2.53e-05
Maximum	0.070750
Minimum	-0.134793
Std. Dev.	0.033364
Skewness	-0.867988
Kurtosis	6.143775
Jarque-Bera	30.63022
Probability	0.000000

6.ii Post-SSMS: VECM

Appendix 6.3: Normality test

System Residual Normality Tests
Orthogonalisation: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 10/12/16 Time: 14:49
Sample: 2004M04 2015M12
Included observations: 141

Component	Skewness	Chi-sq	df	Prob.
1	-0.354241	2.948943	1	0.0859
2	0.042714	0.042876	1	0.8360
Joint		2.991818	2	0.2240

Component	Kurtosis	Chi-sq	df	Prob.
1	3.550586	1.780977	1	0.1820
2	3.530420	1.652907	1	0.1986
Joint		3.433883	2	0.1796

Component	Jarque-Bera	df	Prob.
1	4.729919	2	0.0940
2	1.695782	2	0.4283
Joint	6.425701	4	0.1695

Appendix 6.4: Portmanteau Tests for Autocorrelations

System Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Date: 10/12/16 Time: 15:01
Sample: 2004M04 2015M12
Included observations: 141

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	0.128511	0.9980	0.129429	0.9980	4
2	0.752343	0.9994	0.762237	0.9994	8
3	5.698158	0.9305	5.815569	0.9251	12
4	15.06297	0.5200	15.45381	0.4917	16
5	18.10896	0.5802	18.61179	0.5472	20
6	25.14866	0.3977	25.96436	0.3550	24
7	30.84280	0.3241	31.95596	0.2763	28
8	39.02796	0.1832	40.63345	0.1408	32
9	40.89136	0.2643	42.62390	0.2076	36
10	43.51596	0.3241	45.44886	0.2555	40
11	44.17294	0.4643	46.16142	0.3830	44
12	82.53941	0.0014	88.09687	0.0004	48

*The test is valid only for lags larger than the System lag order.
df is degrees of freedom for (approximate) chi-square distribution

Appendix 7: Supply and demand functions

The study used the 2SLS to estimate equations in this Appendix. The estimated results include coefficients, t-statistics, and elasticities for each equation and a detailed description of the variables are included in Section 3.4 in Chapter 3. It is recommended that the results in this Appendix be used with caution because of a lack of statistically significant coefficients in the Tables below. The lack of statistically significant coefficients can be attributed to the small sample used dating from 1999 to 2015, and perhaps due to the selection of the instrumental variables essential for the 2SLS estimation. There is still a substantial amount of work to be done to improve the PEF.

7.i Supply system

This synthesis estimated the domestic supply function because of the relationship expected between sheep producer prices and domestic supply. Therefore, the probable effect of the SSMS on the supply function is likely to influence domestic price levels. The supply system comprises the domestic sheep production and a small quantity of imported meat and live sheep. In most cases, imported live sheep are used for breeding purposes to avoid double counting, quantities of imported live sheep are not included in the estimation. The synthesis focused on domestic supply of live slaughter sheep, and evaluated the domestic sheep production equation without imported quantities.

Appendix 7.1: Production equation results

R-Squared	60.58%			
	Variables	**Coefficient**	**t-Statistics**	**Elasticity**
SHEEP PRODUCTION (per head)	$SHPTOLPRO_t^{NAM}$			
	INTERCEPT	3751.39	1.17	
Lagged sheep production	$SHPTOLPRO_{t-1}^{NAM}$	-0.06	-0.12	-0.06
lag(2)sheep price	P_{t-2}^{NAM}	15.63	0.36	0.24
sheep price	P_t^{NAM}	-0.49	-0.0083	-0.01
lag(2)lick price	$INPUTP_{t-2}^{NAM}$	-1723.13	-2.11*	-1.95
Lagged rainfall	$RAIN_{t-1}^{NAM}$	0.04	0.043	0.01
SSMS	*SSMS*	-9.64	-0.28	-0.013
Health and safety trend	*HEALTH-SAFETY TREND*	162.20	1.17	0.18
level of significance: 1%*, 5%**, 10%**				

In the sheep production equation lag(2) lick price is the only significant variable, and it is significant at 10 per cent. However, in the PEF, elasticity forms an important part of the results. According to Regorsek *et al*. (2011), the lagged endogenous variable enters as a predetermined variable of the current equilibrium period, and the expected lagged production coefficient ought to be less than one. Meyer (2005) reasons that the coefficient of a lagged dependent variable greater than 1 establishes an explosive model, and this compromises the success of the model. As expected, the coefficient of lagged production has a magnitude of less than one, giving basis to conclude that the model is valid. The lagged sheep production variable negatively affects the current year's sheep production, with an elasticity of 0.06. This is plausible, because an increased lagged production increases the current year's supply. Large numbers of sheep on the market are central to lowering domestic prices.

The lagged own price coefficient ought to be positive and greater than zero (Meyer, 2005), because there exists a positive relationship between price and quantity supplied. In this case, lagged own price had a positive impact on sheep production with an elasticity of 0.24. The current year's own price indicates an unexpected elasticity of -0.01, which is close to zero and negligible. Sheep producers are anticipated to increase production at increased price levels, holding other factors constant. Sheep producers conduct farming to maximise profit, so if producer prices are favourable, farmers might increase sheep production. Nevertheless, an increase in live sheep on the market is bound to reduce domestic producer prices, and this is seen in the Namibian sheep market.

There is a negative elasticity, -1.95, between lagged input price and supply. The negative effect is possible because a negative relationship between input prices and production exists. Increases in input prices reduce producers' profits. In effect, producers cut costs by reducing production. Reduced production affects the market supply of live sheep.

Climatic conditions influence the supply side dynamics and prices because conditions such as low rainfall affect vegetation growth, and limit fodder production and water capacities. Low rainfall decreases vegetation palatability and sheep productivity. The lagged rainfall variable reveals an expected positive effect on sheep production, with an elasticity of about 0.01. Although the elasticity is positive it is very close to zero, and thus confirms a very low effect on sheep production. This could be because sheep are suited to dry-arid climatic conditions. Dry-arid conditions characterise the southern part of Namibia where most sheep farming activities occur.

The trend variable includes the health and safety of sheep that affect sheep production and supply. The health and safety trend variable shows a positive effect on the supply function, with an elasticity of 0.18, as expected. This means that an increase in the health and safety of sheep leads to an increased supply of sheep on the market.

The variables in the estimated sheep production function influence the sheep supply by moving the function to either the left or the right. When these variables shift the supply function, they in turn affect domestic producer prices. An increase in lagged sheep production, own prices and health and safety trend are bound to shift the supply curve to the right. This results in increased supply, which causes producer price levels to decrease. Moreover, variables such as lick cost, and the lack of rainfall ought to shift the supply function to the left. This causes a decrease in sheep production. A decrease in live sheep on the market leads to increased sheep producer prices.

7.ii Demand system

This section presents the demand system results. The demand system comprises per capita consumption (PCC), and slaughter of live sheep at export abattoirs and non-export abattoirs, because all these three equations determine the number of sheep demanded in the market. The study only estimates the slaughter of live sheep at export abattoirs and non-export abattoirs because the SSMS does not seem to have had an effect on PCC.

7.ii.a Domestic slaughter of sheep

The domestic slaughter of live sheep equations comprises slaughter of sheep at export abattoirs and non-export abattoirs. Export abattoirs and non-export abattoirs both demand slaughter sheep, which affects the quantity demand for marketable sheep. There is a need to estimate the two equations separately, because the SSMS states that producers should sell sheep for slaughter to export approved abattoirs before the exportation of live sheep to South Africa. This has a direct application to export abattoirs, then non-export abattoirs.

Appendix 7.2: Slaughter at export abattoir equation results

R-Squared	84.33 %			
	Variables	**Coefficient**	**t-Statistics**	**Elasticity**
SLAUGHTER at EXPORT ABATTOIRS (per head)	$EXP\_ABATTOIRS_t^{NAM}$			
	INTERCEPT	698.75	1.190024	
Real sheep producer price (Nam)	P_t^{NAM}	-31.52	-0.897616	-1.50
Real producer prices (SA)	P_t^{SA}	1.23	0.055715	0.08
Drought	*DRGHT_Dummy*	-203.17	-1.830294*	-0.12
Shift2013	*SHIFT13*	-264.91	-0.603869	-0.08
Health and safety trend	*HEALTH-SAFETY TREND*	41.73	0.877689	0.14
SSMS	*SSMS*	6.99	0.117468	0.03
Average carcass mass	*SHPACMS*	24.24	1.558104	0.75
Level of significance: 1%*, 5%**, 10%**				

Appendix 7.3: Slaughter at non-export abattoirs' equation results

R-Squared	60.35 %			
	Variables	**Coefficient**	**t-Statistics**	**Elasticity**
SLAUGHTER at NON-EXPORT ABATTOIRS (per head)	$NON-EXP\_ABATTOIRS_t^{NAM}$			
	INTERCEPT	103.13	0.57	
Real sheep producer price (Nam)	P_t^{NAM}	6.31	0.93	1.98
Real goat auction prices	P_t^{GOAT}	-6.91	-0.92	-1.28
Drought	*DRGHT_Dummy*	-4.76	-0.13	-0.02
Shift2013	*SHIFT13*	291.05	2.16*	0.57
Health and safety trend	*HEALTH-SAFETY TREND*	-26.15	-1.91*	-0.58
SSMS	*SSMS*	34.56	1.92*	0.93
Level of significance: 1%*, 5%**, 10%**				

The export abattoir equation has one significant variable that is the drought dummy variable significant at 10 per cent. The non-export abattoir equation has three significant variables (shift variable, health and safety trend, and SSMS) that are significant at 10 per cent. When producer prices are favourable, a high throughput to export abattoirs and non-export abattoirs is possible. Yet, the slaughter at export abattoir equation results demonstrate a negative elasticity (-1.59) of the domestic producer price variable, and a positive elasticity (1.98) in the non-export abattoir's equation. The negative elasticity of -1.59 on the producer price variable suggests that a decrease in sheep producer prices, increases export abattoirs' demand for slaughter sheep. This is expected because export abattoirs are anticipated to minimise costs (including prices offered to producers) to increase their profit. However, since the SSMS policy is not directly applicable to non-export abattoirs, producers could increase throughput to non-export abattoirs when producer prices increases. This explains the positive responsiveness of slaughter at non-export abattoirs to changes in domestic producer prices.

The South African producer prices have a positive and expected effect on the marketing of slaughter sheep to export abattoirs. The elasticity is 0.08, indicating that slaughter at export abattoirs has a slow response to changes in the SA prices. This is due to the SSMS policy, which protects the Namibian sheep export abattoirs. The goat price variable has a negative elasticity of -1.28 on slaughters at non-export abattoirs. This is plausible because an increase in goat prices will lead to a decrease in sheep supply. Producers are likely to switch from farming with sheep to farming with goats because both small stock animals are suited to the same type of climatic conditions.

The negative effect of drought, which is demonstrated in both equations, is probable. This is possible because of the severity of the drought experienced in Namibia, which affected vegetation. Droughts influence sheep productivity, which leads to low marketing of live sheep to export abattoirs and non-export abattoirs.

The shift variable influenced slaughter at export abattoirs and non-export abattoirs differently. Low throughput to export abattoirs led to the closure of one of the export abattoirs, Namibia Allied Meat (NamCo), in 2013. The low throughput was a result of low sheep productivity caused by drought. The NamCo closure caused a shift in the sheep industry by reducing the total slaughter capacity of export-approved abattoirs. Hence, a negative sign on the shift variable in the export abattoir equation is probable, with an elasticity of -0.08. On the other hand, the positive shift variable demonstrated in the non-export abattoir equation is possible, because of the oversupply of live sheep to export abattoirs. The oversupply of sheep to other export abattoirs after NamCo's closure led to an increased throughput to non-export abattoirs' slaughter facilities, hence the positive elasticity of 0.57.

The health and safety trend variable represents compliance to the required health standards and safety of live sheep. The estimation shows a positive effect of the health and safety trend variable in the export abattoir equation and a negative sign in the non-export abattoir equation. The elasticity in the export abattoir equation is 0.14, and that in the non-export abattoirs equation is -0.58. These results seem plausible because producer compliance with the export abattoirs' health standards and sheep safety requirements guarantees slaughter space, and better prices for live slaughter sheep. Improved adherence of producers to health standards and safety requirements improve animal quality, which fetches better prices at export abattoirs, and reduces live sheep marketing to non-export abattoirs. Hence, the negative sign on the health and safety trend variable in the non-export abattoir equation.

The effect of average carcass mass demonstrates an elasticity of 0.75, and so a 10 per cent increase in average carcass mass increases slaughter by 7.5 per cent. This is probably because a high carcass mass and sheep quality improves producers' incentives. Over all, the high dependency of sheep producers on export abattoirs has limited producers' power to bargain for better prices. Abattoirs are likely to demand more live sheep when domestic price levels are low.

7.iii Price linkage equation

The price equation is set as a function of South African producer prices, excess supply represented by the domestic consumption relative to total production ratio, beef producer prices (substitute commodity), average carcass mass, and the SSMS variable.

Appendix 7.4: Price linkage equation results

R-Squared	90.94 %			
	Variables	**Coefficient**	**t-Statistics**	**Elasticity**
SHEEP DOMESTIC PRICES	P_t^{NAM}			
	INTERCEPT	-8.58	-1.65	
Real producer prices (SA)	P_t^{SA}	0.51	7.39***	0.67
Excess supply	$\frac{D_{CONSUMPTION}}{TOLPRO} RATIO$	-19.46	-3.23***	0.63
Average carcass mass	*SHPACMS*	-0.28	-2.93***	-0.18
Real beef producer prices	P_t^{BEEF}	0.22	1.98*	0.19
SSMS	*SSMS*	-0.052	-0.46	-0.0044
Level of significance: 1%*, 5%**, 10%**				

In the sheep domestic price equation, most variables are significant except for the SSMS variable. The study identified a price transmission elasticity of less than 1 (0.67) between the two spatial markets, as expected. An elasticity of 0.67 indicates that an increase in the South African producer prices could translate into an increase in the Namibian producer prices, which is plausible because market integration exists between the two markets. The domestic price equation has a positive responsiveness to changes in excess supply, this means that a 10 per cent increase in excess supply increases domestic prices by 6.7 per cent. This is possible because increasing supply to the South African market means South African producer prices are favourable and this creates competition for the local abattoirs resulting in an increase in domestic producer prices.

The average carcass mass showed a negative effect on domestic producer prices. This result is unexpected, as an increase in average carcass mass ought to increase incentives accruing to producers. The result is probable because of an increased domestic supply of live sheep due to the SSMS, which has led to low producer prices. The effect of beef producer prices, in which beef is a substitute good, had a positive elasticity on domestic sheep producer prices. This is plausible because the beef sector is the leading livestock sector in Namibia. Any increases or decreases in the beef sector prices are bound to affect the sheep producer prices.