RICE MARKET INTEGRATION AND PRICE TRANSMISSION IN BURUNDI

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DECLARATION

Declaration by the candidate

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DEDICATION

This thesis is dedicated to:

- my father: Simon
- my mother: Marie
- my brothers and sisters: Didace, Oswald, Chrisostome, Pelagie, Renilde, Patricie and Caritas.
- my husband: Sylvain

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ABSTRACT

Rice is economically important food security crop. It constitutes an essential food for the majority of the population in Burundi. It ranks third cereal produce behind maize and sorghum. Burundi's rice price realized an increase of almost 60 % from 2000 to 2013 while production and imports increased by 80% and 300%, respectively. The 2007-2008 world financial crisis, which resulted in food price increase, had a huge impact on rice price in Burundi. The price of rice continues to increase yet the purchasing power of the Burundians has remained low. In an effort to better understand pricing behavior in the food industry it is necessary to investigate the nature of price transmission in local markets of Burundi. The analysis of spatial price transmission allows one to better understand the overall functioning of the markets. The extent and speed with which shocks are transmitted between different levels of the marketing chain and spatial separate markets can have important implications for pricing practices and may reflect the level of competition in the market. The aim of this study was three fold: to analyse short-run and long-run spatial rice retail price relationships between spatial separated markets; to examine the nature of price transmission between retail spatial separate rice markets; and to estimate the extent of world price transmission to Burundi market. Four domestic rice markets namely Bujumbura, Muyinga, Gitega and Ruyigi, as well as world prices were considered in the study. The methodological framework used in this research was based on the law of one price (LOP). Augmented Dickey Fuller (ADF) and Phillips Perron (PP) unit root tests were used for testing the variables for the presence of unit roots. Two types of adjustment models, namely threshold autoregressive (TAR) and momentum threshold autoregressive (M-TAR) models were used to investigate price transmission in spatial separate markets. Monthly retail price of rice were collected from June 2001 to August 2015. Such secondary data came from various sources such as National Institute of Economic Statistics of Burundi (ISTEEBU), FAO and World Bank. The research findings indicated that there was short and long run relationship between domestic markets. Price transmission between domestic market pairs was asymmetric, in the sense that negative shocks were eliminated faster than positive shocks. It was found that world price was cointegrated with Burundi price with asymmetric adjustment but unlike domestic markets, Burundi price respond more swiftly to price decrease than to price increase in world price. The study recommends that the government of Burundi should improve the flow of information by putting into place a rice marketing board and reduce the asymmetric information in local rice markets.

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LIST OF ABBREVIATIONS AND ACRONYMS

ADF	Augmented Dickey Fuller
AIC	Akaike Information Criterion
APT	Asymmetric Price Transmission
ARIMA	Autoregressive Integrated Moving Average
BIF	Burundi International Franc
BRB	Central Bank of Republic of Burundi
DRC	Democratic Republic of Congo
EAC	East Africa Community
ECM	Error Correction Model
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistics
GDP	Gross Domestic Product
GoB	Government of Burundi
HQIC	Hannan and Quin Information Criterion
IDEC	International Data Evaluation Center
ISTEEBU	National Institute of Economic statistics of Burundi
Kgs	Kilograms
LOP	Law of One Price
M-TAR	Momentum Threshold Autoregressive
OLS	Ordinary Least Squares
SBIC	Schwarz Bayesian Information Criterion
SRDI	Société Rizicole de Développement de l'Imbo
TAR	Threshold Autoregressive
TIC	Threshold cointegration
USAID	United States Agency International Development
VECM	Vector Error Correction Model

DEFINITION OF TERMS

Market integration: is a situation in which separate markets for the same product become one single market. It is an indicator that explains how much different markets are related to each other. Integrated markets may be defined as locations connected by trade and exhibiting high price correlations (Harriss, 1979 in Chepng'eno, 2015).

Spatial price relationships: relate to the price linkage across spatially distinct markets where arbitrage depends on whether the price difference is less than, equal to or greater than the transaction costs.

Symmetric price transmission: price transmitted at the same rate. This implies that a shock to producer prices of a given magnitude would elicit the same response in retail prices regardless of whether the shocks reflected a price increase or a price decrease. Asymmetry: Lack of symmetry.

CHAPTER ONE

INTRODUCTION

1.0 Introduction

This section of the study deals with the background of the study, statement of the problem, objectives of the study, research hypotheses, justification of the study and scope of the study.

1.1 Background of the Study

A key premise of several arguments in economics is that markets allow for price signals to be transmitted both spatially and vertically (FAO, 2004). Economists have always had an interest in relationships between prices, even though theory in general argues that other variables (product attributes) are equally important in describing and explaining market equilibrium (Asche *et al.,* 2011). Analysis of relationships between prices is a common tool in market integration analysis. Existence of a proportional price relationship between spatial markets results from short-run price transmissions and long-run price co-movements (Kaltsas, 2000 in Getnet *et al*. 2005).

Market integration plays a pervasive role in both agricultural and industrial development (Mafimisebi, 2011). This is owing to the fact that a well-linked market is capable of facilitating optimum allocation of goods and resources. The absence of market integration or inefficient price transmission from one market to another has important implications for economic welfare. Incomplete price transmission arising either due to trade and other policies, or due to transaction costs such as poor transport and communication infrastructure, results in a reduction in the price information available to economic agents and consequently may lead to decisions that contribute to inefficient outcomes (FAO, 2003). An efficient marketing system encourages farmers to boost their productivity thereby contributing to the improvement of rural income in developing countries (Edet *et al.*, 2013). Markets play a fundamental role in managing risk associated with demand and supply shocks; well-integrated markets facilitate adjustment in net trade flows across space and in storage over time, thereby reducing price variability faced by consumers and producers (Moser *et al.*, 2009).

Thus, a country like Burundi whose economy is largely based on agricultural sector should develop its marketing system, enhance price information flow and try to stabilize price as an incentive to development in general and to production in particular. Burundi's agriculture sector has accounted for about 50% of the Burundi's GDP compared to 35% for the service sector and 15% for the industrial sector in 2005 (IDEC, 2009). A recent study by the Institute of the Statistics and Economic Studies (ISTEEBU) revealed that over 90% of the population is engaged in subsistence agriculture, 3% in the secondary industry and 5% in the tertiary sector. The agriculture sector is the main source of income for the majority of the population and earns more than 90% of the export earnings for the country (USAID, 2010).

Rice is an economically important food security crop (Ammani, 2010). It constitutes an essential food for the majority of the population in Burundi. It was introduced in Burundi in 1960s (USAID, 2010), and it ranks third cereal produce behind maize and sorghum (Ndayitwayeko *et al.*, 2012) and seventh, in order of importance, after sweet potatoes, cassava, beans, maize and bananas of all varieties and sorghum (USAID, 2010). The importance of research into the interaction among markets and rice prices cannot be over emphasized due to the incessant population increases coupled with ever increasing demand in virtually every household in the country and particularly in institutions (army, police, schools...) (USAID, 2010). According to this former organization, an increase in population is accompanied by an increase in demand for rice. Burundi's population growth is estimated at three per cent per year (Kida, 2013).

Since 2000, the research stations have introduced high yielding varieties of rice, causing the trend of production to shoot up upwardly (Ndayitwayeko, 2011). However, increased production without a corresponding efficient marketing strategy in place for ensuring accessibility would not stimulate farmers to enhance production. An increase in production should be accompanied by an efficient marketing so that the commodity would reach to the final consumer at an affordable price, thus leading to generation of profit to all participants in the market. Hence, for the country to enjoy self-sufficiency in rice production and marketing, there should be transmission of marketing information from areas where there are surpluses to areas of acute shortage so as to lessen the aftermath effect of shocks arising from changes in demand and supply due to climate change, disease and pests, and other vagaries of nature since agriculture in the country is rain-fed. One of the ways of achieving the food security goal is effective transmission of market information as well as co-movement in prices within the market (Ojo *et al.*, 2015).

In a free market economy, the price system and competition provides the coordinating mechanism for determining the flow of resources into production and the flow of goods and services into use. It is within the marketing system that prices, allocation of resources, income distribution and capital formation are determined. Efficient marketing system promotes economic development of any country by encouraging specialization and leading to output enhancement (Edet *et al*. 2013). The ability of a marketing system to efficiently carry out its functions of contributing positively to the development of a country depends on the ease with which price changes and responses are transmitted spatially, temporally and vertically between markets for a homogeneous commodity (Berumen *et al.,* 2011). Price transmission studies are ostensibly an empirical exercise testing the predictions of economic theory and providing important insights as to how changes in one market are transmitted to another, thus reflecting the extent of market integration, as well as the extent to which markets function efficiently (FAO, 2003 and Ojo *et al*., 2015). Agricultural markets have been one of the central targets for the analysis of price transmission.

Although domestic production in Burundi appears to be increasing, the country has to import rice from neighboring countries and the world market in order to meet demand, particularly in the capital, Bujumbura. The rice imported contributes to 11 % of rice consumed in Burundi (FAO, 2015). It is important to study the market integration and price transmission for this commodity whose demand was estimated to reach 100% in 2015 (USAID, 2010).

1.2 Overview of World's Rice Industry

Rice is an agricultural commodity with the third-highest worldwide production, after sugarcane and maize (FAOSTAT, 2012). As a cereal grain, it is the most widely consumed staple food for a large part of the world's human population, especially in Asia. Since a large portion of maize crops are grown for purposes other than human consumption, rice is the most important grain with regard to human nutrition and caloric intake, providing more than one fifth of the calories consumed worldwide by humans. World trade figures are very different from those for production, as less than 8% of rice produced is traded internationally because the world countries producer are the main consumer of rice. Many countries consider rice as a strategic food staple, and various governments subject its trade to a wide range of controls and interventions (FAOSTAT, 2012). Developing countries are the main players in the world rice trade, accounting for 83% of exports and 85% of imports. While there are numerous importers of rice, the exporters of rice are limited. Five top producers of rice in 2012 were China (204.3 million tons), India (152.6 MT), Indonesia (69 MT) Vietnam (43.7 MT) and Thailand (37.8 MT) in decreasing order. In late 2007 to May 2008, the price of grains rose greatly due to droughts in major producing countries (particularly Australia), increased use of grains for animal feed and US subsidies for bio-fuel production.

1.3 Overview of Rice Industry in Burundi

Rice is a staple crop with a large acceptability in most families in Burundi especially in urban area. Therefore, the country has an ambition to turn rice into an import-substitution food as underlined in the country's strategy plan of 2008-2015 (GoB, 2008). This may be possible if Burundi achieves self-sufficiency objective in rice production (Ndayitwayeko *et al.*, 2012).

Currently, Burundi's rice has gained a large importance in term of research, production, marketing and consumption.

1.3.1 Rice Production in Burundi

Rice was introduced in Burundi in the 1960s and promoted in the plains of Imbo and Lower Rusizi. Since then, production has been growing steadily to reach an estimated 90,000 tons of paddy in 2011 (FAO, 2014) while the production was estimated at 50,000 tons in 2000 either an increase of 80% in 12 years. The following figure illustrates the evolution of rice production, harvested area and yield for the last 14 years.

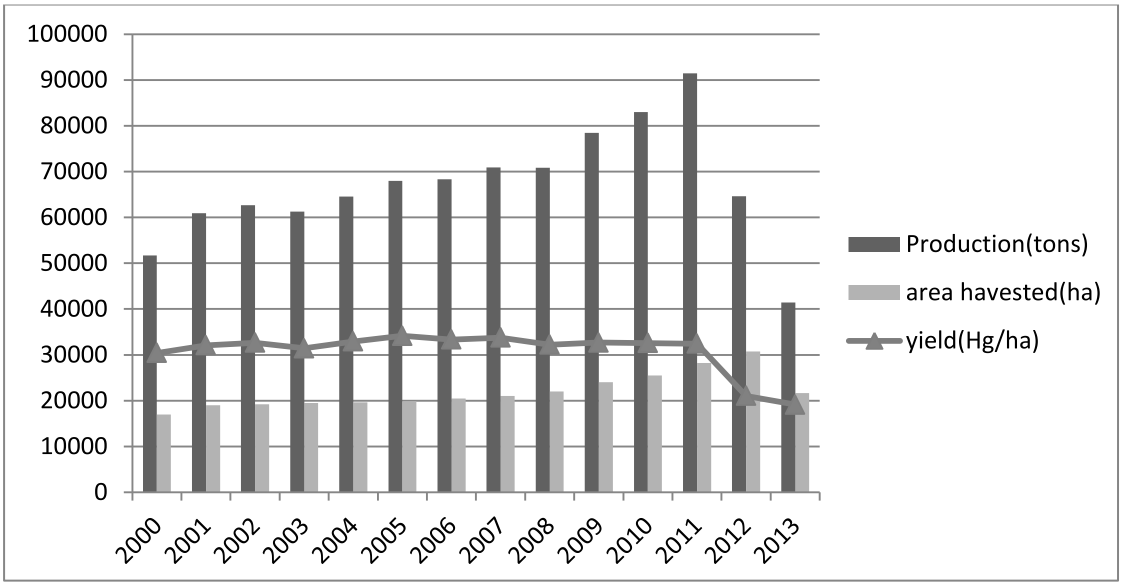

Figure 1.1**: Evolution of Rice's Production, Area Harvested and Yield in Burundi (2000-2013)**

Source: FAOSTAT, 2015

According to figure 1.1, it can be seen that both production and harvested area have increased from 2000 to 2011. The production had been moved from 51,000 tons in 2000 to almost 91,000 tons in 2011 which represent an increase of 77% over 2000. The strong growth of domestic production of rice is attributed to the increase in the area cultivated and to improvements in yields. However, the decline of production from 2011 is attributable to the poor weather conditions occurred in Burundi in that year causing the area under cultivation to decrease the following years as a consequence. Some argue that the rice import has increased as a response to this decrease in production making the domestic production to keep on decreasing. In general, the steady increase in production and area under rice in 2000/2013 period show the importance given to this commodity in the last pass years.

Rice is mostly grown in the three provinces of Burundi; inter alia, Kirundo and Muyinga under rain-fed system and Bubanza under intensive irrigated production system (Ndayitwayeko *et al,* 2012). Rice is produced on hills as upland rice, the marshlands, the framework of uncontrolled irrigation systems and the plains and marshlands developed under controlled irrigation. Its cultivation is practiced throughout the country: the plains and marshlands and in valleys below 1,700 m altitude (Gahiro, 2013).

1.3.2 Rice Commercialization in Burundi

In plains and marshlands rice production is usually for commercial reasons rather than for consumption. In rural areas, production is largely for domestic consumption and is integrated into the crop rotation system in combination with other commodities. Rice commercialization allow to the participant to gain margin even if it is not well distributed. The financial rewards of farmers vary according to production and prices. In irrigated systems in plains and lowlands, particularly under intensive control of water, rice cultivation allows significantly higher returns but in the hills and in rain-fed systems, farmers' profits from rice production are low. There are two kinds of producers of rice grown in the flat area - those organized and trained by the SRDI (a parastatal company) and those outside the SRDI (USAID, 2010). Collectors buy small quantities of rice from farmers and from local markets and sell the rice for a margin to traders. They also sell some of the rice bought from farmers and markets to markets based in provinces. Traders mostly buy the rice from farmers both inside and outside the SRDI area. They are based in large towns. They also buy the rice from middlemen and operate in and around the markets of Bujumbura and sell rice directly to consumers. However, SRDI (a parastatal company) is the main buyer of rice produced in Imbo plain whose payments exclude the deduction of the credit in kind given to farmers. SRDI-Rice has initiated a scheme by which rice producers were supplied both agricultural inputs and other crucial agricultural services on credit basis in Imbo plain where the most fertile soil of Burundi are found (Ndayitwayeko *et al.*, 2012).

The rice sector in Burundi suffers from lack of competitiveness. The commercial sector is less open and transparent to competition. The rice market in Burundi is characterized by an increasing number of operators which take large margin of approximately 62 % of the total supply (Gahiro, 2013). This increases the price paid by the final consumer. Figure 1.2 illustrates the evolution of producer and consumer prices in Burundi.

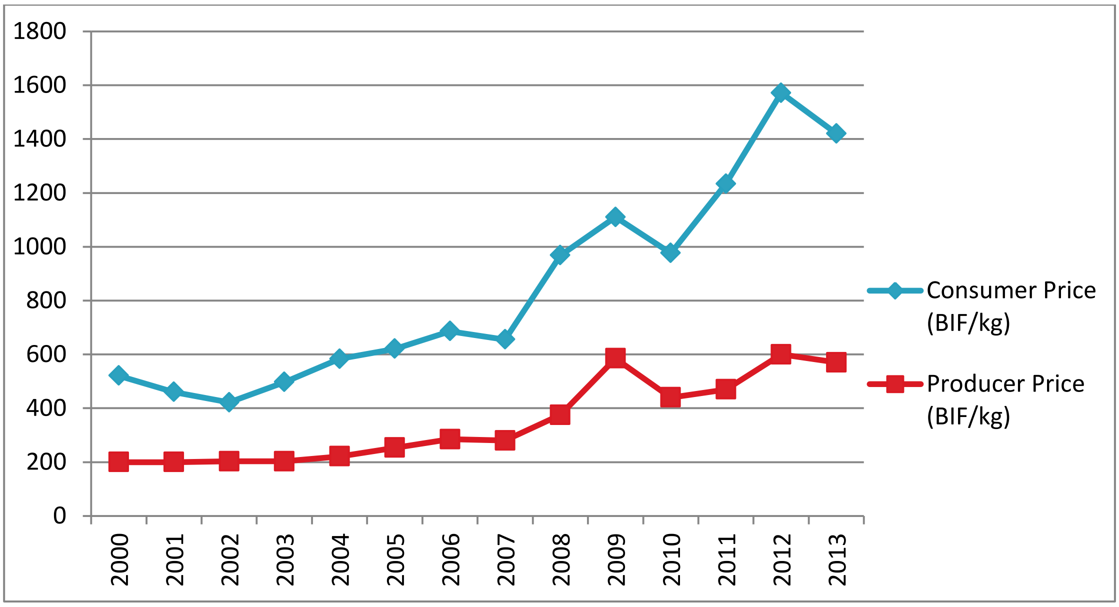

Figure 1.2: Evolution of Producer and Consumer Price of Rice in Burundi (2000/2013) in francs/kg

Source: FAOSTAT, 2015

There is a widening gap between producer and consumer prices in Burundi rice market Producer price is relatively modest as compared to consumer price. They are low compared to the producer price in EAC which gives room for Burundi rice export.

1.3.3 Rice Consumption in Burundi

Preferences of rice by consumers depend to a large extent on their localities and income. Urban population prefers good quality rice compared to the rural population. The big communities (boarding schools, military and police camps) have no requirement which is really expressed because of the budgetary constraint. They eat the cheapest rice of which the quality is not the major concern but it is the quantity that matters. Figure 1.3 shows the evolution of consumption in Burundi.

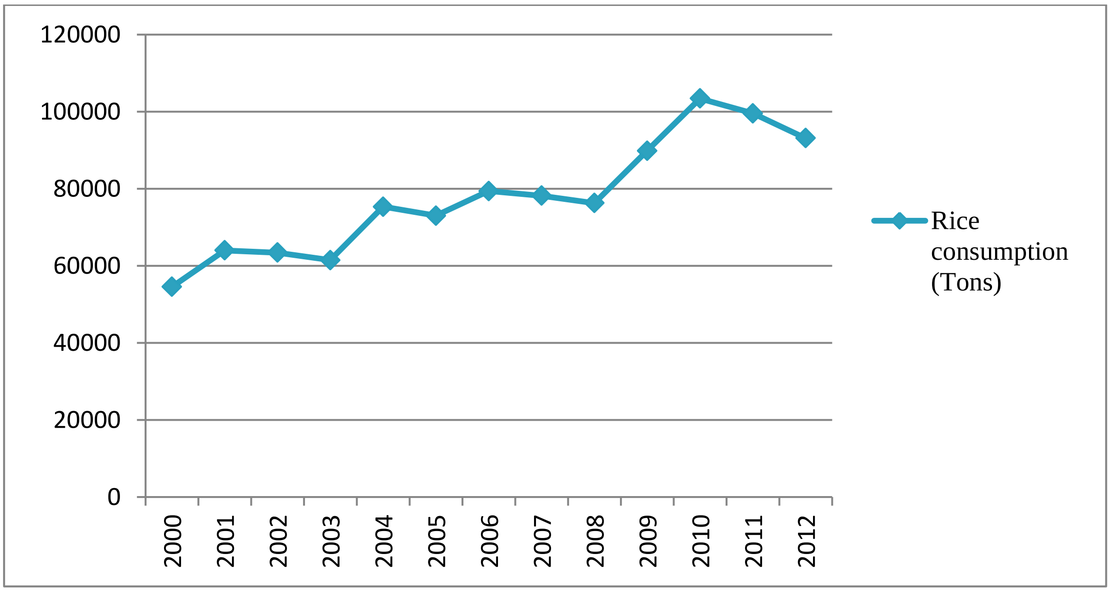

Figure 1.3: Evolution of Rice Consumption in Burundi (2000-2012)

Source: FAOSTAT, 2015

The demand for rice has increased for about 70 % in 2013 over 2000. It has registered a peak in 2010 but due to the decrease in production as discussed earlier in this study, the consumption has reduced from 2012. This shows that the demand for this commodity may be not satisfied even if at the same period the rice import has increased. Demand for rice has increased and has become an essential commodity for individuals and institutions (army, police and schools) (USAID, 2010).

1.3.4 Rice Imports in Burundi

The rice imported count for 11 % of rice consumed in Burundi (FAO, 2015). Rice is imported from the world's top rice producers such as India, Pakistan, Thailand and Vietnam for about 78% and the rest, are mostly from the EAC region (UN Comtrade Data, 2013). However, Tanzanian rice is the most frequently found in Burundi's markets although this does not appear in official statistics (USAID, 2010). Given the increasing demand on rice consumption, Burundi has to import rice in order to meet the demand. The following table shows the evolution of rice import in Burundi.

Table 1.1: Evolution of Rice Import in Burundi (2000-2012)

Year	Quantity (tons)	Value (1000 US$)
2000	2909	1280
2001	3125	1117
2002	820	1613
2003	261	44
2004	10856	3959
2005	5116	2227
2006	11137	4666
2007	7328	3237
2008	5499	2162
2009	11477	10175
2010	20455	9944
2011	8193	10151
2012	28549	15693

Source: FAOSTAT, 2015

According to table 1.1, there is fluctuation of rice import in Burundi but with main trend to increase. The year 2012 has recorded the highest rice imports which can be explained by the poor domestic production in that year. This explains the importance taken by rice in population's consumption basket.

According to Barreiro-Hurle (2012), rice and other commodities such us: maize beans, and sorghum accounted for 64 percent of informal staple food trade flows in 2013. In EAC, Uganda was the region’s largest informal staple food exporter in 2013 (accounting for 72 percent informal exports), followed by Tanzania. The following figure shows the evolution rice production and imports in Burundi.

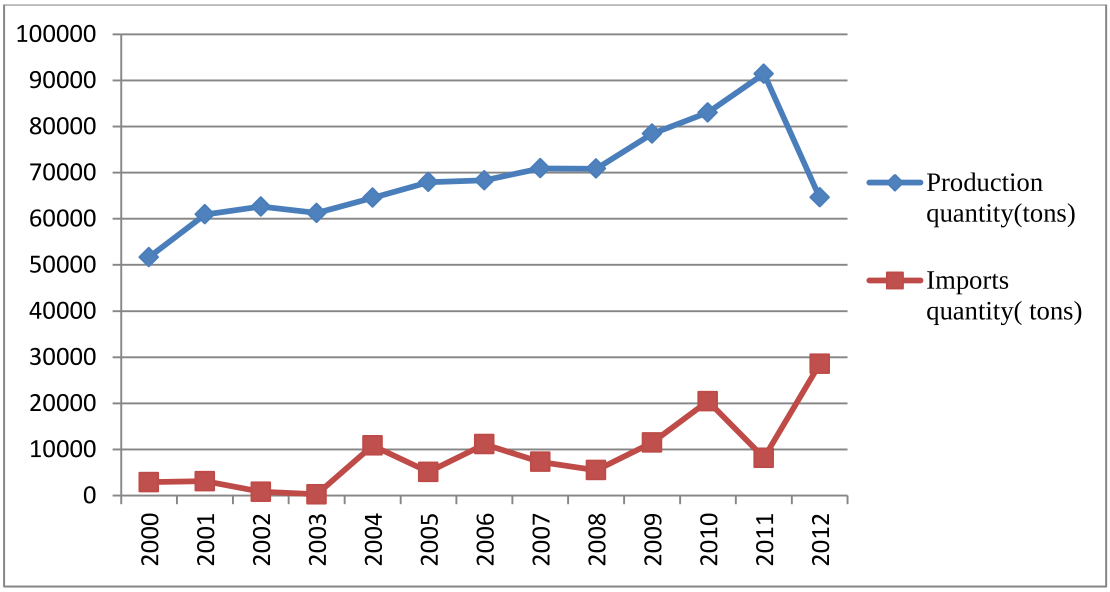

Figure 1.4: Evolution of Rice Production and Imports in Burundi (2000-2013)

Source: FAOSTAT, 2015

According to figure 1.4, since 2000, rice production and import have been increasing except years 2011/2012 where rice import sharply increased to fill the gap of the decrease on production as shown above. There is a steady growth of demand for rice in Burundi due to the growth of population and urbanization, the increasing demand for rice by household family. The rice produced is consumed locally; the country does not export rice.

1.4 Statement of the Problem

Poor price signals in different markets shows how the agricultural commodity markets are poorly integrated. Therefore it is necessary to determine the nature of price transmission in different markets and the degree by which price uncertainty in one market influences another market. Pricing signals regulate production, consumption and marketing decisions (Kohls & Uhl, 1998). Thus, asymmetric price transmission causes inefficient marketing and may result in skewing of welfare distribution. Rice price in Burundi is relatively high compare to last years. The price of rice continues to increase while the purchasing power has remained low. Burundi's retail rice price realized an increase of almost 80 % from 2000 to 2013 (ISTEEBU, 2015).

A widening gap has been observed between producer and consumer prices in Burundi rice market. The variation of price within one year is modest but it is fluctuating. However, the research stations have introduced high yielding varieties of rice, causing the trend of production to shoot up upwardly since 2000 (Ndayitwayeko, 2011). The production has increased from 50 000 tons in 2000 to almost 90 000 tons in 2011 which represents an increase of 80 % over 2000 (FAO, 2014). The strong growth of domestic production of rice is attributed to the increase in the area cultivated and to improvements in yields. This increase in production did not meet the increasing demand for this commodity. The country imports rice from neighboring countries and others countries but at high world market price. The 2007-2008 world financial crisis, which resulted in food price increase, had a huge impact on rice price in Burundi.

The agreement on EAC common market and the trade liberalization has resulted in massive food imports that may weaken the agricultural production capacity and in the long-term may cause poverty to farmers in general and rice producers in particular

(Ndayitwayeko *et al*., 2012). One of the commodities which have got a high increase on import quantity is rice which its import has increased for more than 300% during the period 2000-2012 (FAO, 2015). Despite this multifaceted offers that Burundi benefits, the price of rice was supposed to reduce instead of increase as predicted by the law of supply and demand. One may be interested to know whether the nature of price transmission and the poor market integration of rice in Burundi are contributing to this increase in price while both production and rice import have had a considerable increase in the last years.

1.5 Research Objectives

1.5.1 General objective

The leading objective of this study is to analyze price transmission and market integration of rice in Burundi.

1.5.2 Specific objectives

The specific objectives are to;

i) Analyze short-run and long-run spatial rice retail price relationships between markets in Burundi.

ii) Examine the nature of price transmission between spatial separate markets of rice in Burundi.

iii) Estimate the extent of world price transmission to the domestic market in Burundi

1.6 Research Hypotheses

$H_{01:}$ There is no short run and long run relationship between spatial separate retail rice markets in Burundi.

$H_{02:}$ There is no asymmetry in price transmission between spatial separate retail rice markets in Burundi.

H_{03}: There is no significant price transmission between world and domestic market of rice in Burundi.

1.7 Significance of the Study

The study of market integration and price transmission had a great significance given the few economic studies which have been done in many commodities in Burundi by contributing to the literature on rice in Burundi. Price is the primary mechanism by which different levels of the market are linked (Hassouneh *et al,* 2010).The analysis of price transmission allows one to better understand the overall functioning of the market. The extent and speed with which shocks are transmitted between different levels of the marketing chain and spatial separate markets can have important implications for pricing practices and may reflect the level of competition in the market. In a competitive market with perfect information, price changes at one market level will usually cause changes in other levels (Uchezuba, 2010). Some authors have hypothesized that the long-run relationship between prices may be asymmetric. This may occur if middlemen in the marketing chain pass input price increases to customers more quickly and completely than input price reductions (Serra & Goodwin, 2002).

Therefore, analyzing the functioning of the rice markets is an important issue since price asymmetry can cause marketing inefficiency (Bailey & Brorsen, 1989). Asymmetry in price transmission from wholesalers to retail markets prevents consumers enjoying earlier and greater reductions in retail prices and prevents wholesalers from benefiting from faster and larger increases in retail sales as wholesale prices decrease. Consumers are generally very concerned when retailers decide to increase the price of products as a consequence of increases of wholesales/producer prices but not to reduce the price as a consequence of a fall in wholesale/producer prices. This sharp attention to product price variations is particularly addressed to those goods which significantly contribute to the consumers' daily expenditure (Frey & Manera, 2005). The study investigates the spatial market integration and the nature of price transmission and gave recommendation on how producer and consumer welfare can be improved. In Burundi in most agricultural commodities in general and rice particularly there is inefficient price transmission influenced by the seasonality of those products. As said above, studies done in rice market in Burundi have been concentrated on marketing margin and production. The study suggested policy measure needed to ensure efficient market integration and price transmission within the study area.

1.8 Scope and Limitation to the Study

This study employed monthly retail price of rice for the period ranging from June 2001 to August 2015. The study period was limited by data availability. The study was limited to market integration and price transmission of rice in Burundi. The study was limited to four domestic rice markets Bujumbura, Muyinga, Gitega and Ruyigi, and the world prices.

There are few economic studies that have been done on market integration and price transmission in many commodities in Burundi and particularly rice. This leads to lack of relevant literature that could be useful to this study. Given the current political insecurity in Burundi, it was difficult to get information from appropriate institutions and factories for the secondary data. However, the researcher did the best to achieve all the research objectives.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The aim of this chapter is to present the synthesis of theory and past studies that provide a systematic framework based on market integration and price transmission. Hence, both theoretical and empirical literatures on market integration and price transmission are reviewed. The first section underpins the theoretical micro-foundations that elucidate the market integration and price transmission. The second section captures the empirical literature of price integration and price transmission.

2.1 Concept of Market and Price Relationship

2.1.1 Market Integration

Market integration is a situation in which separate markets for the same product become one single market. It is an indicator that explains how much different markets are related to each other. Barrett (1996) categorized market relationships into spatial, inter-temporal and vertical (Uchezuba, 2010; Abidoye & Labuschagne, 2014). Inter-temporal relationship refers to markets linked by efficient arbitrage in an inter-temporal across periods. The concept of a spatial market relationship relies largely on arbitrage (Uchezuba, 2010; Chepng'eno, 2015). It is used in spatial market studies to signify exploitation of profit opportunities created by market inefficiency. Vertical relationship refers to relation along market value chain. The transmission of spatial and vertical price signals has been studied extensively in economics. One of the main arguments in this area is that appropriate level of price transmission has the ability to broadly predict efficient market arbitrage in two markets. It also serves as a signal for a well-functioning and efficient market (Abidoye & Labuschagne, 2014).

2.1.2 Spatial Market Integration

Spatial price relationships relate to the price linkage across spatially distinct markets where arbitrage depends on whether the price difference is less than, equal to or greater than the transaction cost (Uchezuba, 2010). If the price difference in the spatial market is less than or equal to the transaction cost, there will be little incentive to engage in trade – that is, no arbitrage (Chepng'eno, 2015). The most populated theory used to analyze spatial market integration is the Law of One Price.

The Law of One Price postulates that at all points of time, given prices for a commodity in two spatially separated markets p_{1t} and p_{2t}, and transfer costs c, for transporting the commodity from market 1 to market 2, the relationship between the prices is as follows:

$$p_{1t} = p_{2t} + c \qquad (2.1)$$

If a relationship between two prices, such as (2.1), holds, the markets can be said to be integrated. However, this extreme case may be unlikely to occur, especially in the short run. If the joint distribution of two prices is found to be completely independent, then one might feel comfortable saying that there is no market integration and no price transmission (FAO, 2003). In general, spatial arbitrage is expected to ensure that prices of a commodity will differ by an amount that is almost equal to the transfer costs with the relationship between the prices being identified as the following inequality:

$$P_{2t} - P_{1t} \leq c \quad (2.2)$$

The spatial arbitrage condition implies that market integration lends itself to a co-integration interpretation with its presence being evaluated by means of co-integration tests (Tuyishime, 2014). Co-integration can be thought of as the empirical counterpart of the theoretical notion of a long run equilibrium relationship. If two spatially separated price series are co-integrated, there is a tendency for them to co-move in the long run according to a linear relationship. In the short run, the prices may drift apart, as shocks in one market may not be instantaneously transmitted to other markets or due to delays in transport and/or other factors; however, arbitration opportunities ensure that these divergences from the underlying long run (equilibrium) relationship are transitory and not permanent (Abdulai, 2002; FAO, 2003).

Therefore, factors, such as exchange rates, trade and public policies, market power, transaction costs, economies of scale, and product differentiation, are considered to be the major cause of price differentials (Abidoye & Labuschagne, 2014). Thus, effective price transmission between two markets is considered to be the product of a perfectly competitive market.

2.1.3 Vertical Market Integration

Vertical price relationships are typically characterized by the magnitude, speed and nature of the adjustments through the supply chain to market shocks that are generated at different levels of the marketing process (Vavra *et al.*, 2005). Efficiency in the price transmission mechanism is measured by investigating the type of interrelationship between farm-retail prices in rice sector. In general, the primary focus of studies that analyze vertical price transmission is the assessment of the characteristics such as: the extent of adjustment, the timing of the adjustment and the extent to which adjustments are asymmetric.

2.1.4 Price Transmission

Price transmission is said to occur when a change in one price causes another price to change. To further understand the evolution of the price process, it is important to understand the price transmission mechanism by determining whether the price changes in different markets are symmetric or asymmetric. If price changes are symmetric, prices are transmitted at the same rate. This implies that a shock to producer prices of a given magnitude would elicit the same response in retail prices regardless of whether the shocks reflected a price increase or a price decrease. Alternatively, if price transmission is asymmetric, the nature of price movements from upstream (producer) to downstream (retail) markets differs in terms of size and timing. In markets with highly asymmetric relationships, welfare distribution is skewed –thus efficiency is compromised (Meyer & Von Cramon-Taubadel, 2004).

Given the wide range of ways in which prices may be related, the concept of price transmission can be thought of as being based on three notions, or components (FAO, 2003). These are; co-movement and completeness of adjustment which implies that changes in prices in one market are fully transmitted to the other at all points of time; dynamics and speed of adjustment which implies the process by, and rate at which, changes in prices in one market are filtered to the other market or levels; and asymmetry of response which implies that upward and downward movements in the price in one market are symmetrically or asymmetrically transmitted to the other (Tuyishime, 2014; FAO, 2003). Both the extent of completeness and the speed of the adjustment can be asymmetric.

Output prices influence the demand for agricultural commodities. Consumers wish to maximize their welfare and the utility they derive from the consumption of a unit of agricultural product subject to their budget constraint. Since they are price-takers, they often adjust their demand as the prices of basic commodities change. When the prices of commodities increase, consumers tend to adjust their consumption expenditure, because high
prices diminish their purchasing power (Uchezuba *et al.*, 2010).

According to Vavra and Goodwin (2005), recent research has recognized more complex aspects of price transmission relationships and explored the extent to which price adjustments may be asymmetric. These studies typically distinguish between positive and negative price shocks. A finding of asymmetric price transmission may allow a researcher to make some inferences about the behavior of agents in the market, particularly as their actions impact on links across different market levels.

Knowledge of asymmetric price transmission between markets is essential because analyzing the degree of asymmetry gives an indication of how markets are linked. It helps in the process of measuring the flow of information by determining how price expectations are formed – an indication of causality. Causality implies that market channels (from the producer to the retailer) use information from one another when forming their price expectation. Also important issue is the direction of causality, which indicates whether the flow of information is uni-or bi-directional (Uchezuba, 2010).

Peltzman (2000) argues that asymmetric price transmission is the rule, rather than the exception, and concludes that, since asymmetric price transmission is prevalent in the majority of producer and consumer markets, standard economic theory that does not account for this situation must be incorrect. Meyer & Von Cramon-Taubadel (2004) observe that a possible implication of asymmetric price transmission is that consumers are not benefiting from a price reduction at the producers level, or producers might not benefit from a price increase at the retail level. Thus under asymmetric price transmission, the distribution of welfare effects across levels and among agents following shocks to a market will be altered relative to the case of symmetric price transmission.

A number of reasons are put forward in the literature on price asymmetry attempt to explain the asymmetries of prices (FAO, 2003). First, agents possessing perishable goods may not increase prices to avoid the risk of being left with unsold spoiled product. Note that this would cause asymmetries in price changes that are beneficial for suppliers and consumers and detrimental for retailers. Market power could be a second cause of asymmetry. Different costs of adjustment, depending on whether prices rise or fall, might be a third cause. Different price-elasticity at different levels of the marketing chain may be a fourth reason. Finally, public intervention to support producer prices and asymmetric information could also cause price asymmetry (Serra & Goodwin, (2002); Bailey & Brorsen, (1989) and Uchezuba *et al*. (2010)). In Burundi the two major causes of asymmetric price transmission are market power and asymmetric information in the market (Karenzo & Mutoni, 2009).

2.2 Some models Used in Market integration and Price transmission

A number of competing theories have been put forward to explain the existence of asymmetric farm-retail price transmission (Abdulai, 2002). The most popular econometric models for price asymmetries, namely autoregressive distributed lags, partial adjustments, error correction models, regime switching and vector autoregressive models and finally, their multivariate extensions (Frey & Manera, 2005). Co-integration and error correction models provide an analytical tool that can focus beyond the case of market integration or complete price transmission, in testing notions such as completeness, speed, and asymmetry of the relationship between prices (FAO, 2003). However, there are five main approaches that can be used for testing market integration: correlation analysis, the law of one price (LOP), the Granger-causality approach, the Ravallion model and co-integration.

The approach used to measure price-dynamic interrelationships in the literature is extensive. Emphasis has been put on lack of consistency in the various empirical tests due to the ignorance of some important statistical protocols and analytical procedures (Uchezuba, 2010). The possibility of a structural shift in estimating interrelationships between economic variables, the assumption of continuous adjustment to shocks, and the bias in the assumptions of constant variance in volatile market prices are examples explaining this issue.

Many studies of asymmetric price relationships simply test for the presence or absence of asymmetric price relationships without accounting for the possibility of a structural shift in the trend function of the data-generating process. The co-integration test proposed by Engle & Granger (1987) has been widely applied to test for long-run adjustments among economic variables in an error correction framework.

However, this model assumes that the adjustment mechanism of the error correction term is symmetric, which implies that the adjustment coefficients are similar regardless of whether the equilibrium error is positive or negative. Thus, Engle & Granger (1987) procedure will be misspecfied if the adjustment is asymmetric as suggested by Enders & Siklos (2001) and Abdulai (2002). Using conventional linear models in a nonlinear situation leads to the wrong conclusions being drawn. However, the cost of using non-linear models comes with their added complexity.

Therefore, a threshold type of adjustment model was suggested by Enders & Granger (1998). According to Balke & Fomby (1997), the rationale was guided by the notion that adjustment towards equilibrium is not constant but depends on adjustment cost considerations whereby economic agents do not adjust continuously. Hence the two authors introduced threshold co-integration and error correction models. They conveyed a grid search procedure whereby threshold parameters are chosen by minimizing a sum of squared errors (SSE) criterion. In the context of multivariate models, such an approach may be less preferred to a criterion that recognizes the potential non-independence of residuals across equations.

The threshold models allow for asymmetry in adjustment speed and, because economic agents do not adjust continuously, the non-linear threshold effect can be used to explain price changes in alternate regimes defined by a threshold value. Among the family of nonlinear models, the threshold autoregressive (TAR), momentum threshold autoregressive (MTAR) and bilinear model are perhaps the most popular one in the literature. The threshold autoregressive model was first proposed by Tong in 1978 (Hansen, 2011). Threshold autoregressive (TAR) and momentum-threshold autoregressive (M-TAR) co-integration has become increasingly popular in the literature on asymmetric price transmission during the last years.

A significant set of analyses addressing the asymmetry question has involved the use of variations of the econometric specification introduced by Wolffram (1971) and refined by Houck (1977). Specifications that use some variation of the Wolffram (1971) method have been criticized because they ignore the time-series properties of the data. In particular, many analysts have not considered the problems associated with non stationary data. To adequately study asymmetry of price transmission, Von Cramon-taubadel (1998) proposed a modification of the standard Wolffram specification to allow for an error correction term. To take into account the potential for nonlinear and threshold-type adjustments in error correction models, Goodwin and Holt (1999) proposed the use of threshold vector error correction models (TVECM). This model is a multivariate version of threshold autoregressive (TAR) models. It allows one to investigate the adjustment process of individual prices and provide more information about short-run price dynamics.

According to the M-TAR approach, a correction to the margin between prices at different levels of the marketing chain does not depend on the size of this margin at a given point in time but rather on the magnitude and direction of its change in the previous period. It is in this sense that M-TAR behavior is said to exhibit ‘momentum’ (Cramon-Taubadel & Meyer, 2001).

This study analysis evaluated spatial market integration and price transmission in Burundi rice markets. The emphasis was made on price transmission in four selected domestic markets and world price transmission to the domestic market of rice. The study measured price transmission by estimating threshold-type adjustments to shocks.

2.3 Empirical Literature Review

Threshold co-integration has been a popular technique used to analyze the nature of price transmission, especially in the agricultural economics and energy economics literature. This method captures price asymmetries by splitting the price series of interest according to deviations of prices from equilibrium, permitting different speeds of adjustment depending on whether a particular variable is above or below the threshold (Pozo *et al*. , 2013).

Many studies have been done in market integration and price transmission but the finding are different depending on the research objectives and the model used. Meyer (2003) estimated a threshold vector error correction model in order to analyze price transmission between pork markets in Germany and the Netherlands Based on Hansen & Seo (2002) model in markets at different level. Meyer's report has two threshold values which is symmetric around zero. Vector models take care of the possible endogeneity problem and make the analysis of adjustments more complete by allowing feedback from both variables.

Tuyishime (2014) investigated a study on assessment of world rice price transmission to domestic rice market in Rwanda. The findings indicated that rice markets in Rwanda are integrated to world rice markets with a high speed of adjustment. The study used VECM that was not able to capture asymmetric adjustment.

According to Abdulai (2000), the Ghanaian maize market were well integrated and wholesale maize prices in local markets respond faster to price increase than to price decrease in central market. He used threshold cointegration model like this study and estimate the nature of price transmission between two local markets and the central market. Abdulai (2002) found that producer price increases move faster to consumer prices than reductions in producer prices in his study of Swiss pork market using threshold cointegration model. Harper and Goodwin (2000) used grid search to determine the thresholds and find important asymmetries in U.S. pork farm, wholesale and retail prices. Asymmetry appeared so that large negative deviations from the equilibrium were accompanied by especially significant error correction terms. In addition, price interrelationships existed between wholesale and retail prices rather than between farm and wholesale prices. Unlike this study which used retail price transmission between spatial retail prices, they analyzed the nature of price transmission between wholesaler and retail price using the same model.

McLaren (2015) studied asymmetric price transmission from international to local markets and find that there was asymmetric price transmission especially when prices fall. The study was different from this study in the sense that he used yearly producer price and the conclusion was drown based on whether there is market power or not. Acquah (2012) used threshold cointegration model to study price transmission between retail and wholesale prices of maize in Ghana. He found that the retail and wholesale prices were cointegrated with threshold asymmetric adjustment. Von Cramon-taubadel (1998) investigates study on asymmetric price transmission using error correction in producer and wholesale pork prices in northern Germany. His analysis demonstrates that price transmission between producer and wholesale pork prices in northern Germany is asymmetric. This asymmetry was explained by the belief that the margin is corrected more rapidly when it is squeezed relative to its long-run level, than when it is stretched. Bailey and Brorsen (1989) conducted a study on asymmetric price transmission in spatial fed cattle markets investigated for three large markets (Texas Panhandle, Nebraska, and Colorado) and one small market (Utah). Their results of the asymmetry test suggest that price increases in the Texas

Panhandle have more immediate impact on the other three markets than price decreases.

Moser *et al*. (2009) test the extent to which markets in Madagascar are integrated across space at different scales of analysis and explain some of the factors that limit spatial arbitrage and price equalization within a single country. The study aimed to test the extent of market integration at three different spatial scales: sub regional, regional, and national. Their findings indicate that markets are fairly well integrated at the sub regional level and that factors such as high crime rates, remoteness, and lack of information are among the factors limiting competition.

Amikuzuno (2010) used the threshold autoregressive (TAR) model to estimate wholesale price series from four major fresh tomato markets in Ghana between pre liberalization and post liberalization periods. He discovers a mixed pattern of price transmission between market pairs and an improvement in the integration of the markets after import tariffs were lowered in the post liberalization period. The study is different with this one in the way that he estimated the price transmission between two different periods, pre and post- liberalization.

According to Abidoye and Labuschagne (2014) the relationship between South African price and world price for maize indicates the presence of nonlinearity in price transmission. This is the result of their study on the analysis of the relationship between domestic maize price in South Africa and world maize prices using TAR and threshold cointegration (TIC) models.

Most of these empirical studies have used threshold cointegration models. Threshold models are better able to capture the dynamics of the arbitrage process underlying markets that are connected. These models incorporate transaction cost by allowing for a different relationship between variables once a certain threshold has been surpassed (Van Campenhout, 2006 in Abidoye & Labuschagne, 2014).

Although a generalization of the results of these analyses is somewhat difficult to make, most research has detected asymmetries in price adjustments at different market levels, although the extent of asymmetry is generally small. In addition, most existing research has found that price changes tend to flow from the farm to wholesale and retail markets.

Thus, this study was done in Burundi and analyzed spatial market integration and the nature of price transmission in four rice markets and international price transmission to the domestic market in Burundi using nonlinear time series models (TAR and MTAR models). The detail on models used in the study is discussed in chapter three.

2.3 Conceptual Framework

The study used five price series from four domestic markets namely Bujumbura, Muyinga, Gitega and Ruyigi, and the world price. Figure 2.1 shows price transmission between domestic markets and the world price. Bujumbura being the first town, the capital of Burundi and given its high population, is the main consumer market of rice. Gitega is a consumer market and being at the central of Burundi, it is acting as a wholesale market also. Muyinga is a producer market and plays an important role as a transit market of rice imported from Tanzania. Ruyigi is a producer market and does not have a direct causal relationship with Bujumbura market. In general, the three domestic market cause price formation in Bujumbura. World price has an impact on domestic market especially Bujumbura which is main consumer market.

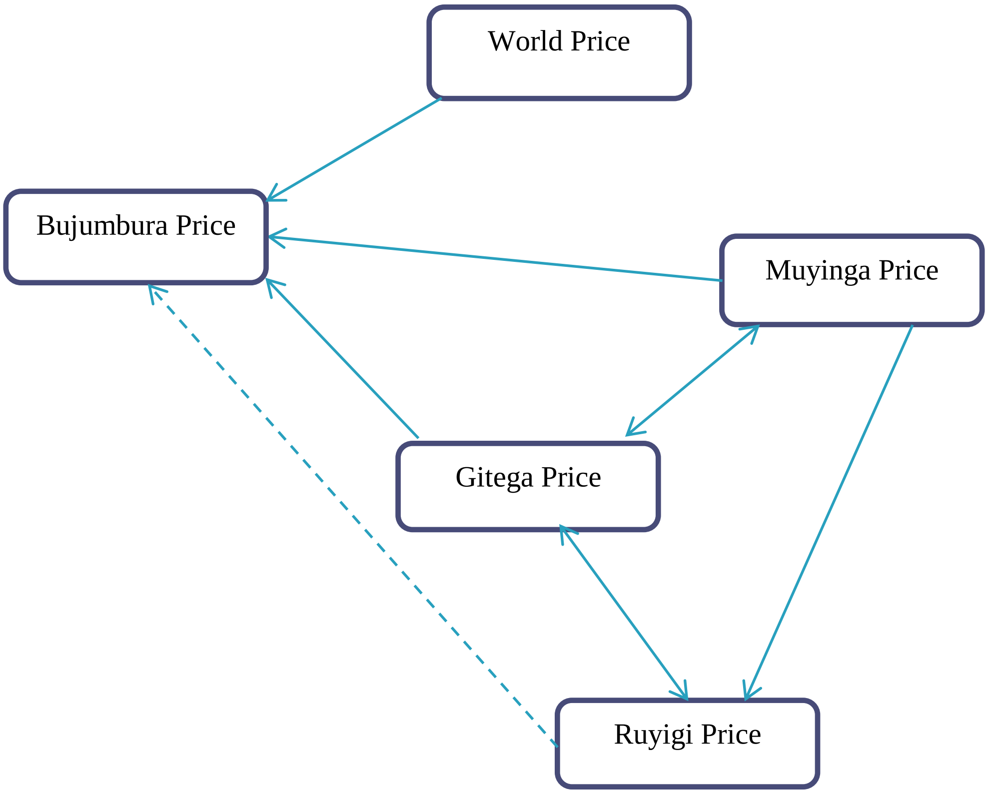

Figure 2.1: Conceptual Framework

Source: Conceptualization by Author, 2016

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter provides a summary of the study area and the research methodology that was used in the study. It describes the research design, data types and sources, sample size and method of data analysis. The main objective of this chapter is to highlight the approaches and models used to analyze price transmission and market integration of rice in Burundi.

3.1 Study Area

Burundi covers an area of 27,834 km^2, including 2,000 km^2 of lakes and 2,350 km^2 of arable land. It is located at 1,200 km off the coast of the Indian Ocean and 2,000 km from the coast of the Atlantic Ocean. It borders with the DRC in the West, Rwanda in North and Tanzania in the East and the South. Burundi's population stood at 8.06 million inhabitants in 2008 (USAID, 2010) and the annual rate of growth of the population is about three per cent on average. Burundi has experienced a civil war from 1993 until 2000. During this period per capita income fell by almost 40 % during the war.

Agriculture is the largest sector of the economy of Burundi, source of employment and a vital determinant of reduction of poverty. It is contributing to GDP for almost 50 percent (IDEC, 2009).The main cash crops; coffee, tea and cotton; play a great role in fetching the most needed export foreign earnings for the country. However, Burundi's agriculture remains almost totally rain-fed, traditional and hardly mechanized. It is divided between growing food crops (30 per cent of arable land) for consumption by farmers (admittedly 90 percent of the population) and cash crops. Prior to the 1993 war, Burundi was self-sufficient in various food crops. Currently, the demographic pressure is forcing farmers to increase food crops and to go down to the low-laying marshland or destroy the natural forest in order to increase production. This issue has exacerbated food insecurity and the possibility of expansion of arable land (Ndayitwayeko et *al*., 2014). Prices for most of food crops have increased which may be explained by many factors such as: the increase of the population, devaluation of local currency, low domestic production, and inefficient marketing system among others. The study was done in four markets namely Bujumbura, Muyinga, Gitega, Ruyigi. Bujumbura and Gitega are consumer and main markets of rice in Burundi; and Muyinga and Ruyigi are producer markets. It analyzed also world price transmission to the domestic market in Burundi.

3.2 Research Design

The study applied an explanatory research design, with objective to analyze the price transmission between spatial markets of rice in Burundi and world price transmission to the domestic market in Burundi. The study investigated relationship between retail prices in four markets: Bujumbura-Muyinga-Gitega-Ruyigi; and between world rice price and domestic price of rice in Burundi. Quantitative and qualitative methods were used in this study.

3.3 Theoretical Framework

The study used the theory namely the Law of One Price. This theory postulates that at all points of time, given prices for a commodity in two spatially separated markets p_{1t} and p_{2t}, and transfer costs c, for transporting the commodity from market one to market two, the relationship between the prices is as follows:

$$p_{1t} = p_{2t} + c \tag{3.1}$$

If a relationship between two prices, such as (3.1), holds, the markets can be said to be integrated.

Therefore, for the vertical market to be integrated, price theory suggests that a long-run equilibrium relationship should exist between the upstream and downstream prices, implying that in the long-run, prices of goods engaged in the economic activity should reflect their scarce economic value (Veselska, 2005).

In this instance, rational economic agents should be able to price their goods to maximize their utility, while in the process equitable distribution of economic welfare to consumers is ensured. Given this equilibrium relationship, it is expected that any external shocks to the upstream prices should trigger short-run and long-run adjustments towards the long-run equilibrium (Uchezuba, 2010). For example, increases or decreases in upstream prices should simultaneously trigger appropriate changes in the downstream price both rapidly and completely. This type of equilibrium price relationship is called symmetric price transmission. In contrast to symmetric price behavior, analysts have found evidence to suggest that in practice, the adjustment of prices to shocks may not be symmetric but asymmetric (Abdulai, 2002; von Cramon-Taubadel, 1998). For example, retail prices may adjust more quickly to farm price increases than to price decrease. In this situation, asymmetric price transmission (APT) would imply a different distribution of welfare than would be the case under symmetry (Meyer & Von Cramon-Taubadel, 2004). On the other hand a negative asymmetry results if downstream (output) prices react more rapidly and completely to decreases in upstream (input) prices than to increases (Uchezuba, 2010).

Von Cramon-taubadel (1998) discussed the development of testing price transmission in general and specifically asymmetric tests. Early studies before co-integration methods used variants of the following model:

$$\Delta p_t = c + \beta^{+}\Delta P_t + \beta^{-}\Delta P_t + \varepsilon_t \qquad (3.2)$$

In this model, Δ is a difference operator so that $\Delta p_t = p_t - p_{t-1}$. Again, p_t is the price in market one and Pt is the price in market two. The response of the former to the latter is decomposed into positive and negative changes. Term c is a constant, while β^+ and β^- are adjustment coefficients of the positive and negative changes in P. If $\beta^+ = \beta^-$, then price adjustment is symmetric. It is possible to distinguish between short-term and long-term adjustment by adding lags to the above equation.

Von Cramon-taubadel (1998) made a fundamental clarification. The estimation of equations like (3.2) does not fully consider the time series properties of the data used, which are typically non-stationary leading to problems in the testing. Making the data stationary by differencing is part of the solution to the problem, but equation (3.2) is still incompatible with co-integration and long-term information between time series. A proper way to proceed is to use the error correction models introduced by Engle and Granger (1987). Their model utilizes both short-term dynamics and long-term information. A typical formulation for an error correction model is:

$$\Delta p_t = c + \beta_1 \Delta P_t + \alpha ECM_{t-1} + \beta_2(L)\Delta p_{t-1} + \beta_3(l)\Delta P_{t-1} + \varepsilon_t \qquad (3.3)$$

Where αECM is the error correction term and $\beta_2(L)$ and $\beta_3(l)$ are lag polynomials. Long-term information is given by the cointegrating relation $p_t = c_0 + \beta P_t + \mu_t$, which in its basic form is just a static regression model in levels. The lagged value of the error term in the co-integrating regression is given by

$$ECM_{t-1} = \mu_{t-1} = p_t - c_0 - \beta P_t$$

In order for the system to be stable in single equation models, the error correction coefficient α has to be negative and significant. A new family of models that tackles the instant adjustment problem was started from the article by Balke & Fomby (1997) with the illuminating title "Threshold co-integration". Co-integration as a whole is still maintained but between estimable thresholds r_1 and r_2 there may be a range of unit root adjustment. Deviation from equilibrium will result in a price change only if the deviation is larger than the threshold value.

3.4 Data Types and Sources

To carry out this study, secondary data of rice retail price for the period of June 2001 to August 2015 was collected. The prices are measured in common currency, that is, nominal US dollar per kilogram of rice. The secondary data was collected from different sources including: FAOSTAT (Food and Agriculture Organization Statistics), World Bank and ISTEEBU (National Institute of Economic statistics of Burundi). The data was based on time-series monthly observations of retail prices in four main domestic rice markets dated from June 2001 to August 2015 and world price. This period corresponds to the period after civil war (1993- 2000). The choice of this period was guided by the availability of data.

3.5 Statistical Properties of Time Series Data Set

3.5.1 Test for Stationarity

In line with time series analysis, the first step was to test for stationarity in order to check whether price series were stationary at level, at first difference or at second difference. This leads to the best choice of the model. The choice of the most appropriate unit root test is difficult (Mohammad and Zulkorian (2010) in Chepng'eno, 2015). To counter this difficulty, Enders (2004) suggests that one should use both conventional unit root tests; ADF and PP tests. Thus, two unit roots tests; Augmented Dickey Fuller (ADF) and Philips- Perron (PP) were used to test for stationarity price series.

To carry out the test of cointegration, the variables must be integrated of order zero (I (0)) or integrated of order one (I (1)), it is necessary to test for unit root to ensure that all the variables satisfy this condition. This also goes a long way in ensuring that variables that integrated of order two (I (2)) are not included in the model. If there is a unit root, but differencing the series once makes it stationary, it is said to be integrated of order one [denoted as I (1)].

The first unit root test that was used is ADF. This test was suggested by Dickey and Fuller (1979) and Dickey and Fuller (1981). This test was based on the following model:

$$\Delta p_t = \alpha + \beta_t + \varphi p_{t-1} + \sum_{i=1}^{k} \theta \Delta p_{t-i} + \varepsilon_t \qquad (3.4)$$

Where $\varphi = (1 - \rho)$ and ρ is a parameter estimate of a first-order or autoregressive (AR) (1) process. Under the null hypothesis of $\varphi = 0$, and the alternative of $\varphi < 0$, the first-difference series follows an autoregressive integrated moving average (ARIMA) (p q), process. This regression model is valid if the number of lag structure k of the first difference used as an extra regressor increases at a controlled rate with the sample size (Perron, 1988).

The second unit root test that was used is Philips-Perron test suggested by Philips and Perron (1988). This test statistics was applied for the three functional forms on the following regression equation;

$$p_t = \delta_t + \gamma p_t + \gamma_1 \Delta p_{t-1} + \cdots + \gamma_p \Delta p_{t-p} + \varepsilon_t \quad (3.5)$$

Where δ_t may be 0, or may be μ or $\mu + \beta_t$. The procedure modifies the Dickey-Fuller test statistics as shown in the following equations.

$$Z_t = \sqrt{C_0\left(\frac{\hat{\gamma}-1}{v}\right)} - \frac{1}{2}(\alpha - C_0)\frac{T_v}{\sqrt{\alpha s^2}} \quad (3.6)$$

$$Z_\gamma = \frac{T(\hat{\gamma}-1)}{1-\hat{\gamma}_1-\hat{\gamma}_2-\cdots-\hat{\gamma}_p} - \frac{1}{2}\left(\frac{T^2 v^2}{s^2}\right)(\alpha - C_0) \quad (3.7)$$

Where

$$S^2 = \frac{\sum_{t=1}^{T} e_t^2}{T-K} \quad (3.8)$$

$v^2 =$ estimated asymptotic variance of $\hat{\gamma}$,

$C_j = \frac{1}{T}\sum_{s+1}^{T} e_t e_{t-s}, j = o, 1,2, \ldots \ldots \ldots, p = jth$ auto covariance of residuals, (3.9)

$$C_0 = [(T-K)/T]S^2 \quad (3.10)$$

$$\alpha = C_0 + 2\sum_{j=1}^{L}\left(1 - \frac{j}{L-1}\right)C_j \quad (3.11)$$

3.5.2 Determination of the Optimum Lag Length

Before performing Johansen co-integration test, it is a necessary to select the optimum lag Length. The aim of determining the best lag length is to remove the autocorrelation in the series so that the error term becomes white noise (Uchezuba, 2010). Proper lag estimation ensures that the model is correctly specified. It is not uncommon for agricultural product prices to be affected by their past values.

Models that are used to estimate causal relationships between variables are very sensitive to the number of lags involved in the autoregressive integrated moving average (ARIMA) model. Following Greene (2008), the optimum lag length in the $ARIMA_{(p,d,q)}$ model was determined by combining a measure of model fit that is regression residuals with various information criteria for both single time series and the multivariate time series models. The first information criterion that was used to estimate the optimum lag length was the akaike information criterion (AIC) which chooses ρ to minimize the following equation:

$$\mathrm{AIC_p} = \ln\left|\hat{\sum_p}\right| + 2\,\frac{\mathrm{M(p^2+1)}}{\mathrm{T}} \tag{3.12}$$

In this model, M is the number of parameters in all of the equations in the VAR model.

The second information criterion that was used is the Schwarz Bayesian Information criteria (SBIC). This information criterion chooses p to minimize the following equation; $\mathrm{SBIC} = \ln\left|\hat{\sum_p}\right| + (\ln\mathrm{T})\,\frac{\mathrm{M(p^2+1)}}{\mathrm{T}}$ (3.13)

The third information criterion was the Hannan and Quin Information Criterion (HQIC) which chooses p to minimize the following equation;

$$HQIC_p = \ln\left|\hat{\sum_p}\right| + (2\ln\mathrm{T})\,\frac{M(p^2+1)}{T} \tag{3.14}$$

3.6 Model Specification

Studies on price asymmetry differ and depend on the type of asymmetry being investigated, which is a function of the type of model used. Early studies on asymmetric price transmission focused on the irreversible behaviours of demand and supply functions. Emphasis has been on the short-run contemporaneous impact and the distributed lag effects of the variations in the input prices, while the long-run equilibrium relationship (cointegration) has been ignored. Due to the progress made in the modification of the statistical and analytical methods, studies that ignore the long-run relationship are assumed to give an inaccurate account of the asymmetric price relationship. Therefore the asymmetric price transmission literature is classified into studies with or without an equilibrium adjustment consideration (Uchezuba, 2010).

3.6.1 Modeling Cointegration Relationship

The first objective of the study was to identify the short and long run price relationship in major domestic rice markets. If the non- stationarity tests reveal that the series are integrated of the same order I (1), the second step is to test for co-integration of price series. Johansen (1988) technique was employed to test for cointegration. The method was selected because of the advantages it has over other traditional regression methods. The method, unlike Engle-Granger method, can accommodate more than two price series in analysis. Using this test, the study was able to determine how many cointegrating relationships existed between different markets. Johansen procedure helps to determine and identify the cointegrating vectors. The number of cointegrating vectors should be less than the number of variables. In domestic markets, there are four price series and thus, the number of cointegrating vectors should be less than four that is $0 \leq r \leq 4$.

The Johansen test utilizes two test statistics, namely eigenvalues and trace statistics. This is a maximum likelihood ratio test involving a reduced rank regression between two variables, say I(0) and I(1) providing an n eigenvalues $\hat{\lambda}_1 > \hat{\lambda}_2 > \ldots\ldots\hat{\lambda}_n$ and corresponding eigenvectors $\hat{V} = (\hat{v}_1, \ldots, \hat{v}_n)$, where the r elements of $\hat{V}$ are the cointegration vectors. The magnitude of λ is a measure of the strength of correlation between the cointegrating relations for i = 1…r. The trace statistic tests the null hypothesis of r cointegrating vectors against the alternative of r +1. The maximum eigenvalue statistic tests the null hypothesis of r = 0 against the alternative of r =1. The null hypothesis that there are r cointegrating vectors can be stated as follow:

H_0: $i_f = 0$ $\quad\quad\quad\quad$ i = r + 1……, n

The maximum eigenvalue (λ- max) statistic is given by:

λ_{max}= - T ln (1 - $\hat{\lambda}_{r+1}$) $\quad\quad$ r = 0, 1, 2…………..n-1 $\quad\quad$ (3.15)

Where T is the sample size and (1 $-\hat{\lambda}_{r+1}$) is the max-Eigenvalue estimate.

The trace statistic is computed as:

λ_{trace}= - T $\sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i)$ $\quad\quad$ r = 0, 1, 2…………..n-1 $\quad\quad$ (3.16)

Both tests have the null hypothesis that there are at most r co-integration vectors and the procedure for determining the number of co-integrating vectors follows a sequential procedure. First, the null hypothesis H_0 (r_0 = 0) against alternative hypothesis H_1 (r_0 > 0) is tested. If this null is not rejected then it is concluded that there are no co-integrating vectors among the n variables. If H_0 (r_0 = 0) is rejected then it is concluded that there is at least one co-integrating vector and the process proceeds to test H_0 (r_0 = 1) against H_1 (r_0 > 1). If this null is not rejected then it is concluded that there is only one co-integrating vector. The criterion of estimating the number of cointegrating equations is to accept the first r for which the null hypothesis is not rejected.

In case markets are co-integrated, a Vector Error Correction Model (VECM) is estimated to assess the price transmission between domestic markets. Consider market pairs, market one and market 2;

$$\Delta P_t^1 = \alpha + \theta(P_{t-1}^1 - \beta P_{t-1}^2) + \rho P_{t-1}^1 + \delta P_{t-1}^2 + \varepsilon_t \quad (3.17)$$

$$\Delta P_t^2 = \alpha + \theta(P_{t-1}^2 - \beta P_{t-1}^1) + \rho P_{t-1}^1 + \delta P_{t-1}^2 + \varepsilon_t \quad (3.18)$$

Where P_t^1 is price in market one and P_t^2 price in market two. The error-correction coefficient (θ) reflects the speed of adjustment. It is normally expect to fall in the range of $-1< \theta <0$.

The hypothesis relies on the sign and magnitude of the ECT. The ECT term should be negative and significant either at 5 percent or at 1 percent level of significance for the relationship to converge to long run equilibrium. A negative and significant ECT coefficient confirms the existence of long term relationship between the variables. Note that, if cointegration is not detected VECM is not required and in such case the VAR model should be estimated (Johansen, 1988).

3.6.2 Modeling Price Transmission Using Nonlinear Model

Extending Engle & Granger's (1987) linear cointegration test, Enders and Granger (1998) and Enders and Siklos (2001) developed a threshold cointegration test where negative and positive deviations from the long-run equilibrium are not corrected in the same way, that is, in which the adjustment towards the long-run equilibrium is asymmetric (Stigler, 2012 in Ndoricimpa & Achandi, 2014). Two threshold co-integration models, namely the threshold autoregressive (TAR) model and the momentum-threshold autoregressive (M-TAR) model, are used to measure the threshold co-integration and equilibrium adjustment processes. TAR model uses lag of a variable, whereas M-TAR model prefers previous period's change as a threshold variable. The M-TAR model is an alternative to the TAR model and is introduced where the exact nature of the non-linearity is not known. It then becomes possible to alloy the autoregressive decay to depend on the change in μ_{t-1} ($\Delta\ \mu_{t-1}$) rather than the level of μ_{t-1} as depicted in the TAR model discussed above.

Threshold co-integration is used to model the possibility that the short-run dynamic relationship behaves in different ways depending on the magnitude of deviation from the equilibrium. The TAR model captures asymmetrically 'deep' movements in the series, while the M-TAR model captures asymmetrically sharp or 'steep' movements.

Using TAR and M-TAR models, Enders and Siklos (2001) propose the following steps to test for threshold cointegration. In the first step, the following long-run equilibrium relationship is estimated:

$$p_t = c_0 + \beta P_t + \mu_t \qquad (3.19)$$

Where p and P are price of rice in two market pairs and μ is the disturbance term. In the next step, the following equation is estimated using Ordinary Least Squares (OLS):

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1 - I_t)\ \rho_2\mu_{t-1} + \sum_{i=1}^{k} \beta\Delta\mu_{t-i} + \varepsilon_t \qquad (3.20)$$

Where μ_t is the residuals series from equation (3.20), k is the lag length and I_t is the Heaviside indicator function such that:

$$I_t = \begin{cases} 1 \text{ if } \mu_{t-1} \geq \lambda \\ 0 \text{ if } \mu_{t-1} < \lambda \end{cases}$$ for TAR model and;

$$I_t = \begin{cases} = 1 \text{ if } \Delta\mu_{t-1} \geq \lambda \\ = 0 \text{ if } \Delta\mu_{t-1} < \lambda \end{cases}$$ for MTAR model

The lagged dependent variable values are added in order to ensure that the residuals are white noise. The lag lengths are selected using AIC and SBIC.

Finally, TAR and MTAR co-integration and adjustment process are specified as

$$\Delta\mu_t = \begin{cases} \rho_1\mu_{t-1} + \varepsilon_t & \text{if } \mu_{t-1} \geq \lambda \\ \rho_2\mu_{t-1} + \varepsilon_t & \text{if } \mu_{t-1} < \lambda \end{cases} \quad \text{For TAR model} \qquad (3.21)$$

And

$$\Delta\mu_t = \begin{cases} \rho_1\mu_{t-1} + \varepsilon_t & \text{if } \Delta\mu_{t-1} \geq \lambda \\ \rho_2\mu_{t-1} + \varepsilon_t & \text{if } \Delta\mu_{t-1} < \lambda \end{cases} \quad \text{For MTAR model} \qquad (3.22)$$

Where λ is the threshold value; ρ_1 and ρ_2 are the speeds of adjustment parameters to be estimated. The sufficient condition for the stationarity of $\{\mu t\}$ is $-2< (\rho_1, \rho_2) <0$

According to Enders & Granger (1998), the convergence to equilibrium is the point where $\Delta\mu_t = 0$. When $\mu_{t-1}=\lambda$, $\Delta\mu_t =0$. Note that adjustment is symmetric if $\rho_1=\rho_2$; if $\rho_1\neq\rho_2$, the adjustment process is asymmetric.

The null hypothesis tested in the threshold model: $\rho_1 = \rho_2 = 0$ that is, there is no threshold cointegration. It is tested using t-statistic following (Enders & Siklos, 2001). If the null hypothesis of no threshold cointegration is rejected, then a standard F-test of symmetric adjustment can be performed by testing if $\rho_1=\rho_2$. If both null hypotheses $\rho_1 = \rho_2 = 0$ and $\rho_1=\rho_2$ are rejected it implies threshold cointegration and asymmetric adjustment (meaning price pairs exhibit nonlinear adjustment).

Using AIC and SBIC, the number of lags k to include in the TAR and M- TAR models was also selected. The optimal threshold value λ minimizing the residuals sums of squares was estimated using Chan's (1993) method.

$\rho_1 < \rho_2$ implies positive asymmetry exists while $\rho_1 > \rho_2$implies negative asymmetry exists. Given the alternative models, model selection procedures such as the AIC and BIC provides a basis for choosing between TAR and MTAR. A model with the lowest AIC and BIC should be preferred (Acquah, 2012).

3.6.3 Granger Causality Equation

The usual ordinary least squares (OLS) model only identifies the correlation between variables; it does not help in determining the direction of the relationship. While causality is an elusive concept that can never be proved with certainty, time-series econometrics can help sort out these timing issues. If changes in P precede changes in p, we can rule out p causing P.

$$p_t = \alpha_0 + \sum \beta_t p_{t-1} + \sum \gamma_t P_{t-1} + \mu_t \tag{3.23}$$

Where p is the price in market one and P is the price in market two. If past values of P help to determine current values of p, P Granger causes p. The test of H_0: $\gamma_t = 0$ can be carried out with an F test. To test for the direction of causation, the Granger causality model in error correction was estimated:

$$\Delta p_t = \alpha + \sum_{j=1}^{n} \beta_t \Delta p_{t-1} + \sum_{j=1}^{n} \gamma_t \Delta P_{t-1} + \mu_t \tag{3.24}$$

Where p_{t-1} a lagged difference of the dependent variable at time t is, P_{t-1} is the lagged difference of the independent variable at time t. The null hypothesis is $\gamma_t = 0$ versus the alternative hypothesis that$\gamma_t \neq 0$. If the coefficient γ_t is significant, then P causes p. To calculate the magnitude of causality $\sum \gamma_t$ represents a short-run effect of P. Since there is a feedback effect from lags of p in the long run, the long-run effect is$\sum \gamma_t / (1 - \sum \beta_t)$.

3.7 Assumptions

Threshold autoregressive models recognize thresholds, caused by transactions costs that deviations must exceed before provoking equilibrating price adjustments which lead to market integration. Threshold effects occur when larger shocks (shocks above some threshold) bring about a different response than do smaller shocks. The resulting dynamic responses may involve various combinations of adjustments from alternative regimes defined by the thresholds (Goodwin & Piggott, 2001). These models incorporate transaction cost by allowing for a different relationship between variables once a certain threshold has been surpassed (Van Campenhout, 2006 in Abidoye & Labuschagne, 2014). Threshold models are better able to capture the dynamics of the arbitrage process underlying that markets are connected. According to Enders (2015), threshold autoregressive (TAR) models of the type developed by Tong (1983, 1990) can be estimated using ordinary least square (OLS).

3.8 Tools of Data Analysis

This study used descriptive and inferential statistics in the analysis. To analyze the data, software package such as Stata 12.0 and R 3.2.4 were used; and TAR and MTAR model were used in this study. The sample size of this study was constituted by 171 observations because the time series data involved monthly price from June 2001 to August 2015.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter presents the study findings. A descriptive analysis of the variables used in the study is presented in Section 4.2. Thereafter stationarity and cointegration test results are presented and discussed thematically based on each objective. Section 4.3 and section 4.4 report the short run and long- run domestic price relationships and nature of price transmission respectively in four major domestic rice markets in Burundi. The extent of price transmission between Burundi rice market and the world rice market are given in section 4.5.

4.1 Descriptive Statistics of Rice Prices

This section gives the descriptive statistics. As noted in chapter three, five rice price series (Bujumbura, Muyinga, Gitega, Ruyigi and World) were used in the study. The prices were measured in USD per kilogram of rice.

Figure 4.1 shows a plot of the five prices series for the period June 2001 to August 2015. The graph shows that there was tendency of co-movement of price series during the period of the study. The lowest domestic price was recorded by Ruyigi in July 2002 and the highest was recorded by Muyinga in March 2012 where there was a peak in the domestic rice markets. This sharp increase of price at domestic markets was caused by the poor weather conditions.

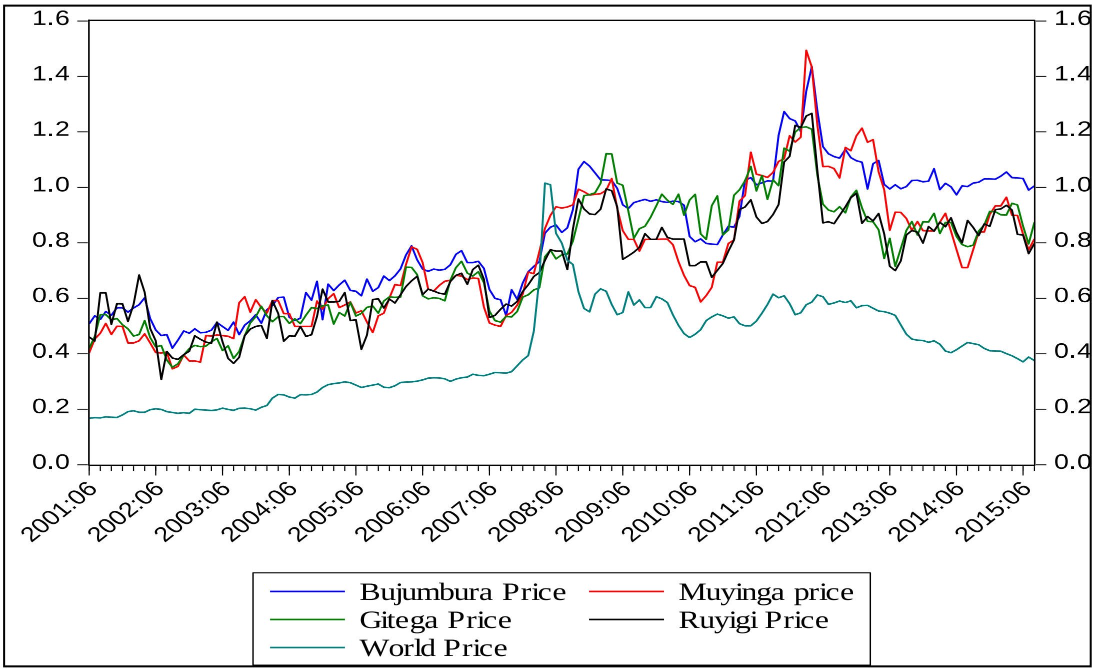

Figure 4.1: Price Levels across Time by Market from June 2001 to August 2015 in USD

Source: Research Findings, 2016

As discussed above, it was in April-May 2008 where world price was above the domestic price in Burundi due to the world financial crisis. It can be seen that the domestic price series did not respond to the sharp price increase at the same rate because financial system of Burundi being a developing country is not integrated with the international finance. However, after that sharp world price increase in April-May 2008, the shock was transmitted to the domestic market gradually as it can be seen from the graph.

Table 4.1 shows the summary of monthly price series. The descriptive statistics outlined include: mean, maximum, minimum and standard deviation for each of the five price series. Bujumbura market recorded the highest mean at 0.8138 USD followed by Muyinga at 0.7439 USD.

Table 4.1: Descriptive Statistics of rice Prices (June 2001-August 2015 period)

Measures	Bujumbura	Muyinga	Gitega	Ruyigi	World
Observations	171	171	171	171	171
Mean	0.8138	0.7439	0.7367	0.7123	0.4076
Standard Deviation	0.2332	0.2376	0.2173	0.1952	0.1716
Minimum	0.4201	0.3459	0.3509	0.3077	0.1677
Maximum	1.435	1.4942	1.2185	1.2665	1.0152

Source: Research Findings, 2016

Muyinga and Bujumbura recorded almost the same standard deviation at 0.2376 USD and 0.2332 USD respectively. Ruyigi market recorded the lowest mean and standard deviation for domestic price series at 0.7123 USD and 0.1952 USD respectively. The highest price recorded in the study period was 1.4942 USD in Muyinga market while the minimum price was 0.3077 USD in Ruyigi market without taking into account the world price. The World price recorded the lowest mean, standard deviation, maximum as well as minimum price compare to the domestic rice markets. It was almost half of the domestic price except in 2008 where world price increased sharply due to world financial crisis.

4.2 Price Relationship in Major Domestic Rice Markets in Burundi

The first objective sought to identify the short run and long run price relationship in major domestic rice Market in Burundi. The following sub-section presents the results of unit roots tests.

4.2.1 Unit Root Tests

A summary of the results of ADF and PP unit roots tests at 5 per cent significance level is given in table 4.2. The results showed that all variables were not stationary at levels but were all stationary at first difference. Therefore, the series under the study were at (first) difference stationary processes that is they have unit root (*I (1)).* The lack of stationarity at level laid the basis for cointegration tests in the next section.

Table 4.2: Unit Root Tests Results

Markets	Levels			First-differences		
	ADF	PP	Conclusion	ADF	PP	Conclusion
Buj.	-2.601	-1.458	Nonstat.	-12.734***	-12.782***	Stationary
Muyinga	-2.207	-2.031	Nonstat.	-11.206***	-11.208***	Stationary
Gitega	-2.486	-1.857	Nonstat.	-12.416***	-12.436***	Stationary
Ruyigi	-3.292	-2.2034	Nonstat.	-11.853***	-11.83***	Stationary
World	-1.588	-2.079	Nonstat.	-8.149***	-7.789***	Stationary

Note: The null hypothesis of these tests is that the time series has a unit root or non stationarity. ***denotes rejection of the null hypothesis of unit root at 1 percent. The critical values for Augmented Dickey-Fuller were -4.017 at 1% and -3.441 at 5%. The critical values for Phillips-Perron unit root test were -3.487 at 1% and -2.885 at 5%. P – Value is the MacKinnon (1999) p – value test. Nonstat. and buj denote nonstationary and Bujumbura respectively.

Source: Research findings, 2016

4.2.2 Johansen Cointegration Test

Since all price series were (*I(1))* processes, they could not be estimated using ordinary regression as this would lead to spurious regression. With evidence that the price series were not stationary at level, the study proceeded to establish whether the variables were related in the long run using Johansen's cointegration technique (Yaffee & McGee, 2000). Before performing Johansen cointegration test, it was necessary to select the optimum lag length. According to Uchezuba (2010), the optimum lag lengths should ensure randomness in the error term yet leave sufficient degrees of freedom. The aim of determining the best lag length is to remove the autocorrelation in the series so that the error term becomes white noise process. A short lag length introduces autocorrelation while too many lag lengths consume degrees of freedom (Gujarati, 2003). Proper lag estimation ensures that the model is correctly specified. It is not uncommon for agricultural product prices to be affected by their past values (Chepng'eno, 2015). Table 4.3 shows the results for optimal lag selection process. The optimum lag length was identified to be two by the majority of methods.

Table 4.3 Selection of Optimum Lag Length

Lag	LR	FPE	AIC	HQIC	SBIC
0		2.20E-09	-8.59845	-8.53783	-8.44909
1	810.61	2.00E-11	-13.2608	-13.0789	-12.8127*
2	61.86	1.7e-11*	-13.4396*	-13.1365*	-12.6928
3	28.661*	1.70E-11	-13.4196	-12.9953	-12.3741
4	13.682	2.00E-11	-13.3099	-12.7643	-11.9656

Note: * indicates lag order selected by criterion.

Source: Author's Own Computation, 2016

The next step was to determine the number of cointegrating relationships which was found to be two as it can be seen in table 4.4.

Table 4.4: Johansen Tests for Cointegration

Trend: Constant

Number of observation = 169

Sample: 2001m8 - 2015m8
Lags = 2

Rank	Parameters	LL	Eigenvalue	Trace Statistic	5% Critical Value
r=0	20	1121.018	.	90.1166	47.21
r=1	27	1148.511	0.27773	35.1315	29.68
r=2	32	1159.945	0.12655	12.2644*	15.41
r=3	35	1164.997	0.05804	2.1601	3.76
r=4	36	1166.077	0.0127		

Note: H_0: no cointegration. r denotes the number of cointegrating relationships. * indicates number of cointegration relationship.

Source: Research findings, 2016

The null hypothesis of the absence of one cointegration relation between the variables was rejected by the trace statistic test. From the tests result, it was concluded that rice markets in Burundi contain two cointegrating relations. It therefore means that Bujumbura, Muyinga, Gitega, and Ruyigi prices were cointegrated, meaning that both prices move together in the long run. The presence of two cointegrating relationship implied that there was two long run relationships (equilibriums) existing among the four price series.

The presence of cointegrating relationship means that the four price series converge towards equilibrium in the long run even though they may deviate in the short run. Thus, it was important to estimate the speed at which the series adjust to equilibrium following a shock.

Based on Johansen cointegration results, a vector error correction model was estimated to assess the short run dynamics. The speed of adjustment to long run equilibrium was 9.8 percent for Gitega market. This indicates a feedback of 9.8 % of the previous month's disequilibrium from the long-run elasticity of rice price transmission. This implies that the speed with which prices in domestic markets adjust from short-run disequilibrium to changes in price in Gitega in order to attain long- run equilibrium is 9.8% within one month. The speed of adjustment was found to be small due to asymmetric information and market power in the marketing system. The coefficient was negative and significant at 5 percent level as expected. The speed of adjustment was about 60 percent for Ruyigi market implying that the price in this market adjusts fast to shock than other markets. This may explain the reason why Ruyigi market recorded the lowest price series in the period under study.

Table 4.5: Vector Error Correction Model for Domestic Market

Dependent Variable	independent Variable	coefficient	Standard error	Z statistic
D_Gitega	CE1	-.0986274**	0.0455327	-2.17
	CE2	-.0987899***	0.0338444	-2.92
	Gitega LD	-0.0716469	0.0825861	-0.87
	Muyinga LD	.2954226***	0.081672	3.62
	Bujumbura LD	-0.0834498	0.0977132	-0.85
	Ruyigi LD	.1961774**	0.0813021	2.41
	Constant	0.0014598	0.0036668	0.4
D_Bujumbura	CE1	-.131374**	0.063337	-2.07
	CE2	.0699348**	0.0301645	2.32
	Bujumbura LD	-.1860412**	0.087089	-2.14
	Muyinga LD	.1578274**	0.0727919	2.17
	Gitega LD	0.1120118	0.0736066	1.52
	Ruyigi LD	.1613287**	0.0724623	2.23
	Constant	0.0026224	0.0032681	0.8
D_Muyinga	CE1	-0.0278203	0.0386593	-0.72
	CE2	-0.02865	0.0520105	-0.55
	Muyinga LD	492886	0.0932912	0.53
	Gitega LD	.3249552***	0.0943353	3.44
	Bujumbura LD	-0.0932401	0.1116144	-0.84
	Ruyigi LD	0.1246459	0.0928686	1.34
	Constant	0.0012511	0.0041884	0.3
D_Ruyigi	CE1	-.6035879***	0.0902454	-6.69
	CE2	.3128991***	0.0765029	4.09
	Ruyigi LD	.1957802**	0.087525	2.24
	Bujumbura LD	0.0435665	0.1051921	0.41
	Muyinga LD	.2495487***	0.0879232	2.84
	Gitega LD	.160911*	0.0889072	1.81
	Constant	-0.0001661	0.0039474	-0.04

Note: ***, ** significant at 1% and 5% level. LD is lag difference, Det (Sigma_ml) = 0.0000. Log likelihood = 1159.944

Source: Research findings, 2016

The coefficients were tested to check whether they jointly cause short run adjustment following a shock. It was found that all coefficients were jointly significant at 5 percent level meaning that there was short run adjustment. However, error correction term for Muyinga Market was found to be positive and not significant at 5% level implying that the shocks were not corrected to long run equilibrium. If there is not a significant adjustment coefficient, this aspect means that the short-run equation does not adjust to deviation from the long-run equilibrium, that is, it is montly exogenous on long-run. This may be one of the reasons why rice price in Burundi are increasing given the role played by Muyinga rice market as a main producer market and main transit market of rice imported from Tanzania.

4.2.3 Granger Causality Test

Cointegration on its own can't be used to understand the direction of price transmission and thus causality tests are necessary (Rapsomanikis *et al.*, 2003 in Chepng'eno, 2015). Granger causality tests do not only confirm cointegration but also show the direction of price transmission between two price series.

Granger causality tests were performed on each market pair and the results were presented in table 4.6. The null hypotheses of no Granger causality were rejected in seven market pairs and the other five market pairs failed to reject it. The results suggest that Muyinga market Granger causes Bujumbura, Gitega and Ruyigi at one per cent level of significance. Gitega market Granger causes Muyinga at one per cent level of significance and Bujumbura and Ruyigi at five and ten per cent level of significance respectively.

Table 4.6: Granger Causality Tests

Price	ΔBujumbura	ΔMuyinga	ΔGitega	ΔRuyigi
ΔBujumbura		1.3712	1.6791	4.2116
ΔMuyinga	10.3036***		13.5397***	12.4387***
ΔGitega	6.4056**	10.7021***		5.3016*
ΔRuyigi	4.4586	3.8349	26.2736***	

Note: H0: No Granger causality. ***; **; * Significant at 1 percent, 5 percent and 10 percent levels respectively of Granger causality tests.

Source: Research findings, 2016

Ruyigi Granger causes Muyinga but Bujumbura Market does not Granger cause any other market. This implies unidirectional causality from Muyinga to Bujumbura and Ruyigi prices, and from Gitega to Bujumbura price. Granger causality was bidirectional for Muyinga and Gitega price, and Gitega and Ruyigi price. In other word, Muyinga market causes price formation in Bujumbura, Gitega and Ruyigi market but Bujumbura market does not cause any price formation in other markets.

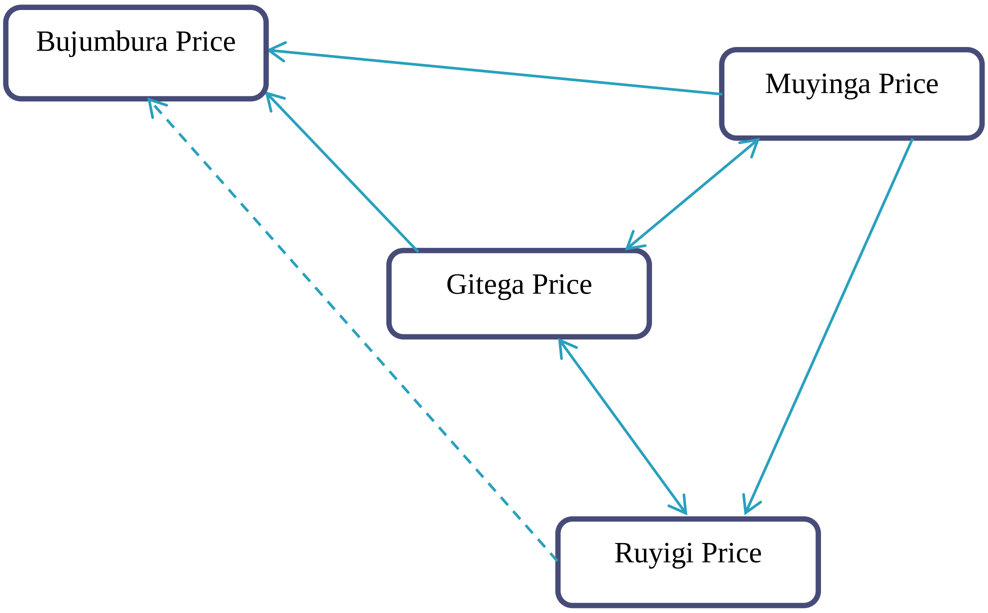

Figure 4.2: Granger Causality in Domestic Markets

Source: Author's Own Conceptualization, 2016

Overall, the most prices related markets were Gitega and Muyinga as they transmit their price movement to both markets. Based on these results, in the short run, Gitega and Muyinga markets could be said to occupy leadership position in rice price formation and transmission in the other three markets. Hence, the study concluded that Gitega and Muyinga are the price leaders while Bujumbura is price follower. In other word, Muyinga which is a producer market plays a leading role in price formation of rice market in Burundi but also bordering Tanzania where the most imported rice transit to may be the second reason. The reason why Gitega plays a leading role in price formation while being a consumer market is its geographical location in the central of Burundi which makes it trade with others domestic markets as main wholesaler market. Another reason is that Gitega is a second biggest town in Burundi after Bujumbura. In general, price in Bujumbura is influenced by both three other markets although Ruyigi market does not have a direct influence but it has an indirect influence by influencing Gitega price which is its nearby market.

The study analyzed short and long-run spatial rice retail price relationships between markets in Burundi. The first hypothesis of the study stated that there is no short run and long run relationship between spatial separate retail rice markets in Burundi. Results indicated that there was short run and long run relationship between spatial separate retail rice markets in Burundi. Johansen cointegration test revealed that there were two cointegrating relations. This implied that the dynamics of price of rice was explained by two cointegrating equations. Based on these results the first hypothesis of no short and long run relationship between domestic markets was rejected. Therefore it was concluded that there was short run and long run relationship between spatial separate retail rice markets in Burundi.

4.3 Price Transmission in Major Domestic Rice Markets Using Nonlinear Model

The second objective sought to analyse the nature of price transmission in major domestic rice markets in Burundi. As noted in table 4.2, the price series in all markets were non stationary and the unit root tests showed that the prices were (*I(1))* processes. Two related models; TAR and MTAR were employed in the investigation.

Tables 4.7 and 4.8 present the results of threshold cointegration test between domestic market pairs (producer and consumer markets) namely, Bujumbura, Muyinga, Gitega and Ruyigi, using TAR and M-TAR models. Gitega, the second major town in Burundi and being in the central of the country, was taken as a price leader as well as Muyinga which is producer market. Bujumbura is the main consumer market of rice opposing Ruyigi which is mainly producer market.

Two hypotheses were used to test for cointegration and nature of price adjustment under the TAR and M-TAR models. The first null hypothesis was: $H1$: $\rho_1 = \rho_2 = 0$ of no cointegration between market pairs and the second null hypothesis was: $H2$: $\rho_1 = \rho_2$ of symmetry adjustment between market pairs.

The results of the TAR and M-TAR models are shown in table 4.7 and table 4.8 respectively. The optimal threshold value λ minimizing the residuals sums of squares was estimated using Chan's (1993) method. For the TAR model for instance the estimated threshold value is $\hat{\lambda} = -0.064$ for Bujumbura-Muyinga, $\hat{\lambda} = -0.069$ for Bujumbura-Gitega, $\hat{\lambda} = -0.045$ for Gitega-Muyinga as it can be seen in table 4.7. For the M-TAR model, the estimated threshold value for each market pairs is reported in table 4.8. The results in tables 4.7 and 4.8 indicate also that Ljung-Box Q-statistics fail to reject the null hypothesis of no serial correlation at 5 % level of significance for both TAR and M-TAR models.

Table 4.7: Threshold Cointegration Test Results with the TAR Model for Domestic Markets

Market pairs	Bujumbura-Muyinga	Bujumbura-Gitega	Gitega-Muyinga	Gitega-Ruyigi	Ruyigi-Muyinga
ρ_1	-0.093	-0.053	-0.099	-0.438***	-0.252***
	(0.061)	(0.070)	(0.053)	(0.083)	(0.069)
ρ_2	-0.319***	-0.264***	-0.156**	-0.333***	-0.361***
	(0.069)	(0.077)	(0.068)	(0.090)	(0.088)
Φ* statistic	11.873***	5.898***	4.175***	20.779***	14.990***
F-Statistics	6.050***	4.711**	0.452	0.727	0.939
λ	-0.064	-0.069	-0.045	0.060	-0.077
Aic	-547.978	-511.234	-510.053	-476.906	-506.406
Bic	-538.570	-492.526	-497.533	-467.498	-496.998
LB (4)	0.807	0.995	0.252	0.152	0.334
LB(8)	0.660	0.824	0.235	0.213	0.872
Lags	0	3	1	0	0

Notes: λ is the estimated threshold value. Between the parentheses (.) are the standard errors. ** and *** denote rejection of the null hypothesis respectively at 5% and 1% level. Φ is the threshold cointegration test statistic. F-statistic is the test for symmetry adjustment. The values presented for Ljung-Box (LB) test are the p-values. The lag length used was selected using AIC and SBIC.

Source: Research findings, 2016

Table 4.8: Threshold Cointegration Test Results with the M-TAR Model for Domestic Markets

Market pairs	Bujumbura-Muyinga	Bujumbura-Gitega	Gitega-Muyinga	Gitega-Ruyigi	Ruyigi-Muyinga
ρ_1	-0.145***	-0.076	-0.061	-0.441***	-0.198***
	(0.056)	(0.070)	(0.048)	(0.069)	(0.074)
ρ_2	-0.294***	-0.244***	-0.303***	-0.206	-0.406***
	(0.083)	(0.081)	(0.082)	(0.127)	(0.080)
Φ* statistic	9.716***	4.879***	7.525***	21.587***	16.544***
F-Statistics	2.237	2.756*	6.848**	2.623	0.057
λ	-0.031	-0.031	-0.038	-0.046	-0.012
Aic	-540.092	-509.264	-516.424	-475.392	-506.029
Bic	-530.702	-490.556	-503.905	-466.002	-496.639
LB (4)	0.821	0.999	0.434	0.124	0.869
LB(8)	0.628	0.861	0.374	0.184	0.942
Lags	0	3	1	0	0

Notes: λ is the estimated threshold value. Between the parentheses (.) are the standard errors. ** and *** denote rejection of the null hypothesis respectively at 5% and 1% level. Φ is the threshold cointegration test statistic. F-statistic is the test for symmetry adjustment. The values presented for Ljung-Box (LB) test are the p-values. The lag length used was selected using AIC and SBIC.

Source: Research findings, 2016

Using AIC and SBIC, the number of lags k to include in the TAR and M- TAR models was also selected. For the TAR model, out of a maximum of 12 lags, AIC selects a lag of 0 for Bujumbura-Muyinga, Gitega-Ruyigi and Ruyigi-Muyinga, a lag of 1 for Gitega-Muyinga and a lag of 2 for Bujumbura-Gitega. It should be noted that for the MTAR model, AIC and SBIC select also the same lags. The study took into account the estimated threshold value and optimal lag length selected to test for threshold cointegration between market pairs in Burundi.

Threshold cointegration tests results based on the TAR model are reported in table 4.7. They indicate that the Φ test statistic rejects the null hypothesis of no threshold cointegration at 1% level of significance for both Burundian market pairs. The estimated TAR model for Bujumbura-Muyinga market can be written as follow with standard error in parentheses:

$$\Delta\hat{\mu}_t = -0.093 I_t \hat{\mu}_{t-1}(0.061) - 0.319(1 - I_t)\hat{\mu}_{t-1}(0.069) + \varepsilon_t \qquad (4.1)$$

Where $I_t = \begin{cases} 1 \text{ if } \hat{\mu}_{t-1} \geq -0.064 \\ 0 \text{ if } \hat{\mu}_{t-1} < -0.064 \end{cases}$

Based on the M-TAR model, the results of threshold cointegration are reported in table 4.8. They show that the null hypothesis of no threshold cointegration can be rejected at 1% level of significance for all Burundian market pairs. The estimated M-TAR model for Bujumbura-Muyinga market pair can be written as follows with standard error in parentheses.

$$\Delta\hat{\mu}_t = -0.145 I_t \hat{\mu}_{t-1}(0.056) - 0.294(1 - I_t)\hat{\mu}_{t-1}(0.083) + \varepsilon_t \qquad (4.2)$$

Where $I_t = \begin{cases} 1 \text{ if } \Delta\hat{\mu}_{t-1} \geq -0.031 \\ 0 \text{ if } \Delta\hat{\mu}_{t-1} < -0.031 \end{cases}$

Together, table 4.7 and 4.8 indicate that the null hypothesis of no threshold cointegration is rejected for all Burundian market pairs at 1% level of significance (Φ* statistic) for both TAR and M-TAR models implying that all market pairs converged to equilibrium in the long-run. The long run cointegration equations are reported in table 4.9.

Table 4.9: Result of Threshold Cointegration in Domestic Markets Using TAR and MTAR

Market Pairs	Equations
Bujumbura-Muyinga	$\hat{P}_{Bt} = 0.129 + 0.921\hat{P}_{Mt} + \mu_t$ (0.020) (0.026)
Bujumbura-Gitega	$\hat{P}_{Bt} = 0.073 + 1.005\hat{P}_{Gt} + \mu_t$ (0.022) (0.029)
Gitega-Muyinga	$\hat{P}_{Gt} = 0.130 + 0.815\hat{P}_{Mt} + \mu_t$ (0.025) (0.032)
Gitega-Ruyigi	$\hat{P}_{Gt} = -0.009 + 1.047\hat{P}_{Rt} + \mu_t$ (0.022) (0.029)
Ruyigi-Muyinga	$\hat{P}_{Rt} = 0.149 + 0.757\hat{P}_{Mt} + \mu_t$ (0.019) (0.025)

Note: between parentheses are standard errors. μ_t is error term.

Source: Research findings, 2016

The results suggest therefore that there is a positive long-run relationship between domestic markets. For Bujumbura-Muyinga Market 10 % price increase in Bujumbura market causes 9% increase in Muyinga market in the long-run.

Given that the price series are cointegrated, the null hypothesis of symmetric adjustment (ρ_1=ρ_2) can be tested using a standard F-distribution. The results indicate that $\rho_1 \neq \rho_2$ in all Burundian market pairs. Therefore, the point estimates of ρ_1 and ρ_2 for Bujumbura-Muyinga markets (as an example) in the TAR model are -0.093 and -0.319, respectively. These values suggest that approximately 9 percent of a positive deviation and 32 percent of a negative deviation from the long-run equilibrium relationship are eliminated within a month. This implies 91 percent and 68 percent of positive and negative discrepancies from the equilibrium would still persist in the following months.

Test for symmetric adjustment $\rho_1 = \rho_2$ for each market pairs using the F-distribution produced sample value of 6.050 for Bujumbura-Muyinga market, 4.711 for Bujumbura-Gitega market in TAR model. However, the estimated F-values for the remaining domestic market pairs were not significant in TAR model. The results of this test are reported in table 4.7.

M-TAR model result also suggests that all value of positive deviation were different from the value of negative deviation in the all domestic market pairs. The F - values were 6.848 for Muyinga-Gitega and 2.756 for Bujumbura- Gitega, significant at 5 percent and 10 percent respectively. F-values were not significant in other market. The results of this test are reported in table 4.8 for M-TAR.

Since both the TAR and M-TAR models suggest asymmetric adjustment mechanism for the series, it would be interesting to ascertain whether adjustment follows a TAR or M-TAR process. For such a test, Enders & Granger (1998) and Enders & Siklos (2001) suggest using the SBIC or AIC test values to select the model with the best overall fit. As is evident in Table 4.7 and 4.8, the TAR model yields the lowest SBC and AIC and is therefore preferable to the M-TAR model for explaining asymmetric adjustment in domestic rice market pairs. M-TAR model yields the lowest SBIC and AIC for Gitega-Muyinga market pairs where it was preferable to TAR model.

The results suggest therefore that all market pairs in Burundi were cointegrated with asymmetric adjustment. The evidence provided in this section indicated that the transmission of price changes in domestic markets in Burundi displays some asymmetry. The study concluded that the null hypothesis of symmetry adjustment was rejected meaning that the nature of price transmission in domestic market was asymmetric. Moreover, domestic markets pairs suggest much faster adjustments in response to negative shocks (such as price increase) than positive shocks (such as price decrease). The threshold cointegration models revealed that domestic market pairs respond more swiftly to price increase than to price decrease. This finding corroborate Abdulai (2000)’s research findings. The results of his study indicate that major maize markets in Ghana were well integrated and that wholesale maize prices in local markets respond faster to price increase than to price decrease in central market. In the same line, Abdulai (2002) found that price transmission between the producer and retail levels in Swiss pork market was asymmetric, in the sense that increases in producer prices that lead to declines in marketing margins are passed on more quickly to retail prices than decreases in producer prices that result in increases in the marketing margins.

4.4 Extent of World Price Transmission to Domestic Rice Market

The third objective sought to analyse the extent of price transmission between domestic rice market in Burundi and the world market. The nature of price transmission between world and Burundi prices was examined.

Burundi has become very much dependent on food import and food aid to meet its food availability and nutrition needs while it was self-sufficient in food production before 1990's. Due to the given increase of Value Added Tax (VAT) on imported commodities and fuel price volatility, the price for food import are high which renders commodities inaccessible to the majority of the population especially the rural and urban poor (Ndayitwayeko *et al.*, 2014). The agreement on EAC common market and the trade liberalization has resulted in massive food imports that may weaken the agricultural production capacity and in the long-term may cause poverty to farmers in general and rice producers in particular (Ndayitwayeko *et al*., 2012). Rice is one of the commodities which has noticed a high increase on importation due to the increasing demand for the commodity. As it is seen in figure 4.1, the world rice price is low compare to price in domestic market but it is not reflected at domestic market. At domestic market, the imported rice is sold at a high price due to some cost of adjustment, market power and asymmetric marketing information.

This section investigates analysis of the extent of price transmission between Burundi rice price and world price. As noted in table 4.2, the price series in all markets were non stationary and the unit root tests showed that the prices were (*I (1)).* Two related models; TAR and MTAR were employed in the investigation.

Tables 4.10 presents the results of threshold cointegration model for Burundi-world market pair. Two hypotheses were used to test for threshold cointegration and nature of price adjustment under the TAR and MTAR models. The first null hypothesis was: $H1$: $\rho_1 = \rho_2$ = 0 of no threshold cointegration between market pairs and the second null hypothesis was: $H2$: $\rho_1 = \rho_2$ of symmetry adjustment between market pairs.

The results of the TAR and MTAR models are shown in table 4.10. The optimal threshold value λ minimizing the residuals sums of squares was estimated using Chan's (1993) method. For the TAR model the estimated threshold value is $\hat{\lambda} = 0.15$ for Burundi-World prices. The estimated threshold value for MTAR model is reported in table 4.10. Threshold cointegration tests results based on the TAR model are reported in table 4.10. They indicate that the Φ test statistic rejects the null hypothesis of no threshold cointegration at 1% level of significance for Burundi-world market pair.

Table 4.10: Threshold Cointegration Test Results with the TAR and M-TAR models (Burundi and World Markets)

Market pairs	TAR Burundi-World	MTAR Burundi-World
ρ_1	-0.04	-0.157***
	(0.047)	(0.040)
ρ_2	-0.123***	-0.002
	(0.039)	(0.045)
Φ* statistic	5.173***	7.769***
F-Statistics	1.878	6.821**
λ	0.15	0.009
Aic	-479.302	-484.206
Bic	-466.783	-471.687
LB (4)	0.951	0.675
LB(8)	0.573	0.246
Lags	1	1

Notes: λ is the estimated threshold value. Between the parentheses (.) are the standard errors. *, ** and *** denote rejection of the null hypothesis respectively at 10%, 5% and 1% level. Φ is the threshold cointegration test statistic. F-statistic is the test for symmetry adjustment. The values presented for Ljung-Box (LB) test are the p-values. The lag length used was selected using AIC and SBIC.

Source: Research findings, 2016

The estimated TAR model for Burundi-World market pair can be written as follows with standard error in parentheses:

$$\Delta\hat{\mu}_t = -0.04 I_t \hat{\mu}_{t-1}(0.047) - 0.123(1 - I_t)\hat{\mu}_{t-1}(0.039) + 0.191\Delta\hat{\mu}_{t-1}(0.076)$$

(4.3)

Where $I_t = \begin{cases} 1 \text{ if } \hat{\mu}_{t-1} \geq 0.15 \\ 0 \text{ if } \hat{\mu}_{t-1} < 0.15 \end{cases}$

Based on the M-TAR model, the results of threshold cointegration are reported in table 4.10. They show that the null hypothesis of no threshold cointegration can be rejected at 1% level of significance for Burundi-World market pairs. The estimated MTAR model for Burundi-World market pair can be written as follows with standard error in parentheses.

$$\Delta\hat{\mu}_t = -0.157 I_t \hat{\mu}_{t-1}(0.040) - 0.002(1 - I_t)\hat{\mu}_{t-1}(0.045) + 0.155\Delta\hat{\mu}_{t-1}(0.075)$$

(4.4)

Where $I_t = \begin{cases} 1 \text{ if } \Delta\hat{\mu}_{t-1} \geq 0.009 \\ 0 \text{ if } \Delta\hat{\mu}_{t-1} < 0.009 \end{cases}$

Table 4.10 indicates that the null hypothesis of no threshold cointegration is rejected for Burundi-World market pairs at 1% level of significance for both TAR and M-TAR models. The results of the test for the long-run equilibrium (Φ* statistic) suggest that Burundi-World market pairs converge to equilibrium in the long-run. All coefficients were significant at 1% level of significance. This implies that even though the price adjustment was asymmetric, it goes back to equilibrium in the long-un. The estimated equation for Burundi-world market pairs was as follow:

$$\hat{p}_{Bt} = 0.390(13.097) \quad + 1.041(15.463)\hat{P}_{Wt} \qquad (4.5)$$

There was a positive relationship between Burundi Price and World Price.

Given that the price series are cointegrated, the null hypothesis of symmetric adjustment ($\rho_1 = \rho_2$) can be tested using a standard F-distribution. The results indicate that $\rho_1 \neq \rho_2$ in Burundi-World market pair for both TAR and MTAR models. Therefore, the point estimates of ρ_1 and ρ_2 for Burundi-World markets pairs in the TAR model are -0.04 and -0.123, respectively. The result indicate that Burundi market responds more faster to price increase in World price than to price decrease in the world market for TAR model while Burundi price responds faster to price decrease in World price than to price increase for MTAR model . For MTAR model the point estimates of ρ_1 and ρ_2 are reported in table 4.10. The speed of adjustment is small meaning that they are some cost of adjustment.

Test for symmetric adjustment $\rho_1 = \rho_2$ for Burundi-World market pair using the F-distribution produced sample value of 6.821 for Burundi-World Market pairs significant at 5 percent in M-TAR model. The sample value of F-test was not significant for TAR model. Thus, Model estimation results suggest that the M-TAR model detects asymmetry while TAR model fails to support this evidence.

Using the SBIC or AIC test values to select the model with the best overall fit, the result indicate that MTAR model yields the lowest SBIC and AIC and is therefore preferable to the TAR model for explaining asymmetric adjustment in World price and Burundi price.

It is therefore concluded that world price and Burundi price are cointegrated with asymmetric adjustment. The evidence provided in this section indicates that the transmission of price changes from world market to Burundi market displays some asymmetry. Thus, the null hypothesis of no price transmission was rejected, meaning that world price is transmitted to Burundi market with asymmetry adjustment. Moreover, price in Burundi adjust faster to positive shocks (such as price decrease) than to negative shocks (such as price increase) in world price in MTAR model which was preferable to TAR model. The results corroborate with (Acquah, 2012)'s research findings in price transmission between retail and wholesale prices of maize in Ghana. The results indicate that the retail and wholesale prices were cointegrated with threshold asymmetric adjustment. There was faster convergence to negative deviations from long-term equilibrium than for positive deviations implying that price increase tends to persist whereas decreases tend to revert quickly towards equilibrium.

McLaren (2015) studied asymmetric price transmission from international to local markets and find that there was asymmetric price transmission especially when prices fall but the model and data (yearly) used in the study were different from those used in this study. According to Abidoye and Labuschagne (2014) the relationship between South African price and world price for maize indicates the presence of nonlinearity in price transmission. Tuyishime (2014) investigated a study on assessment of world rice price transmission to domestic rice market in Rwanda. The findings indicated that rice markets in Rwanda are integrated to world rice markets with a high speed of adjustment. The results indicate how Rwanda, like Burundi, depends on food import and are price takers. However, the model used (VECM) could not detect the nature of price transmission.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

The purpose of this chapter is to give a synopsis of analytical findings from empirical study on market integration and price transmission of rice in Burundi for the period of June 2001-August 2015.This chapter is organized as follows: section 5.2 presents the summary of the main findings of the current study, section 5.3 and 5.4 present conclusion and recommendation respectively. Section 5.5 provides suggestion for further research.

5.1 Summary

The study aimed at analyzing market integration and price transmission of rice in Burundi. Secondary monthly data were collected from ISTEEBU, FAO and World Bank. Johansen, TAR and MTAR models were used as analytical tool to analyze the short and long run relationship between rice price in domestic markets, to examine the nature of price transmission between retail spatial separate rice markets and to estimate the extent of world price transmission to domestic markets. Descriptive statistics were used to give a picture of the data. Bujumbura market price was found to be high compare to other prices in domestic markets followed by Muyinga, Gitega and Ruyigi prices. This means that Ruyigi Market recorded the lowest price during the period of the study. The world price was lower than domestic prices except during the financial crisis in 2007-2008. The data were tested for presence of unit roots using ADF and PP unit root tests and were found to be integrated with order one (*I(1))*. The absence of unit roots justified cointegration tests which were done using Johansen, TAR and MTAR cointegration techniques.

Johansen cointegration test results indicated that there was at least two cointegrating equations implying that there exists a long run relationship between the price series. Short run relationship and speed of adjustment to equilibrium following a shock were also analyzed using the VECM. The sign and significance of the ECT coefficient confirmed the existence of a long run relationship among the four domestic prices series and the significance of the short –run coefficient provided evidence of short run relationship between domestic markets in Burundi. Granger causality tests indicated that Gitega and Muyinga were price leaders because they granger cause price formation in all other domestic markets. Bujumbura does not granger cause any market being a main rice consumer market in Burundi. Both TAR and MTAR models were involved in testing for threshold cointegration and the nature of price transmission. The result revealed that there is threshold cointegration and asymmetric adjustment between market pairs in Burundi. The adjustment following a shock was found to be faster when there is negative deviation than when there is positive deviation. Moreover, the findings indicate that Burundi rice market was cointegrated with world rice market and that the adjustment was asymmetric. Unlike domestic markets pairs, Burundi market adjust faster to positive deviations than to negative deviations in world price. TAR model was found to best fit the data for domestic markets while MTAR model was the best for Burundi-world market pair.

5.2 Conclusion

Johansen's cointegration test results indicate that prices in domestic markets converge in the long run and thus, the first null hypothesis that prices in domestic markets do not converge in the short run and in the long run was rejected at 5 percent significance level. The short run relationship captured by VECM model also confirmed convergence of the domestic price series even though correction back to equilibrium occurred at a slow rate with 10 percent of the deviations being corrected in a month. The negative and significant ECT coefficient further confirmed that the prices had a long run relationship.

The results of TAR and MTAR models indicate that there is threshold cointegration and asymmetric adjustment between market pairs in Burundi. The adjustment following a shock was found to be faster when there is negative deviation than when there is positive deviation. The second null hypothesis of no asymmetric price transmission in domestic markets in Burundi was rejected at 5 per cent significance level.

It has been pointed out that the market power and asymmetric marketing information flow are the measure factors that contribute to inefficient marketing (Karenzo and Mutoni, 2009) while agriculture sector is the mainstay of the economy of Burundi and rice constitutes an important food for the majority of population. There is a need to develop the marketing system, enhance price information flow and to stabilize price as an incentive to development in general and to production in particular. Burundi’s rice production has increased at 80 percent during the period of the study. This increase on production seems to have no significant impact on price of rice given the increasing price of this commodity.

TAR and MTAR models results reveal that Burundi rice market was cointegrated with world rice market and that the adjustment was asymmetric. The third null hypothesis of no price transmission between world price and domestic price was rejected at 1 per cent significance level.

The asymmetric price transmission in Burundi rice market may be one of the reasons why price of rice remained high at domestic market given the increase on production and import of rice. Hence, an increase in production should be accompanied by an efficient marketing so that the commodity would reach to the final consumer at an affordable price, thus lead to generation of profit to all participants in the market. Moreover, policy makers need to be informed on the ability of Burundi agricultural markets to respond to changes in international prices of agricultural commodities hence become more effective in developing strategies to address challenges raised by higher domestic prices. Before the 1993 war, Burundi was self-sufficient in most of the commodities and was exporting rice to neighboring countries (USAID, 2010). Hence, for the country to enjoy self-sufficiency in rice production and marketing there should be transmission of market information.

5.3 Recommendations

Based on the findings, the study recommends that the government of Burundi should improve the flow of information by putting into place a rice marketing board and reduce the asymmetric information in local rice markets so that the information needs of each agent are understood and made available. The government should strengthen the national bureau of statistics and make sure that data is available given the lack of data availability in Burundi. The daily statistics on price should be collected and published for availability and accessibility.

All stakeholders of rice sector should work in collaboration so that the rice can be available at affordable price. The NGOs, especially SRDI, which deal with rice sector, should extend their action in all producing areas to improve production and also the marketing information.

5.4 Suggestions for Further Research

The study focused on retail spatial price transmission, further research is required to include producer price, wholesale price and retail price. This may help to give more information in Burundi’s rice price transmission. Moreover, researches that can incorporate transaction costs and calculate the marketing margin are also needed in rice sector.

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APPENDICES

Appendix 1: Evolution of Rice's Production, Area Harvested and Yield in Burundi (2000-2013)

Year	Production (tons)	Area harvested (ha)	Yield (Hg/ha)
2000	51678	17000	30399
2001	60920	19000	32063
2002	62648	19200	32629
2003	61256	19500	31413
2004	64532	19600	32924
2005	67947	19900	34144
2006	68311	20500	33322
2007	70911	21000	33767
2008	70846	22000	32203
2009	78432	24000	32680
2010	83019	25500	32556
2011	91415	28200	32417
2012	64620	30711	21041
2013	41454	21670	19130

Source: FAOSTAT, 2015

Appendix 2: Evolution of Producer and consumer Price of rice in Burundi (2000/2013) in francs/kg

Year	Consumer Price (BIF/kg)	Producer Price (BIF/kg)
2000	520,7	200
2001	460,3	200
2002	421,4	202,5
2003	496,8	202,5
2004	583,3	221,2
2005	620,5	253,3
2006	686	285
2007	655	280
2008	967,7	375
2009	1109,8	585
2010	976	440
2011	1233,8	470
2012	1571,3	600
2013	1420,6	570

Source: ISTEEBU (Consumer price) and SRDI (Producer price), 2015

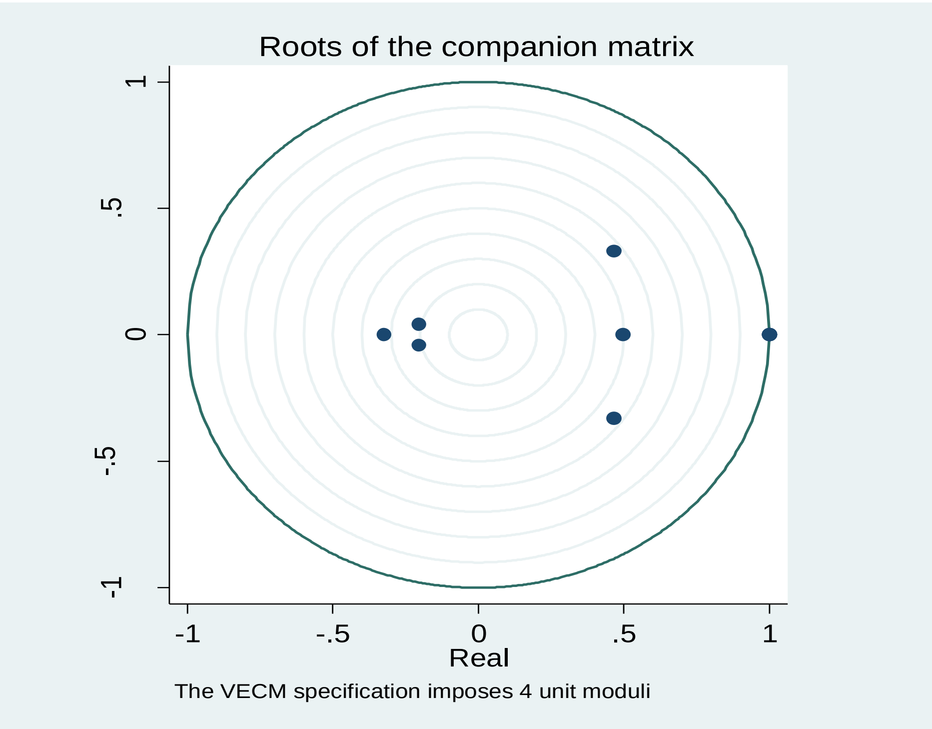
Appendix 3: Evolution of Rice Production and Imports in Burundi (2000-2013)

Year	Production quantity (tons)	Imports quantity (tons)
2000	51678	2909
2001	60920	3125
2002	62648	820
2003	61256	261
2004	64532	10856
2005	67947	5116
2006	68311	11137
2007	70911	7328
2008	70846	5499
2009	78432	11477
2010	83019	20455
2011	91415	8193
2012	64620	28549

Source: FAOSTAT, 2015

Appendix 4: Stability test of the time series (Roots of Companion Matrix)

The moduli of the companion matrix were all within the unit circle as shown in the following figure. This implies that the model was correctly specified.



Source: Research Findings, 2016

Appendix 4: Map of Burundi

Source: UN cartographic section, 2016