Analysis of main determinants of soya bean price volatility in Malawi

By

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DECLARATION

I **Aubrey Victor Chimaliro** declare that the dissertation is my own work and I hereby submit it for the degree of Masters of Science in Agricultural Economics at the University of Pretoria. The dissertation has not previously been submitted by me for a degree at this or any other tertiary institution.

Signature ……………………………

Date …………………………….

DEDICATION

I dedicate this work to my late mother and my lovely wife Mercy.

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To God the Almighty in whom are hidden all the treasures of wisdom, knowledge and understanding be all the praise and honour.

Analysis of the extent and main determinants of soya bean price volatility in Malawi

By

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Degree : MSc in Agricultural Economics

Department : Agricultural Economics, Extension and Rural Development

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ABSTRACT

The study primarily focuses on analysing the extent of soybean price volatility in Malawi. The interest in the study was triggered by the findings from literature noting soybean prices in Malawi as being particularly volatile. Soybean is one of the most important oilseed crops in Malawi and has the potential to become a major export crop. It offers good export prospects to neighbouring countries in Southern Africa, but has also been prioritised for its potential domestic contribution in Malawi. It is regarded as one of the value chains that promotes better nutrition in Malawi since most diets are dominated by maize, which contributes to malnutrition in Malawi.

The study empirically estimates soybean price volatility using a GARCH (1,1) model and results indicate that both the lagged squared residual and the lagged conditional variance have an effect on the conditional variance of soybean prices. GARCH terms are significant, indicating some volatility clustering in monthly returns of soybeans in Malawi, South Africa and the world. The study confirms that soybean prices in Malawi have been more volatile relative to South Africa and the USA.

To evaluate the extent to which domestic soybean price volatility can be attributed to regional and global market volatility, the Engle-Granger procedure was employed to estimate long-run co-integration between soybean prices in Malawi, South Africa and the world. The prices are categorised into six pairs and testing the long-run co-integration between these pairs involve both directions. Five out of the six pairs of prices exhibit long-run co-integrating relationships.

An error correction model (ECM) is also employed to estimate the speed of adjustment to the equilibrium for five co-integrated price series. South Africa is the fastest in responding to the USA price changes, taking two months. Malawi is the second fastest since it takes about four months for soybean prices to respond to shocks in South African markets. However, it takes about seven months for the USA soybean prices to respond to price shocks in the South African markets which is longer than the period that Malawi takes to respond. South Africa takes nine months to respond to the shocks that occur in the Malawian markets. USA is the lowest in terms of the speed of adjustment since it takes about sixteen months to respond to the Malawian market shocks. Therefore, this study agrees with expectation that changes in the international markets affect the domestic markets. This is so because South Africa is a small nation in the international soybean market and Malawi is even much smaller – the volumes traded in these markets are considered too small to have any meaningful impact on world market prices.

Lastly, to evaluate the influence of shocks on the South African prices, as well as selected macro-economic variables in Malawi on soybean price volatility in Malawi, the study employs a vector error correction model (VECM) to evaluate the long- and short-run relationship between soybean prices and explanatory variables (South Africa soybean prices, exchange rates and consumer price index). The error correction coefficient of -0.2089 is negative and highly significant which is in line with expectations. The Johansen test points to the possibility of 1 or 2 cointegrated relationships between variables. The Wald test results show that the probability values of the joint F-statistics for South African soybean prices and Malawi exchange rate are significant at 10% and 5% levels respectively. Based on the significance of both the error correction term and the joint F-statistics of the two lagged variables in the Wald test results, the study concludes that South Africa soybean prices and Malawi exchange rate are significant drivers of volatility in Malawi soybean prices.

Key words: Price volatility, Price transmission, Generalised Autoregressive Conditional Heteroskedasticity (GARCH) and Vector Correction Model (VECM).

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ADD	: Agricultural Development Division
ADMARC	: Agricultural Development and Marketing Corporation
AMIS	: Agricultural Market Information System
ARCH	: Autoregressive Conditional Heteroskedasticity
AusAids	: Australian Aids
FAO	: Food and Agricultural Organisation
FEWS NET	: Famine Early Warning Systems Network
GARCH	: Generalised Autoregressive Conditional Heteroskedasticity
GDP	:Gross Domestic Product
IFPRI	: International Food Policy Research Institute
IMF	: International Monetary Fund
JSE	: Johannesburg Stock Exchange
MoAIWD	: Ministry of Agriculture, Irrigation and Water Development
NAMC	: National Agricultural Marketing Council
NGO	: Non-Governmental Organisation
NSO	: National Statistical Office
RBM	: Reserve Bank of Malawi
SADC	: Southern African Development Community
SeedCo	: Seed Company
UNICEF	: United Nations Children's Emergency Funds
USA	: United States of America
USDA	: United States Department of Agriculture
WFP	: World Food Programme

CHAPTER 1: INTRODUCTION

1.1 Background

Since 2006, the world has experienced wide swings in agricultural commodity prices (Donmez and Magrini, 2013). This is attributed to the global food crisis of 2007-2008 and the rapid increases in food prices in 2011/12 that resulted from the drought in the USA (Minot, 2014). Kornher and Kalkuhl (2013) note that annual averages for food prices globally have increased sharply and remained volatile during the past decade, however views on specific commodities remain mixed. Von-Braun and Tadesse (2012) suggest that prices of commodities such as maize, rice and soybeans increased more than in the early 2000's. However, Gilbert and Morgan (2010) argue that, between the 2007-2009 period and previous years, out of the 19 commodities examined during 2000-2012 period, only soybeans, soybean oil and groundnut oil reflected a significant increase in price volatility.

Despite mixed views on the volatility of prices in agricultural commodities, it is widely accepted that price volatility has negative impact on developing countries (FAO, 2010). Minot (2014) observes that when prices of the staple food are not stable, poor households in developing countries (particularly in Sub-Saharan Africa) become more vulnerable to shocks than in developed countries. As such, volatile prices result in a welfare loss and hinder growth prospects of society. From a producer's perspective, price volatility has been noted to complicate planning for agricultural production (Balcombe, 2009), yet Aizeman and Pinto (2005) argue that better-off farmers can benefit from higher price volatility if they are able to increase production. They admit however that volatility hurts net food consumers.

In Africa food price volatility has been a major concern because food prices have been more volatile in recent years, relative to other regions (Gerard et al. and G20, 2011). Food price volatility has triggered the interests of many researchers because it is so problematic for low-income smallholder farmers, typically found in developing countries (Pierre, Morales-Opazo and Demeke, 2014), and is particularly prominent in Africa. It is agreed by a number of researchers that higher and more volatile food prices adversely affect net food consumers, because they allocate a large part of their budget to food (Cohen & Garrett, 2009 and De Hoyos & Medvedev, 2011). That is why Minot (2011) argues that the impact of high and volatile food prices erodes the purchasing power of poor net food consumers, particularly in Africa.

Concerns of high price volatility of agricultural commodities have not spared Malawi. Minot (2011) observes that Malawian food prices have not been stable for the past two decades. Generally, prices of agricultural commodities rose rapidly in Malawi from 2005 to 2006 (Minot, 2010). Figure 1.1 displays the graphs of average annual soybean prices in Malawi, South Africa and the USA for the period of 1990-2015. The USA soybean price has been used as a world reference price, whereas the South African price can be seen as a regional reference.

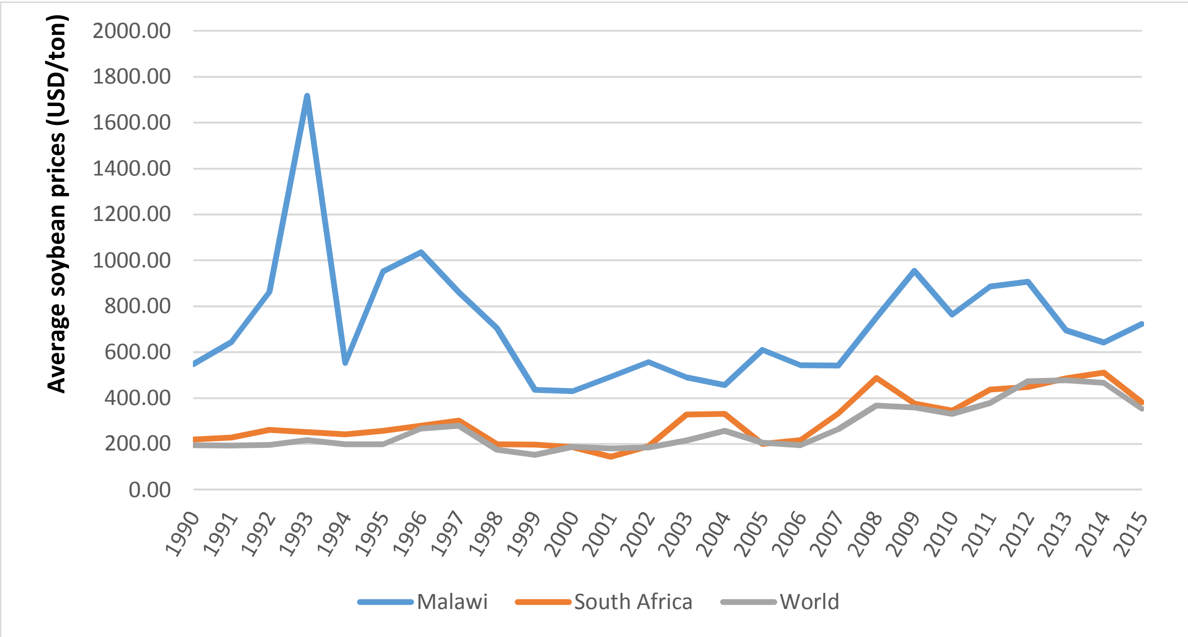

Figure 1.1: Annual average soybean prices (nominal) for Malawi, South Africa and USA

Source: Compiled from MoAIWD, Abstract and FAOSTAT

Figure 1.1 shows high fluctuation of average annual soybean prices in Malawi. Prices rose very high in 1993 and drastically declined in 1994 before rising again. The lowest average annual soybean prices were observed from 1999 to 2004. Average annual soybean prices in South Africa also fluctuated through the period of 1990-2015 (Figure 1.1). The lowest and highest soybean prices were experienced in 2001 and 2014 respectively. It also shows that USA soybean prices, which represent the world, were marginally more stable than soybean prices experienced in South Africa. However, Malawi experienced higher and seemingly more volatile soybean prices than South Africa and the USA.

Malawi is ranked as one of the poorest countries in the world with an official rate of poverty at 50% (FEWS NET, 2013). It is completely landlocked and represents the most densely populated country in Southern Africa (Minot, 2010). According to the 2008 census, its population is estimated at 13.1 million people with a population density of 110 inhabitants per square kilometre (Minot, 2010). Agriculture accounts for about 34% (about one third) of the gross domestic product and contributes about 90% of Malawi's export earnings (Food and Agricultural Policy Decision Analysis (FAPDA) Team, 2015). The level of malnutrition in children, as well as mortality, is very high (Malawi National Statistics Office and the World Bank, 2014). It is estimated that 56 % of deaths in children under five in Malawi are caused by malnutrition. (Manary; Ndkeha; Ashorn; Maleta & Briend, 2004).

Tinley (2009) reports that soybeans are amongst the most important non-staple food commodities in Malawi and have the ability to provide dietary diversity due to their high protein content. Soybeans are processed into high protein supplements, such as infant and baby formula, which improves the nutrition status of infants and babies (Feed the Future Report, 2013). There is also a substantial demand for soybeans for nutrition relief programmes, implemented by various non-governmental organisations that work in hospitals, refugee camps and orphanages (Tinley, 2009). Other products from soybeans include soya pieces and likuni phala, which are used as a meat substitute and baby formula respectively (Feed the Future Report, 2013). Soybeans are also used for animal feed, but the share processed for human consumption presently exceeds that of the animal feed market (Feed the Future Report, 2013 and Tinsley, 2009).

An increasing demand for soybeans as a source of both food (supporting improved nutrition) and animal feed (Nzima and Dzanja, 2015), has supported prices. This has made it an increasingly popular option for producers, where it has the potential to increase margins and diversify revenue streams. Figure 1.2 shows an increase in soybean production from approximately 3,000 and 132,417 metric tonnes in 1990, to 11,000 and 724,600 metric tonnes in 2016, for Malawi and South Africa respectively. In Malawi, approximately 10,000 tonnes of soybeans are exported, using either official channels or otherwise (Feed the Future Report, 2013), which allows it to contribute to foreign revenue earnings.

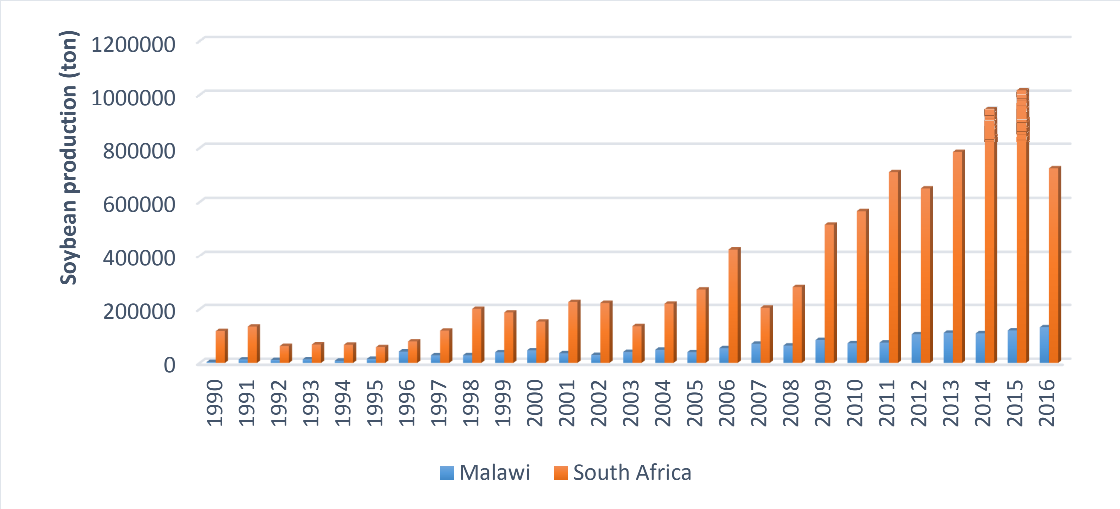

Figure 1.2: **Soybean production for Malawi and South**

Source: *Compiled from FAOSTAT*

Substantial growth in production and consumption, as well as growing relevance in dietary diversification, support the conclusion that soybeans are becoming an increasingly important crop in Malawi. At the same time, price volatility remains a concern to both producers and consumers. This study therefore conducts an empirical analysis of the extent , as well as the determinants, of soybean price volatility in Malawi. Establishing the causes of continued price volatility in this increasingly important sector will provide a first step in helping policy makers address the problem of price volatility.

1.2 Problem Statement

Soybeans are one of the most important oilseed crops in Malawi. Soybeans are overwhelmingly produced by smallholder farmers as a source of food and income (Deloitte, 2012 and Techno-Serve, 2011). As such the Government of Malawi has identified soybeans as one of the commodities in the oilseed sector that has the potential for creating wealth and economic spill-over effects on other sectors, in terms of oil and poultry feed processing (Government of Malawi, 2013b). Soybean is regarded as one of the value chains that promotes better nutrition in Malawi (Feed the Future Report, 2013). This is because most diets are dominated by maize, which contributes to malnutrition in Malawi. Maize provides a good source of carbohydrates but it has low protein content. Soybeans, when processed, have the potential of offering an affordable alternative source of protein to Malawians. This oilseed also provides supplements of iron and zinc nutrients of which both nutrients are severely deficient in most Malawians (Ecker & Qaim, 2011 and USDA Agricultural Research Service, 2014).

Soybean is also promising to become a major export crop in Malawi and offers good export prospects to neighbouring countries in Southern Africa. These include Zambia, Zimbabwe, Tanzania and South Africa. Varieties of soybeans that are grown in Malawi are not genetically modified, which allows them to attain good prices internationally (Feed the Future Report, 2013). Despite these contributions that soybeans make to the economy of Malawi, production is still low with unstable marketing (Government of Malawi, 2008 and Nzima & Dzanja, 2015).

Soybean prices have been noted as volatile (Feed the Future Report, 2013 and Aberman & Edelman, 2014), which is thought to be one of the factors that has contributed to lower production in Malawi. While anecdotal evidence points to a volatile market, little empirical evidence exists to contextualise this volatility, relative to other regions. Furthermore, an extensive literature review did not yield investigations related to the causes of such volatility. The majority of the studies in Malawi have focused on the price volatility of maize (Cornia, Deotti & Sassi, 2012; Sassi, 2013 and Minot, 2014), which represents the core staple. Soybeans have great potential in Malawi however, both in terms of improved nutrition, crop diversification and its impact on soil quality, which will in turn support maize yields. Inadequate empirical evidence related to soybean price volatility however can affect both producer and consumer decisions related to the industry, preventing it from reaching this potential. As such, this study aims to provide empirical evidence regarding the extent of soybean price volatility over the past 15 years. It also aims at investigating the determinants of soybean price volatility during the period 2002-2016.

1.3 Research Objectives

The purpose of this study is to evaluate the main determinants of volatility of soybean prices in Malawi. To do so, it aims to achieve the following objectives:

- To provide an overview of the evolution of soybean markets in Malawi since 2002;
- To investigate the patterns and trends of soybean prices in Malawi from 2002 to 2016 qualitatively;

- To examine the relative soybean price volatility for Malawi, South Africa, and the United States as world reference, from 2002 to 2016;
- To examine the co-integration relationship of soybean prices between Malawian markets and South African as well as the USA markets during the period of 2002-2016;
- To analyse the effects of exchange rate, and consumer price inflation on soybean price volatility in Malawi from 2002 to 2016.

1.4 Hypothesis of the study

The world experienced significant volatility in agricultural commodity prices from 2007 to 2013 (Donmez and Magrini, 2013). The situation of agricultural commodity price volatility has been worse in African developing countries for the past few years (Gilbert and Morgan, 2010). In evaluating soybean price volatility in Malawi, this study aims to test the following hypotheses:

- Soybean prices in Malawi have not been more volatile than those in South Africa and the USA during the period of 2002-2016;
- The domestic soybean prices in Malawi do not have a co-integration relationship with the prices in South Africa and the USA during the period of 2002-2016;
- Exchange rate and the consumer price index (CPI) as measure of inflation have not had a significant impact on the price volatility of soybeans in Malawi during the period of 2002-2016.

1.5 Delineation of the study

The study was limited to analyse the volatility of soybean prices in Malawi and it did not consider other agricultural commodities. Although the study considered world prices as the cause of soybean volatility, it did not aim at investigating the drivers of volatility in the world markets.

1.6 Significance and research contribution of the study

The study focuses on soybean price volatility in Malawi because there is little empirical evidence that exists to contextualise this volatility and its causes, relative to other regions. In view this, the outcomes of the study will help bridge this gap by providing an in-depth understanding of soybean markets and price volatility in Malawi. The outcomes of study will provide guidance to policy makers in divising policy strategies that will help in forecasting soybean prices and come up with measures that will mitigate price volatility which has the potential to compromise improved nutrition.

The study results will also guide the policy makers in coming up with good strategies in order to improve access to market information among the soybean players in Malawi. This could minimise uncertainties and enhance better decisions by the producers, consumers and traders. Possibilities include investment in information and communication technology that will improve access to market information. This will enhance knowledge sharing between farmers and traders, pertaining to product quality, volume and pricing.

The outcomes will help the Government and other players in soybean industry to promote market based programmes such as certification, contract farming and market analysis which facilitate market access. Strategies that will improve business development and enhance value chain investment that will also enable improved market access.

1.7 Outline of the study

Following this introduction, Chapter 2 provides some context through an overview of the evolution of soybean markets globally, regionally and in Malawi. Chapter 3 evaluates the extent of soybean price volatility in Malawi and compares soybean price volatility in Malawi to South Africa, as well as the USA. Chapter 4 considers the impact of international market movements on Malawian soybean price volatility, before Chapter 5 adds some macro-economic variables and isolates the main determinants of volatility in Malawian soybean prices. Lastly, Chapter 6 concludes with a summary of key findings and recomendations.

CHAPTER 2: OVERVIEW OF SOYBEAN MARKET EVOLUTION

2.1 Introduction

This chapter considers the evolution of soybean markets in terms of global market dynamics and regional soybean markets in Southern Africa. It provides an overview of the structure of the soybean value chain, highlighting players and various market dynamics that affect pricing of soybeans in Malawi. It describes the linkage between soybean production and the final products delivered to the consumer. In light of Malawi's small contribution to global soybean production, it highlights policies that affect the Malawian soybean market. Its purpose is to provide context and guide understanding of salient market features, prior to the empirical analysis.

2.2 Global soybean market dynamics

Soybeans is regarded as one of the major oilseed crops globally, contributing about 54% to the world's total oilseed production (Opperman and Varia, 2011; World Bank, 2016)**.** It is primarily produced for its high oilcake yield and constitutes the largest component of global protein meal production. In the international vegetable oil market, soybean oil comes in second after palm oil.

Thoenes (2006) observes that soybean markets are well established across the world and soybean products, such as soybean oil and soybean meal, are traded in almost every country. The bulk of soybeans is produced by the United States of America (USA), Argentina and Brazil - these three countries comprise about 81% of total world production (Opperman and Varia, 2011). China is the largest consumer of soybean products, followed by the USA and Europe. Consumption of soybean products in China represents about 61% of the world soybean meal demand and 56% of the soy oil demand. The high demand for soybean meal and soy oil in these countries benefit the soybean producers and importers due to increase in prices. The high demand of soybean oil in China made Argentina to resume exportation of soybean oil to China, as announced by the Ministry of Agroindustry on 24 August, 2017 (AMIS Market Monitor, 2017).

Conventional soybeans are also in high demand in European and Asian countries and, for these countries to meet their demand, they import soybeans from Brazil. The demand for soybeans has been increasing globally, due to the European Soybean Declaration signed by thirteen member states of the European Union on 31 July, 2017 (AMIS Market Monitor, 2017). The aim of the Declaration was to support domestic and international initiatives, including European initiatives, to enhance availability of extracted soybean protein supplies.

The OECD-FAO Agricultural Outlook (2017-2026) projects that soybean production will keep on expanding in the coming decade, though at a slower growth rate (1.9 % per annum) than in the previous decade, which was around 4.9 %. However, it is observed in the Agricultural Outlook that soybean production in Brazil is estimated to grow at a rate of 2.6 % per annum because it has more land to expand its production. The projected growth rate of Brazil will surpass those for Argentina and China whose production growth rates are expected to be 2.1 % and 1.0 % per annum respectively.

2.3 Regional soybean markets in Southern Africa

In Southern Africa, the soybean industry is well established with an approximate production of 861 000 metric tonnes and demand equivalent to approximately two million metric tonnes (Opperman, 2011). Despite rapid growth in the past decade, production in Southern Africa still constitutes less than one percent of the world total production of soybean (NAMC, 2011). Agronomic conditions are favourable for the cultivation of soybean and the region has vast available land which could allow the region to increase its production. Low production in the region is attributable to low yields - the average yield is estimated at 1.5 metric tonne per hectare as compared to 3.4 metric tonnes for Argentina (Opperman and Varia, 2011).

Major soybean producing countries in Southern Africa include South Africa, Zambia, Malawi, Zimbabwe, Democratic Republic of Congo (DRC) and Mozambique. Production of soybean is dominated by commercial farmers in South Africa, Zambia, Angola and Zimbabwe. Commercial farmers in these countries produce about 98%, 85%, 70% and 65% of total soybean production respectively (Opperman, 2011). However, Opperman (2011) also reports that almost 100% of soybean production in DRC is done by smallholder farmers, followed by Malawi, where smallholders contribute 95% and Mozambique, where they contribute 94%. Soybean is grown as a cash crop and it gives smallholder farmers a chance to diversify, resulting in increased income (Walker and Cunguara, 2016). Before 2011, Southern

Africa used to import about 2 million metric tonnes of soybean cake and soybean oil annually.

Since 2003, production of soybean in South Africa has increased to over one million tonnes from less than 0.5 million tonnes, due to increase in area and improved yields (OECD/FAO, 2016). Despite an increase in soybean production, domestic supply has failed to meet market demand for soybean (BFAP, 2016). According to NAMC (2017), South Africa has the largest market for soybean in the Southern African region and there is high demand for soybean oil, soybean cake and soybean products for human consumption. The high demand for soybean products, especially oilcake, has supported the rapid expansion of soybean processing capacity the past years in South Africa (OECD/FAO, 2016). As of 2013, the capacity to crush soybeans was estimated at 1.75 million tonnes (BFAP, 2016). The increasing crushing capacity has decreased soybean oilcake imports from over 950 thousand tonnes in 2011 to less than 550 thousand tonnes in 2017 (Sihlobo, 2018). Expansion in the crushing capacity and increasing production of soybeans imply that in the near future South Africa could become self sufficient in soybeans and soybean oilcake (BFAP, 2018).

Zambia comes second after South Africa in terms of soybean production in Southern Africa. Commercial farmers also dominate production, accounting for approximately 85% of soybeans produced (Technoserve, 2011). Smallholder farmers find it less attractive to produce soybeans because of unavailability of inputs, expertise and markets (Mwansa, 2015). Zambia produces enough soybeans to meet its demand and excess soybeans are exported to South Africa and Zimbabwe (Technoserve, 2011). Mwansa (2015) reports that overall production has increased by over 100 percent from almost 70 tousand tonnes in 2011 to over 200 thousand tonnes in 2013. Soybean prices in Zambia are determined by the Zambian Agricultural Market Commodity Exchange (ZAMACE) and commercial farmers make use of this exchange to set prices for their soybeans (Techno-serve, 2011).

Soybeans are also widely grown in Malawi, primarily as a cash crop for sale and, after selling, they are processed into soybean related products for food and livestock feed. Thus soybean products are consumed directly by humans or fed to farm livestock. By 2010, statistics indicate that Malawi produced eight percent of the soybeans in Southern Africa and it is ranked as the fourth largest producer of soybeans in the region (Feed the Future, 2014). Research studies show that soybeans grow well in almost all agro-ecological zones in Malawi

(Tinley, 2009; Kananji and et al, 2013 and Nzima & Dzanja, 2015). As shown in Figure 2.1, almost every district produces soybean though major producing areas include Kasungu, Lilongwe and Mzuzu Agricultural Development Division (ADDs). It is reported that approximately 80 percent of soybeans are produced in these ADDs (Techno-Serve, 2011) and also estimated that almost 95 percent of soybean production is done by smallholder farmers at national level (Feed the Future, 2014).

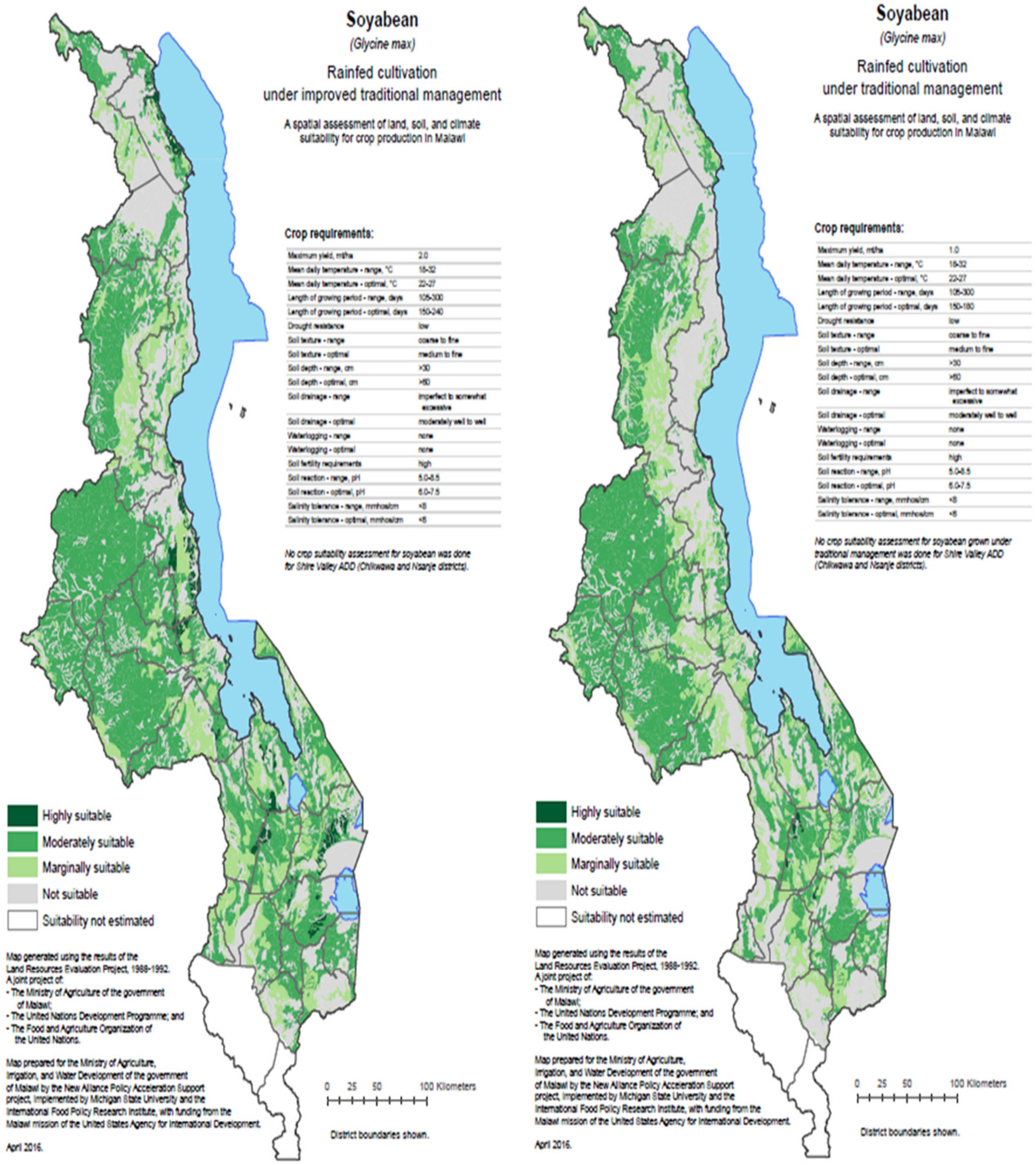

Figure 2. 1: Map illustrating the regions with potential soybean production in Malawi

Source: *Benson, Mabiso and Nankhuni (2016)*

The government input programme, known as Farm Input Subsidy Programme (FISP), is thought to have contributed to the increase in production (Technoserve, 2011). Malawi's Government includes soybean seed in the FISP package as one way of enhancing the growing and utilisation of soybeans in order to meet the increasing demand in domestic as well as international markets (Tinsley, 2009). Dorward (2009) reports that FISP is implemented in Malawi with the objectives of improving economic growth, enhancing input use efficiency, improving soil fertility (through fertilizer application and use of legume seed) and boosting food security. FISP implementation also aims at reducing poverty levels which in turn improves living standards of smallholder farmers (Africa Centre for Biosafety, 2016). Therefore one of the strategies that the Government undertakes in order to achieve FISP objectives is to encourage farmers in Malawi to grow more soybeans. Figure 2.2 presents soybean production in Malawi from 1990 to 2016 and the figure confirms that overall production has increased to about 130 thousand tonnes representing a total growth rate of approximately 39%.

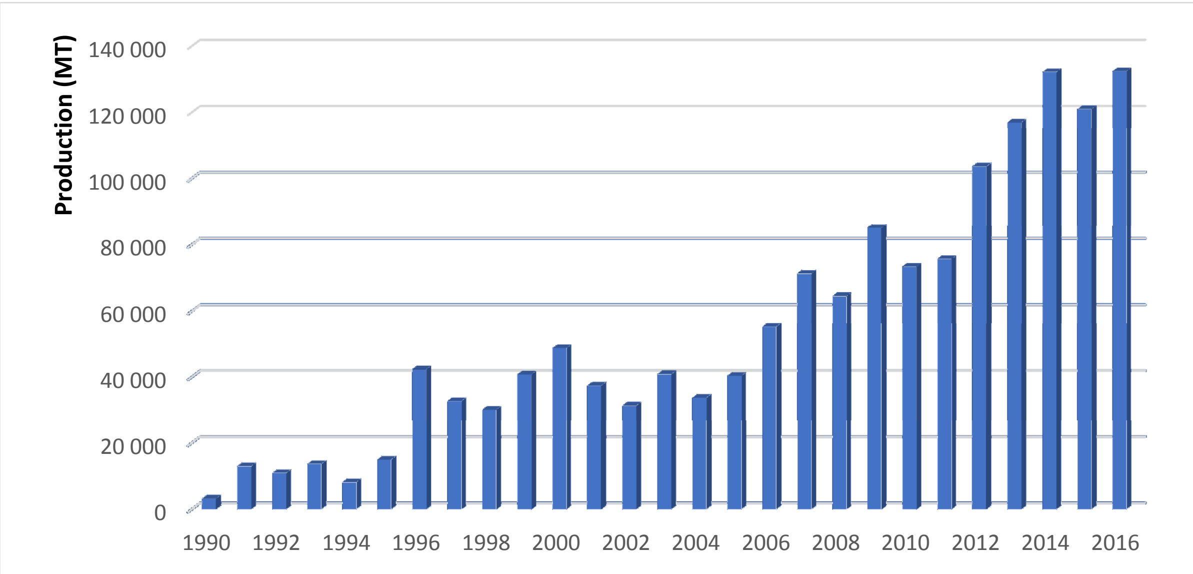

Figure 2. 2: Malawi soybean production 1990-2016

Source: *Compiled from MoAIWD data*

The overall increase in area planted with soybeans, from approximately 6,000 hectares in 1990 to about 150,000 hectares of land as shown in Figure 2.3, has been the biggest driver underlying production growth. Increase in demand for soybeans over the past two decades has made soybean prices to increase which encouraged farmers to increase area planted with soybeans.

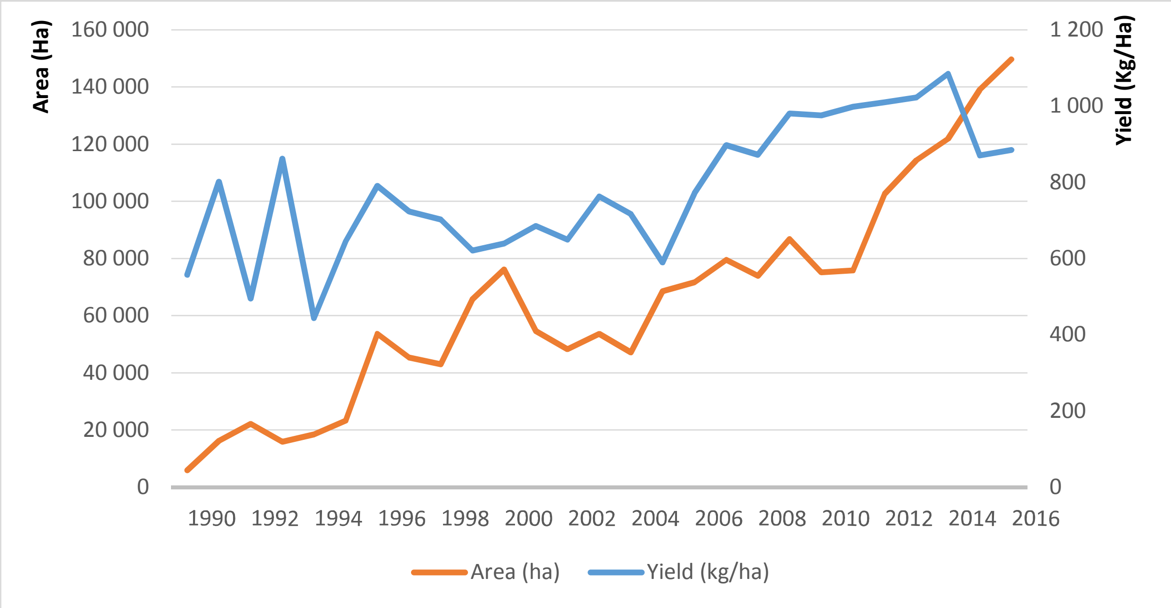

Figure 2. 3: Malawi soybean area (Ha) and yield (Kg/Ha), 1990-2016

Source: Compiled from MoAIWD data

Despite the crop being well adapted for production in all agro-ecological zones in Malawi, average yields are still very low and they range from 600 to 800 kg/ha, leaving a significant gap relating the potential yields of 2000-2500 kg/ha (Kananji, Yohane, Siyeni, Kachulu, Mtambo, Chisama, Malaidza, Tchuwa and Mulekano, 2013). According to Technoserve (2011), these yields are much lower compared to average yields in Argentina (3.4 mt/ha), Zambia (2.6 mt/ ha), South Africa (1.9 mt/ha) and Zimbabwe (1.8 mt/ha). Production of soybeans in Malawi is done under rainfed conditions, unlike in Zambia where soybeans are produced under irrigation. While production area has expanded in Malawi, yield improvements have been minimal at an average of merely 13kg per hectare per annum between 1990 and 2016 (Figure 2.2). Pest and disease attack, low farm gate prices, drought, unfertile soils and limited access to improved seed are reported to be responsible for low soybean yields in Malawi (Kananji and et al, 2013). The Government of Malawi has facilitated the development and promotion of new soybean varieties that have slightly improved the productivity of soybeans.

Tinley (2009) anticipates that the major demand for soybeans in Malawi is expected to increase due to increasing use of soybeans for human consumption and the expanding operations of the confined livestock industry, especially in small scale poultry and dairy enterprises. As noted earlier, soybean production is increasingly becoming more important because soybeans are used to enrich maize flour with approximately 20% of soy-maize blend (Tinley, 2009). This is usually encouraged by Non-Governmental Organisations (NGOs) that implement nutritional relief programmes in schools, hospitals, orphanages and refugee camps (Tinley, 2009). The flour (soy-maize blend) is used to make porridge for breakfast (Feed the Future, 2014). There is also direct consumption of soybeans in terms of infants and baby formula. For the past ten years, the national demand for soybeans was estimated to be 111 thousand tonnes.

Soybeans are processed before direct consumption by humans or feeding to livestock (Feed the Future, 2013). Raw soybean has a natural inhibiting factor called trypsin which makes it toxic when consumed directly. It has also a high concentration of protein and a good combination of essential amino acids. Malawi has experienced a rapid expansion in the processing capacity during the last decade which in turn has also contributed to the expansion in soybean production (Meyer, Traub, Davids, Chisanga, Kachule, Tostão, Vilanculos, Popat, Binfield & Boulanger, 2018). Currently, Malawi sits with a much bigger capacity to crush soybeans than the local size of the crop. As of 2016, about 60 thousand tonnes of soybeans were crushed against the crushing capacity that is estimated at 400 thousand tonnes (Meyer *et al.*, 2018). Soybeans are primarily processed into soybean cake for the animal feed industry and edible oil for human consumption, but also alternative products such as soy flour, soy pieces, soy milk, coffee and soy powder (Feed the Future, 2014).

2.4 Structure of the soybean value chain in Malawi

The soybean value chain in Malawi comprises of input suppliers, producers, aggregators and traders, storage, processors, feed manufacturers and consumers. The role of input suppliers is to make available inputs needed for soybean production at an affordable cost. Producers include both commercial and smallholder farmers that are involved in the growing of soybeans. Volumes of soybeans produced are assembled by aggregators and stored in silos until required by the processors. Consumers comprise of industries that are involved in livestock production and final products of soybean form part of animal feed. They also include industries and relief food organisations that use soybean final products for human consumption.

Approximately 95% of soybeans are produced by smallholder farmers in Malawi. The smallholder farmers form small groups for easy interaction with the service providers such as the Ministry of Agriculture and Food Security (MoAFS), farmers' organisations and non-governmental organisations (NGOs) (Feed the Future, 2014). All these organisations play a role in the soybean value chain through provision of training, supplying inputs and delivery of extension services. Smallholder farmers buy soybean inputs from agricultural input dealers such as SeedCo. Inputs include quality soybean seeds and inoculants which are mainly imported from other countries. One of the high yielding and early maturing varieties, known as Tikolore, has been developed locally by the International Institute for Tropical Agriculture (IITA) and was released in 2011 (Feed the Future, 2014). They sell their soybean produce directly to local markets, companies and Non-Governmental Organisations (Nzima and Dzanja, 2015).

Procurement of soybean produce was initially done by the Agricultural Development and Marketing Corporation (ADMARC) which was the sole supplier of farm inputs and buyer of farm produce (Nzima and Dzanja, 2015). The market was liberalised by government around the 1980s to allow private traders to actively participate in selling farm inputs and buying farm produce for crops such as soybeans. This was after implementing Structural Adjustment Programme (Chirwa, 2005). As a result of market liberalisation, small scale soybean farmers are able to sell their produce directly to local small-scale traders, companies and non-governmental organisation (NGOs) (Feed the Future, 2014).

Nzima and Dzanja (2015) report that approximately 85 % of the smallholder soybean farmers sell their produce to traders and almost 30% of them sell directly to consumers through government markets. A group of traders would include vendors, retailers, wholesalers, companies, governmental organisation (NGOs) and individual farmers (Nzima, 2013). Vendors dominate soybean markets and it is reported that an average of 63.5% of the farmers sell their produce to vendors (Nzima and Dzanja, 2015). Other players in the soybean markets include the National Smallholder Farmers Association of Malawi (NASFAM), ADMARC, Mulli Brothers Group of Companies, Farmers World Company, Export Trading Company, Takondwa Company, CNFA Agro-Dealers (Tinley, 2009). Companies establish retail outlet stores that are scattered throughout the country. The outlet stores are maintained and act as buying centres (Nzima, 2013).

Dzanja and Nzima (2015) identify five marketing channels in the soybean value chain, as shown in Figure 2.4. The first marketing channel involves farmers selling their produce directly to vendors on local markets. The vendors sell the produce, bought from farmers, to consumers (individual farmers and institutions such schools and hospitals). The second channel includes farmers who sell their produce to vendors who in turn sell to retailers and then the retailers sell to consumers. Retailers include super markets and retail shops. The third channel consists of farmers who sell their produce directly to retailers who in turn sell to the consumers. The fourth marketing channel consists of farmers selling their produce directly to consumers on rural markets. Consumers in the rural areas include fellow farmers who buy soybeans for consumption and they also use them as seed. The fifth marketing channel comprises of farmers selling their produce to companies (wholesalers and retailers) who in turn sell to the consumers.

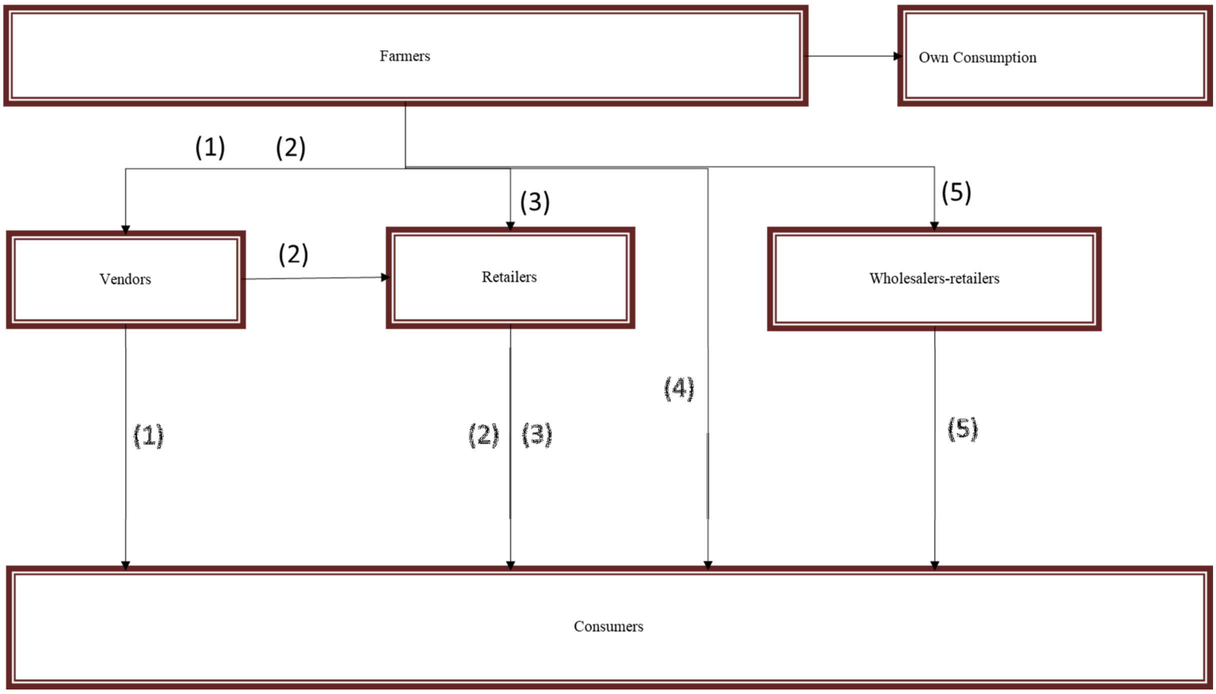

Figure 2.4: Soybean marketing channels

Source: Dzanja and Nzima (2015)

The soybean value chain also involves marketing functions which include storing soybeans in sacks (storage), grading and processing soybeans into soybean products such as soy pieces, milk, flour, soy powder and animal feed (processing) (Dzanja and Nzima, 2015**).** Tinley (2009) reports that there are many processors in Malawi that directly buy soybean produce that is not meant for subsistence use from smallholder farmers. The processors are mainly found in the central and southern parts of the country. Some of the notable processing companies include Asime Milling in Dedza, JJ Enterprise in Lilongwe and Lakeside Agro-Processing Enterprise (LAPE) which located is outside Lilongwe. Asime Milling and LAPE mainly process feed that goes to small scale poultry and dairy farmers. JJ Enterprise works with the nutritional programmes of the World Vision and World Food Programme (WFP).

Soybeans are also exported to other Southern African Development Community (SADC) countries such as South Africa, Zambia, Zimbabwe and Mozambique (Nzima and Dzanja, 2015). Meyer et al (2018) also report that Malawi has been a net exporter of soybeans for the last decade and the beans fetch higher prices than those trading on the world market. This is because Malawian soybeans are free from GMO.

Although smallholder farmers and traders in Malawi have access to markets, soybean production is still low with unstable marketing (Government of Malawi, 2008). Low and fluctuating production and marketing of soybeans are said to have partly contributed to low household income, poor status of human nutrition and slow growth of crop cereals as well as livestock, and decreased export earnings from soybeans (Nzima and Dzanja, 2015).

2.5 Policies affecting the soybean market in Malawi

The Southern African region has implemented a number of policies, including those that were initiated by the International Monetary Fund (IMF) and the World Bank, through the structural adjustment and stabilisation programmes that happened around the 1980s and early 1990s (Sibande; Bailey and Davidova, 2015). Since 1981, Malawi is said to be one of the first countries in Southern Africa that has adopted and implemented policies under the structural adjustment programmes (Chirwa, 2005). International and domestic trade was liberalised through agricultural subsidy removal, agricultural commodity prices, reducing tariff rates and elimination of non-tariff barriers to trade.

However, many countries in the Southern African region including Malawi have reversed their decision on the removal of farm input subsidies (DANIDA, 2011; Druilhe and Barreiro-Hurle, 2012; Ricker- Gilbert *et al.,* 2013). The aim behind for the reintroduction of farm input subsidies is that governments use it as a policy tool to increase food security and income at both household and national levels (Sibande; Bailey and Davidova, 2015).

Several studies reveal that before the structural adjustment programmes, the Malawian Government used to follow policies that were associated with international trade restriction (Chirwa, 2005; Dzanja and Nzima, 2015; Sibande, Bailey and Davidova, 2015).The Agricultural Development Marketing Corporation (ADMARC) was the only organisation that the Malawian Government allowed to trade in agricultural commodities on the domestic market. The study by Chirwa (2005) notes that government intervention policies in the agricultural sector resulted in low agricultural commodity prices which demotivated smallholder farmers to actively participate in agricultural production. This was manifested by the economic crisis that occurred during the period of 1980-1981, which resulted in negative growth rates in gross domestic product (GDP) (Deraniyagala and Kaluwa, 2011).

The policies under the structural adjustment reforms allowed several players of the economy to focus on export orientation which in turn liberalised the exports of most agricultural products. However, export licences were only required for maize but for other agricultural commodities, international trade was almost free.

The study by Aberman and Edelman (2014) observes that Malawi has formulated and adopted trade policy reforms regarding macro-economic and regional trade measures that facilitate exports. It is revealed in their study that a number of reforms, which include those that potentially affect the exports of the oilseeds, have been implemented. These reforms include liberalisation of the exchange rate and reducing the number of days from 44 to 36, as well as the number of documents from 16 (2007) to 9 (2013), required for export. Malawi has also adopted measures that enhance competition among smaller traders and cross-border exports such as COMESA's Simplified Trade Regime (STR). The STR exempts cross-border traders from import duties when exporting a consignment valued at no more than 1000 USD (Aberman and Edelman, 2014).

As noted above by Feed the Future (2014), market liberalisation has allowed soybean farmers to sell their product to any trader. However, some traders, particularly vendors, exploit small scale farmers by offering low prices as they take advantage of their ignorance and desperation for money. Despite exploitation by vendors, market liberalisation has provided incentives for farmers to increase soybean production, as evidenced by Figure 2.1.

2.6 Conclusion

In order to provide some background and context, this chapter provided an overview of the soybean market structure in Malawi, as well as the policy environment that affects it. Historically, performance of agricultural markets in Southern Africa were characterised by government interventions before the implementation of policies that were promoted by the International Monetary Fund (IMF) and the World Bank through the structural adjustment and stabilisation programmes that happened around the 1980s and early 1990s. The structural adjustment reforms were mainly implemented with the aim of liberalising agricultural markets in the region.

Market liberalisation allowed various traders to participate in the agricultural market by selling and buying farm inputs as well as agricultural produce. Market liberalisation has also allowed farmers to sell soybean produce to any trader of their choice. This provided incentives for farmers in Malawi to increase soybean production.

CHAPTER 3: EXTENT OF PRICE VOLATILITY IN MALAWIAN SOYBEAN MARKETS

3.1 Introduction

This chapter evaluates the extent of soybean price volatility in Malawi. It reviews previous studies on price volatility of agricultural commodities, focussing on how price volatility has affected agricultural markets. After evaluating some methodological approaches that have been used to model and estimate soybean price volatility in Malawi, it presents results of the GARCH (1,1) model to quantify the extent of soybean price volatility in Malawi, relative to the global market.

3.2 Price voltility in agricultural markets

Price volatility is defined as a measure of the degree of variation in prices over time and it does not measure the direction of changes experienced (Gilbert and Morgan, 2010). Minot (2013) defines price volatility as the standard deviation of the returns. Returns in this context are defined as the proportional change in prices from one period to the next. Economists are usually interested in the standard deviation of logarithmic prices, since these do not have units.

Globally, agricultural commodities have experienced high fluctuations in prices over the past three decades. Prices have been characterised by sharp increases and decreases, especially after the food crisis experienced during the 2007-2008 period (Gilbert & Morgan, 2010; Minot, 2012 and Elzen, 2014). The food crisis is said to have increased nominal commodity prices by more than half (Tadesse, Algieri, Kalkuhl and Braun, 2013). Over the period 2006 to 2009, agricultural commodities, particularly major grains and oilseeds, recorded sharp increases in price volatility (Donmez and Magrini, 2013; Rosa and Vasciaveo, 2012) This increase in volatility is attributed to tight supplies and strong demand for agricultural commodities, as well as macroeconomic factors that influence world markets. Kornberg and Kalkuh (2013) note however that grain price volatilities in developing countries are not the same, citing maize as an example, which price has been more volatile.

Volatility of agricultural commodity prices has been a major concern due to the persistence of price changes. For instance, food prices on the international markets remained unstable between 2007 to 2011 (Korner and Kalhuhl, 2013; Braun and Tadesse, 2012). The monthly unconditional price volatility during 2007-2010 was substantially higher than the price volatility that occurred in the previous four years (2003 to 2006), and it was also higher than the long-term volatility during 1980-2006 period (Minot, 2013).

The study by Donmez and Magrini(2013) points out that the extent of volatility has stimulated a heavy debate on the major determinants of large price swings in agricultural commodities. For instance, Rosa and Vasciaveo (2012) investigated the causal relationships between increasing crude oil volatility and high price changes in selected agricultural commodities on the US and Italian markets, using linear as well as non-linear Granger causality methods. In their analysis they discovered that price volatility from the world markets affects prices in the domestic markets, but no evidence is found for domestic prices responding to global oil prices. Korner and Kalhuhl (2013) note that stability in stocks and low production can make domestic prices unstable.

At national level, price volatility affects food security and there is typically a correlation between domestic and world price volatility, which differs from one country to another (Díaz-Bonilla, 2016). A report by FAO, IFAD, IMF, OECD, UNCTAD, WFP, the World Bank, the WTO, IFPRI and the UN HLTF (2011) states that the transmission of world prices to domestic prices depends on the integration of the world and domestic markets. However, a number of factors are thought to constrain price transmission from international to domestic markets. These factors include poor infrastructure, rising costs of import duties, transportation, domestic policies, exchange rate instability and consumer preferences.

Minot (2012) reveals that African agricultural commodity markets have experienced severe price volatility since the global food crisis that occurred between 2007 and 2008. The study measures the changes in volatility over time by focusing on price series, covering the period from 2003 to 2010, with allowable missing observations of at most 10 percent. It confirms some significant evidence of price volatility in 67 countries sampled, using the standard deviation of the monthly proportional change in price. For instance, maize price volatility in countries such as Malawi, Kenya, Zambia and Zimbabwe is considerably higher than other sampled countries. This raises concern as to the welfare impact of high price volatility in developing countries of Africa.

Studies conducted in Malawi on price volatility of agricultural commodities indicate that poor households, particularly net food consumers, have been severely affected by price volatility (Feed the Future Report, 2013). Sassi (2014) investigates maize price volatility in Malawi, using an ARCH/GARCH approach in order to estimate the welfare costs. In her study she uses monthly price data from nine local markets during the period of January 1991-March 2013. The findings of the study agree with those in existing literature, arguing that maize price volatility is mainly affected by domestic factors, and not by shocks on the international markets. Maize price volatility levels are higher during certain periods which reflect the effect of seasonality on the unconditional volatility. This demonstrates the need to have better storage, marketing and trade facilities for inter-seasonal and spatial arbitrage. In view of this, the study suggests the need of improving poor farmer productivity and market knowledge, with an aim of reducing maize price volatility.

Edelman and Baulch (2016) use co-efficient of variation to investigate the effects of maize and soybean export bans on prices in Malawi from May 2004 to December 2015. The study sources monthly data from the AMIS of Malawi; the Ministry of Industry, Trade and Marketing of Tanzania; the Ministry of Agriculture and Livestock of Kenya; the Central Statistics Office of Zambia; the Statistical Agency of South Africa, FEWSNET-Zimbabwe and the South African Future Exchange (SAFEX). The study found that maize prices in Malawi experienced higher price volatility relative to regional prices. It concluded that export bans favour the consumers in a short-run but they negatively affect the poor small scale farmers. Aragie, Pauw, and Pernechele (2016) note that in the long-run, export bans lead to low prices of maize or soybeans, which limit supply because there are no incentives to produce.

3.3 Methodology

There are two categories of volatility models that are commonly used to measure and forecast price volatility (Engle and Patton, 2000). The first category expresses the conditional variance as a function of the observables and the commonly used models in this category include ARCH and GARCH models. The second common category of volatility models does not express the conditional variances as functions of solely observables and the models in this class are sometimes called latent or stochastic volatility models. A simple stochastic volatility model might be formulated as follows:

$$\upsilon_t = m_t + \sqrt{\upsilon_t \varepsilon_t} \quad (1)$$

$$\upsilon_t = \omega \upsilon_{t-1}^{\beta} \exp(\kappa \eta_t) \quad (2)$$

$$\varepsilon_t \eta_t \sim in(0.1) \quad (3)$$

-where υ is not expressed as a function of elements of information set of the previous returns and cannot be a conditional variance. This is because two shocks exist with only one observable, which makes it difficult to observe current and past υ precisely in the model . However, the model has a well-defined conditional variance but it is not easy to calculate because it depends on a nonlinear filtering problem. Simulation of latent volatility models is possible but it is difficult to use these models to estimate and forecast volatility (Engle and Patton, 2000).

Some researchers note that descriptive models can be used to investigate price volatility but these models can not be used to examine the determinants of price volatility (Clapp, 2009; Gilbert and Morgan, 2010; Wright, 2011; Anderson and Nelgen, 2012; Chandrasekhar, 2012; and Nissanke, 2012). Price volatility is also analysed, using partial equilibrium models from studies, based on mathematical modelling (Miao et al., 2011 and Babcock, 2012). The analysis of price volatility has been done using reduced-form models (Balcombe, 2009 and Ott, 2013), co-integration analysis (Pietola, Liu, and Robles, 2010) or GARCH (1,1) models involving different specifications (Zheng, Knnucan and Thompson, 2008; Roache, 2010; Hayo, Kutan and Neuenkirch, 2012; Karali and Power, 2013; Minot, 2013). The GARCH (1,1) model has an advantage over other models because it not only expresses the conditional variance as a linear function but also includes lagged conditional variances (Engle and Patton, 2000). It has also been proven to do well against the alternative specifications when modelling food price volatility (Hansen and Lunde, 2001).

This study employs a generalised auto-regressive conditional heteroscedasticity (GARCH) model to investigate soybean price volatility. In this approach the conditional variance is tested. The GARCH Model is a generalisation of Auto-regressive Conditional Heteroskedasticity (ARCH) models and it was introduced by Engel (1982) and Engle & Bollerslev (1986). The ARCH model only specifies the conditional variance as the linear function of the previous sample variances. However, the GARCH model not only expresses the conditional variance as a linear function but also includes lagged conditional variances (Bollerslev, 1986). The conditional variance in GARCH models depends on the squared residuals, as well as on its values in the previous periods. GARCH expresses the conditional variance as a linear function of the squared values from the previous period of the time series. As such, generalising ARCH enables the model to be prudent and prevents over fitting. Brooks (2008) reports that GARCH models are extensively used to model price volatility in time series. The model was specified as follows:

Mean equation: $r_t = \mu + \mathcal{E}_t$ (4)

$var(\mathcal{E}_t) = \sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \mathcal{E}_{t-i}^2 + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^2$ (5)

-where σ_t^2 is the estimated current conditional variance which depends on the q lags of the squared residues ($\mathcal{E}_{t=i}^2$) p lags of the conditional variance ($\sigma_{t=j}^2$). This is subject to constraints:

$\omega > 0$, $\alpha_i \geq 0$ (for all $i = 1,2,\ldots,q$) and
$\beta_j \geq 0$ (for all $j = 1,2,\ldots,p$).

The GARCH model was chosen to measure the price volatility because it allows the variance of returns (r) to change over time as a function of the lagged squared residuals ($\mathcal{E}_{t=i}^2$) and lagged variance ($\sigma_{t=j}^2$). The estimated value of the conditional volatility was σ_t^2. Gilbert and Morgan (2010) and Sassi (2013) used this approach in their studies.

3.3.1 Data Sources

The empirical analysis of this study uses secondary data of monthly soybean prices for Malawi, South Africa and the USA (represents the world soybean prices). The data spans the period from April 2002 to November 2016. Table 3.1 presents definitions of variables, data source, data frequency, units of the variables and the period from which the data was extracted.

Table 3.1: Data definitions

Title	Series ID	Source	Frequency	Units	Range Date
Malawi Soybean price	$MWSP_t$	MoAIWD	Monthly	USD/ton	2002-2016
South Africa Soybean Price	$SASP_t$	Abstract SAGIS FAOSTAT	Monthly	USD/ton	2002-2016
US Soybean price	USP_t	FAOSTAT	Monthly	USD/ton	2002-2016

3.3.2 Time series properties of the data

Both descriptive and econometric analyses are used to examine patterns and trends of soybean prices over time. Gujarati and Porter (2009) state that when analysing time series empirically, it is assumed that the series exhibits a stationary process. Therefore it is recommended to check for stationarity of the time series before proceeding with econometrics analysis. This is because non-stationarity is common in economic time series which leads to spurious regression (Granger and Newbold, 1974). As such there is need to transform non-stationary time series to become stationary by differencing. Woodridge (2013) notes that relationships among variables that are non-stationary do not make any economic sense, though they might be significant. As a consequence, forecasting becomes questionable since results are misleading and invalid.

In view of this, pre-tests for stationarity are conducted prior to any other econometric analysis. Stationarity refers to the process that is mean reverting and its variance is constant over time (Gujarati and Porter, 2009). In contrast, non-stationarity is the process in which its mean and variance change over time. Stationarity of time series can be informally detected using graphical analysis as well as correlograms. It can also be detected formally using unit root tests. The study conducted a series of unit root tests, both formal and informal.

Gujarati and Porter (2009) point out that presenting time series graphically helps to spot certain sequences that are not stationary. Most time series exhibit variability that can be noticed by a graph. Both graph plots and correlograms are used as a first indication to establish whether time series data is stationary or non-stationary. A correlogram is a graphic presentation of a particular sample estimate (time series) of the autocorrelation function and the partial autocorrelation function (Gujarati and Porter, 2009). However, using graphs to detect trends that are either stationary or non-stationary does not provide enough evidence to prove that the series has a white noise process or a unit root. Therefore there is need to conduct formal unit root tests in order to triangulate graph and correlogram results.

Hill et al. (2008) report that unit root tests are required to check whether the time series data exhibits a co-variance stationary process. Thus a variable is considered to have a unit root if it is non-stationary. For example, if given that $Z_t = \beta Z_{t-1} + \mathcal{E}_t$ with $\mathcal{E}_t$ as white noise, the data generating process (DGP) is said to be non-stationary if $\beta - 1 = 0$. Equivalently DGP is non-stationary if $\beta = 1$. Therefore the series is said to be stationary if the value of the coefficient β is less than unity in absolute terms, that is, $-1< \beta < 1$.

The results of the time series analysis can only be valid when stationarity is achieved. In view of this, the study first performed a conventional Augmented Dickey-Fuller (1979) test. Augmented Dickey-Fuller (ADF) is a common procedure used to test for unit root and is based on an autoregressive (AR) model. It is mostly used in literature to test the null hypothesis of non-stationarity against the alternative hypothesis of stationarity. The main feature of an ADF test is that it considers a deterministic constant ($\boldsymbol{\alpha}$) and trend (λ_t) while Z_{t-1} in the equation below is the unit root stochastic process.

$$\Delta Z_t = \alpha + \lambda_t + \gamma Z_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Z_{t-1} + \mathcal{E}_t \qquad (6)$$

The constant and trend are poorly estimated in the least squares method when a unit root is present. The reason is that the least squares procedure fails to accurately detach the stochastic process from the deterministic part. Thus the ADF test suffers from the problem of very low statistical power. The remedy to this problem is choosing unit root tests that have high power as proposed by Enders (2010). As such a unit root test called Phillip-Perron (PP) was employed to control for serial correlation as proposed by Phillip and Perron (1988). This test is performed in comparison with ADF test, which is usually favoured for checking stationarity (Rosa and Vasciaveo, 2012). As outlined in ADF approach, PP test is also aimed at testing the null hypothesis of non-stationarity against the alternative of stationarity. In both unit root tests, rejection of the null hypothesis indicates the presence of stationarity. The last unit root test to be performed was the Kwiatkowsiki-Phillip-Schmidt-Shin (KPSS) test. This test is different from both ADF and PP tests in that it tests the null hypothesis of stationarity against the alternative hypothesis of non-stationarity. Rejection of the null hypothesis of stationarity at 1%, 5% and 10% levels of significance indicates that the time series is non-stationary. Combined, the tests can provide strong evidence of the presence of a unit root.

3.4 Results

3.4.1 Summary statistics of Soybean Price Data

A summary of a descriptive analysis of all the variables for the period ranging from 2002 to 2016 is presented in Tables 3.2 and3.3. The analysis includes 175 observations for each variable. Table 3.2 presents descriptive statistics of the actual series, whilst Table 3.3 presents the descriptive statistics of the return series.

Table 3.2: Descriptive Statistics for soybean prices, 2002-2016

	$MWSP_t$	$SASP_t$	USP_t
Mean	670.8171	403.7220	408.8204
Median	623.1868	397.3407	407.5000
Maximum	1326.693	717.4384	684.0000
Minimum	283.9619	170.3000	195.0000
Std. Dev.	197.4888	120.3981	121.7156
Skewness	1.0015	0.155856	0.1033
Kurtosis	4.1659	2.1778	1.9338
Jarque-Bera	39.3868	5.6701	8.6491
Probability	0.0000	0.0587	0.0132
Observations	176	176	176

Table 3.2 indicates that Malawi had the highest average monthly price (670.82 USD per tonne) followed by the USA (408.82 USD per tonne) whilst the average monthly price for South Africa was the lowest over the period specified (403.72 USD per tonne). Both minimum and maximum monthly prices for Malawi series appeared to be very high, compared to other series.

The results show that none of the series were normally distributed, as indicated by the positive skewness, which was greater than zero for each series. For the series to be normally distributed, it must have a skewness of zero. A positively skewed series indicates a right tail distribution, which was the case for the series in question. The standard value for kurtosis, that indicates a normal distribution, is about 3.

The normality tests results, as indicated by Jarque-Bera, is significant at 1%, 5% and 10% levels for Malawi, USA and South Africa series respectively. This means that the null hypothesis for each series, being normally distributed, is rejected, implying that all the series are not normally distributed. The Jarque-Bera test results agreed with the results for skewness and kurtosis.

Before conducting formal unit root tests, all the series were transformed into logarithms meaning that $MWSP_t$, $SASP_t$ and USP_t became $LMWSP_t$, $LSASP_t$ and $LUSP_t$. This is because logarithm values have no units and they allow the coefficients to be interpreted as elasticities. Use of logarithms also dampens the exponential trends in explosive series. From the monthly soybean prices, return series are calculated in order to establish the extent of soybean price swings during the 2002-2016 period. The formula for the returns is specified as follows:

$$R_t = Log(\frac{P_t}{P_{t-1}}) \qquad (7)$$

-where P_t stands for the current monthly price of soybeans and P_{t-1} is the price from the previous month. A summary of statistics for the return series of 2002 to 2016 is presented in Table 3.3 below.

Table 3.3: Summary statistics for return series

	$\boldsymbol{MWR_t}$	$\boldsymbol{SAR_t}$	$\boldsymbol{USR_t}$
Mean	0.002012	0.004098	0.004233
Median	0.009548	0.006378	0.003752
Maximum	0.885063	0.748637	0.160623
Minimum	-0.707963	-0.876975	-0.256097
Std. Dev.	0.153212	0.116034	0.057678
Skewness	0.643486	-1.169486	-0.586634

Kurtosis	12.39104	29.93690	5.436750
Jarque-Bera	655.1407	5330.701	53.33348
Probability	0.000000	0.000000	0.000000
Observations	176	176	176

Table 3.3 shows that South Africa and the USA had almost the same average monthly return of 0.004 which is higher than the average monthly return for Malawi (0.002). But Malawi has the highest maximum monthly return (0.8851), seconded by South Africa (0.7486) and the USA with the lowest maximum return of 0.1606. For the minimum monthly returns, the world has the highest (-0.256) followed by Malawi (-0.70796).

The results show that all the series are not normally distributed, as indicated by the positive skewness for each series. Malawi returns are positively skewed, indicating a right tail distribution. Both South Africa and USA returns have skewness with a negative sign and this implies that they have a left tail distribution. South Africa has the largest kurtosis of 29.9369 while the kurtosis for Malawi is 12.39104 and the World has the smallest kurtosis of 5.43675. The accepted kurtosis for a normally distributed series is 3.

Results from Table 3.3 confirm that application of ARCH/GARCH models to test volatility of the data is appropriate, since all series are concluded to be not normally distributed, fat tailed and leptokurtic.

3.4.2 Graphical Analysis

As a starting point in the analysis of stationarity, Figure 3.1 provides a visual inspection of all the variables. By itself, this is insufficient to conclude stationarity, but it provides an early indication from which to form expectations, which can be confirmed through formal testing. This Figure includes all three charts of soybean prices for Malawi, South Africa and USA.

It is indicated in Figure 3.1 that Malawi experienced much higher spikes in soybean prices during the period of 2007-2011 than South Africa and the USA. Although Malawi experienced higher spikes in soybean prices, South Africa and the world also recorded some increase in prices during the same period. It is however observed from the Figure that all the countries experienced a decline in prices during the period of late 2012 to 2016. Notable from the Figure, Malawi soybean prices temporarily rose in January 2015 and then started declining again. These results agree with findings in literature that large agricultural price swings have been observed during the period of 2007-2011 (Frankel and Rose, 2010; Minot, 2012; Rosa and Vasciaveo, 2012; Donmez and Magrini, 2013; Elzen, 2014 and Sujithan, Avouyi-Dovi and Koliai, 2014). A visual inspection of Figure 3.1 suggests that all series exhibit unit root processes and was confirmed by formal unit root tests. Results of the formal unit root tests are presented in the subsequent section.

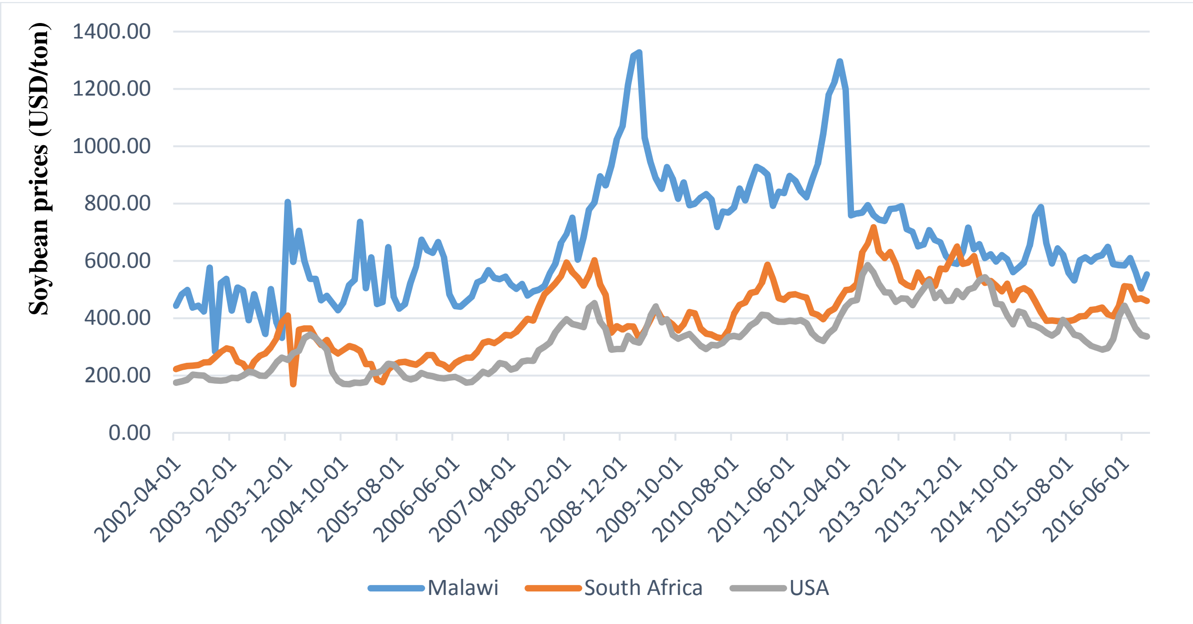

Figure 3. 1: Soybean monthly prices (2002-2016)

Source: Compiled from MoAIWD, SAGIS and FAOSTAT

Graphically, soybean price return series from 2002 to 2016 are also presented in Figure 3.2 below.

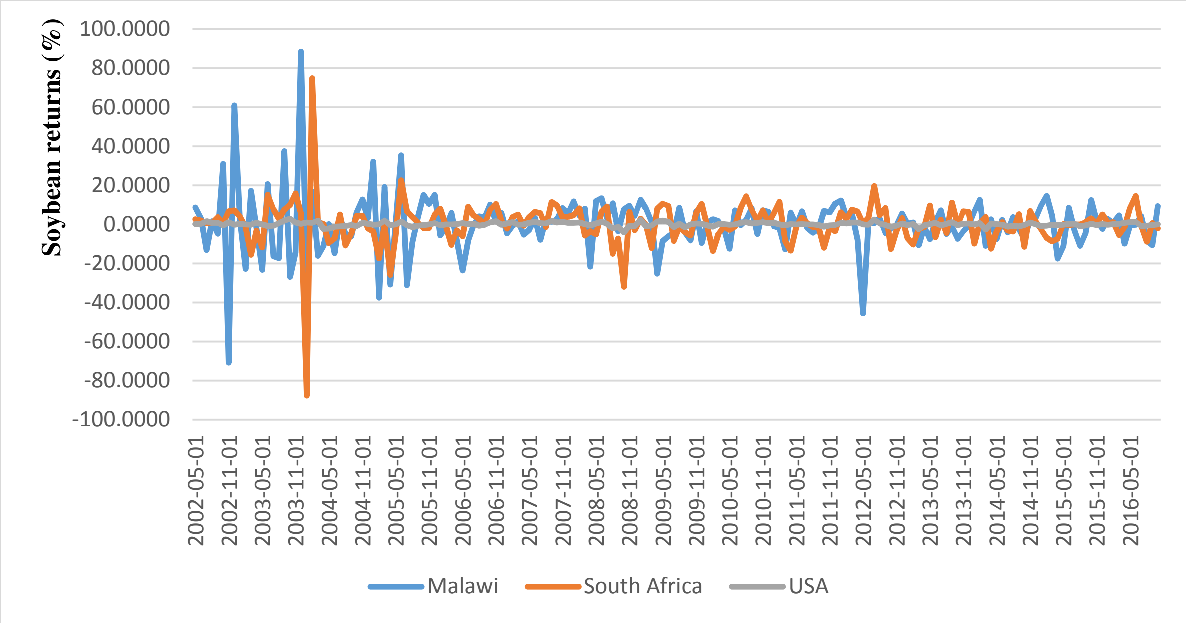

Figure 3. 2: Return chats for soybean prices

Source: Compiled from MoAIWD

The return series chats presented in Figures 3.2 are indicative of a white noise process, which would imply stationarity. The results imply that price transformation into returns through logarithms make the non-stationary series become stationary. However, formal unit root tests are performed in Section 3.4.3 to verify results from the visual inspection.

3.4.3 Stationarity testing

The study uses Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) procedures to test for stationarity of the returns series. Both the ADF and PP methods test the null hypothesis of non-stationarity against an alternative of stationarity. The unit root tests are performed in levels, observing all three steps which include intercept, intercept and trend, as well as no trend and no intercept. The results are presented in Table 3.4.

Table 3.4: ADF and PP Test Results in levels for returns

Variable	Model	ADF		PP		KPSS	
		Lags	ADF	Bandwidth	PP	Bandwidth	KPSS
$MWSR_t$	Trend & intercept	0	-19.1796***	16	-24.0002***	48	0.1178
	Intercept	0	-19.2190***	16	-23.5761***	45	0.1937

	None	0	-19.2721***	16	-23.6012***		
$SASR_t$	Trend & intercept	0	-16.2973***	7	-16.9425***	10	0.0354
	Intercept	0	-16.3253***	6	-16.8649***	10	0.0714
	None	0	-16.3479***	6	-16.8562***		
USR_t	Trend & intercept	0	-9.7128***	1	-9.7097***	4	0.0316
	Intercept	0	-9.6491***	2	-9.6786***	5	0.1620
	None	0	-9.6376***	2	-9.6664***		

*Notes: ***, ** and * denote statistical significance at 1%, 5% and 10% levels respectively*

Table 3.4 shows that both ADF and PP statistics are significant at 1% level which makes the null hypothesis, that the variables are non-stationary, be rejected. It is also indicated in the table that KPSS statistics are not significant at 10% level. Thus the null hypothesis, that the variables are stationary, is not rejected, concluding that the variables are stationary. This implies that all the variables are stationary and integrated in the order of *I*(0). These results formally confirm that return charts presented in the Figure 3.2 above have a white noise.

3.4.4 Empirical estimation of soybean price volatility

Having confirmed the order of integration, a GARCH model can be estimated to evaluate the extent of price volatility in Malawi. Table 3.6 shows the estimates of GARCH (1,1) model for Malawi soybean returns and all the coefficients, constant (C), ARCH term (RESID(-1)^2) and GARCH term (GARCH(-1)) are significant at 1% level. This means that the lagged squared residual and the lagged conditional variance had an effect on the conditional variance. It also indicates that, conditional on the information obtained from the previous month, soybean price volatility has the power to explain the current volatility of the prices.

The sum of $\boldsymbol{\alpha}$ (ARCH term) and $\boldsymbol{\beta}$ (GARCH term) is close to unity, implying that the shocks to volatility were highly persistent with a long memory in the conditional variance. This indicates that there was a slow decay of shocks to volatility over time.

GARCH (1,1) with a normal distribution was used to model the volatility of Malawi soybean prices during the period of 2002-2016. The soybean prices were converted into log returns (r) hence the volatility modelling involved returns for Malawi. The maximum likelihood function was used to estimate the GARCH models under the assumption that the errors had a conditional normal distribution. The parameters of the variance equations were estimated and the results are presented in Table 3.5.

Table 3.5: GARCH (1,1) results for Malawi soybean returns

Variable	Coefficient	Std. error	z-Statistic	P-value
C	0.002222	0.000821	2.707091	0.0068
RESID(-1)^2	0.202641	0.031812	6.370254	0.0000
GARCH(-1)	0.797349	0.031812	25.06440	0.0000

Notes: The number in brackets (-) indicates number of lags

The study also uses GARCH (1,1) to estimate soybean price volatility in South Africa and the USA and results are shown in Tables 3.7 and 3.8. The estimates of a GARCH (1,1) model for South African soybean returns presented in Table 3.7 shows that the co-efficient constant (C) is significant at 10 % level, while co-efficients on ARCH (1,1) and GARCH (1,1) terms are highly significant. This also implies that the information about volatility from the previous month influenced the current volatility, since the lagged squared residual and lagged conditional variance had an effect on the conditional variance. GARCH term also shows volatility clustering in the monthly returns as indicated by its significance.

Table 3.6: GARCH (1,1) results for South Africa returns

SAR	Coefficient	Std. error	z-Statistic	P-value
C	0.001058	0.000626	1.688741	0.0913
RESID(-1)^2	0.238662	0.034830	6.852265	0.0000
GARCH(-1)	0.761338	0.034830	21.85887	0.0000

Notes: The number in asterisk (-) indicates number of lags

As is the case with Malawi soybean monthly returns, Table 3.7 shows that the sum of $\boldsymbol{\alpha}$ (ARCH term) and $\boldsymbol{\beta}$ (GARCH term) is also close to unity, implying that the shocks to volatility were highly persistent with a long memory in conditional variance. Likewise, this means that there was a slow decay of shocks to volatility over time. It is however noted that the beta co-efficient for soybean monthly returns in Malawi is slightly larger than the beta co-efficient in South Africa. Larger beta in Malawi implies larger changes in the volatility that will have larger effects in future than in South Africa.

Table 3.7: GARCH (1,1) results for the USA returns

Variable	Coefficient	Std. error	z-Statistic	P-value
C	0.000888	0.000595	1.492777	0.1355
RESID(-1)^2	0.176933	0.065498	2.701363	0.0069
GARCH(-1)	0.558524	0.230804	2.419907	0.0155

Notes: The number in asterisk (-) indicates number of lags

Table 3.8 shows results of estimated parameters of GARCH (1, 1) model for the USA soybean returns. The co-efficients on ARCH term (RESID (-1) ^2) and GARCH term (GARCH (-1)) were significant at 1% level and 5% levels respectively. This means that the lagged conditional variance and the lagged squared residual (ARCH term) had an effect on the conditional variance. It also indicates that, conditional on the information obtained from the previous month, soybean price volatility has the power to explain current price volatility.

In the USA, the sum of **α** (ARCH term) and **β** (GARCH term) is a bit further from unity, implying that the shocks to volatility were less persistent with a shorter memory in conditional variance than in Malawi and South Africa . This indicates that there was a faster decay of shocks to volatility over time.

These findings are consistent with conclusions reached by Gilbert & Morgan (2010), Lesaona *et al.* (2011), Niyitegeka & Tewari (2013) and Samoulhan & Shannon (2008) on Johannesburg Stock Exchange (JSE) return behaviour.

3.5 Conclusion

Agricultural commodities experienced high price volatility over the past two decades. During the period of 2007-2008, prices of agricultural commodities were characterised by sharp increases and decreases. High price volatility has been a major concern across the world. Poor producers and consumers in developing countries have been mostly affected by persistent changes in prices.

From the stationary test results, soybean prices for all the three countries had a unit root in level implying that they were non-stationary. They became stationary after differencing them once using ADF, PP and KPSS unit root tests.

Results of GARCH (1, 1) model for the empirical estimation of monthly returns of soybean prices indicate that there was a persistent volatility in soybean prices for Malawi, South Africa and the USA. However, the beta co-efficient for soybean monthly returns in Malawi is slightly larger than the beta co-efficients in South Africa and USA. Therefore, the study concludes that Malawi soybean prices are more volatile, relative to the other two countries. Since it is concluded in this chapter that soybean prices in Malawi have been volatile during the period of 2002-2016, the study intends to collect empirical evidence on what makes the prices to be volatile. As such, the empirical analysis of the impact of international prices on the domestic markets is conducted in the subsequent section.

CHAPTER 4: IMPACT OF INTERNATIONAL MARKETS ON DOMESTIC SOYBEAN PRICE VOLATILITY IN MALAWI

4.1 Introduction

Globally, the degree of price volatility from 2006 to 2009 sparked the interest of numerous researchers, questioning the cause of this volatility (Elzen, 2014; Kornher and Kalkuh, 2013 and Donmez and Magrini, 2013). In terms of global markets, a number of factors have been identified as causes of volatility. These include supply and demand dynamics (Gilbert & Morgan, 2010), which are often influenced by weather induced shocks to supply (Santeramo, Lamonaca, Conto, Nardone & Stasi, 2017), low price elasticities associated with basic food products, additional demand in the form of biofuel when oil prices increase sufficiently, aggressive stock holding policies in large countries and trade restrictions in response to rising prices (Abbott, Hurt and Tyner, 2009 and 2011; Gilbert, 2010 and Roache, 2010). While supply and demand conditions in small countries such as Malawi are unlikely to influence volatility in global markets, volatility in global markets could spill over into Malawi.

Having evaluated the extent of volatility in Malawian soybean markets, relative to other regions in Chapter 3, this chapter evaluates price formation in Malawian soybean markets. It also starts to explore possible causes of volatility in domestic soybean markets. As a first step in identifying the causes of soybean price volatility in Malawi, this chapter evaluates the extent to which volatility in international and regional soybean markets is transmitted to domestic soybean markets in Malawi, through the use of co-integration and price transmission techniques.

4.2 Price formation in Malawian soybean markets

In Malawi, minimum farm gate prices for all crops, including soybeans, are primarily set by the government. However, enforcement of the minimum prices is not effective (Tinley, 2009 and Feed the Future Report, 2013). According to the analysis of the soybean market conduct, done by Dzanja and Nzima (2015), trader based organisations operating in all the markets in all the regions (Northern, Central, Eastern and Southern) do not bargain for prices. This implies that prices are individually determined.

A poor enforcement mechanism of minimum prices has allowed individual traders to set prices for soybean produce that are not in line with the Government minimum farm gate prices. Feed the Future (2013) also states that prices of soybeans are locally determined. Soybean prices are subject to high volatility due to sudden government inventions such as export bans and devaluation of currency. The major determinants have been noted as demand and supply, grading, purchasing price and transport costs (Dzanja and Nzima, 2015).

4.3 Testing for co-integration between international, regional and Malawian soybean prices

The effect of international food price movements on domestic markets in Africa has been evaluated by Cornia, Deotti and Sassi (2012). Over the period of 2000-2010, they evaluated the degree of transmission of international food prices to domestic food prices in Malawi and Niger, using a Vector Error Correction (VEC) model, as proposed by Minot (2010). The study covered maize and millet in Malawi and Niger respectively. Findings suggest that, in the case of Malawi and Niger, world prices did not have a significant impact on domestic food prices.

Maize in particular represents somewhat of a special case however, in that Africa typically consumes white maize free of genetically modified (GM) technology, a product which is arguably differentiated from the yellow maize often traded on the global market. In soybean markets, where products are more comparable, the influence of international markets on domestic price volatility may be more pronounced. There is however still a lesser degree of differentiation in that Malawi typically produces non-GM soybeans, whereas South Africa and the USA produce GM soybeans. In order to evaluate the extent of international market influence in Malawi, this section tests for co-integrated relationships between soybean prices in Malawi and those in the USA (global reference) and South Africa (regional reference).

4.3.1 Methodology

As suggested by econometric theory, regression of time series data that is non-stationary can yield spurious results (Gujarati and Porter, 2009). Thus the analysis of time series data must be pre-empted by evaluation of the time-series properties of the data used. This section relies on secondary price data of soybeans in Malawi, South Africa and the USA.

4.3.2 Stationarity testing

The stationarity of these data series is evaluated with the same techniques employed in Chapter 3, with the results presented in Tables 4.1 and 4.2. From the results presented, it is clear that all three series are integrated of order 1, as all series became stationary after first differencing.

Table 4.1 presents the results of all three tests, in levels. It shows that almost all the ADF and PP statistics, with and without intercept, has a negative sign and are not significant at 10% level. The negative sign is in line with expectation. However, variables without constant and trend have positive co-efficients and are not significant at 10% level. Therefore, the null hypothesis, that variables are non-stationary, is not rejected and it is concluded that the variables have a unit root. All the KPSS statistics have a positive sign and are highly significant, hence the null hypothesis of stationarity is rejected. This confirms the results from ADF and PP tests that the soybean price series for Malawi, South Africa and the world are non-stationary.

Table 4.1: ADF, PP and KPSS Test Results in levels

Variable	Model	ADF		PP		KPSS	
		Lags	ADF	Bandwidth	PP	Band width	KPSS
$LMWSP_t$	Trend & intercept	1	-2.7752	4	-3.5754*	10	0.3122***
	Intercept	1	-2.6928*	2	-3.4167*	10	0.6738***
	None	1	0.0719	45	0.3987		
$LSASP_t$	Trend & intercept	1	-3.6507**	3	-3.3698*	10	0.1455***
	Intercept	0	-2.3337	3	-2.4605	10	1.1819***
	None	1	0.4425	10	0.5587		
$LWSP_t$	Trend & intercept	1	-2.3201	5	-2.1616	10	0.2687***
	Intercept	1	-2.4141	5	-2.3483	10	1.0981***
	None	1	0.5772	5	0.6299		

*Notes: ***, ** and * denote statistical significance at 1%, 5% and 10% levels respectively*

ADF, PP and KPSS tests are also conducted in first difference form, to evaluate whether the variables become stationary after differencing. Results are presented in Table 4.2. It shows that all the variables became stationary after differencing, implying that they are integrated in the order of $I(1)$. First differenced ADF and PP statistics are significant at 1% level. This means that the null hypothesis, that the variables are non-stationary after differencing them once, is rejected. For KPSS test, all the statistics are not significant at 1% level, hence the null hypothesis of stationary is also not rejected.

Table 4.2: ADF, PP and KPSS Test Results in first Difference

Variable	Model	ADF		PP		KPSS	
		Lags	ADF	Brand Width	PP	Brand Width	KPSS
$\Delta LMWSP_t$	Trend & intercept	0	-19.1796***	16	-24.000***	45	0.1178
	Intercept	0	-19.2190***	16	-23.576***	48	0.1937
	None	0	-19.2721***	16	-23.601***		
$\Delta LSASP_t$	Trend & intercept	0	-16.2973***	6	-16.943***	10	0.0354
	Intercept	0	-16.3253***	7	-16.865***	10	0.0714
	None	0	-16.3479***	6	-16.856***		
$\Delta LWSP_t$	Trend & intercept	0	-9.7128***	2	-9.7097***	5	0.0316
	Intercept	0	-9.6491***	1	-9.677***	4	0.1620
	None	0	-9.6376***	2	-9.6664***		

Notes: *Δ denotes the first differenced operator*
**** denote statistical significance at 1% level*

Econometric theory states that if variables are integrated of the same order, they may yield a co-integration relationship. Co-integration is an econometric concept that simulates the presence of a long- run equilibrium among economic series data (Granger, 1981; Engel and Granger, 1987). The basis for co-integration analysis rests in the spatial equilibrium theory and the law of one price. Variables are said to be co-integrated if these variables are individually integrated of the same order and at least one stationary linear combination exists amongst the variables (Gujarati and Porter, 2009).

According to Vavra and Goodwin (2005), the concept of co-integration is strong since it enables the equilibrium relationship of random walk series to be captured in a stationary model. Co-integrated time series of prices may drift apart in the short run but they move closely together in the long run. Co-integration analysis therefore aims at estimating the long run economic relationship of non-stationary variables that are co-integrated.

In order to examine price transmission of soybeans from the international markets to the markets in Malawi, the study applies the Engle Granger (1987) procedure. In this case, the procedure is applied in order to test for co-integration in soybean price series for Malawi, South Africa and the USA. The Engle Granger method is relatively simple and useful when examining the long-run equilibrium relationship between variables. The major interest in examining the price transmission is to quantify long-run and short-run dynamics of the co-integrated series. The Engle Granger (1987) tests price pairs for evidence of co-integration. If the series in each pair are co-integrated, an error correction model (ECM) will be applied in order to quantify the short run effects in the form of rate of adjustment to the equilibrium.

Engle Granger applies a two-step estimation procedure using the OLS to test for co-integration and familiar unit root tests are applied to the residuals to test for stationarity. The absence of a unit root leads to the rejection of the null hypothesis, implying that the variables are co-integrated. Bilgili (1998) notes that the OLS estimator is preferred when investigating relationship between co-integrating vectors since it is simple to perform. However, Bilgili (1998) further notes that Maximum likelihood estimator yields best results if the model is perfectly specified and there are no auto-correlated co-integrating errors.

In order to estimate the long-run relationship between price series, using the Engle-Granger procedure, the following co-integration equation is used:

$$\boldsymbol{Inp_t^{MWS} = \alpha_0 + \beta_i Inp_t^{IS}} + \varepsilon_t \qquad (1)$$

Where:

p_t^{MWS} is the soybean price in Malawi

p_t^{IS} is the international soybean price (South Africa and the USA)

β_i is the long-run elasticity (co-integrating factor)

ε_t is the error term

Various studies have used the two-step estimation procedure by Engle-Granger (1987) to estimate the co-integration relationship between a set of variables, include the following:

- Lee (1993) also applies the two-step estimation procedure by Engle-Granger (1987) to estimate the co-integration relationship between total consumption and the disposable income on Japanese data covering the period of January 1961 to April 1987. The results show that total consumption and disposable income are integrated in the same order. Furthermore, the results reveal that both series are non-stationary with regular seasonality, which varies significantly over the period under study.
- Kanioura and Turner (2003) also apply the Engle-Granger (1987) procedure in order to test for the presence of a co-integrating vector between two nominal interest rates of the United Kingdom (UK) and the United States of America (USA). They use data from the International Monetary Fund (IMF) International Financial Statistics database covering the period of February 1977 to December 2002. After conducting the Engle-Granger co-integration test, they fail to reject the null hypothesis of no co-integration between the two series at the 5% level of significance, implying that the two variables are not co-integrated.
- Davids, Schroeder, Meyer, and Chisanga (2016) use the Engle Granger (1987) procedure in order to test for co-integration between a set of maize prices in Malawi, Mozambique, South Africa, Zambia and Zimbabwe. The study finds that 13 of the 18 pairs of the price series were co-integrated.

The results from the co-integration test determine whether to apply the Error Correction Model (ECM) or not. If the co-integration relationship exists between the two price series, ECM is applied in order to examine the short-run dynamics around the long run relationship. A number of studies have applied this model to analyse the extent of price transmission and some of them include the following:

- The study by Vavra and Goodwin (2005) applies ECM proposed by Goodwin and Holt (1999), Goodwin and Harper (2000) and Goodwin and Piggott (2001) to estimate the asymmetric price transmission between a set of commodities. The study uses monthly price data for U.S. farm, wholesale and retail markets for eggs, chicken and beef from USDA database, covering the period of January 1974 to December 2001. The study findings show significant asymmetric responses to negative and positive shocks regarding speed and extent of adjustment.

- Conforti (2004) also applies ECM in order to come up with empirical evidence of price transmission in a variety of agricultural markets. It uses monthly producer, wholesale and retail prices of basic food commodities from sixteen countries. The secondary price data was collected from FAOSTAT, covering the period of January 1969 to May 2001. The results of the study reveal that the extent of price transmission in African countries was lower than in Latin American and Asian countries. Davids, Schroeder, Meyer, and Chisanga (2016) estimate the short-run changes from the long-run relationships of the co-integrated price pairs using ECM. The findings of the study indicate that the degree of market shocks was associated with different rates of adjustment and the influence of these shocks originated from both directions, as shown by the error correction terms.
- Davids & Meyer (2017) apply an ECM to quantify the relationship between international poultry prices and the domestic chicken price in South Africa.

In this study, the short-run dynamics of the co-integrated price series are estimated using the Error Correction Model which is specified as follows:

$$\Delta \boldsymbol{Inp_t^{mws}} = \boldsymbol{\alpha_0} + \sum_i^n \boldsymbol{\beta_i}\, \Delta \boldsymbol{Inp_{t-i}^{Is}} + \sum_j^n \boldsymbol{\theta_j}\, \Delta \boldsymbol{Inp_{t-j}^{mws}} + \boldsymbol{\alpha_1 \bar{\mathcal{E}}_{t-1}} + \mu_t \quad (2)$$

Where:

p_t^{mws} is the soybean price in Malawi

p_t^{Is} is the international soybean price (South Africa and the USA)

Δ is the difference operator

$\boldsymbol{\bar{\mathcal{E}}_{t-1}}$ is the error correction term

μ_t is the error term

The error correction term co-efficient shows the short-run adjustment of prices to the long-run equilibrium (Conforti, 2004). The short-run changes among variables are evaluated when the co-efficient of the error correction term co-efficient is negative and significant. The negative co-efficient implies that the short-run dynamics will result in a stable long-run relationship as a result of external forces. The size of the co-efficient shows how long it could take for the system to get to its stable position.

4.3.3 Results

The first step in co-integration analysis involves determination of the appropriate number of lags for the analysis. A disproportionately large number of lags reduces the sample size, and this is not desirable because dealing with small samples might lead to misleading results. The appropriate number of lags were achieved after running a diagnostic test on the unrestricted Vector Auto Regressive (VAR) model.

Table 4.3: Summarised lag selection order results for soybean prices

Variables	Lags	LogL	LR	FPE	AIC	SC	HQ
$LMWSP_t$	2	94.257	17.514	0.0203	-1.0611	-1.0062*	-1.0389
$LSASP_t$	2	132.256	6.0347*	0.0130*	-1.5030*	-1.4481*	-1.4807*
$LUSAP_t$	2	531.658	41.605	5.2900*	-5.9379*	-5.5536	-5.7820*

*Notes: * denotes 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

Table 4.3 reports results of the diagnostic test which includes lag criteria such as LR, FPE, AIC, SC and HQ. The number of lags were selected based on the lowest value as indicated by the asterisk (*) in the model. VAR lag order selection criteria included 172 observations and 2 was selected to be the appropriated number of lags, as indicated by the selection criteria.

4.3.3.1 Co-integration test

The results of co-integration test are shown in Tables 5.2 and 5.3. The co-integration analysis aimed at testing the following:

H_0: No long term co-integration exists between variables
H_1: Long term co-integrating relationship exists between variables

Table 4.4: Results of Engle-Granger Cointegration Procedure for soybean prices

Dependent	Independent	Lag	β_1	Engle-Granger Procedure			Conclusion
				ADF	PP	KPSS	
Malawi	**South Africa**	2	0.4359***	-2.8824***	-3.9058***	0.7068	Cointegrated
South Africa	**Malawi**	2	0.5448***	-2.7104*	-3.1161**	2.5593	Cointegrated
Malawi	**USA**	2	0.5872***	-3.3531**	-4.8103***	0.4104***	Not cointegrated
USA	**Malawi**	2	0.7285***	-3.2720**	-3.5590***	2.2144	Cointegrated
South Africa	**USA**	2	0.9162***	-4.2040***	-5.9490***	0.8818	Cointegrated
USA	**South Africa**	2	0.9094***	-4.1453***	-5.4880***	0.7484	Cointegrated

*Notes: ***, ** and * denote statistical significance at 1%, 5% and 10% levels respectively*

Tables 4.4 presents results of Engle-Granger procedure for Malawi, South Africa and USA soybean price series. Results show that ADF and PP tests agree with KPSS tests in the five pairs of the price series, implying that the series in these pairs are co-integrated. However, there is a contradiction in the remaining one pair since KPSS tests indicate that the series are non-stationary, while ADF and PP tests indicate stationarity of the series. This leads to a conclusion that the series in this pair (Malawi-USA) is not co-integrated.

As indicated in Table 4.4, regression results in the four co-integrated series are consistent with expectations. The β_1 co-efficients in the co-integrated series have a positive sign which conforms to prior expectations for the impact direction. β_1 denotes the elasticity of the price transmission and it measures the long-run dynamics**.** The estimated parameters in the co-integrated series are directly interpreted as elasticities of price transmission from one country to another. Long term price transmission elasticities range between 0.44 and 0.92, with the highest elasticity related to US prices being transmitted to domestic markets in South Africa and the lowest associated with the transmission of South African prices into Malawi. A transmission elasticity of 0.44 implies that a 10% increase in South African prices will be accompanied by a 4.4% increase in Malawian soybean prices. All other elasticities in Table 4.4 can be interpreted the same way.

The conclusions drawn are statistical in nature, but factors such as trade volumes and relative market size suggest that market prices in Malawi for instance would not affect those in the USA. Its total crop of approximately 200 thousand tonnes is too small in the global context.

On the other hand, it was expected that Malawi can still have an effect on the SA market with some surplusses out of Malawi entering the region.

However, interpretation of the parameters should be handled with care since there is a possibility of such parameters being influenced by factors that allow the transmission of price signals (McNew, 1996; Barrett and Li, 2002; Brooks and Melyukhina, 2003). This can make the two integrated markets to have a low parameter. In view of these cautions, factors such as transactional costs, border effects, domestic policies, degree of product homogeneity and variations in exchange rates that affect price signals can be revealed by the price transmission parameters (Conforti, 2004).

After establishing a long-run relationship between pairs of co-integrated series, the analysis is expanded to examine the speed of adjustment to the long-run equilibrium, as quantified by the short-run impact of the estimated parameters of an ECM.

4.3.3.2 Error Correction Model (ECM) for Price transmission

The ECM approach takes into account the short term deviations from the potential long-run relationship between variables. It helps to determine the speed of adjustment to the long-run equilibrium and examines the short-run impact of the estimated parameters (Rapsomanikis, 2009). If the ECM co-efficient is negative as well as significant, it points to convergence, suggesting that any short run changes between variables will lead to stable relationship of the variables in the long run. The results of the ECM, as well as the Breusch-Godfrey test for serial correlation, are presented in Table 4.5.

Table 4.5: ECM results for price transmission (short-run equation)

Dependent	Independent	Lag	ECM Coeff.	Months of adjustment to equilibrium	LM Test		F-Stat
					Test Stat	P-value	Test Stat
Malawi	**South Africa**	0,2	-0.1901***	4	12.85320	0.4232	13.3473***
South Africa	**Malawi**	0,2	-0.0807**	9	3.562047	0.1685	7.1557***
USA	**Malawi**		-0.0425**	16	17.7637	0.2490	2.658476*
South Africa	**USA**	0,4	-0.3602***	2	6.4672	0.1669	33.8087***
USA	**South Africa**	0,2	-0.0954***	7	10.8980	0.2016	16.7951***

*Notes: ***, ** and * denote statistical significance at 1%, 5% and 10% levels respectively*
LM test is the test for serial correlation

As indicated by the Engle-Granger co-integration procedure earlier, five pairs of the series are found to be co-integrated and Table 4.5 shows ECM results for co-integrated series (long-run causality). The results indicate that the error correction terms for all the co-integrated series are negative at 5% level. The negative signs are in line with expectations. It is observed that the error correction term for each co-integrated price pair is less than unity (absolute value) which was also expected since the speed of adjustment is not expected to be 100 percent.

Table 4.5 also indicates that Breusch-Godfrey Serial Correlation LM test results are not significant at 10% level, implying that the null hypothesis of no serial correlation in the model is not rejected. Thus the model is accepted since there is no auto-correlation (serial correlation) and this means that the errors in the model are not misspecified. The model is also validated since the probability values for the F-statistics are significant at 10% level.

The error correction term means that if the change in price in one country is above its long run relationship with the other price, it gradually returns to the equilibrium. The co-efficient of the Malawi-South Africa price pair is highly significant, implying that price shocks of soybeans in South Africa would have an impact on prices in Malawi. Likewise, the co-efficient of the South Africa-USA price pair is highly significant, indicating that changes in the USA soybean prices would cause the prices in South Africa to change. This is because

South Africa imports about 37% of its oilcake (BFAP, 2018), which in turn influences the derived price of soybeans in South Africa. The Department of Agriculture, Forestry and Fisheries (2018) reports that South Africa imports about 28 thousand tonnes of soybeans from other countries in order to meet the local demand. Countries such as Malawi and Zambia from the SADC region also export soybeans to South Africa (Nzima and Dzanja, 2015). Malawian soybeans are also exported to other Southern African Development Community (SADC) countries such as Zimbabwe and Mozambique (Nzima and Dzanja, 2015).

It is however surprising to note that both error correction terms for South Africa-Malawi and USA-South Africa are also significant, indicating that price shocks in Malawi and South Africa would influence prices in South Africa and USA respectively. This is contrary to prior expectation given that Malawi and South Africa account for a very small share of the global market.

The rate of adjustment to the equilibrium takes an average of seven and half months in the all three countries. South Africa, at 2 months, is the fastest in responding to the USA soybean price changes (Table 4.5). Malawi is the second fastest since it takes about four months for soybean prices to respond to shocks in South African markets. USA soybean prices take about seven months to respond to South African market shocks. USA soybean prices take nearly nine months to respond to Malawian markets. Lastly USA is the slowest in responding to shocks in the Malawian markets. This makes sense given the smaller size of the Malawian market (approximately 200 000 tonnes), which was not expected to have an impact on the USA markets.

In Malawi, co-integration of soybean prices to other markets is not surprising, as good policy reforms are thought to have facilitated efficient movement of trade involving soybeans. For example, Malawi has adopted trade policy reforms regarding macro-economic and regional trade measures that facilitate exports. Reforms such as liberalisation of the exchange rate and reducing the number of days from 44 to 36, as well as the number of documents from 16 (2007) to 9 (2013), required to export a product (Aberman and Edelman, 2014). Malawi is also implementing trade measures that enhance competition among smaller traders and cross-border exports such as COMESA's Simplified Trade Regime (STR). The STR exempts cross-border traders from import duties when exporting a consignment valued at no more than 1000 USD (Aberman and Edelman, 2014).

Results from Table 4.5 are in line with prior expectations and consistent with the findings made by Kornher and Kalkuhl (2013), who concluded that international price volatility was highly significant in influencing the domestic prices. The results also agree with findings by Minot (2011) in which he observed some significant price transmission from international markets to the Africa markets.

4.3.3.3 Diagnostic test of the model

Diagnostic tests were conducted in order to establish the validity of the results from the analysis. The tests conducted included serial correlation, heteroscedasticity and residual normality. The results of the two residual diagnostic tests are reported in Table 4.6.

Table 4.6: Diagnostic tests

Dependent	Independent	Lag	LM Test	ARCH Test
Malawi	**South Africa**	2	0.8029 (0.4232)	0.4037(0.6869)
South Africa	**Malawi**	4	0.6077(0.5442)	-1.0304 (0.3043)
South Africa	**USA**	2	1.2820(0.2016)	-0.7778 (0.4378)
USA	**South Africa**	1	-1.2042(0.2302)	0.7764 (0.4386)

Notes: The number in ( ) indicates the probability value

Table 4.6 shows that Breusch-Godfrey Serial Correlation LM test results are not significant at 10% level, meaning that the null hypothesis of no serial correlation in the model is not rejected. Therefore the model is accepted since there is no auto-correlation (serial correlation) and consequently no model misspecification of errors.

The probability values for Auto Regressive Conditional Heteroscedasticity (ARCH) test are also not significant at10% level as indicated by results in Table 4.6. This implies that the null hypothesis of no heteroscedasticity (ARCH effect) is not rejected suggesting that there was no heteroscedasticity in the model, which was desirable.

4.4 Conclusion

This chapter evaluated the extent to which domestic price volatility in Malawi can be attributed to volatility in international and regional markets. It highlighted long-run co-integration between soybean prices in South Africa and Malawi as well as South Africa and USA, which is in line with prior expectations, given that trade occurs between the countries.

Results suggest that volatility in South Africa is a contributing factor to soybean price volatility in Malawi, but the transmission elasticity was found to be less than 0.5 and Minot (2011) reports that Malawian food prices have increased more than world prices over the past few years, suggesting that domestic factors have also influenced price volatility. The prices of agricultural commodities rose rapidly in Malawi between 2005 and 2006, peaking early 2006 (Minot, 2010). In the case of soybean, the prices sharply increased in 1993, 1996 and 2012 as indicated in Figure 1.1 in Chapter one. Macro-economic factors can also contribute to volatility in domestic markets, with international studies identifying factors such as interest rates, exchange rates and money supply as possible influences on price volatility in the domestic markets. Domestic supply and demand of agricultural commodities also tend to affect prices.

CHAPTER 5: EFFECT OF MACRO-ECONOMIC FACTORS ON VOLATILITY IN MALAWIAN SOYBEAN PRICE

5.1 Introduction

This chapter continues the empirical assessment of possible causes of soybean price volatility in Malawi. It builds on the analysis of international impact conducted in Chapter 4 by considering the influence of macro-economic factors in soybean price volatility in Malawi. To do so, it considers literature related to international studies on the effect of macro-economic factors on volatility in agricultural commodity markets, before presenting some methodological considerations and results of the empirical analysis pertaining to Malawi.

5.2 Domestic factors influencing price volatility in agricultural markets

Multiple factors in domestic markets can influence the volatility of agricultural commodity prices. These include macro-economic considerations, as well as domestic supply and demand conditions of the relevant, as well as competing commodities.

5.2.1 Macro-economic factors

Donmez and Magrini (2013) examine the macro-economic determinants of volatility in agricultural prices by using the GARCH -MIDAS model of Engle, Ghysels, and Sohn (2013). Their study focuses on the volatility of the cereal market prices in the world, particularly for wheat, corn and soybeans, covering the period 1982 to 2012. They note that supply and demand factors are able to explain price volatility with a low frequency. They found that reductions in inventory greatly worsen price volatility in wheat markets while increased lobal economic activity and weather effects influence price volatility in maize and soybean markets. They also found that monetary factors such as interest rate and exchange rate are essential in explaining price volatility in all three markets (wheat, maize and soybeans).

The study by Elzen (2014) also uses a GARCH-MIDAS approach, which was proposed by Engel et al. (2013), to analyse the main drivers of commodity price volatility, using daily prices and monthly macro-economic variables. The study targets commodities such as wheat, soybeans, gold, silver and crude oil across the world from 2006 to 2009. These commodities are selected based on the degree of trading. It observes that the global economic cycle, interest rates and yield are some of the main determinants of price volatility in the sampled commodities. However, the study did not find evidence that speculative activity caused commodity price volatility during the last decades.

5.2.2 Domestic supply and demand of agricultural commodities

Demand for food, especially staples in low income countries, is inelastic, implying little change in demand when prices increase (PDPE, 2007). Prices are regarded as one of the factors that are critical in making production and consumption decisions since changes in price levels affect profits and food costs for the producers and consumers respectively (Diaz-Bonilla, 2016). Diaz-Bonilla (2016) observes that high and low prices may cause adjustments in supply and demand under normal market operations and when producers and consumers are able to get indications of price changes.

While consumers respond to changing prices, inelastic demand for agricultural commodities implies that substantial price movements are required to generate the required reduction in domestic demand when supply is under pressure. Whilst high prices stimulate supply, short term supply reductions are often attributed to factors such as changing weather conditions floods or drought (Tadesse, Algieri, Kalkuhl, and von Braun, 2013; Wright, 2014; Brümmer, Korn, Schlubler, and Jaghdani, 2015) which are not influenced by producer decisions. The response to high prices can however induce a supply response in the following year, leading to sharp reductions in prices, again increasing volatility. Apart from weather related yield shocks, numerous researchers also note that agricultural commodity prices may be influenced by spill-over effects of other commodity prices (Fisher, Hanemann, Roberts and Schlenker, 2012; Baffes and Dennis, 2013; Brummer et al., 2015).

5.3 Empirical analysis of the impact of macro-economic factors on soybean price volatility in Malawi

The empirical analysis of this section uses the secondary data of monthly soybean prices, consumer price index, and exchange rates for Malawi. The study also includes the monthly soybean prices for South Africa since, as is shown in Chapter 4, it is co-integrated with Malawi soybean prices. The data spans the period of April 2002 to November 2016. Table

5.1 shows definitions of variables, data source, data frequency, units of the variables and the period from which the data was extracted.

Table 5.1: Data definitions

Title	Series ID	Source	Frequency	Units	Range Date
Malawi Soybean prices	$MWSP_t$	MoAIWD	Monthly	MWK/ton	2002-2016
South Africa soybean prices	$SASP_t$	SAGIS	Monthly	USD/ton	2002-2016
Malawi Exchange Rates	$MWER_t$	RBM	Monthly	LCU/USD	2002-2016
Consumer Price Index (CPI)	$MWCPI_t$	RBM	Monthly	Index	2002-2006

Notes: MWK stands for Malawi Kwacha

As is indicated in Table 5.1 , the unit for Malawi soybean prices is kwacha per tonne, unlike in the previous analysis of price transmission which was US dallars per tonne. Leaving Malawi soybean prices in US dollars per tonne would compromise the impact of exchange rates on the prices. Therefore the exchange rate would give a clear picture of its impact when the prices of soybeans in Malawi are defined in the local currency. However, the units of the other variables remain same as in the previous chapters.

5.3.1 Data Analysis

Both descriptive and econometric analyses are used to examine patterns and trends in consumer price index and exchange rates for Malawi during the 2002-2016 period. For Malawian and South Africa soybean prices, descriptive analysis was already done in Chapter 3. Series of unit root tests (formal and informal) have also been conducted before proceeding with econometrics analysis in order to check for stationarity.

Time series for exchange rates and consumer price index for Malawi during the 2002-2016 period are presented graphically in order to visually determine certain sequences that are not stationary. However, this is complemented by formal unit root tests in order to triangulate graph results. The study also conducts a co-integration test in order to check the existence of a long-run relationship between soybean prices and series of consumer price index and exchange rates.

This analysis of the determinants of soybean price volatility uses the Johansen test of co-integration (Johansen, 1988). The Johansen method does not depend on the OLS estimation, instead it directly uses the Maximum Likelihood estimation to form co-integrated variables. In this analysis, the method is employed to examine the effects of South Africa soybean prices and the two macro-economic factors (exchange rates and consumer price index) on soybean price volatility in Malawi from 2002 to 2016. This method is appropriate for the analysis because the nature of the set of data employed is multivariate, which possibly could have more than one co-integrating relationship. Thus, if more co-integrating relationships exist, the Johansen procedure can easily identify them.

The Johansen procedure depends on the ranked matrix and random walk characteristics. In testing for co-integration, basically two methods are performed which include Trace statistics and Maximum eigenvalue statistics. Whilst many econometric analyses focus Trace statistics, this analysis uses both methods to test the null hypothesis - that there are *r* or fewer co-integration relationships against the alternative hypothesis - that there are more co-integration relationships.

For the co-integrated parameters, a vector correction model (VECM) is applied to examine the short-run impacts in the form of speed of adjustment to the long-run equilibrium. However, the short-run dynamics can be evaluated when the co-efficient of the VECM is negative and significant implying that short-run adjustment will result in a stable long-run relationship. The VECM is specified as follows:

$$\Delta Y_t = \boldsymbol{\beta}_0 + \sum_{i=1}^{n} \boldsymbol{\beta_i} \Delta Y_{t-i} + \sum_{i=1}^{n} \boldsymbol{\delta}_i \Delta X_{t-i} + \boldsymbol{\varphi Z_{t-1}} + \mu_{\mathbf{t}} \quad (3)$$

-where X is the vector of macroeconomic factors, Y_t is the natural logarithm of the price of soybeans (USD per tonne) on the local market, Δ is the difference operator, $\boldsymbol{\beta_0}$, is constant, $\boldsymbol{\beta_I}$, δ_i and φ co-efficients, Z is the error correction term and μ_t is the error term.

5.4 Results

5.4.1 Descriptive statistics for the macro-economic variables

Table 5.2 shows that monthly average values for exchange rates and consumer price index were approximately 237.22 MK per USD and 83.42 respectively. Malawian currency had depreciated from 76.20 MK per USD in April 2002 to 751.50 MK per USD in October 2016 which indicates a huge loss in value for the local currency. This is said to have been caused by a number of factors such as weather shocks, increased instability in major macro-economic variables, and a decline in business confidence (World Bank, 2015). Consumer price index monthly values ranged from 22.38 to 268.98, suggesting high fluctuation in consumer prices during the period of 2002-2016. Instability in the selected macro-economic variables was perceived to have been caused by parastatal losses, uncontrolled spending on emergency relief items, poor regulatory mechanisms on spending and mismanagement of donor aid (Conticini, 2004).

Table 5.2: Summary statistics for macroeconomic variables (2002-2016)

	$MWER_t$(MWK/US Dollar)	$MWCPI_t$
Mean	237.2163	83.42264
Median	141.3100	58.18815
Maximum	751.4955	268.9835
Minimum	76.20000	22.37851
Std. Dev.	179.7139	65.60034
Skewness	1.437202	1.414542
Kurtosis	3.962055	3.914322
Jarque-Bera	64.69709	61.24778
Probability	0.000000	0.000000
Observations	172	172

5.4.2 Graphical Analysis of the macro-economic variables

After analysing the data using descriptive statistics, the study conducts a graphical analysis of Malawi exchange rates and consumer price index as presented below:

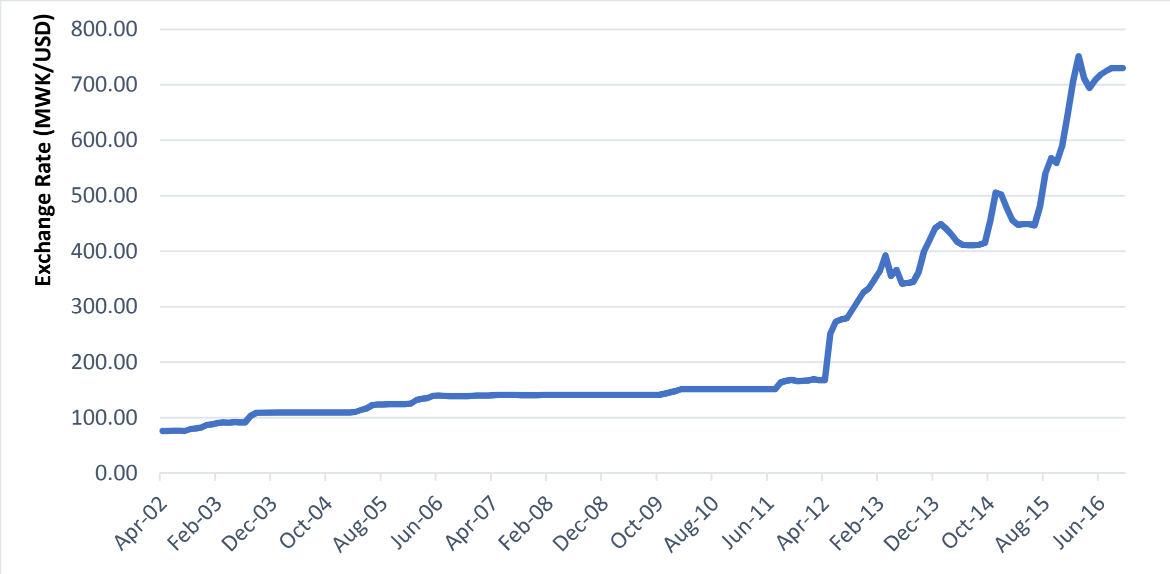

Figure 5. 1: Malawi exchange rates

Source: Compiled from Reserve Bank of Malawi data

Figure 5.1 shows that the monthly exchange rates in Malawi experienced high variability from 2012 to 2016. The instability of the exchange rate during this period was due to the adoption of economic reforms by the Malawian government in May 2012. One of the economic reforms was the exchange rate adjustment in which the government immediately removed restrictions on the foreign currency bureau market. The exchange rate adjustment also included the devaluation of the Malawi Kwacha against the United States dollar (USD) and other foreign currencies. The government adopted a flexible exchange rate regime in which the Malawi Kwacha was allowed to float freely against major trading currencies (Malawi Government, 2012). Before 2012, the Government of Malawi used to manage the Kwacha by allowing it to remain at the same exchange rate against foreign currencies for some time.

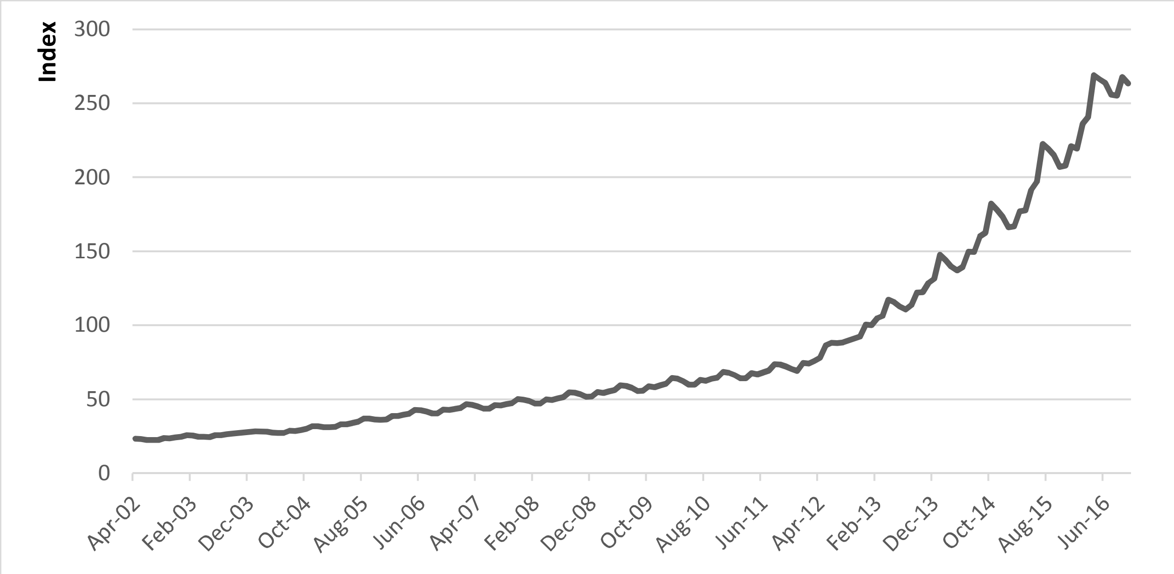

Figure 5.2: Malawi consumer price index

Source: Compiled from Reserve Bank of Malawi data

During the entire period of the study, consumer price index kept on increasing, as shown in Figure 5.2. A sharp increase in the consumer price index (CPI), especially from the middle of 2012, was due to a high increase in the inflation rate as a result of the devaluation of the Malawi Kwacha by almost 50 percent in May 2012 during the President Joyce Banda era (Jombo, Simwaka and Chiumia, 2014). The World Bank (2012) observed that the instability in the inflation rate was also due to weather shocks, increased instability in major macro-economic variables, and a decline in business confidence

5.4.3 Unit root test results

Unit root tests were also conducted on Malawian soybean prices, South African soybean prices, exchange rates and consumer price index using ADF, PP and KPSS methods at level and first differenced. ADF and PP tests were performed in order to test the following hypothesis:

$\mathbf{H_0}$: The series are non-stationary.
$\mathbf{H_1}$: The series are stationary.

KPSS procedure aimed at testing the following hypothesis:
$\mathbf{H_0}$: The variables are stationary

H_1: The variables are non-stationary

Results of level and first differenced unit root tests are reported in Tables 5.3 and 5.4 below.

Table 5.3: ADF, PP and KPSS Level Test Results

Variable	**Model**	**ADF**		**PP**		**KPSS**	
		Lags	**ADF**	**Brand Width**	**PP**	**Brand Width**	**KPSS**
$MWSP_t$	Trend & intercept	2	-2.3008	2	-2.4030	2	0.9351***
	Intercept	2	0.0704	2	0.0375	2	5.1069***
	None	2	1.4834	2	1.4479		
$SASP_t$	Trend & intercept	2	-2.8946	2	-2.3681	2	0.5439***
	Intercept	2	-2.4948	2	-2.2330	2	3.3762***
	None	2	-0.4473	2	-0.2777		
$MWER_t$	Trend & intercept	2	-0.0680	2	-0.0411	2	1.2029***
	Intercept	2	1.9834	2	2.1731	2	4.3675***
	None	2	3.2241***	2	3.6402***		
$MWCPI_t$	Trend & intercept	2	-2.7459	2	-2.4354	2	0.6556***
	Intercept	2	-2.7579*	2	-2.4582	2	1.1002***
	None	2	-0.6537	2	-0.5758		

*Notes: *** and * statistically significant at 1% and 10% levels*

Table 5.4: First Differenced ADF, PP and KPSS Test Results

Variable	Model	ADF		PP		KPSS	
		Lags	ADF	Brand Width	PP	Brand Width	KPSS
$\Delta MWSP_t$	Trend & intercept	2	-8.1147***	2	-12.2267***	2	0.0179
	Intercept	2	-8.0284***	2	-12.1874***	2	0.1299
	None	2	-7.7556***	2	-12.0194***		
$\Delta SASP_t$	Trend & intercept	2	-7.0148***	2	-10.3624***	2	0.0334
	Intercept	2	-7.0071***	2	-10.3559***	2	0.0879
	None	2	-7.0205***	2	-10.3742***		
$\Delta MWER_t$	Trend & intercept	2	-10.1168***	2	-10.0111***	2	0.0935
	Intercept	2	-10.0607***	2	-9.9894***	2	0.2700
	None	2	-9.4007***	2	-9.3743***		
$\Delta MWCPI$	Trend & intercept	2	-2.7556***	2	-13.5705***	2	0.0911
	Intercept	2	-1.8127***	2	-12.8732***	2	0.3942
	None	2	-0.3627***	2	-11.1276***		

Notes: Δ denotes the first differenced operator

**** statistically significant at 1% levels*

Almost all level results from Table 5.3 show that ADF and PP test statistics for soybean prices (Malawi and South Africa), exchange rates and consumer price index (CPI) are not significant at 10% level. Thus the null hypothesis that the variables in question are non-stationary is not rejected. KPSS level results also show that the variables are non-stationary at level. This conclusion is reached because the KPSS test statistics results shown in Table 5.3 are highly significant (at 1% level), which leads to the rejection of the null hypothesis of stationarity.

First differenced results presented in Table 5.4 show that both ADF and PP test statistics are highly significant, while for the KPSS test, statistics are not significant at 10% level. This means that null hypothesis for ADF and PP tests, that the variables have a unit root, is rejected while that of stationarity by KPSS test is not rejected.

5.4.4 Johansen Co-integration test for macro-economic variables

Table 5.5: Johansen co-integration Trace test results

Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Trace statistic**	**5% critical value**	**P- value****	**Hypothesised no. of co-integration equations**
r = 0	**r = 1**	0.1900	62.9207	47.8561	0.0011	None *
r ≤ 1	**r = 2**	0.0820	27.0948	29.7971	0.0993	At most 1
r ≤ 2	**r = 3**	0.0711	12.5526	15.4947	0.1323	At most 2
r ≤ 3	**r = 4**	0.0001	0.0190	3.8417	0.8903	At most 3

*Notes: * denotes rejection of the null hypothesis at the 5% level*

*** denotes MacKinnon-Haug-Michelis (1999) p-values*

Table 5.6: Johansen co-integration Max-eigenvalue test results

Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Trace statistics**	**5% critical value**	**P- value****	**Hypothesised no of co-integrating equations**
r = 0	**r = 1**	0.1900	35.8259	27.5843	0.0035	None *
r ≤ 1	**r = 2**	0.0820	14.5422	21.1316	0.3223	At most 1
r ≤ 2	**r = 3**	0.0711	12.5336	14.2646	0.0922	At most 2
r ≤ 3	**r = 4**	0.0001	0.0190	3.8415	0.8903	At most 3

*Notes: * denotes rejection of the hypothesis at the 5% level*

*** denotes MacKinnon-Haug-Michelis (1999) p-values*

Both Tables 5.5 and 5.6 show results of co-integration test conducted on Malawian soybean prices and the three explanatory variables (South African soybean prices, exhange rates and consumer price index). It is observed from the tables that both trace test and eigenvalue statistics indicate that one co-integrating equation exists among the variables.

5.4.5 Estimating causes of soybean price volatility in Malawi

Having conducted the Johansen co-integration test, the study applied a vector error correction model (VECM) since the variables are co-integrated. VECM rsults are presented in Table 5.7.

Table 5.7: VECM results for factors affecting soybean price volatility

Explanatory variable	Coefficient	Std. Error	t-Statistic
Error Correction Term	-0.2089	0.0514	-4.0661***
ΔMWSP(-1)	0.0652	0.0808	0.8065
ΔSASP(-1)	-47.9267	41.9041	-1.1437*
ΔMWER(-1)	230.7290	89.0688	2.5905**
ΔMWCPI(-1)	36.3480	47.0246	0.7730
Constant	1310.665	1192.653	1.0990

*Notes: ***, ** and * denote significance at 1 %, 5% and 10% levels*

Δ denotes the first differenced operator, the number in brackets (-) indicates number of lags

The estimation period (n) = 172 (April, 2002-October, 2016), R^2: 0.1842, S.E of regression: 14813.13, Sum squared residue: 3.55E+10, Log likelihood: -1890.669, F-statistic: 4.0639 and Prob. (F-statistic): 0.0001

Results from Table 5.7 show that the error correction co-efficient was -0.2089 and this measures the speed of adjustment of soybean prices towards the long-run equilibrium, after experiencing deviations. The error correction co-efficient is negative and highly significant which is in line with theory. Since the probability value for the error correction term is significant at one percent level, the null hypothesis of no long-run relationship is rejected. It is worthy to note that the error correction co-efficient is less than one in absolute terms, which was also expected since 100 percent adjustment is not feasible. The negative sign for the error correction co-efficient means that the system will gradually return to equilibrium following an exogenous shock. The speed of adjustment in absolute term between soybean prices and the explanatory variables analysed is approximately twenty percent, thus the adjustment would take approximately 5 months.

As shown in Table 5.7, the model has an F-statistic of 6.174303 which tests the hypothesis that all the co-efficients are jointly equal to zero. The probability of the F-statistic is 0.0001, indicating that the estimated long-run model is highly significant.

The study conducted the Wald test in order to examine the short-run effect of each independent variable on Malawian soybean prices during the period 2002 to 2016. The Wald test gives the joint F-statistics for the each lagged independent variable in its first differenced form. The following hypothesis for each explanatory variable is tested:

H_0: There is no short-run effect between dependent variable and the independent variables
H_1: There is short-run effect between dependent variable and the independent variables

The dependent variable is the Malawian soybean prices while the independent variables are South African soybean prices, Malawi exchange rate and consumer price index. The results of the Wald test are presented in Table 5.12.

Table 5.8: Wald test results

Variable	F-statistic	Degree of freedom	Probability value
ΔSAP(-1)	2.6685	(2, 162)	0.0724*
ΔMWER(-1)	3.6358	(2, 162)	0.0285**
ΔMWCPI(-1)	0.5713	(2, 162)	0.5659

*Notes: * denotes significant at 10%*
Δ denotes the first differenced operator
the number in brackets (-) indicates number of lags

The Wald test results in Table 5.8 show that the probability values for F-statistics of the South African soybean prices and exchange rate are significant at 10 % and 5% levels respectively. Therefore the null hypothesis of no causality effect in a short-run is rejected. This suggests that in a short-run, South African soybean prices and exchange rate have an impact on the changes in Malawi soybean prices.

In the VECM results presented in Table 5.7, the co-efficients on South African soybean prices and exchange rate are -47.93 and 230.73 respectively. This implies that a one percent increase in soybean prices in South Africa will cause prices of soybeans in Malawi to decrease by approximately 48 percent, holding other factors constant. A one percent increase in the exchange rate will cause prices of soybeans in Malawi to increase by over two hundred percent, ceteris paribus.

The probability value for joint F-statistic of the two lagged of the consumer price index is not significant at 10% level, as indicated in Table 5.8. Therefore the null hypothesis of no causality effect in a short-run is not rejected. This suggests that consumer price index is not significant in explaining the short-run effects on the changes of soybean prices in Malawi.

Table 5.9: Diagnostic tests

Test	LM Test	ARCH Test	Jarque-Bera Test
Chi-square	18.8146 (0.3203)	51.1882 (0.2715)	11.9080 (0.002596***)

Notes: the number in brackets indicates probability value
**** denote statistically significant at 1% level*

After estimating the model, diagnostic tests are conducted in order to examine the validity of results. Table 5.9 shows that LM test of 18.8146 is not significant, implying that the null hypothesis of no serial correlation was not rejected. This means that the residuals in the model are not serially corrected, which is a good thing. The Autoregressive Conditional Heteroscedasticity (ARCH) Test is 51.1882 and also not significant. As such the null hypothesis of no heteroscedasticity (ARCH effect) is not rejected. This means that there is no heteroscedasticity in model which is also desirable.

However, Table 5.9 shows the Jarque-Bera Test of 11.9080 and it was highly significant. This means that the null hypothesis, that the residuals are normally distributed, is rejected. It is therefore concluded that residuals are not normally distributed in the model, which is not desirable. However, overall the model could be accepted since the residues are not serially correlated and there is no heteroscedasticity in the model.

5.5 Conclusion

This chapter evaluated the extent to which soybean price volatility can be attributed to volatility in selected macro-economic variables. Co-integration analysis indicated a long-run relationship between Malawian soybean prices and the explanatory variables (South African soybean prices, exchange rates and consumer price index) in Malawi. Therefore, it can be concluded that, in a long run, South Africa soybean prices, exchange rates and consumer price index affected soybean prices in Malawi during the period of 2002-2016, as indicated by the error correction model results. However, the Wald test results indicate that in a short run, South African soybean prices and exchange rate have an effect on Malawian soybean prices. On the hand, consumer price index does not have a short run impact on soybean prices in Malawi.

CHAPTER 6: SUMMARY AND RECOMMENDATIONS

6.1 Introduction

This chapter gives a summary of the study before drawing some conclusions. It also makes recommendations that could act as benchmarks for the policy makers to come up with good interventions in addressing some of the bottlenecks affecting the soybean industry in Malawi.

6.2 Summary of the study

The study primarily aims at analysing the main determinants of soybean price volatility. Food price volatility has triggered the interests of many researchers because it is so problematic for low-income smallholder farmers, typically found in developing countries and particularly prominent in Africa. Soybean prices in Malawi are noted as volatile. This causes a big concern since soybean is regarded as one of the value chains that promotes better nutrition in Malawi as most diets are dominated by maize, which contributes to malnutrition .

Surprisingly, no study has been conducted to establish the causes of soybean price volatility in Malawi. This was discovered after an extensive literature review which did not yield investigations related to the causes of such volatility. It is noted that soybean is one of the most important oilseed crops in Malawi and is promising to become a major export crop and offers good export prospects to neighbouring countries in Southern Africa.

The study reviewed the evolution of the soybean market and value chain. It observes that soybeans are globally produced and form part of the major oilseed crops, contributing about 54% of the world's total oilseed production. The study also revealed that the major producers of soybeans in the world include the USA, Argentina and Brazil, contributing about 81% of the world total production. China is the largest consuming country of soybeans, followed by the USA and Europe, representing about 61% of the world soybean meal demand and 56% of the soybean oil demand. Soybean markets are well established and soybean products, such as soybean oil and soybean meal, are traded in almost every country in the world.

The study noticed that there is very low production of soybeans in the Southern African region, less than one percent of the world total production, yet the conditions for growing soybeans are favourable in this region. Major producing countries of soybean in Southern

Africa include South Africa, Zambia, Malawi, Zimbabwe, DRC and Mozambique. South Africa has the largest market for soybeans in the Southern African region and it has a demand for soybean oil, soybean cake, as well as soybean products for human consumption. In Malawi, soybeans are produced by 95% of the smallholder farmers and the majority of these smallholder farmers sell their soybeans to traders.

The study reviewed literature related to agricultural commodity price volatility, models used to estimate price volatility, drivers of agricultural commodity price volatility and market integration as well as price transmission. A review of soybean price determination in Malawi was also considered. Numerous studies reveal that Agricultural commodity prices have been volatile worldwide for the past three decades. GARH models have been commonly used to estimate price volatility since they are able to express conditional variance as a linear function and include lagged conditional variances. Studies conducted in Malawi have confirmed that maize prices have been volatile for the past three decades. However, no study has attempted to estimate the soybean price volatility and its determinants.

The review of literature revealed that the analysis of market integration exposes the problems of information asymmetry and trade barriers in different markets. It was revealed by some studies that changes in the world prices have an impact on the domestic prices. But there was little evidence to substantiate the fact that agricultural commodity prices in Malawi are affected by the world agricultural commodity prices. Prices in Malawi are set by the government but there are no effective mechanisms to implement the minimum prices.

The study empirically estimated soybean price volatility using GARCH (1,1) model and the results indicate that the lagged squared residual and the lagged conditional variance had an effect on the conditional variance. GARCH terms are significant, indicating some volatility clustering in monthly returns of soybeans in Malawi, South Africa and the USA.

The Engle-Granger procedure was employed to estimate long-run co-integration between soybean prices in Malawi, South Africa and the world. The prices were categorised into six pairs and testing the long-run co-integration between these pairs involve both direction. Five out of the six pairs of prices exhibit long-run co-integration relationships, as indicated by β_1 co-efficients in the co-integrated series.

An Error correction model (ECM) was also employed to estimate the short-run dynamics on the long-run relationships in the four co-integrated prices. South Africa was the fastest in responding to the USA price changes, that is within two months. Malawi is the second fastest since it takes about four months for soybean prices to respond to shocks in South African markets. However, it takes about seven months for the USA soybean prices to respond to price shocks in the South African markets, which is longer than the period that Malawi takes to respond. South Africa takes nine months to respond to the shocks that occur in the Malawian markets. USA is the slowest in terms of the speed of adjustment since it takes about sixteen months to respond to the Malawian market shocks.

After observing literature and the empirical results from the GARCH model, that soybean prices in Malawi have been volatile for the past three decades, the study conducted an analysis on the determinants of soybean price volatility. Johansen's co-integration test was employed to test for co-integration between Malawian soybean prices and the three explanatory variables (South African soybean prices, exchange rates and consumer price index). Eigenvalue statistics for the co-integration test indicated the existence of at least two co-integrating equations among the variables in question.

Lastly, the study employed a vector error correction model (VECM) to evaluate the long-run and short-run relationships between the co-integrated series. The error correction co-efficient of 0.2089 is negative and highly significant which is in line with prior expectations. The Wald test results showed that the probability values of the joint F-statistics for South Africa soybean prices and Malawi exchange rate are significant at 10% and 5% levels respectively. Based on the significance of both the error correction term and the joint F-statistics of the two lagged variables in the Wald test results, the study concludes that South Africa soybean prices and Malawi exchange rate are significant drivers of volatility in Malawi soybean prices.

In conclusion, the study confirms that soybean prices in Malawi have been more volatile relative to South Africa and USA during the 2002-2016 period. During this period, it is observed that changes from South Africa soybean prices are transmitted to soybean prices in Malawi. Therefore, the study concludes that when South Africa soybean prices experience some changes, Malawi soybean prices are affected by the changes. The study also concludes

that soybean prices in South Africa are affected by changes in the prices of soybeans in the USA, which represents the world.
Regarding the determinants of soybean price volatility, South Africa prices (representing regional prices) and exchange rates are significant drivers of the soybean price volatility in Malawi. Lastly, the study did not find any evidence of impact of consumer price index on soybean prices in Malawi.

Given that prices in South Africa, combined with exchange rate fluctuations were found to be the major drivers of volatility in the soybean market, policies aimed at reducing volatility should be focused on the efficiency of trade, as well as stability in the macro-economic environment which influences exchange rate fluctuations. In order to aid producers and consumers in dealing with the inherent volatility of this market, both government and private sector alike would do well to consider a range of effective, market based risk management alternatives. Improving access of small scale producers to such alternatives will reduce the risk they face as a result of an inherently volatile market.

6.3 Recommendations

The study makes the following recommendations for the policy makers:

- Implementation of good strategies in order to improve access to market information among the soybean players in Malawi. This could possibly minimise uncertainties and enhance better decisions by the producers, consumers and traders. Possibilities include investment in information and communication technology that will improve access to market information. This will enhance knowledge sharing between farmers and traders, pertaining to product quality, volume and pricing.

- Promote market based programmes such as certification, contract farming and market analysis which facilitate market access. Strategies that will improve business development and enhance value chain investment will also enable improved market access.

- The government should encourage soybean smallholder farmers to form associations so that they increase the bargaining power for the farm gate prices. It should also improve the linkage between the smallholder farmers and commodity markets

- Improvements to the delivery of extension services has the ability to boost soybean production. This will increase supply of soybeans domestically, thereby stabilising soybean prices.

6.4 Suggestions for further research

More research is required to analyse the causes of soybean price volatility in Malawi using other models such as GARCH-MIDAS. In addition, more factors should be included when examining the causes of soybean price volatility.

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