SPATIAL PRICE TRANSMISSION AND MARKET INTEGRATION OF SOME SELECTED LOCAL RICE MARKETS IN GHANA

BY

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MPHIL. AGRICULTURAL ECONOMICS DEGREE.

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DECLARATION

I, Berko Bernice Ofosua, author of this thesis titled "Spatial Price Transmission and Market Integration of some selected Local rice Markets in Ghana" do hereby declare that with the exception of the references duly quoted, this work was undertaken by me from August 2016 to July 2017 in the Department of Agricultural Economics and Agribusiness, University of Ghana, Legon. I do hereby declare that, this work has not been submitted in part or whole for a degree or diploma in this University or elsewhere.

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This thesis has been presented for examination with our approval as supervisors

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Dr. Akwasi Mensah-Bonsu	Mr. Ditchfield P.K Amegashie
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DEDICATION

This work is dedicated to God and my late father, Mr. Alfred Berko.

ABSTRACT

Movement of price within a country is of great significance to economists since it experiential evaluation of how a change in price in one local market can affect prices of a similar commodity in another local market. Usually, due to poor nature road infrastructure transfer costs are higher in developing countries compared to developed countries since price hints that are transferred to producers are totally different from the consumer price. The aim of this work was to give proof of price transmission and market integration of local rice in some selected markets.

Monthly wholesale prices of milled rice over the period 2006 to 2015 were used in the analysis. The Augmented Dicky-fuller test was used to check for stationarity of all the separate price series. All the price series data that were used tested for Unit Root. They were all found to be stationary after first difference at 1%. Cointegration analysis was done using the Momentum Consistent Threshold Autoregressive Model (MC-TAR). All the price pairs were found to be cointegrated. The market pairs were found to also exhibit asymmetric adjustments. It was found from the Error Correction Model estimates that in Ho and Accra markets, following a positive shock that creates disequilibrium, 46% of such shocks will be eliminated within a month. Similarly, in Tamale and Kumasi markets, positive shocks that leads to disequilibrium 1.6% of such deviation will be eliminated within a month.

The results of Granger causality revealed that Ghanaian rice markets are well integrated. The markets exhibit both bidirectional and unidirectional causality with the producer markets exhibiting price leadership. It is suggested that, policy be focused on price stabilization and also, the SRID unit of MoFA should be equipped financially to inform market participants about current prices through the media and other outlets.

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ABBREVIATIONS

ADF	Augmented Dickey Fuller
AIC	Akaike Information Criterion
APT	Asymmetric Price Transmission
ARDL	Auto Regressive Distributed Lag
AVECM	Asymmetry Vector Error Correction Model
BIC	Bayesian Information Criterion
CPI	Consumer Price Index
ECM	Error Correction Model
ECT	Error Correction Term
FAO	Food and Agriculture Organization
FIML	Full Information Maximum Likelihood
GSS	Ghana Statistical Service
HQIC	Hannan-Quinn Information Criterion
LOP	Law of One Price
MOFA	Ministry of Food and Agriculture
MC-TAR	Momentum Consistent Threshold Autoregressive model
OLS	Ordinary Least Squares
PBM	Parity Bound Model
SRID	Statistical Research Information Directorate
SRM	Switching Regime Model
TAR	Threshold Autoregressive Model
VAR	Vector Autoregressive Model
VECM	Vector Error Correction Model
TVECM	Threshold Vector Error correction model

CHAPTER ONE

INTRODUCTION

1.1 Background

Rice (*Oryza sativa*.L) has become an important staple food to both urban and rural dwellers in Ghana. It is the second most essential staple after maize according to Diako et al. (2010) and the consumption of it continues to rise as a result of growth in population, development and change in the habits of consumers. Rice, the main grain import item, costs the nation about $500M import yearly Rice, (Amikuzuno, 2013). According to MoFA (2014), Ghana is just 30% self-sufficient in rice production, producing only about 2.4Mt/Ha compared to an achievable yield of 6.5Mt/Ha. In terms of production, annual average production was estimated to be 417,000Mt for milled rice and between 2013 and 2015, it was also observed that, Volta region, Northern and Upper west produced the most rice with 184, 2279.32Mt, 168407.25Mt, 114702.19Mt respectively**.** This low self-sufficiency level has caused the nation to depend on large imports to meet the domestic demand.

Addison et al. (2015) noted that, the local rice industry does not possess the capacity to take care of the expanding demand which is because of population development, quick urbanization and change in buyer propensities. This expanding interest for rice is driving enthusiasm for growing Ghana's own domestic rice production. However, According to Abdulai (2000), differences in ecological conditions often influence patterns of crop production regionally, and as such deficit producing regions have to be supplied by surplus producing regions. Such movements of produce across regions involve price movements. This is the same with Ghana's rice production. It is not produced largely in all regions and such stakeholders possibly will be concerned in finding the link in movements of prices of staple foods in different regions as deficit areas are being supplied.

There have been some interventions to increase the production of domestic rice in other to meet the country's rice demand, and one intervention is the rice value chain. The aim of this intervention is to strengthen both vertical and horizontal linkages between the chains with the hope of ensuring food security (FASDEP II, 2009-2015).This value chain intervention was triggered as Ghana was among countries which embarked on economic reforms that directed the privatization of sectors that are controlled by the state. The events that activated agricultural market reforms were for the most part subject to more extensive political and monetary changes in many nations and subsequently the results are connected also. In essence, the idea behind market reforms is to increase productivity by improving the productiveness of human skills and physical resources (Akiyama et al., 2003). Such reforms are consistent with economic theory, which proposes that the correct operations of markets based on comparative advantage and channels of marketing is necessity for ideal resource allocation (Abdulai, 2000).

There has been discussions or debates on these market reforms and one of them is as to whether the implementation of market reforms that started in the 1980s have enhanced price transmission spatially between domestic markets or not (Badiane and Shively, 1997)

The supposed ability of liberalization of trade to incorporate foreign markets to local markets and local markets to each other, by the forces of supply and demand, and also to give higher price incentives to farmers remained a key economic necessity that directed Ghana and a number of developing countries to heed to liberalization strategies (Amikuzuno, 2010).

Price transmission and trade liberalization are related complementally. On one side, trade liberalization has the ability to increase the size of local markets and enhance their integration and efficiency by creating (export) price incentive or to cause danger to local markets by discouraging market integration and effectiveness through little import price disincentives. On the other hand, if local markets in a country have the ability to convey price signals between themselves and across the borders of their countries, the welfare impact of trade liberalization would be realized (Winters et al., 2004). Efficiency of markets then becomes very important, and by the continuous determination of developing and improving agricultural markets and the development of Ghana to middle income country from a low income country, raises concern of the current performance and the reaction of spatially divided markets to each other. In cereal markets, spatial price behavior has been used by several authors as an indicator of the performance of cereal market in a number of countries. For instance, Alderman (1993), argues that the ease with which stabilization policies can be effected and the extent to which internal markets are integrated have a direct relationship. If markets are integrated, the accurate price signals will be transferred through the marketing channels and farmers will be able to specialize according to long-term comparative advantage and they will be able to realize the gains from trade through increased price and demand for their output. Also, when markets are integrated, a shortage or excess in one market will be transferred to the other market through arbitrage.

Barrett and Li (2002), describe market integration as how commodities are tradable when there are no barriers to trade between markets, and this comprises of when market is cleared, where demand, supply and cost of operation in different markets define prices and trade moves together causing the transfer of price changes from one market to the other.

According to Amikuzuno et al. (2013), spatial price transmission and market integration measures the extent to which markets that are in different areas share the same long-run information on price on trade of a similar good. In other words, when there is co-movement of prices in markets with different places or when shocks as a result of demand and supply rising in a market is transferred to other markets in different locations markets can be said to be integrated. That is, if changes in price in one market is reflected in a different market then these markets are said to be integrated spatially (Mukhtar and Javed, 2008). Otherwise, markets that are not integrated may transfer wrong price information that might mislead the marketing decisions of producers and contribute to wasteful movement of products.

There have been studies on price transmission such as Badiane and Shively (1997) who assumed that, response to price is symmetric in the sense that, a shock of a certain magnitude in the central market would cause the same reaction in the local markets, irrespective of the shock revealed a decrease or increase in price. Nevertheless, certain characteristics connected to imperfect competition such as when small number of firms control a large part of a market, Government interference, menu costs in the case of perfect competitive markets and inventory behaviour of traders can add to asymmetry in price responses. Asymmetry may also occur when actors react in a different way to price changes (Abdulai, 2002; Belton and Nair-Reichert, 2007). In addressing the issue of asymmetric adjustment, Enders and Siklos (2001) modified the conventional Augmented Dickey–Fuller (ADF) methodology to allow statistical estimations taking into consideration the likelihood that price adjustment might also be asymmetric. This approach is employed in this study and also, the Error Correction Model (ECM) is used to evaluate the link between average wholesale prices in four selected rice markets.

1.2 Problem statement

Rice producers in Ghana is largely made up of smallholder farmers and it takes place in the rural areas of the country (FAO, 2013). According to Addison et al. (2015), the fast-growing demand for rice is driving interest in expanding Ghana's own rice production. The 2010 population census has shown that the urban population has increased to 51% from 44% in 2000 and considering this increasing rate of urbanization, the market system will continue to be relevant in the course of food distribution. According to Nkegbe et al. (2014), majority of the population spends significant portion of their budget on food and it is therefore imperative that systems be put in place to enhance production and distribution ensuring food security. Rice in the country is not produced in all regions which required that it should be able to flow from regions that produce in excess to deficit regions. The bulk of it comes from the Upper East, Volta and the Northern region (FAO, 2013) accounting for nearly 80% of total national output and 73% of total production area in 2010. However, the lack of good road networks, poor flow of information between farmers and traders as well as low levels of value adding activities which could have increased the storage time of produce, actors face huge farm gate price fluctuations, hence acting as a barrier to trade (Rashid et al., 2010).

According to Winter et al. (2004), due to low quality of road structures, transfer costs are usually high in countries that are developing compared to developed nations since price signals which are carried on to producers are totally different from the consumer price. Also, in locations where public agents control the markets or a small number of traders control the market which is very popular in developing countries economic signals are often lost completely. According to Alderman (1993), price movements in a country is an area that is of meaning to economists since it offers first-hand examination of how variations in price from one local market can influence price of a similar item in market, its yield, utilization and public welfare in the nation where opportunity for trade exist.

Karfakis and Rapsomanikis (2007) explain that, within the neoclassical paradigm, in a competitive market condition, spatial arbitration is relied upon to guarantee that, costs of a product in two spatially isolated markets will vary by a sum that is at most equivalent to the exchange cost. These are made up of cost of transportation that are usually determined by distance and road quality, vehicle efficiency and also other costs associated with arranging a transaction. In agricultural commodity trading in developing countries, trade is done in an environment with features such as poor rood system, bad communication system, terrible and old vehicles, causing cost of transfer to be high and that may inhibit arbitration between two settings causing isolated markets.

Additionally, in designing of policies with the aim of stabilizing commodity prices, the extent to which regional markets are integrated globally and/or within a country has effect on economic well-being as well as the level of effect of liberalizing trade. A similar thought holds at the consumer level also, where households that face high transfer costs as a result of distance, old vehicles and poor infrastructure, at large result in inadequate selling opportunities. The results of high transfer costs is that, it may result in selling household receiving lower prices and buying household paying higher prices (de Janvry et al., 1991; Key et al., 2000).Therefore understanding the movement of prices in a country and the point to which prices are transferred across regions is of economic significance to a country. This is because, it provides information to be able to forecast on how farmers and consumers in the local markets will react to changes in price from external markets (Ankamah-Yeboah, 2012).

Furthermore, whether markets alter symmetrically or asymmetrically to each other is one other problem that has motivated the interest of stakeholders when managing how markets react to each other. According to Ben-Kaabia et al. (2002), symmetric adjustment are often anticipated to represent competitive markets where as asymmetric responses are associated with the presence of some inadequacies in markets. Miller and Hayenga (2001) asserts that, asymmetry in price transmission can come from a search costs. In such instance even though, costumers have a stable option of opposing retailers, they may not get significant price information and this will enable retailers to use local market power. Some other reasons for asymmetric price transmission is 'menu costs' (i.e. costs which occurs as a result of re-pricing and the embracing of a new pricing strategy), the presence of inflation characterized by high increase rates and/or lengthy inflationary setting, Government backing (Kinnucan and Forker, 1987) or several stock management practices. According to Wlazlowski et al. (2009), the existence of asymmetry in price transmission means that loss of welfare for set of stakeholders in the market since the distribution of welfare could be different in symmetry since it changes the planning as well as the extent of the welfare changes that are connected with price changes.

Asymmetric price transmission also means that, a group is not gaining from price decrement (buyers) or increment (sellers) that would, under a state of symmetry, have occurred earlier and/or have been of a larger magnitude than observed since well-being could be distinctive in symmetry (Wlazlowski et al., 2009)

Many studies have been conducted in an effort to look at price transmission and the extent to which markets are integrated as well as price trends. For instance, Amanor-Boadu (2012), studied price trends in Ghana from 2006 to 2011. The results reveal dominance of imported rice in the country. The research also indicated that, local rice price is determined by imported rice price, with a less than unit elasticity. For price transmission, Amikuzuno et al. (2013) studied the transmission of price signals between rice that are imported and local rice prices from 2006 to 2011 in order to understand what role liberalization played in this regard in Ghana. The results reveal that, there is a long-run equilibrium relationships and partial transmission of price shocks from local to imported rice prices, but the latter do not dictate prices of the local rice.

Also according to Blay and & Kumari (2016), they assert that there has been disagreement in Ghana on whether foreign rice market meaningfully influences the price changing aspects of the domestic market and has crowded-out the production and distribution as well as the prices of the local rice market in Ghana. Their Study was concentrated on examining how competitive and efficient the local rice market and foreign markets ensure that the producers and consumers appreciate the gains from trade liberalization.

Similarly, Asuming-brempong and Osei-Asare (2007) argue that, the per capita intake of rice in Ghana has increased steadily since the 1980s, from 12.4 kg/person/year in 1984 to an expected 20 kg per person per year in 2005. This is as a result of an increase in population from 12.3 million in 1984 to about 21 million in 2004 which indicates an increase of more than 70%. Nonetheless, the sudden increment in the imports of products such as imported rice, poultry meat, and tomato paste, from countries which are developed to countries which are developing into the Ghanaian market is competing with locally produced goods such as local rice.

There has been some studies on the Ghanaian rice market comparing imports and local rice. However considering the efforts of policy makers in the fight in the direction of attaining market efficiency locally, the possible effect of agents regarding the behavior of the market as well as the changes in rice production locally lead to the following key research questions**;**

1. What has been the trends in the prices of local rice in the markets?
2. How is price transmitted in the long run across the various markets under study?
3. What is the degree of speed of adjustment with which market participants respond to price changes as a result of price shocks in the markets
4. Is the transmission of price between the markets symmetric or asymmetric?

1.3 Objectives of the Study

The main objective of the study is to assess the spatial price transmission and market integration of local rice in Ghana. Specifically the study seeks:

1. To describe the trends in the prices of the local rice markets
2. To analyze the long run transmission of rice across the markets
3. To evaluate the degree of speed of adjustment of market participants to price shocks.
4. To determine if the transmission of price between markets are symmetric or asymmetric

1.4 Justification of the study

Rice in the Ghanaian economy is very important and as such, there is the need for policy makers, producers and consumers to understand the dynamics of price movement between the producer and the consumer markets in order for consumers to gain from price reduction and also offer producers price incentives leading to increased production of rice ensuring food security.

Additionally, this study will provide an analysis of the variation and trends of rice prices and price transmission between the producer markets and consumer markets and offer clarifications to loss of economic signals between producer markets and consumer markets and its benefits in the country.

Additionally, this study will also add to the knowledge of existing literature on designing strategic and reasonable policies and measures to improve price transmission between spatial rice markets which is an indication of rice market efficiency. This will help to alleviate rural poverty and improve food security through offering correct price signal to both consumers and producers of maize in the country.

Finally, how spatial rice markets in Ghana are integrated is very important in the definition and selection of appropriate pricing policies with the aim of improving food security.

1.4 Organization of the Study

The study is arranged as follows: Chapter One which is the introductory chapter gives a background to study on rice, spatial price transmission analysis and the importance of price transmission of rice in Ghana. This chapter also presents the problem statement, research objectives and justification of the study.

Chapter Two presents a review of literature on market economy for rice in Ghana, methods for evaluating price transmission and experiential confirmation of market integration and asymmetry in price transmission. Chapter Three describes the theoretical framework and empirical framework in price transmission, the methods of analysis used in the study of price transmission that employs times series data. The results and discussions of the study are presented in Chapter Four, while Chapter Five deals with summary and conclusions of the study and policy recommendations.

CHAPTER 2

LITERATURE REVIEW

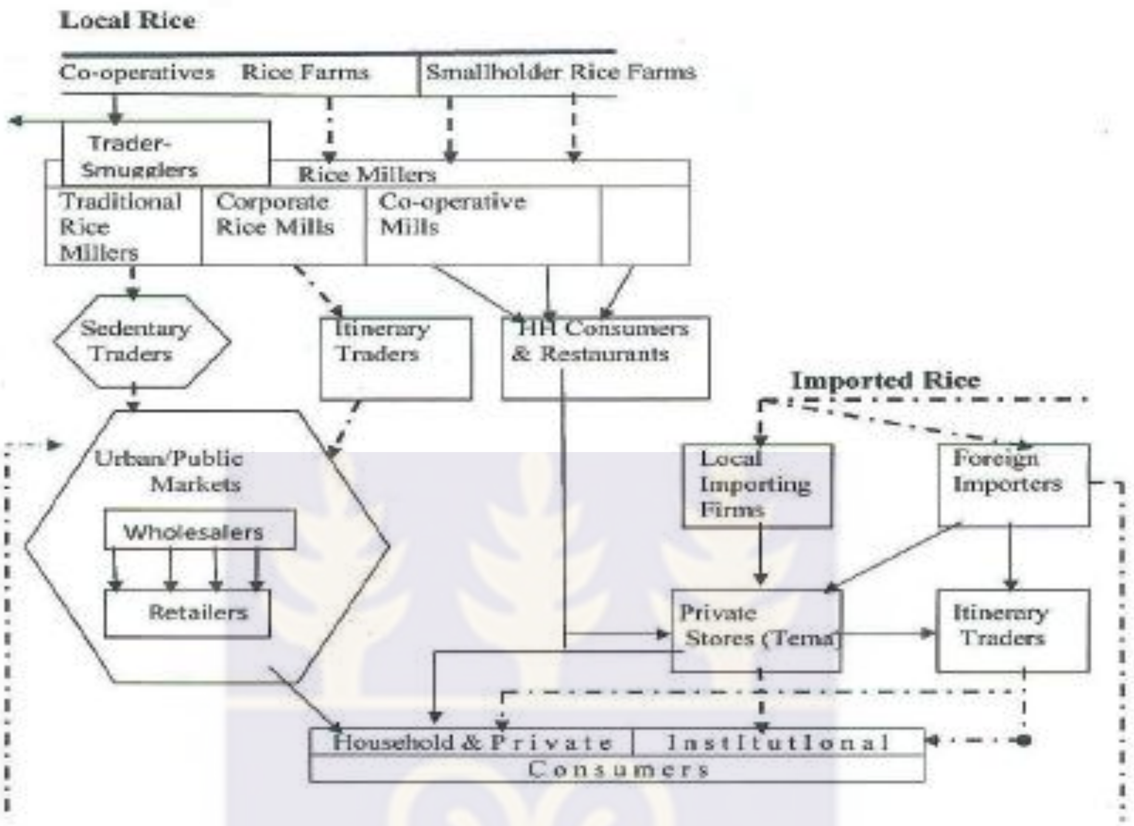
2.1 Introduction

In this chapter, significant writings on theoretical concepts on agricultural price transmission and market integration is presented. In section 2.2, literature on rice marketing system is presented. Section 2.3 also discusses the concepts of price transmission and market integration as well as definitions relevant to the study. Section 2.4 discusses some models used in the estimation of price transmission and market integration and in section 2.5 recent evidence of price transmission and market integration are discussed. Finally section 2.6 gives a summary on the various models discussed and which approach this study employs.

2.2 Rice Marketing System in Ghana

Ghana's rice marketing system has two major supply chains; the domestic rice supply chain and the foreign rice supply chain. Trade liberalization had a significant role in creating the current structure of the rice market. Amikuzuno (2013) explained that, from Government regulation and distribution in the pre-liberalization period, there now exists a host of private traders distributing and determining the price of rice through supply and demand shocks from the farm gate to urban consumers in the local rice supply chain; and/or from the country's ports to consumers in the hinterland along the imported rice supply chain.

Figure 2.2- Supply chain of local and imported rice



Adopted from Amikuzuno, Issahaku and Daadi (2013)

From Figure 2.2, Amikuzuno et al. (2013) explained that, locally milled rice is distributed via four links – sedentary traders (wholesalers and retailers), restaurants, (institutional or household) consumers in the producing areas, and itinerary wholesalers from distant, urban and often rice deficit markets. From the itinerant and sedentary traders, the commodity may either be distributed directly to final consumers, or may be further distributed through different levels of retailing and restaurants before the final consumer.

Using the same Figure 2.1, they also explained that, imported rice, on the other hand, is bought from the warehouses of importing companies by wholesale traders in Ghana's port cities – Tema and Takoradi. The wholesale traders then sell their rice from market stores to sedentary retailers, consumers and restaurants in the same markets; or alternatively to wholesalers from distant markets in the hinterland. In some cases, imported rice may be distributed directly by the importing companies to wholesalers in major cities. Some traders in feeder and urban markets in Ghana often participate in the two supply chains simultaneously by selling both local and imported rice. Both domestic and foreign rice are sold on city markets, nonetheless because of the inconsistency in supplying local rice, foreign rice dictates the scene. According to ODI (2003) in his study conducted in villages which produce rice in Ghana, it was discovered that, most farmers who get price data from traders or "market women", have control over prices. In introducing the mobile expertise in the nation however, there have been experimental tasks led by a price information company called Esoko which enables farmers to get prices, hence allowing farmers to have a good ability to bargain (FAO, 2013). According to ODI (2003), the market women, who frequently give funds and credit for purchasing of input and also transportation for farmers, function on oligopolistic structure, which limits the market and restrictions on market price for rice is subject to variations in the market.

2.3 The Concept of Price Transmission and Market Integration

This notion is a very broad one and as such economists look at it from a certain point of interest. Price transmission denotes the effect prices in one market have on prices in another market (Conforti, 2004). It is mostly estimated in terms of the transmission elasticity which is explained as the percentage change in the price in one market given a percentage change in the price of another market (Minot, 2010). Spatial price transmission and market integration is explained by Amikuzuno (2010) as measures how markets at geologically different settings share long-run price or how information is exchanged on a similar good. Spatial market integration also refers to how prices move together across markets in different locations and also how increases or decreases in demand and supply in one market is transferred to another markets in distinct locations. Sexton et al. (1991), spatial market integration is very significant in agriculture. He explained that, agricultural products are usually huge or and easily get spoilt and sometimes production might be greater in one area whereas consumption may be higher in another location, which indicate costly transportation. It is therefore, very important for markets to function properly as it informs economic policies and decisions. If markets are not integrated spatially, it restricts stakeholders across space and restricts the transmission of price incentives and the positive welfare effect that comes with lower prices or increase in output. In addition, markets which are not perfectly integrated can transfer wrong information on price to producers and/or some players in the value chain which could lead to wrong production and selling decisions (Bakucs and Ferto, 2007).

The Enke-Samuelson-Takayama-Judge model is central to analyzing spatial market integration. This model makes the assumption that, the relationships between prices in competitive markets which are separated based on location rest on the extent of the operation costs (Barrett, 2005).

A study by Goletti et al. (1995) also indicated that, market integration is dependent on the act of agents and also on the location in which traders operate. This includes marketing infrastructure such as transportation, credit, communication and facilities for storage which generate huge margins in marketing due to transfer costs. Partly, this can shield local markets. The actions of Governments such as price stabilization, trade restrictions and stabilizations among others can also affect market both positively and negatively. Also, self-sufficiency status can be determined by the level of production surrounding a particular market. In essence, if there is wide variation in markets with respect to their respective self-sufficiency position, then markets are more likely to be integrated.

2.3.2 Spatial Arbitrage

Spatial arbitrage is defined as the movement process between markets in different regions with the objective of getting the advantage of where the price differential exceeds the transfer (Burker and Myers, 2014).

Sulaiman et al. (2016) define market information arbitrage as the process of exchanging market information between actors to take advantage of price differences between the markets and seasons, when the costs of this information or transaction are relatively low. When traders are well informed about the prices, they have an advantage over farmers who cannot access market information. Thus, providing market information to farmers should give them a better bargaining position to negotiate with traders and lead to receiving significantly higher prices. Additionally, market information helps reduce information asymmetry between actors in the supply chain. The spatial arbitrage conditions ensures that, the differences in price between areas in a market where traders do not control price and that trade with each other for a homogeneous product should equal the transaction cost (Tomek and Robinson, 2003).

Assuming price of a similar goods in two different markets are, P_{At} and P_{Bt} at time, T. If price in these two markets are the same, the two markets are said to be integrated and corrected only by the transport cost, thus,

$$P_A = P_B + T. \quad (2.1)$$

Where P_A and P_B are the prices of a good homogenous good in markets A and B respectively and T is the transportation cost.

Trade between these two locations happens only if $P_A - P_B > T$.

2.3.3 The Law of One Price (LOP)

The basis of several experiential works of market integration is the law of one price (LOP). The LOP in the strong form is expressed as $P^B - P^A = C^{AB}$ (2.2)

where C^{AB} is the cost of transferring the good from position A to position B, P^A *and* P^B are the price of a homogenous product in markets A and B, respectively. This relationship states that, if arbitrage is efficient for a single homogenous product and there is a balance between these markets connected by trade, then a change in price in one of the markets will be transmitted instantaneously to the next market (Tanko and Amikuzuno, 2015). The LOP in its weak takes into consideration deviations in the short-term from equilibrium after a price shock with likelihood of returning to equilibrium in the long-run.

In the LOP estimation, it is assumed that agents in a market have all the important information needed to carry out arbitrage at its optimum and there are no barriers to trade (Jensen, 2007). Using the LOP to examine market integration is just idealistic since the assumption is seldom the case in practice. It only stands when in instances of no hindrances to trade or when cost of transportation in markets is not significant as McNew (1996) noted. The LOP is only fundamental for efficiency in spatial market integration. When there is flow of trade from market *B* to *A* till the price variance between both markets is equivalent to the inter-market transfer costs, then a strong form of the LOP is achieved.

2.3.4 Spatial Market Efficiency

Often, spatial integration is used to test for efficiency of agricultural market in price analysis. According Negassa et.al. (2003), the use of spatial market efficiency and spatial market integration can be interchanged. They are related but not equivalent. Efficiency in spatial market is defined as an equilibrium situation where all possible benefits from arbitration are exploited. If a spatial price differential is less than transfer cost in the absence of trade, then it is not different from market efficiency. Nonetheless, if the spatial price difference is higher than cost of transfer, the market is not proficient with or without trade (Negassa et.al. 2003).

2.4 Techniques for evaluating Price Transmission and Spatial Market Integration

With market integration estimation, it is mostly ideal if all potential information on prices and production quantities, transaction costs are used to conclude on mechanisms for demand and supply (Negassa et al., 2003). Due to unavailability of data, however, researchers depend on assumptions that are led by theory and use methods that are based on price such as transmission econometrics or parity bound techniques which apply not just data on price in establishing equilibrium (Abunyuwah, 2007). Several of these models are examined below.

2.4.1 Static Price Correlation Methods

Market integration study started by using static price relationships in testing for spatial market integration. This method comprises the evaluation of bivariate correlation and regression coefficients of similar commodity in separate markets (Hossain and Verbeke, 2010).The idea in this method is that, prices between markets which are integrated move together. Hence, when the correlation coefficients are high or low, they are interpreted as market integration or segmentation, respectively. For instance, if P_t^i and P_t^j are two price series in markets i and j which are linked by trade for the same good, the correlation coefficient which is , r, is gotten from estimating the equation:

$$r = \sum_{k-1}^{n} \left[(P_t^i - \overline{P}^i)(P_t^j - \overline{P}^j) \right] \tag{2.3a}$$

Where $\overline{P}^i$ and $\overline{P}^j$ are average values of P_t^i and P_t^j respectively

The specification of the bivariate regression model (BRM) for estimating price transmission and market integration is:

$$P_t^i = B_0 + B_1 P_t^j + B_2 T_t + B_3 R_t + \varepsilon_t \tag{2.3b}$$

Where P_t^i and P_t^j may be in their first-difference or logarithms form, T_t is transaction cost, R_t signifies other elements affecting prices. This $\beta_i s$ represents the coefficients to be estimated and ε_t is the error term.

The static models are simple to estimate by the use of price data only. However, they assume stationarity in price behaviour and fixed transactions costs which can result in miscalculation of the level of market integration (Barrett, 1996; Baulch,1997). There have been current improvements in time series econometrics which permits testing a broader idea of spatial market integration by evaluating long-run price co-movements which leaves the Law of One price (LOP) a hypothesis to be tested.

The static method is extremely straightforward, nonetheless it presents significant shortcomings and consequently confronts threats when reaching inferences from the parameters evaluated. The primary shortcoming being that, relationship doesn't propose causality (Cirera and Arndt, 2006).

Timmer, (1974) documented that due to problems of inter-seasonal transfer of goods which are often seen in regions with poor infrastructure, using co-movement of price as an indicator of market integration is unreliable because prices vary occasionally. Analysis of bivariate correlation covers the existence of some factors such as the effect of Government strategy and general increase in prices (Golleti et al., 1995). This method presumes that, adjustment in prices is instant and thus not able to capture the ability of price to change. Prices are likely to co-move even if market integration does not exist and this has the ability to cause spurious market integration that can be swayed by general rise in prices, differences in seasons or autocorrelation (Ravillion, 1986).

This study of correlation also fails to identify that heteroscedasticity which is common in price information could exist. Also, in situations where a lag in reaction to price is generated by lags in market information, test of correlation may overestimate absence of market integration (Barrett, 1996). This analysis cannot be used to examine the whole marketing system because it's narrowed to just a pair wise estimation of market.

2.4.2 Ravillion Dynamic Model

In measuring spatial market integration, the Ravillion (1986) approach became the most prominent method which differentiated amongst short and long run market integration and fragmentations after adjusting for changes in season, trends and autocorrelation (Negassa et al., 2003). The slow nature of agricultural markets in the incidence where a surprise is raised that may demand some lags, is the motivation behind this model. By linking dynamic considerations in this model, dangers in inference shown in the static price correlation is avoided.

According to Barrett (1996) and Cirera and Arndt (2006), the Ravallion model neglects the possibility of problems between seasons, and also presumes that cost of transfer between markets is constant. In cases where the cost of transfer are problematic or time varying, conclusion will then be unfair in support of refusing to discard the assumption that markets are fragmented This method speculates an outspread of the structure of spatial market between a set of domestic markets and a particular principal market where the formation of domestic price is controlled by trade with the principal market.

Assuming P_{1t} and P_{it} signify local and central market prices respectively. The specification of model is:

$$P_{1t} = \sum_{j-1}^{n} \alpha_j P_{1t-j} + \sum_{j-0}^{n} \beta_j P_{2t-j} + \gamma X_t + \varepsilon_t \tag{2.4}$$

j is number of lags and X is the constant, seasonal, time and policy variables. In (2.4), the constraint $\beta_j = 0$ for all j refers to full market fragmentation. Integration is examined using the restriction $\beta_j = 1$ and $\alpha_j = \beta_j = 0$ for $j = (1...n)$ and when we fail to reject the hypothesis, it indicates that, when there is a deviation in the principal market, they are transferred totally to the local market once. Since changes in price in spatially different markets might require time to impact other markets, Ravillion examines the long-run integration by using

$\sum \alpha_j + \sum \beta_j = 1$, hence, shocks in price in the central market take more than once to be transferred to the local market which might be as a result of insufficient infrastructure.

2.4.3 Co-integration Models

The idea of cointegration was introduced by Engle and Granger (1987) and Engle and Yoo (1987). They defined cointegration as the presence of long-run relationship amongst different series. In price series data for analyzing market integration, one feature in the usage of the orthodox measures is that the series are frequently not stationary, particularly, those using simple regression since the standard errors from such studies maybe inconsistent and hence tests are not valid. It is as a result of this problem that led to the introduction of cointegration. Ankamah-Yeboah (2012) explain that, if there is no cointegration among two price series, it shows market segmentation whereas otherwise indicates market integration.

Furthermore, Cointegration analysis comprises finding the order of integration by means of a suitable unit root test, creating the cointegration equation if the prices are integrated to same order and lastly analyzing stationarity of the residuals. For two spatial markets with prices P1t and P2t, estimates of standard errors on parameters α and β from the equation

$$\boldsymbol{P1t = \alpha + \beta P2t + \varepsilon t} \qquad (2.5a)$$

will be inconsistent if P1t and P2t are non-stationary. From 2.5a above, cointegration test analyzes the time series properties of the residual:

$$\boldsymbol{\varepsilon t = P1t - \alpha - \beta P2t} \qquad (2.5b)$$

If stochastic trend is absent in the residuals, it shows that there is the presence of a long run link between the prices (Negassa et al., 2003). One weakness of the Engle and Granger method is that it doesn’t allow all possible co-integrating vectors in a multivariate system to be tested and this steered the development of the Johansen (1988) co-integration method for testing long-run equilibrium.

The Johansen technique uses maximum likelihood in testing for cointegrating relationships amongst numerous series. Engle and Granger (1987) also proposed the usage of error correction technique if cointegration exist between variables under consideration in evaluating the short-run dynamics. According to Abunyuwah (2007), the error correction specification explains the adjustment procedure in both short and long run reaction to variations in price which mostly reveals arbitrage and efficiency in markets

The error correction model is specified as:

$$\Delta P_t^c = \delta_1 + \alpha^c \left[ECT_{t-1} \right] + \sum \beta_k^c \Delta P_{t-1}^c + \sum \beta_k^{cs} \Delta P_{t-1}^s + \varepsilon_t^c \qquad (2.6a)$$

$$\Delta P_t^s = \delta_2 + \alpha^s \left[ECT_{t-1} \right] + \sum \beta_k^{sc} \Delta P_{t-1}^c + \sum \beta_k^s \Delta P_{t-1}^s + \varepsilon_t^s \qquad (2.6b)$$

Where $\Delta P_t = [\Delta P^S \Delta P^C]$ is a vector of first difference of prices in the consumer and producer markets respectively.

β = Conditions of short run co-efficient that measure the short-run reactions.

The coefficient $\alpha_1 = [\alpha^S \alpha^C]$ represents the speed of adjustment of the primary and consumer market prices response to deviation from the long-run equilibrium.

Using of cointegration and error correction models help in exploring ideas such as completeness, speed and asymmetry of relationships in price and also the direction in which causality between two markets occur.

Barrett (1996) points out that cointegration among price series is not a necessary condition, neither is it a sufficient condition for market integration. Cointegration is not a sufficient condition because when the coefficient is negative in the central market price, it suggests divergence as a substitute of co-movement under the notion of market integration. The extent of the co-integration coefficient could be questionably extreme from agreement which refutes the logic in market integration. As said by Negassa et al. (2003), if cost of operation is not stationary, and we fail to identify cointegration amongst two market price series, it may be totally consistent with market integration. It is worth knowing that market integration models explained above do not take into consideration transaction cost which when done, has a substantial influence on market integration models. This resulted in the application of model such as the switching regime models proposed by Fackler and Goodwin (2001) in recent analysis of market integration.

2.4.4 Switching Regime Models (SRM)

Fackler and Goodwin (2001) argue that, the use of dynamic regression models in the test of market integration lack clearly articulated alternative to the null hypothesis that markets are integrated. According to the authors, this is a problem when markets are imperfectly integrated because the network of trading linkages may be changing over time due to factors such as seasonality. The switching regime regression model was therefore designed to take care of such changes. The SRM was designed by Spiller and Wood (1998) and they suggested three possible regimes between two-location markets. M1 and M2: regime I, where M1 ships to M2; regime II where M2 ships to M1 and regime III where there is no trade between the two markets. The direction of trade depends on the transport rate from one market to the other with positive supply region having the less net transport rate. When there is equality in the transport rates involved in shipping from M1 to M2 and from M2 to M1, trade will however not occur. The model provides estimate of probability of being in each regime conditional on the size of observed price spread both ex ante and ex post. Integration between the two markets is tested with the hypothesis that a particular regime's probability equals one and all the others are zero.

The Switching regime model therefore uses price spreads as an indicator of market connectedness which maybe be wrong since two markets may be connected simply because they both have a common trading partner. Rezitis et al. (2009) examined the relationships between price and its periodic changes with marketing channels in the Greek lamb market. The results of the study showed that within the channel, there exist three different long-run prices. The results further revealed that, the most important price within the marketing channel was the retail price. A change in retail price results in a long-term imbalance among all the other prices in the channel.

2.4.5 Parity Bound Model (PBM)

The PBM was developed by Spiller and Haung (1986) and Spiller and Wood (1988) and according to Zant (2012), one method of assessing market integration is the use of the Parity Bound Model (PBM). This tool enables users to either reverse or terminate trade flow and among other things, incorporate the cost of transaction. It uses explicit information on transfer cost together with other market data to assess efficiency of inter-regional markets. The model assumes that transfer cost plays a critical role in determining price efficiency bounds (parity bound). The model takes into consideration the spatial differences of transaction cost.

This model was further modified to take into consideration the cost of transaction as well as complementary price associated with trade information.

As emphasized by Barrett and Li (2002), to determine the efficiency of trade behaviour, it is compulsory to obtain information on both price and transaction cost. Trade will however not occur when the inter-market price differential is lower than the transaction cost. In this case the arbitrage condition will not be binding which means lack of market integration. Furthermore, the effects of not observing the spatial arbitrage condition results in lack of market integration

In its application, the model differentiates the periodic trade changes in three different ways; period 1, trade cost equals differences in inter-market price: when there is trade, it will cause the prices between the two markets to move instantaneously and the conditions for spatial arbitrage are restricting if there are no obstructions to exchange among the two. Period two is within the parity bound. Here when the price between markets is less than the cost of transfer, exchange won't happen and conditions for spatial arbitrage are not fulfilled whiles in period three it is outside the parity bound. Where price between markets is higher than the cost of transfer, conditions for spatial arbitrage are disregarded whether exchange happens or not (Baulch 1997; Sonogo, 2008). The point of the technique is to decide the likelihood that an observation will be categorized as one of the three periods and thus needs setting up the upper and lower equality limits for the conditions for spatial arbitrage between the assigned markets. It starts with the determination of the lower and the upper parity bounds for which the spatial arbitrage condition occurs between the markets being considered. Establishing this parity bounds is therefore a key requirement in the PBM and since transfer costs rarely exist, the task could be quite complicated (Barrett, 1996). In estimating the probability of estimating inter-market arbitrage conditions, the PBM uses transaction data which are exogenous. Maximum likelihood estimators are noted to cope well with trade break-offs and time changing transaction costs as reported by Barrett (1996).

2.4.6 Threshold Autoregressive Model (TARM)

This approach developed by Howell Tong, (1983) has been of great influence in economics. The TAR model assumes that transaction costs must exceed a certain threshold before price is adjusted. This invariably leads to market integration (Goodwin and Piggott, 2001).

The threshold approach test is based on the following threshold autoregressive.

$$\Delta\ell_t = I_t\rho_1\varepsilon_{t-1} + (1 - I_t)\rho_2\varepsilon_{t-1} + \varepsilon_t \tag{2.7a}$$

Where I_t is the indicator function such that $I_t = \begin{cases} 1 & \text{if } \varepsilon_{t-1} \geq \tau \\ 0 & \text{if } \varepsilon_{t-1} < \tau \end{cases}$ and τ is the value of the threshold. ρ_1 and ρ_2 are the adjustment coefficients and ε_t

For the first conditions to be met, ρ_1 and ρ_2 should be less than zero and for the second order condition to also be met, $(1+\rho_1)(1+\rho_2) < 1$ for any value of τ (Enders and Siklos, 2001).

From (2.7a), two competing models are incorporated namely; momentum threshold autoregressive (M-TAR) and momentum consistent threshold autoregressive (MC-TAR) models. The (M-TAR) give room for the threshold to rely on changes in the former levels of ε_t . It is proper when the divergence from the long run shows more force in one direction than the other. MC-TAR method is like M-TAR. The simply difference is that τ is not fixed at zero. From the model, test for symmetry in the adjustment is done by examining the null hypothesis that $\rho_1 = \rho_2$ contrary to the alternate hypothesis that $\rho_1 \neq \rho_2$. This deviates from previous models by Engle and Granger (1987) and the approach by Johansen (1988) which supposes that adjustment is linear between variables. The threshold effect occurs when shocks that are above some serious threshold bring about varied responses. As per Rapsomanikis and Karfakis (2007), the thresholds are usually viewed as a component of transaction and cost of adjustment that keep operators from persistently adjusting to changes in markets. Their study was established on a one threshold, two period model. However, some studies use the multiple threshold modelling method. For example, consumers are worried as to why traders react inversely to positive and negative shocks in market prices. According to Manera and Frey (2007), there is limited explanation of asymmetry by economic theory. Their approach even though is a modification on the methods it still has some weaknesses.

Abdulai (2007) in his study emphasizes that the Enders and Siklos approach assumes that cost of transaction is constant which implies a stable neutral band during the period of the study.

Van Campenhout (2007) in an attempt to address this limitation, trend in both the threshold and correction parameter were included and he modelled the threshold as a linear function of time. Abduali (2006) due to different policy periods introduced sub-samples which are different to denote the varying policy and economic setting to capture possible deviation in cost of transaction.

The TAR model violates arbitrage conditions and also as an estimate of the speed at which violations are eliminated.

2.6 Asymmetric Vector Error Correction Model (VECM)

Asymmetry usually refers to how different prices are transmitted which depends on whether prices are increasing or decreasing.

Earlier experiential analysis of asymmetry involved the usage of variation of a variable splitting method which was introduced by Wolffram (1971) and was later modified by Houck (1977) and Ward (1982).

In this method, X_t is splitted into positive and negative constituents in such a way that, X^+_t = X_t for all $X_t > 0$ and 0 otherwise and also, $X^-_t = X_t$ for all $X_t < 0$ and 0 otherwise.

The model developed by Houck (1977) has been used in analyzing spatial price transmission in an effort to explain for asymmetry in adjustments. In this method if, say, price P_1 respond to another P_2, it is estimated with the following equation:

$$\sum_{t=1}^{T} \Delta P_{1t} = \beta_0 + \beta^+ \sum_{t=1}^{\tau} \Delta P_{2t}^+ + \beta^- \sum_{t=1}^{\tau} \Delta P_{2t}^- + \varepsilon_t \qquad (2.8a)$$

Where ΔP^- and ΔP^+ represents the positive and negative changes in P respectively, β_0, β^+ and β^- are co-efficient and T is the current time period. To test for Asymmetry, it is determined by using $\beta^- = \beta^+$. Some analyst introduced long term in $\sum \Delta P_{2t}^+$ and $\sum \Delta P_{2t}^-$ to be able to separate between asymmetry in short-run and long-run. The Long run symmetry is evaluated by finding out if the sum of the co-efficient in these polynomials are equal, whereas the short-run symmetry is evaluated by establishing also, if the polynomials are identical.

Cramon – Taubadel and Loy (1997) established the fact that, the method is basically not compatible with a long-run equilibrium between two price series.

Granger and Lee (1986) also modified the ECM to be able to allow for asymmetric adjustment by applying a split method. The resulting asymmetric Error Correction Model is specified as

$$\Delta P_{1t} = \alpha_0 + \sum_{i=1}^{n} \phi_1 \Delta P_{1t-1} + \sum_{i=1}^{n} \phi_2 \Delta P_{2t-1} + \beta_2^{+} ECT_{t-1}^{+} + \beta_2^{-} ECT_{t-1}^{-} + \varepsilon_t \qquad (2.8b)$$

$$\Delta P_{2t} = \alpha_1 + \sum_{i=1}^{n} \phi_1 \Delta P_{1t-1} + \sum_{i=1}^{n} \phi_2 \Delta P_{2t-1} + \beta_2^{+} ECT_{t-1}^{+} + \beta_2^{-} ECT_{t-1}^{-} + \varepsilon_t$$

Where $\varepsilon_t ....N(0,\sigma^2)$, since $ECT^{+} + ECT^{-} = ECT$.

The model nests the VECM and a proper evaluation of asymmetry hypothesis is $Ho: \beta_1^{+} = \beta_1^{-}$ and $\beta_2^{+} = \beta_2^{-}$. A joint F – test can be used to determine symmetry or asymmetry of the price transmission process.

By this, the doubt farmers express about producer price increases that are passed on faster than producer price decreases can be subjected to the testable hypothesis that positive ECT values are corrected more rapidly than negative ECT.

2.4.9 Asymmetry in Price Transmission

Asymmetry in price transmission exist when prices at various market level respond variedly due to shocks or changes. According to Cramon-Taubadel (1998), price asymmety exist either in the form of magnitude or speed of adjustment or either ways. In terms of magnitude, elasticities in the short-run differ by the sign of the initial change whereas in terms of speed elasticities in the long run is different. Vertical or spatial price transmission is another form of asymmetry and a case where farmers and consumers often complain that increases in farm prices are more fully and quickly transmitted to the wholesale and retail levels than equivalent decreases in farm prices is an example of vertical asymmetric price transmission (APT)

Possible causes of price asymmetry include market power. In agriculture especially, asymmetric price transmission refers to non-competitive market structures. Farmers toward the start and customers toward the end of the marketing chain often presume that imperfect competition in processing and retailing allows middlemen to abuse market power. Generally, it is normal that this will bring about positive APT. Positive asymmetric in price transmission occurs when a response of one price is transmitted fully or faster when there is an increase than a fall in price of another. That is, when movement in price that increases margin is transferred more quickly than movement in price that decreases margin. Also, because of the fear of losing a market share, oligopolists can be unwilling to increase output (Ward, 1982).

Similarly, Bailey and Brorsen (1989) explains that, negative asymmetry will occur if a firm has the belief that, non- competitors will equate an increase in price but will lead to a cut in price (concave demand curve), it bring about negative asymmetry (when one response fully or speedily to decrease in price in a different market than to an increase. Otherwise if demand is convex, the result will be positive asymmetry. This is quite reasonable in a pure monopolistic market. Nonetheless, in the situation of oligopoly, depending on the structure and behavior of the market, there is the possibility of both negative and positive APT.

Additionally, one cause of asymmetry is menu costs which denotes a cost associated with a change in a firms input or output prices. Cost involved in the change in nominal prices, printing of catalogues, information distribution about price changes are all examples of menu cost and these either rising or falling could be asymmetric.

Heien (1980) argues that, commodities that have a longer shelf life have the tendency to change than commodities with a shorter shelf-life. Changes in prices results in high cost of time and loss of goodwill. Under this, Abdulai (2000) indicates that response by firms to increases in price are greater than response to decreases in prices since positive shocks can help correct for expected inflation

Lastly to the causes of price asymmetry is the role of Government. In agriculture especially Government mediations such as price support is very common. According to Kinnucan and Forker (1987) such mediation by Government can bring about APT if traders tend to believe that farm price reductions will not be permanent especially due to the fact that it will cause Government to intervene whereas farm price increment are more likely to be permanent.

2.5 Recent Empirical Evidence of Price Transmission and Market Integration

Several studies have been conducted on price behaviour and how markets respond to one another especially on rice. Abdulai (2000), developed a test for threshold cointegration that permit testing for asymmetric adjustment in the direction of a long-run equilibrium relationship. He examined the linkages in price between the main maize markets in Ghana. In his study, he employed the method that assumes that, when deviations exceed a critical threshold, economic agents will respond to bring the system into its equilibrium position provided the gains of this adjustment is more than the cost. His threshold long-run equilibrium and asymmetric error correction technique showed in the study that, the main maize markets in Ghana are well integrated. Market pairs, Bolgatanga and Accra were revealed to react more speedily to increases more than decreases in central market (Techiman). Although the Accra and Bolgatanga price respond quickly, prices in Accra were seen to react quicker than Bolgatanga to price changes in Techiman market prices.

Asuming- Bempong and Osei-Asare (2007) examined the integration between foreign and domestic rice market by using Engel-Granger co-integration test. To answer the question of whether imported rice has crowded-out domestic rice production in Ghana and what role policies have played, the study employed monthly price data in ten markets in this analysis. A central market for foreign rice and other rice producing canters in Ghana were compared. Additionally, policies that had an effect on rice within the period for the study were analyzed. From the co-integration results, it recognized that there is no integration in the markets which suggests that foreign rice markets in Ghana are not integrated and policies have not favored the production of local rice.

In trying to better understand the role liberalisation plays in transmiting price signals between imported and local wholesale rice prices in Ghana, Amikuzuno et al. (2013) employed the Vector Error Correction Model (VECM). They examined the extent to which price is transmitted between local and imported rice prices within the major Ghanaian rice markets. The result of their analysis showed presence of long-run equilibrium associations and partial transmission of changes in from local to imported rice prices, however, imported rice does not dictate prices of the local rice. They suggested that, prohibiting rice importation or imposing high tariffs on imported rice to satisfy public views in emerging economies may not be best. However, encouraging the upgrade of local rice quality by way of introducing new techniques for processing and improving rivalry between the two grades of rice in local markets must be a major priority of Governments.

Similarly, in assessing causality between consumer and producer price in South Africa, Alemu (2012) also employed threshold autoregressive models (TAR). The model for the analysis was selected out of four other competing models, that is the M-TAR method, MC-TAR, threshold autoregressive model and the Engle-Granger model. The MC-TAR model was chosen to be the best model based on their Akaike Information Criterion (AIC). He explained that, the models consider that there could be equally symmetric and asymmetric reactions to shocks due to demand and supply compared to the Engle–Granger (EG) approach which indirectly assumes that adjustment towards equilibrium is symmetric (Enders and Siklos, 2001). In testing for causality, it was done using estimates from the error correction model.

The model selected was used to test short and long-run causality and it considered that responses to changes in increase regimes could be different. It was found that, causality is unidirectional. It was also revealed that, the consumer price reacts inversely to positive and negative tendencies in producer price rises. This is to say that, the rise in consumer price is faster than it decreases.

Tanko (2015) carried out a study to study the effect importing of rice has on the pricing of local rice in Ghana. Using a Vector Error Correction Model (VECM) to determine the speed of adjustment of the two prices when equilibrium is re-established, it was found that application of the above mentioned models proved the imported rice and domestically produced rice co-move in the long run, and that, imported rice has significant effect on the marketing of domestic rice. It is important to also note that the opposite was true and the VECM results as well indicated a bi-directional responds to price shocks.

Amikuzuno and Tanko (2015) analysed the price transmission between the prices of locally produced and foreign rice. Their findings also indicate a strong long term association between imported rice prices and locally produced rice in different markets. Again, their granger causality results show no price leadership with the exception of a few cases, while, their VECM outcomes showed bidirectional responses. Thus, locally produced rice prices in the some districts respond to shock in prices during instability in the long term and vice versa.

Blay and Vijaya (2016) conducted a study to analyse integration of markets and the transmission of prices between foreign and local rice market in Ghana. Monthly average price was used in the analysis. The MC-TAR Model and Momentum Threshold Error Correction Model (M- TECM) were used in the estimations. From (MC-TAR) Model, a long-run relationship was found between the markets. From the M-TECM also, the markets were found to exhibit asymmetry in price transmission in the long term sand also showed imperfections in the market with just a small adjustment for negative deviations in comparison to large positive shock. This means that arbitrators react speedily to movement in price that increaase the margin of profit than movement in price that decreases margins that end up over burdening consumers.

Jezghani et al. (2013) examined the spatial market integration of rice in Iran for the period of March, 2000 to February, 2009. Using the Vector Error Correction Model (VECM), the results showed that, there is integration among Iran and Thailand markets, with Thailand as the price leader.

Similarly, Greb, (2012) used VECM to study price transmission in cereal market from international to local markets in Africa. The analysis was done using dataset from FAO and international reference price for rice, maize and wheat. It was revealed that, the share of the markets that cointegrated was high in African countries compared with the other countries (49% compared to 35%). It was also shown that on the average, 73% of movement in international price is transferred to local markets and within 2.2months half of it is transferred. Rice from Africa depicted the highest portion of cointegrated price pairs (68%), the highest long-run price transmission coefficient and the fastest price reaction compared to other cereal products. Mostly prices in domestic markets changes to deviations from long-run equilibrium but price of international markets do not.

The threshold cointegration method was employed by Falsafian and Moghaddasi (2008) to evaluate the price adjustment patterns in selected chicken markets which are separated spatially. From estimates, it was confirmed that diverse speed of adjustment exist in reaction to positive and negative shocks in the markets. For instance in, Qom-Tehran markets which was part of the markets under the study, change in response to decreases were greatly faster than increases whereas Ghazvin-Tehran markets indicated faster speed of change to deviations from compared to the model that disregards threshold behaviour.

In studying the integration of market of fish, Adenegan et al. (2010) used the Granger-causality test and Index of Market Concentration. Their result revealed that four market pairs were well integrated and four market pairs were also not well integrated. Their results also showed that, thirty-one market pairs rejected the null hypothesis of no granger causality; seventeen pairs of markets revealed a unidirectional granger causality while fourteen pairs of market showed a bi-directional Granger causality. The price leadership position that can be used in the formation and transmission in the markets was found to be the urban fresh. Also from the Index of market connection (IMC), the markets reveal that market integration is low in the short run.

2.6 Conclusion

Following Alemu, (2012), traditional Engle–Granger (EG) method is different from the method used in testing for cointegration. The Engle-Granger methodcompletely assumes symmetric adjustment towards equilibrium (Enders and Siklos, 2001).However, in the case where the system shows that deviation from equilibrium is asymmetric, the power of the EG becomes doubtful (Enders and Siklos, 2001). Asymmetry may happen when actors do not respond to changes in price equally (Abdulai, 2002; Belton and Nair-Reichert, 2007). It is as a result of this that Enders and Siklos (2001) revised the conventional Augmented Dickey–Fuller (ADF) methodology to be able to carry out estimations, taking into consideration the likelihood that response to price changes could be asymmetric.

Following the procedure used by Alemu (2012), both symmetric and asymmetric adjustments are taken into consideration to address the above shortcomings in this study. So, the procedure by Enders and Siklos is employed to test cointegration and then proceed to test for symmetric adjustments. Within the resulting error correction framework, causality test is conducted to take care of any resulting biases.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents the models and procedures employed in carrying out this study. The basic theory underlying analysis of transmission of price and market integration is discussed. Also, empirical model employed in achieving these objectives set out in the study is also presented.

3.2 Theoretical Framework

The key underlying idea behind measuring market integration is to basically understand the interaction among prices in market that are separated spatially. In the spatial integration model, it helps predict that, under perfect competitive conditions, prices of a similar good in two separate markets will be equal to their inter-market transportation cost. The root of this is from the Law of one price (LOP) by Marshall (1890) which states that, a price of a homogeneous product in one market can vary by at most the cost, C of transferring them from area A to area B. This condition is termed spatial arbitrage

$$P^{A} - P^{B} = C^{AB} \qquad (3.1)$$

If this equation hold as equal then it is known as the robust form of the law of one price

According to Chirwa (2000), Law of One Price assumes that if markets are integrated, price changes in one market will be transferred in a one-for-one basis to other markets instantaneously and the principle of spatial integration predicts that under competitive condition, price differences between two markets in the same economic market for a homogenous commodity will approximately be equal to transaction cost. This idea is a long run concept, however prices can diverge due to various shocks in the short run. Price hints will arouse the price transfer of goods between excess and shortage markets if such a disequilibrium situation occur and thus reestablishing the equilibrium back in the long run. Empirically, the idea of equilibrium can be examined in the context of cointegration evaluation, where it is inferred as a long-rum relationship. The reality of a relationship like that suggests a stationary term which is inferred as the temporal and stochastic deviances from the equilibrium. For such a stationary series, one fundamental characteristic is that it frequently crosses its mean value. According to Rico (2009), this feature can also be inferred as a long run affinity toward the mean. This means that the series does not drift apart from its mean value due to the fact that it is stationary. Such conduct relate closely to the economic understanding of equilibria, which in itself a long run concept.

Based on this theory, the prices in the markets (producer and consumer wholesale prices) used in this study for example Tamale and Accra markets are expected to have a long run equilibrium. That is, in the short-run there could be a possibility of deviations, however, in the long-run, prices are expected to correct to achieve a long-run equilibrium (price transmission).

3.3 Method of Analysis

This section presents the methods that were used in analyzing the data.

3.3.1 Description of Price Trends in Local Rice Market.

In describing the trends, a graph of prices against months and prices against years were plotted and the trends in the markets were described to see the pattern of prices across the markets. Descriptive statistics such as the mean (a five year moving average) and standard deviation of the prices were estimated. The coefficient of variation was also calculated using the formula:

Coefficient of variation, COV= $\mu/\sigma*100$.

Where μ is the mean and σ is the standard deviation of the prices. The coefficient of variation was used to describe the variability of prices in the various markets.

3.3.2 Examining the long-run transmission of prices

To examine the long long-run transmission of prices across the markets, first, a unit root test was done using the Augmented Dickey-fuller(ADF) test. The unit root test was done at level and first difference level to check if the prices are stationary or not and to what degree of integration if they are stationary.

Mathematically, stationarity can be shown as:

$$P_t = \phi P_{t-1} + \mu_t \ldots.. \qquad (3.10)$$

Where μ_t is a random walk of variance, mean and covariance being zero. If $\phi < 1$ it implies the series P_t is stationary. However if $\phi = 1$ then the P_t series is non-stationaary which implies that the mean, variance and covariance of P_t changes with time.

After establishing stationarity, a cointegration analysis was done. Following Alemu (2012), cointegration was tested by incorporating asymmetric adjustment towards equilibrium as part of the alternative hypothesis to address the shortcoming of assuming symmetric adjustment automatically. The Engle-Granger (EG) model, the Threshold Autoregressive Model (TARM), the Momentum Consistent Threshold Autoregressive Model (MC-TAR) and the Momentum Threshold Autoregressive Models (M-TAR) were compared using their (AIC) to select the model that best fit the data. The TAR model was estimated by regressing the price variable on the constant to get the residuals. In the Estimation of MC-TAR approach, it is like the M-TAR. With the MC-TAR, the value of the threshold t, is not fixed at 0. It is considered to be unknown. It was therefore estimated together with the values of ρ_1 and ρ_2.This was done by looking for it over the possible threshold variable space by reducing the residuals in equation 3.1 in the next section.

Residual diagnostic tests were performed to check whether the error term was characterized by a white noise. The null hypothesis of;

No autocorrelation and homoscedasticity were done and the decision to reject or accept was done at conventional levels of significance (1%, 5% and 10%).

The threshold approach test for cointegration was based on the following threshold autoregressive.

$$\Delta\ell_t = I_t\rho_1\varepsilon_{t-1} + (1-I_t)\rho_2\ell\varepsilon_{t-1} + \varepsilon_t \tag{3.1}$$

Where I_t is the indicator function such that $I_t = \begin{cases} 1 \text{ if } \varepsilon_{t-1} \geq \tau \\ 0 \text{ if } \ell\varepsilon_{t-1} < \tau \end{cases}$ and τ is the value of the threshold. ρ_1 and ρ_2 are the adjustment coefficients, ε_t is a sequence of zero-mean, constant variance random variables.

The essential and adequate condition for cointegration are that ρ_1 and ρ_2 must be negative and that $(1+\rho_1)(1+\rho_2)<1$ for every value of τ (Enders and Siklos, 2001).

3.3.3 Evaluation of speed of adjustment price to price shocks in the markets

The Error Correction Model was used in evaluating the speed with which market participants respond to price shocks in the various local rice markets. The equation is specified below,

$$\Delta P_{1t} = \alpha_0 + \sum_{i=1}^{n}\phi_1\Delta P_{1t-1} + \sum_{i=1}^{n}\phi_2\Delta P_{2t-1} + \beta_2^{+}ECT_{t-1}^{+} + \beta_2^{-}ECT_{t-1}^{-} + \varepsilon_t \tag{3.2}$$

$$\Delta P_{2t} = \alpha_1 + \sum_{i=1}^{n}\phi_1\Delta P_{1t-1} + \sum_{i=1}^{n}\phi_2\Delta P_{2t-1} + \beta_2^{+}ECT_{t-1}^{+} + \beta_2^{-}ECT_{t-1}^{-} + \varepsilon_t \tag{3.3}$$

The speed of adjustment is the coefficient on the error terms ECT^{+} and ECT^{-} .

The ECT^{+} and ECT^{-} were obtained from the residuals. The coefficients from the Error Correction Term were interpreted as percentages with which participants responds to either a negative shock or a positive shock in the various markets.

3.3.4 Evaluation of the nature of price transmission between markets

In evaluating the nature of price transmission (whether price transmission is symmetric or asymmetric), a Wald test was done using the estimated coefficients from the cointegration analysis. The Wald test was done for symmetry in the adjustment by analyzing the null hypothesis that $\rho_1 = \rho_2$ in contrast to the alternate hypothesis that $\rho_1 \neq \rho_2$, where ρ_1 and ρ_2 are the coefficients from the cointegration analysis. This test was done to help understand whether actors respond differently to negative and positive changes or in the same way.

3.3.5 Determining causality and Exogeneity in the Local Rice Markets

Testing of causality was done using the estimates from the error correction model. Causality tests in the short-run was done, using F-statistics by examining the significance of the coefficients on the lags of the variations in the prices of the markets. Causality in the Short-run could be in one direction (unidirectional), or in both directions (bidirectional), and that the two consumer prices and producer prices can be free of each other. Causality of market prices in one direction requires that either the consumer price or producer price is not zero, bidirectional causality when consumer price and producer price are not zero and independency when both consumer price and producer price are zeros. Causality in the long-run was also done using t-test for the significance of the coefficient on the error correction term.

3.4 Types and sources of data

Secondary data was used in this study. Data on monthly average whole sale prices of locally produced milled rice from 2006-2015 was gathered from the Statistics, Research and Information Directorate (SRID) unit of the Ministry of Food and Agriculture.

Four main markets were used in this analysis, namely; Tamale, Ho, Kumasi, and Accra markets. These markets are located in the Northern, Volta, Ashanti and Greater Accra Regions respectively.

Among these markets production of rice is concentrated in the Volta and Northern region and hence Ho and Tamale were chosen to be the main producer markets for the study and Kumasi and Accra are the consumer markets.

The price unit of rice was collected in 50kg and so prices can be inferred as GH₵/50kg or pesewas/kg. Since price Data are in nominal form, the price series were deflated by consumer price indices for food (CPIs) issued by Ghana Statistical Services (GSS) with 2012 as the base year.

CHAPTER FOUR

Results and Discussions

4.1 Introduction

The results and discussions from the study are presented in this chapter. Section 4.2 presents discussions on the trends and variability of rice. Also in section 4.3, results of stationarity test are presented. Results of the test for cointegration are also presented in section 4.4. Section 4.5 presents discussions on nature of price transmission. The results of the error correction model are also discussed in section 4.6 and finally discussions on results of Granger causality test are also presented in this section 4.7.

4.2 Description of price trends in local rice Markets

In table 4.1, across the markets, the highest price was found to be in Accra market with a maximum of GH₵190/50kg whereas the minimum was realized in Tamale market with GH₵140/50kg. The average wholesale price was however observed in Accra at GH₵84.24/50kg while the lowest average wholesale price was GH₵52.93/50kg observed in the Tamale market. From 2006 to 2010, the lowest mean price was observed in Tamale at GH₵ 29.56/50Kg while the highest was observed in Kumasi market at GH₵46.06/50Kg.

From 2011 to 2015 also, the lowest average price was observed in Tamale at GH₵76.87/50Kg and Accra recorded the GH₵125.91/50Kg as the highest price.

Table 4.1: Descriptive statistics of wholesale prices in GH/50kg bag of the local rice markets in (2006-2015)

		Accra	Kumasi	Ho	Tamale
Mean	2006-2010	43.42	46.06	45.30	29.56
	2011-2015	125.91	93.41	102.67	76.87
Standard Deviation	2006-2010	15.24	8.08	12.01	6.71
	2011-2015	34.15	33.72	26.03	24.73
coefficient of variation	2006-2010	35.10	17.54	26.51	22.68
	2011-2015	27.12	36.10	25.35	32.17

Source: Author's computation from price Data for 2006-2015

Coefficient of variation, COV= μ/σ*100, where μ is the mean and σ is the standard deviation of the prices.

From the Table 4.1, variability in prices covered in this study was quite high. From 2006 to 2010, variability in prices fluctuated between 35.10% for Accra, 17.54% for Kumasi, 26.51% for Ho and 22.68% for Tamale. High variability translates to a producer income being unstable which is capable of influencing production and production planning negatively and vice versa and also, consumers' welfare could be impacted negatively through poor production planning especially in a country such as Ghana where poverty is very persistent currently about 28.5% (Ghana Statistical Service, 2006) and food expenditures constitute a large proportion of households' disposable income.

4.2.1 Annual Trends in Wholesale Prices

From Fig 4.2, it can be observed that, whole sale price of rice fell in 2007 for all markets and rose again in 2008. From 2009 to 2010 also, prices in the various markets fell. However in 2013, there was a sharp rise in prices for Tamale, Ho and Accra with the exception of Kumasi market. Also in 2014 for Accra, Kumasi and Ho markets, there was a fall in prices. However in Kumasi, prices were high. Also in 2015, prices for all the markets rose sharply with the exception of the Kumasi wholesale market. Though there was a rise in the Kumasi wholesale market, the rise was not as sharp as the other wholesale markets. The Ho and Tamale markets records the least prices due to the high production of rice in the Volta and the Northern regions of Ghana under this study compared to the two consumer markets (USAID 2012).

Figure 4.1: Trend in real Annual local rice prices (2006-2015)

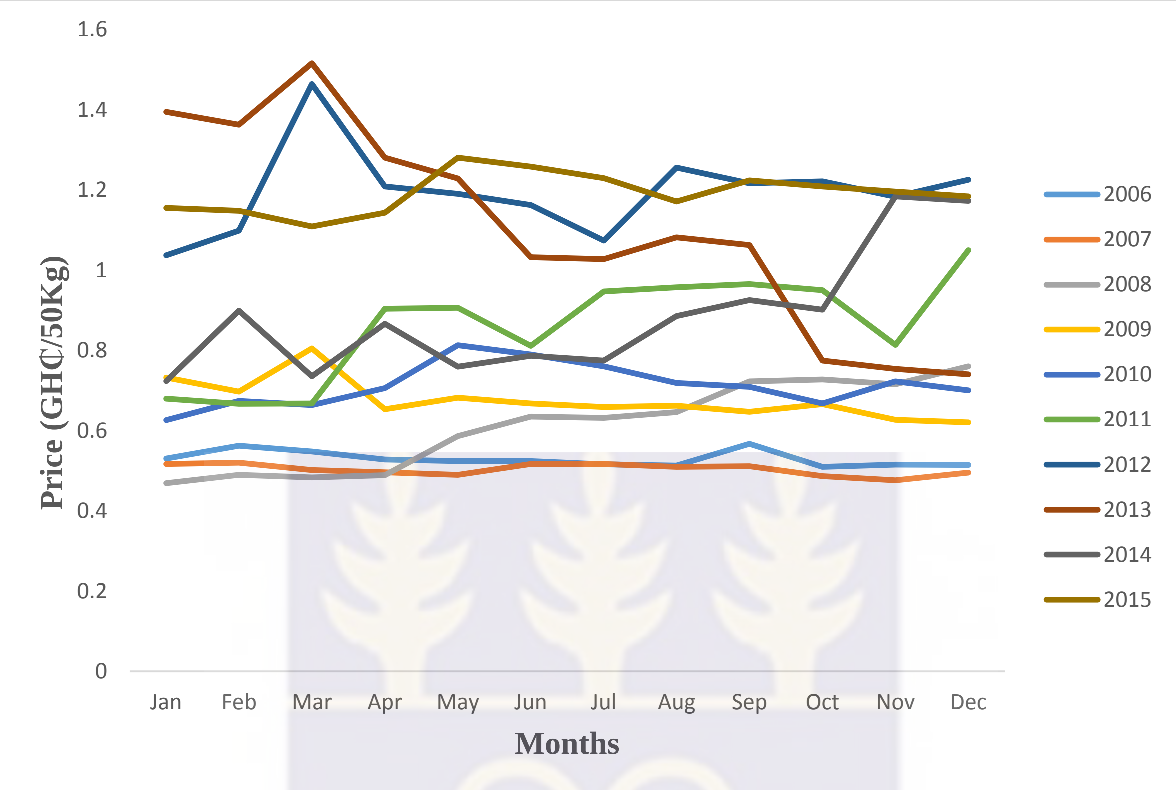
Source: Author's computation from price data

4.2.2 Monthly and seasonal Trends in wholesale prices

Figure 4.2 shows the trend of real prices. The price is at its lowest during the early months of the year and begins to increase. Prices peaked for instance in March for 2009, 2012 and 2013. In March for the other years though the prices were high, they weren't as high as 2009, 2012 and 2013.

From November to December also, it can be seen from the graph that prices were quite stable for all the years with the exception of 2011 which shot up higher than the rest of the years. Generally, it can be observed that prices in the Accra market portray a cyclical trend (rise and fall).

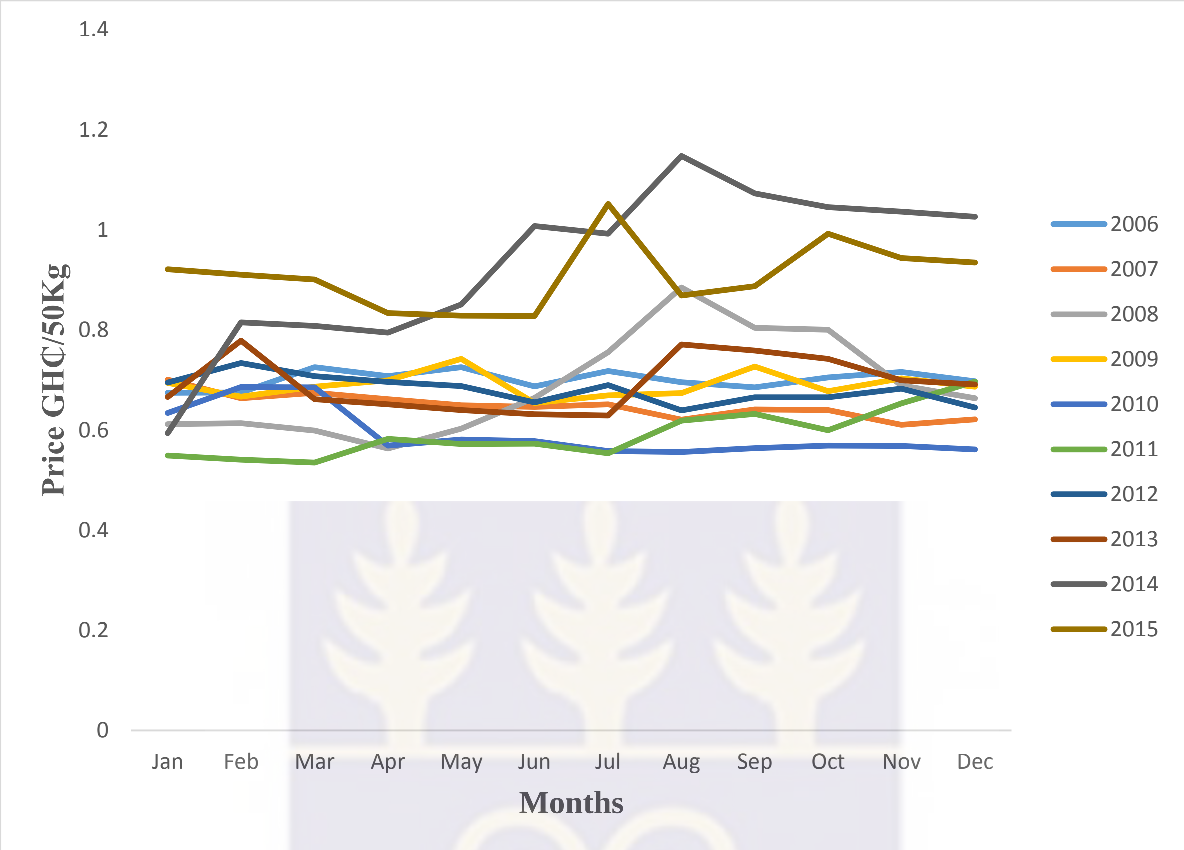
Figure 4.2: Trend in Real price of local rice in Accra Market (2006-2015)



Source: Author's computation from price data

With reference to Figure 4.3, each year begins with prices being at their lowest and then begins to rise to February where it beings to either continue to rise or fall. For instance for 2009, 2012 and2013, there was a fall in price but for the rest of the years, prices continued to rise. In March also, the highest price was recorded in 2013 while the least was recorded in 2008. In March 2009, 2012 and 2013 also, prices were at their peak but decreased suddenly in April. Prices trend was characterized by a rise and fall throughout all the years. In November 2012, 2014 and 2015, prices of rice were the same until the price increase in December for 2012.Genearally prices from November to December became stable except for 2011 where there was a sharp increase.

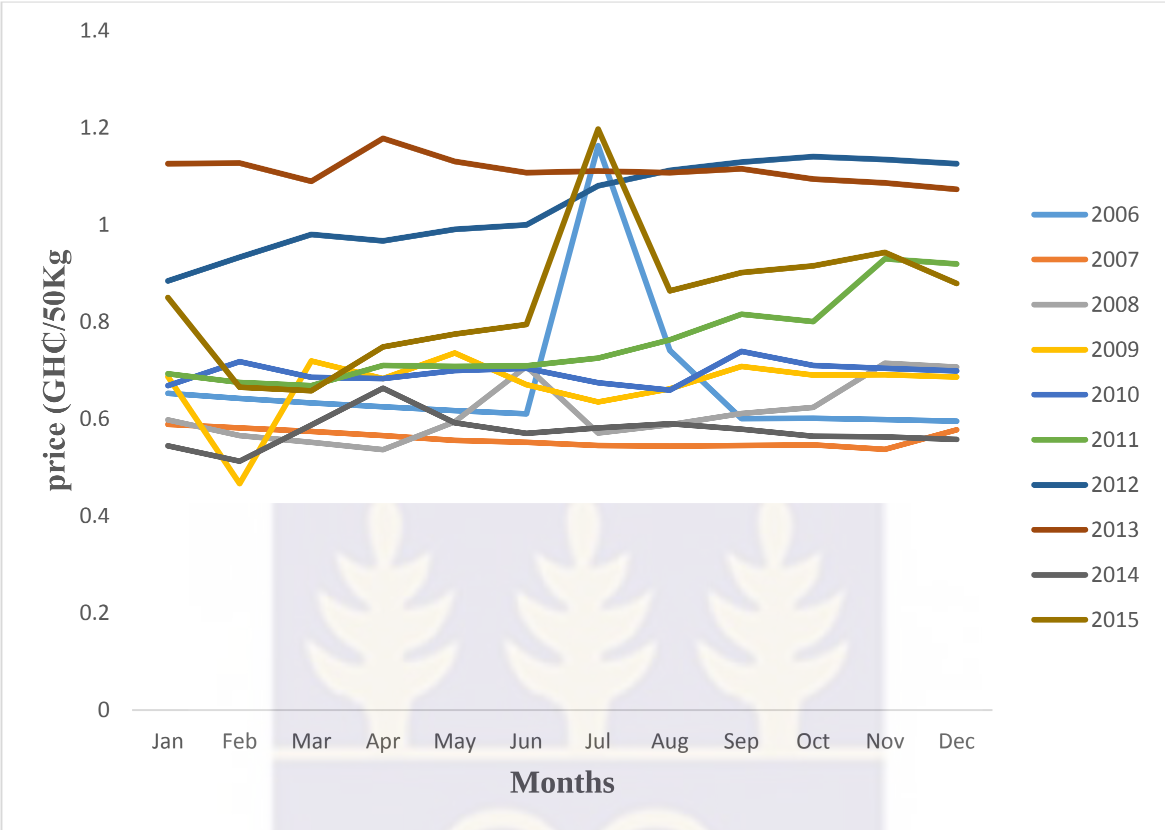
Figure 4.3: Trends in Real price of local rice in Kumasi market (2006-2015)



Source: Author's computation from price data

In Figure 4.4 which shows real prices of local rice in Ho market, prices are at their lowest in January with the exception of 2015 which was quite high. In July, although there was a rise in prices for all the years, prices increased sharply for 2006 and 2015 and then began to fall in August until September when it begun to rise again but with slow momentum. From October to December, it can be seen that the prices in all the years were quite stable with the exception of 2008 and 2011 where there was a rise in price from October to November.2012 records the highest price from August to December while 2007 records the lowest of prices but for January to June the lowest prices were in the year 2013.

Figure 4.4: Trends in Real price of local rice in Ho market (2006-2015)

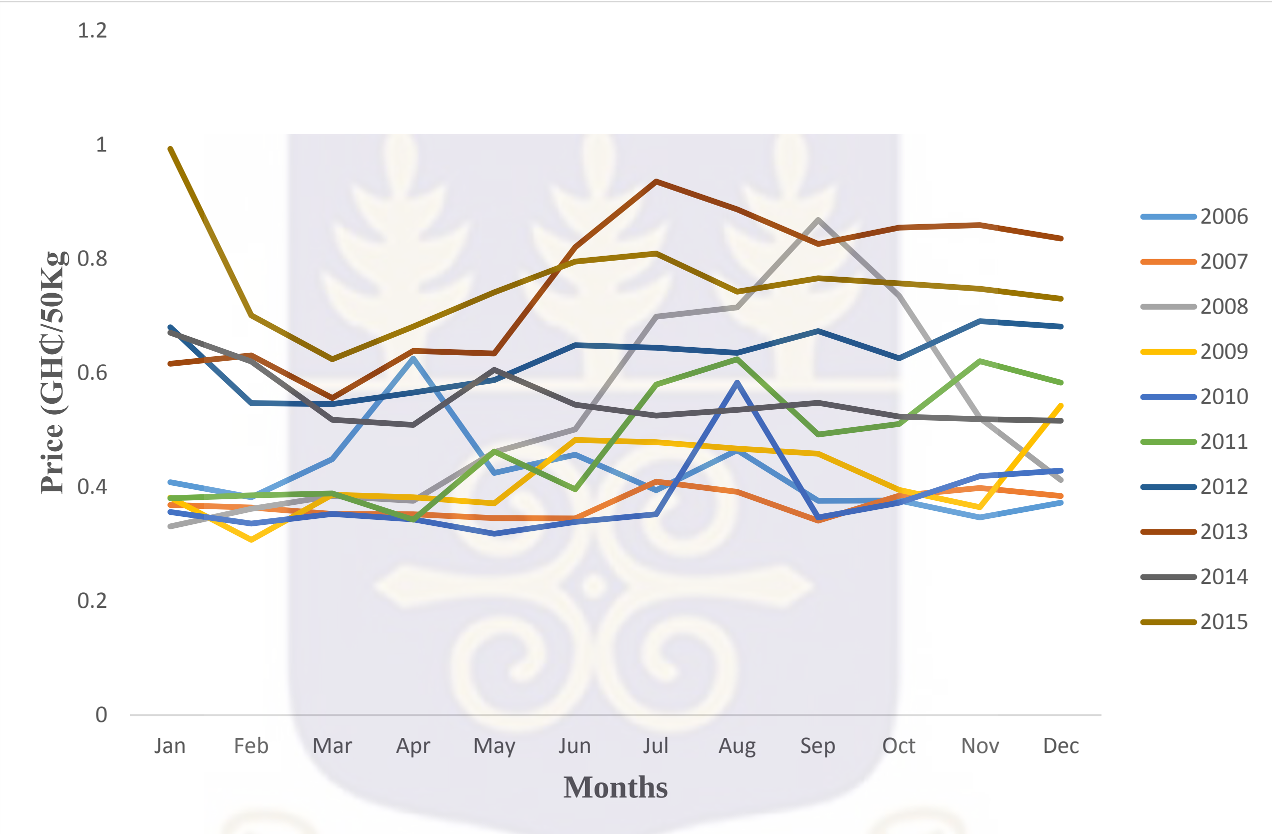


Source: Author's computation from price data

Tamale is a producer market and from Figure 4.5 it can be observed that Tamale market from 2006 to 2011 between January and February had the lowest of prices compared to the other markets. Although prices were high in January for the years 2012, 2013, 2014 and 2015, 2015 recorded the highest price but in that same year February, price of rice fell sharply till March where there was a rise again. 2015 recorded the highest price in January while 2008 recorded the lowest of prices in that same month.

It can also be seen from the same figure 4.5 that, from November to December, with the exception of the years 2006 and 2010, there was a fall in prices for all the years. Generally, prices in all the markets (consumer and producer) where found to be unstable throughout the years. These changes in prices may be as a result of demand and supply factors. According to Gilbert and Morgan (2010), some demand factors include changes in incomes, changes in prices of alternatives and also supply factors can vary either because of variations in area planted or because of yield variations, cost of transportation or typically the weather. These price fluctuations and instability has a high impact on food security since most people spend high proportion of their income on food.

Figure 4.5: Trends Real price of local rice in Tamale market (2006-2015)



Source: Author's computation from price data

4.3 Unit Root Test Results for local rice prices

From the results of the Augmented-Dickey fuller (ADF) test in the Table, 4.2, at level, the Kumasi and Accra markets were non stationary at 1%, 5% and 10% and thus the null hypothesis, $\rho_1 = 0$ which is, there is unit root , we fail to reject. However, the Tamale and Ho markets were stationary at 1% and 5% respectively. At first the difference, all the prices in the various markets were stationary at 1%. The null hypothesis of unit root, that is the price series is non-stationary, was therefore rejected for all four price series. The price series use in the study are therefore at first-difference which implies that they have no unit root and also they are integrated of degree I (1). The finding implies that all the price series were generated by similar stochastic processes and can exhibit the tendency toward long-run equilibrium.

Table 4.2: Unit Root test

Market price	Lag length	ADF statistics	Crit. value (95%)	ADF stats	Crit. val (95%)
		Levels		First Diff	
Tamale	0	-4.418***	-3.449	-13.866***	-3.449
Kumasi	0	-2.845	-3.449	-13.313***	-3.449
Accra	0	-2.988	-3.448	-13.959***	-3.448
Ho	0	-3.677**	-3.448	-14.137***	-3.448

Source: Author's computation from local rice wholesale price data for 2006-2015.
The asterisks ***, ** and * represent rejection of the null hypothesis of unit root at the1%, 5% and 10% levels respectively.

4.4 Cointegration Test Results

The next step in the process of analysis haven differenced the price series to make them stationary is the cointegration test.

Table 4.3: Cointegration from Momentum Consistent Threshold Autoregressive model

Market pairs		Coefficient	Std. Err	P-value
Ho- Accra	ρ_1	-0.25963	0.096305	0.0082
	ρ_2	-0.68416	0.166673	0.0001
Tamale -Accra	ρ_1	-0.07484	0.0496	0.0134
	ρ_2	-0.66928	0.087376	0.0001
Tamale-Kumasi	ρ_1	- 1.23391	0.135405	0.0000
	ρ_2	-0.567733	0.113520	0.0000

Source: Author's computation from price data

In table 4.3 using the necessary and sufficient conditions from the method of analysis explained earlier, which states that, ρ_1 and ρ_2 must be negative and also $(1+\rho_1)(1+\rho_2)<1$, for every value of τ (Enders and Siklos, 2001), we consider the Ho and Accra market pair using these conditions.

So observing from the table and also by calculation,

That is, (1-0.25963) (1+0.68416)

=0.233<1

It can be observed that, ρ_1 and ρ_2 are all less than zero and $(1+\rho_1)(1+\rho_2)<1$. Hence, the two market pairs are confirmed to be cointegrated and thus, it can be conclude that, there is a long-run relationship between the Ho and Accra market pairs

Using the same approach for Tamale and Kumasi market also, the first and the second condition for cointegration was met and hence it is also concluded that, there is cointegration between the two market pairs. That is, there is a long-run relationship between the markets and that prices of the producer and consumer markets do not drift apart in the long run. Thus, market prices adjust to achieve long-run market equilibrium. Tamale and Accra market pair is cointegrated.

Since it is evident from the table that at least there is one cointegrating relationship between the market pairs, the Error Correction Model is used to correct for deviations and also to examine to see if price transmission is symmetric or asymmetric and the extent of transmission.

Table 4.4: Results from the identification of best fit model based on AIC

	HO-ACCRA				KUMASI-TAMALE				TAMALE-ACCRA			
LAGS	EG	TAR	M-TAR	MC-TAR	EG	TAR	M-TAR	MC-TAR	EG	TAR	M-TAR	MC-TAR
0	-1.722	-1.688	-1.691	-1.794	-2.318	-2.385	-2.407	-2.410	-0.593	-0.572	-0.562	-0.691
1	-1.702	-1.666	-1.669	-1.773	-2.336	-2.389	-2.407	-2.420	-0.579	-0.551	-0.541	-0.673
2	-1.681	-1.641	-1.641	-1.748	-2.320	-2.370	-2.384	-2.402	-0.558	-0.529	-0.519	-0.654
3	-1.668	-1.624	-1.626	-1.732	-2.297	-2.343	-2.358	-2.381	-0.537	-0.507	-0.498	-0.629
4	-1.666	-1.621	-1.628	-1.716	-2.295	-2.344	-2.351	-2.365	-0.516	-0.482	-0.475	-0.612
5	-1.664	-1.628	-1.636	-1.709	-2.287	-2.355	-2.360	-2.352	-0.504	-0.467	-0.457	-0.598
6	-1.752	-1.719	-1.726	-1.794	-2.278	-2.376	-2.381	-2.346	-0.486	-0.450	-0.441	-0.577
7	-1.744	-1.713	-1.709	-1.793	-2.258	-2.372	-2.35	-2.323	-0.575	-0.559	-0.537	-0.671

Source: Author's computation from price data

From Table 4.4, the chosen lag lengths for the price analysis are based on the Akaike Information Criteria (AIC) and the table presents the number of lags used for both Ho and Accra market pair as well as Tamale and Kumasi market pairs. For Ho and Accra market pair for instance, the chosen lag length was six and for Tamale and Ho the lag length was one. Beyond an AIC value of six for Ho and Tamale Market pair, the AIC began to fall and also for Tamale and Kumasi also, it begun to fall at one lag length.

In terms of absolute AIC value, the (MC-TAR) model was found to be the best model that fits the price data for this analysis since it had the highest.

4.5 Symmetry in Price Transmission

The evidence of asymmetry between the producer markets and consumer markets in rice markets under study are estimated using the Wald test from the results of the cointegrating test. This test, as earlier on indicated, helps establish whether actors respond differently to negative and positive shocks or in the same way.

From the results in Table 4.5, the symmetric null hypothesis, $\rho_1 = \rho_2$ is rejected at 1% significant level for Ho as well as Tamale and Accra markets but at 5% significant level for Tamale and Kumasi and hence the markets are characterized by asymmetry in price transmission. The results suggests that, for instance in Kumasi and Tamale, 68.4% of the positive shocks and 25.9% of the negative shocks are rolled over to the following month following a shock. In Accra and Ho market also, 96.5% of positive shock and 3.5% of the negative are rolled over to the next month after a shock. The implication of this is that, when there is deviation from equilibrium it persists when it is caused by producer price decrease than when the shock is a negative one (producer price increase). It can also be concluded that, the response of actors to price increases is faster than to response in decrease in prices.

Table 4.5: Wald test results of symmetry in Price transmission

	F stat value	**Prob.**
Ho-Accra	9.65298	0.0001
Tamale-Kumasi	2.55092	0.0122
Tamale-Accra	-3.77019	0.0003

Source: Author's computation from price data

4.6 Error Correction Model (ECM)

Once cointegration has been established, it becomes a necessary condition to use the ECM to determine how price adjust to shocks and the extent to which price adjust to shocks.

Table 4. 6: Results from the Error Correction Estimates

	Ho-Accra			Tamale-Kumasi			Tamale-Accra	
Variable	Coeff.	Prob.	variable	Coeff.	Prob.	variable	Coeff	Prob
ΔAccra			ΔKumasi			ΔAccra		
C	0.0078	0.3556	C	0.0030	0.4566	C	0.007858	0.3556
ΔAcc_{t-1}	-0.1853	0.0690	ΔKum_{t-1}	-0.1713	0.0674	ΔAcc_{t-1}	-0.185373	0.0690
ΔHo_{t-1}	-0.1144	0.0741	ΔTam_{t-1}	0.0202	0.0619	ΔTam_{t-1}	-0.114492	0.0741
ECT+	-0.0828	0.2527	ECT+	-0.1212	0.0161	ECT+	-0.082811	0.2527
ECT-	-0.0939	0.5461	ECT-	0.0356	0.9159	ECT-	-0.093904	0.5461
ΔHO			ΔTamale			ΔTamale		
C	0.0040	0.7319	C	0.0059	0.7006	C	0.020334	0.5805
$\Delta Accra_{t-1}$	-0.2466	0.0789	ΔKum_{t-1}	0.1435	0.4982	ΔAcc_{t-1}	-0.180143	0.3471
ΔHO_{t-1}	-0.2417	0.0067	ΔTam_{t-1}	-0.2544	0.0071	ΔTam_{t-1}	-0.362580	0.0276
ECT+	0.4677	0.0000	ECT+	-0.0023	0.9834	ECT+	-0.193704	0.4878
ECT-	0.3421	0.1121	ECT-	-0.4587	0.5505	ECT-	0.360284	0.3346

Source: Author's computation from price data

***ECT+* and *ECT-* measures adjustment to positive shocks and negative shocks respectively.**

The estimates from the Error Correction Model under which causality test is conducted is presented in table 4.6.

Positive shocks are events that suddenly increase the price of rice in the local/ central markets while negative shocks are events that decrease the price of rice in the markets (both producer and consumer markets). From the results, in Ho and Accra markets, following a positive shock that creates disequilibrium, 12.1% of such shocks will be eliminated within a month while in the events of negative shock (price decreases) that leads to disequilibrium, only 3.5% of such deviations will be corrected within a month.

Similarly, in Tamale and Kumasi markets, for positive shocks that leads to disequilibrium, 0.2% of such deviation will be eliminated within a month while with the event of a negative shock, 45% of such will be corrected within a month.

4.7 Causality and Exogeneity in rice the markets

Knowing the type of market playing leadership position in the formation of price transmission is very important for policy purposes (Mafimisebi, 2012). It has been established that, markets playing leadership exist in any market network for a homogenous commodity which is integrated of the same order with no possibility to deviate from the long-run equilibrium or diverge. In Table 4.7, the results of causality test is presented.

Table 4.7: Test results of Granger Causality

Null Hypothesis	Short-Run Causality		Long –Run Causality		Results
	(F-stat)	P-value	(F-stat)	P-value	unidirectional
Accra-Ho	3.3703	0.0690	0.7872	0.4570	
Ho- Accra	7.6367	0.0067	11.8016	0.0000	
Kumasi-Tamale	3.4111	0.0067	2.9927	0.0540	unidirectional
Tamale-Kumasi	7.5231	0.0071	0.1793	0.8360	
Accra-Tamale	1.792390	0.1833	6.7869	0.0016	unidirectional
Tamale-Accra	4.9799	0.0276	0.8511	0.4297	

Source: Author's computation from price data

From Table 4.7, for Accra and Ho market, the null hypothesis which states that the consumer market does not cause the producer market is rejected in the short run at 10% as well as the reverse which is also rejected at 1%. Hence in the short run, causality is bi-directional. However in the long run, the test fails to reject the null hypothesis that the producer market price does not Granger-cause consumer market price.This means that in the long-run, causality is unidirectional. Also, the null hypothesis that producer market (Ho) does not granger cause the consumer market is rejected in the short run at 10% as well as the reverse which is also rejected at 1% hence in the short run, causality is bi-directional. However In the long run, the test cannot reject the null hypothesis that the producer market price does not Granger-cause consumer market price. This means that in the long-run causality is unidirectional. Unidirectional causality was found in all the market pairs. Unidirectional causality implies that the market is inefficient in transmitting information

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Introduction

The results of the study is summarized in this chapter. Conclusions in this chapter are based on the research results. The chapter ends with policy recommendations based on the findings and conclusions of the study.

5.2 Summary

It is imperative to recognize the behaviour of agricultural price in other to be able to develop plans and policies which are workable. There have been interventions and efforts by Governments to achieve market efficiency which will have implications on food security in both surplus producing regions and deficit regions. In spite of these efforts, most of the concentration has been to increase yield and productivity without really concentrating much on market price analysis. The study sought to analyze some selected rice markets in Ghana using wholesale prices in the last 10 years. Using monthly wholesale prices data from 2006 to 2015 from the SRID unit of the ministry of food and agriculture, this study examined the trends and variation in prices in four selected markets. It also examined the linkages among the net producer markets and consumer markets, whether price transmission adjustments were symmetric or asymmetric was also examined and finally the extent to which markets respond to shocks.

In describing the markets it was realized that, from 2006 to 2010, the lowest mean price was observed in Tamale at GH₵ 29.56/50Kg while the highest was observed in Kumasi market at GH₵46.06/50Kg. From 2011 to 2015 also, the lowest average price was observed in Tamale at GH₵76.87/50Kg and Accra recorded GH₵125.91/50Kg as the highest price. Variability in prices covered in this study was quite high. From 2006 to 2010, variability in prices fluctuated between 35.10% for Accra, 17.54% for Kumasi, 26.51% for Ho and 22.68% for Tamale. The variability in prices were quite close to each other. High variability translates to a quite unstable producer income which has the ability of having a negative result on production and production planning and vice versa.

Across the markets, all the three market price pairs were found to be cointegrated, meaning in the long-run the prices do not diverge. Also, the market pairs were found to exhibit asymmetric adjustments and the error correction model was employed to correct the deviation that occurs in the long-run. It was found that from the ECM that, in Ho and Accra markets, following a positive shock that creates disequilibrium, 46% of such shocks will be eliminated within a month.

Likewise, in Tamale and Kumasi markets, for positive shocks that leads to disequilibrium, 1.6% of such deviation will be eliminated within a month. The results of Granger causality revealed that Ghanaian rice markets are well integrated. The markets exhibit both bidirectional and unidirectional causality.

5.3 Conclusion and Recommendation

The findings of the study revealed evidence of long run relationship between the producer and consumer markets. This means that over the long run, price categories co-move and may be driven by common stochastic processes. All the three market pairs were characterized by asymmetry in price transmission. This implies that actors responds differently to either increases or decreases in prices

Against the above evidence, the error correction model revealed that increase in price in the producer markets are transferred faster to consumer markets and not vice versa and the Granger causality test confirmed it by revealing unidirectional causality in the long run. In the long run, the producer market prices influences or are transmitted to the consumer markets, however the same cannot be said for the consumer markets. According to Fackler (1996), Gupa and Mueller (1982), the failure of one price to be predictive of another when the second is predictive of the first (unidirectional causality) is an indication that the second price is not incorporating the price information from the first region. The Tamale and Ho markets play leadership positions and this can be attributed to the fact that the majority of local rice comes from these areas.

5.4 Policy Recommendations

Based on the results of the study, though there exist a long run relationship, it was revealed that after a shock, the adjustment mechanism was characterized by asymmetry which are signals of market failure and net welfare losses to producers and consumers. Traders were slow in passing on price decrease than prices that decrease their margins. It is therefore recommended that better infrastructural facilities such Storage facilities, communication network be improve. Timely flow of information concerning demand, supply and prices to and from various markets will help increase market integration level with increased speed of price transmission or adjustment.

Additionally, adequate market information on price dissemination through media outlets and the SRID unit of MOFA should be improved. The sector should be equipped financially to be able to perform this task since this is to inform participant about current prices since a regular and wide range of price dissemination and market supply of information will lead to effectiveness of arbitrage among markets and thus reduce uncertainties in market supplies.

Further, it is recommended that, Ghanaian institutions be equipped with mechanisms that is required to be able to manage variability in agricultural commodity prices. Agricultural policies should be a national focus by investing in the agricultural sector to build a solid foundation to be able to sustain growth since the study revealed high percentages of price variability. In this respect, if it is important to have a more technical and financial assistance to strengthen the production, adoption, and dissemination of selected rice varieties in Ghana is very imperative.

Market linkages show both bidirectional and unidirectional causality and this shows that markets are integrated but the producer markets (Tamale and Ho) were found to exhibit price leadership. It is therefore recommended that policies be directed towards these since changes in price will be transferred efficiently to markets which are follower.

5.5 Limitations of the Study and Areas for further studies

One limiting concern to this study was the availability and complete set of price series data. The process of generating or acquiring data should be taken notice by the appropriate bodies. Qualified people should be trained and tasked in collecting data since it has implication welfare and policy implementation. Also, the underlying causes of Asymmetry in the rice markets in Ghana would be better understood if future studies explores this area.

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Appendices

Appendix 1: **Average Nominal Wholesale Price of Local Rice (2006-2015)**

Year	Months	Accra	Kumasi	Techiman	Ho	Tamale
2006	1	26.00	33.06	21.56	32.00	20.00
2006	2	28.00	33.63	22.38	32.00	19.00
2006	3	27.70	36.67	17.90	32.00	22.67
2006	4	27.05	36.25	22.00	32.00	32.00
2006	5	27.17	37.63	19.75	32.00	22.00
2006	6	27.48	36.05	20.51	32.00	23.92
2006	7	27.52	38.25	25.63	62.00	21.00
2006	8	27.31	37.04	21.97	39.50	24.73
2006	9	30.20	36.50	24.00	32.00	20.00
2006	10	27.13	37.50	24.00	32.00	20.00
2006	11	27.54	38.25	24.00	32.00	18.50
2006	12	27.65	37.50	24.00	32.00	20.00
2007	1	28.10	38.10	22.30	32.00	20.00
2007	2	28.60	36.50	21.50	32.00	20.00
2007	3	27.97	37.59	22.95	32.00	19.63
2007	4	28.08	37.42	22.69	32.00	19.91
2007	5	28.19	37.40	22.36	32.00	19.88
2007	6	30.00	37.50	24.00	32.00	20.00
2007	7	30.33	38.25	21.00	32.00	24.00
2007	8	30.00	36.50	27.50	32.00	23.00
2007	9	30.00	37.63	28.00	32.00	20.00
2007	10	28.50	37.50	28.50	32.00	22.50
2007	11	28.33	36.33	27.00	32.00	23.67
2007	12	30.00	37.67	29.25	35.00	23.25
2008	1	28.75	37.50	30.00	36.67	20.25
2008	2	30.50	38.25	30.00	35.25	22.50
2008	3	30.67	38.00	30.00	35.00	24.33
2008	4	31.90	36.75	26.90	35.00	24.50
2008	5	39.50	40.60	32.00	40.00	31.00
2008	6	43.62	45.62	40.50	48.67	34.37
2008	7	43.90	52.50	48.50	39.67	48.50
2008	8	44.88	61.44	49.63	40.83	49.63
2008	9	50.00	55.63	62.00	42.29	60.00
2008	10	50.00	55.00	53.00	42.87	50.50
2008	11	50.00	48.20	50.00	50.00	36.40
2008	12	54.40	47.50	45.90	50.62	29.50
2009	1	53.80	51.00	44.50	50.50	28.00
2009	2	52.25	50.00	50.00	35.00	23.00

2009	3	61.50	52.50	34.00	55.00	29.50
2009	4	51.38	55.00	35.25	53.75	30.00
2009	5	55.10	60.00	33.70	59.50	30.00
2009	6	55.40	54.25	51.00	55.63	40.00
2009	7	55.13	56.00	52.50	53.13	40.00
2009	8	55.00	56.00	51.10	55.00	38.80
2009	9	53.00	59.50	49.50	58.00	37.50
2009	10	54.00	55.00	42.00	56.00	32.00
2009	11	51.25	57.50	45.75	56.50	29.75
2009	12	51.50	57.00	42.75	57.00	45.00
2010	1	52.80	53.50	41.60	56.40	30.00
2010	2	57.75	58.75	42.38	61.50	28.75
2010	3	57.50	59.38	38.00	59.38	30.50
2010	4	62.00	50.00	39.25	60.00	30.13
2010	5	72.70	52.00	37.30	62.60	28.40
2010	6	71.75	52.50	41.75	64.00	30.75
2010	7	69.60	51.10	40.60	61.80	32.20
2010	8	65.38	50.63	40.75	60.00	53.00
2010	9	63.50	50.50	36.88	66.25	31.00
2010	10	59.20	50.50	38.63	63.00	33.00
2010	11	64.42	50.68	39.21	62.76	37.30
2010	12	63.12	50.58	38.87	63.00	38.58
2011	1	62.56	50.56	38.39	63.75	34.97
2011	2	62.33	50.58	38.77	63.13	35.96
2011	3	63.11	50.60	38.81	63.16	36.70
2011	4	86.50	55.75	41.00	68.00	32.75
2011	5	88.25	55.75	46.25	69.00	45.00
2011	6	80.00	56.50	49.50	70.00	39.00
2011	7	94.00	55.00	57.50	72.00	57.50
2011	8	94.38	61.00	56.38	75.25	61.50
2011	9	93.75	61.38	57.00	79.25	47.75
2011	10	91.50	57.75	57.88	77.13	49.13
2011	11	78.75	63.25	63.75	90.00	60.00
2011	12	102.75	68.25	71.25	90.00	57.00
2012	1	103.75	69.50	67.00	88.50	68.00
2012	2	111.50	74.50	67.25	94.75	55.50
2012	3	150.50	72.75	66.75	100.75	56.00
2012	4	126.25	72.75	67.75	101.00	59.00
2012	5	126.75	73.25	68.00	105.50	62.50
2012	6	125.50	70.75	70.00	108.00	70.00
2012	7	116.75	75.00	74.50	117.50	70.00
2012	8	135.50	69.00	80.00	120.00	68.50
2012	9	129.25	70.75	80.00	120.00	71.50
2012	10	128.50	70.00	76.50	120.00	65.75
2012	11	125.13	72.25	75.00	120.00	73.00
2012	12	130.50	68.75	75.75	120.00	72.50

2013	1	151.75	72.50	74.00	122.50	67.00
2013	2	146.50	83.75	74.25	121.25	67.75
2013	3	163.75	71.50	76.25	117.75	60.00
2013	4	140.50	71.50	75.00	129.25	70.00
2013	5	135.75	70.75	75.00	125.00	70.00
2013	6	116.50	71.25	75.00	125.00	92.50
2013	7	116.75	71.50	75.00	126.25	106.25
2013	8	122.00	87.00	75.00	125.00	100.00
2013	9	119.00	85.00	77.25	125.00	92.50
2013	10	88.75	85.00	85.00	125.31	97.81
2013	11	87.00	80.75	85.00	125.39	99.14
2013	12	86.38	80.63	85.00	125.18	97.36
2014	1	87.70	72.00	85.00	66.00	81.20
2014	2	110.25	100.00	85.00	62.88	76.00
2014	3	91.00	100.00	83.00	72.70	64.00
2014	4	109.00	100.00	85.00	83.50	64.00
2014	5	96.40	108.00	85.00	75.20	76.80
2014	6	101.50	130.00	130.00	73.57	70.20
2014	7	101.50	130.00	130.00	76.24	68.75
2014	8	115.75	150.00	140.00	77.13	69.94
2014	9	120.75	140.00	140.00	75.53	71.42
2014	10	120.75	140.00	140.00	75.62	70.08
2014	11	160.00	140.00	140.00	76.13	70.05
2014	12	160.00	140.00	140.00	76.10	70.37
2015	1	163.00	130.00	120.00	120.00	140.00
2015	2	164.00	130.00	100.00	95.00	100.00
2015	3	160.00	130.00	100.00	95.00	90.00
2015	4	168.00	122.50	100.00	110.00	100.00
2015	5	190.00	123.00	116.00	115.00	110.00
2015	6	190.00	125.00	123.75	120.00	120.00
2015	7	190.00	162.50	126.25	185.00	125.00
2015	8	179.58	133.25	126.00	132.50	113.75
2015	9	187.40	135.94	123.00	138.13	117.19
2015	10	190.00	156.00	258.00	143.91	118.98
2015	11	190.00	150.00	250.00	149.88	118.73
2015	12	190.00	150.00	245.00	141.10	117.16

Appendix 2: Cointegration form MC-TAR model

Kumasi and Tamale

Dependent Variable: DRESRETAILS
Method: Least Squares
Date: 07/20/17 Time: 15:42
Sample (adjusted): 2006M02 2015M12
Included observations: 119 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESRETAILS(-1)*DUMPMCS_100	-1.233910	0.135405	-9.112738	0.0000
RESRETAILS(-1)*DUMNMCS_100	-0.567733	0.113520	-5.001150	0.0000

R-squared	0.479991	Mean dependent var	0.003731
Adjusted R-squared	0.475546	S.D. dependent var	0.234486
S.E. of regression	0.169813	Akaike info criterion	-0.691573
Sum squared resid	3.373869	Schwarz criterion	-0.644865
Log likelihood	43.14858	Hannan-Quinn criter.	-0.672606
Durbin-Watson stat	1.869367		

Tamale and Kumasi

Dependent Variable: DRESRETAILS

Method: Least Squares
Date: 03/31/17 Time: 07:33
Sample (adjusted): 2006M03 2015M12
Included observations: 118 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESRETAILS(-1)*DUMPMCS_22	-0.074839	0.049600	-1.508834	0.1341
RESRETAILS(-1)*DUMNMCS_22	-0.669280	0.164838	-4.060231	0.0001
DRESRETAILS(-1)	-0.177519	0.087376	-2.031653	0.0445

R-squared	0.197867	Mean dependent var	0.000355
Adjusted R-squared	0.183917	S.D. dependent var	0.078851
S.E. of regression	0.071232	Akaike info criterion	-2.420667
Sum squared resid	0.583502	Schwarz criterion	-2.350226
Log likelihood	145.8193	Hannan-Quinn criter.	-2.392066
Durbin-Watson stat	2.015656		

Tamale and Accra

Dependent Variable: DRESRETAILS
Method: Least Squares
Date: 07/20/17 Time: 15:42
Sample (adjusted): 2006M02 2015M12
Included observations: 119 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESRETAILS(-1)*DUMPMCS_100	-1.233910	0.135405	-9.112738	0.0000
RESRETAILS(-1)*DUMNMCS_100	-0.567733	0.113520	-5.001150	0.0000

R-squared	0.479991	Mean dependent var	0.003731
Adjusted R-squared	0.475546	S.D. dependent var	0.234486
S.E. of regression	0.169813	Akaike info criterion	-0.691573
Sum squared resid	3.373869	Schwarz criterion	-0.644865
Log likelihood	43.14858	Hannan-Quinn criter.	-0.672606
Durbin-Watson stat	1.869367		

Appendix 3: Results of ECM

ECM For Ho and Accra

Dependent Variable: DLRP
Method: Least Squares
Date: 04/18/17 Time: 14:31
Sample (adjusted): 2006M03 2015M12
Included observations: 118 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.007858	0.008472	0.927623	0.3556
DLRP(-1)	-0.185373	0.100975	-1.835833	0.0690
DLPP(-1)	-0.114492	0.063513	-1.802648	0.0741
RESRETAILS(-1)*DUMPMCS_30(-1)	-0.082811	0.072036	-1.149576	0.2527
RESRETAILS(-1)*DUMNMCS_30(-1)	-0.093904	0.155107	-0.605415	0.5461

R-squared	0.102459	Mean dependent var	0.006310
Adjusted R-squared	0.070687	S.D. dependent var	0.093779
S.E. of regression	0.090404	Akaike info criterion	-1.927614
Sum squared resid	0.923530	Schwarz criterion	-1.810212
Log likelihood	118.7292	Hannan-Quinn criter.	-1.879945
F-statistic	3.224870	Durbin-Watson stat	1.960821
Prob(F-statistic)	0.015114		

ECM for Tamale and Accra

Dependent Variable: DLRP
Method: Least Squares
Date: 04/18/17 Time: 15:21
Sample (adjusted): 2006M03 2015M12
Included observations: 118 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.007858	0.008472	0.927623	0.3556
DLRP(-1)	-0.185373	0.100975	-1.835833	0.0690
DLPP(-1)	-0.114492	0.063513	-1.802648	0.0741
RESRETAILS(-1)*DUMPMCS_30(-1)	-0.082811	0.072036	-1.149576	0.2527
RESRETAILS(-1)*DUMNMCS_30(-1)	-0.093904	0.155107	-0.605415	0.5461

R-squared	0.102459	Mean dependent var	0.006310
Adjusted R-squared	0.070687	S.D. dependent var	0.093779
S.E. of regression	0.090404	Akaike info criterion	-1.927614
Sum squared resid	0.923530	Schwarz criterion	-1.810212
Log likelihood	118.7292	Hannan-Quinn criter.	-1.879945
F-statistic	3.224870	Durbin-Watson stat	1.960821
Prob(F-statistic)	0.015114		

ECM For Kumai and Tamale

Dependent Variable: DLRP
Method: Least Squares

Sample (adjusted): 2006M03 2015M12
Included observations: 118 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003072	0.006728	0.456631	0.6488
DLRP(-1)	-0.171306	0.092752	-1.846923	0.0674
DLPP(-1)	0.020296	0.040730	0.498313	0.6192
RESRETAILS(-1)*DUMPMCS_22(-1)	-0.121211	0.049616	-2.442999	0.0161
RESRETAILS(-1)*DUMNMCS_22(-1)	0.035607	0.336375	0.105855	0.9159

R-squared	0.103838	Mean dependent var	0.002754
Adjusted R-squared	0.072116	S.D. dependent var	0.075631
S.E. of regression	0.072853	Akaike info criterion	-2.359297
Sum squared resid	0.599754	Schwarz criterion	-2.241895
Log likelihood	144.1985	Hannan-Quinn criter.	-2.311629
F-statistic	3.273330	Durbin-Watson stat	2.012688
Prob(F-statistic)	0.014015		

Appendix 4: Test of symmetry

Accra and Ho

Wald Test:

Equation: EQ6_30

Test Statistic	Value	df	Probability
F-statistic	9.652980	(2, 105)	0.0001
Chi-square	19.30596	2	0.0001

Null Hypothesis: C(1)=C(2)=0

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	-0.259629	0.096305
C(2)	-0.684156	0.166673

Restrictions are linear in coefficients.

Test for symmetry Kumasi and Tamale

Wald Test:
Equation: EQ1_22

Test Statistic	Value	df	Probability
F-statistic	9.142058	(2, 115)	0.0002
Chi-square	18.28412	2	0.0001

Null Hypothesis: C(1)=C(2)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	-0.074839	0.049600
C(2)	-0.669280	0.164838

Appendix 5: Causality test

Kumasi and Tamale
Equation: ERROR1

Test Statistic	Value	df	Probability
t-statistic	-1.846923	113	0.0674
F-statistic	3.411126	(1, 113)	0.0674
Chi-square	3.411126	1	0.0648

Null Hypothesis: C(2)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(2)	-0.171306	0.092752

Restrictions are linear in coefficients.

Wald Test:
Equation: ERROR1

Test Statistic	Value	df	Probability
F-statistic	0.787213	(2, 113)	0.4576
Chi-square	1.574425	2	0.4551

Null Hypothesis: C(4)=C(5)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	-0.082811	0.072036
C(5)	-0.093904	0.155107

Restrictions are linear in coefficients.

Wald Test:
Equation: ERROR2

Test Statistic	Value	df	Probability
t-statistic	-2.742822	113	0.0071
F-statistic	7.523075	(1, 113)	0.0071
Chi-square	7.523075	1	0.0061

Null Hypothesis: C(3)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(3)	-0.254447	0.092768

Restrictions are linear in coefficients.
Wald Test:
Equation: ERROR2

Test Statistic	Value	df	Probability
F-statistic	11.80159	(2, 113)	0.0000
Chi-square	23.60319	2	0.0000

Null Hypothesis: C(4)=C(5)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	0.467701	0.099225
C(5)	0.342107	0.213650

Restrictions are linear in coefficients.

Granger causality Kumasi and Tamale

Wald Test:
Equation: ERROR1

Test Statistic	Value	df	Probability
F-statistic	2.992751	(2, 113)	0.0541
Chi-square	5.985501	2	0.0501

Null Hypothesis: C(4)=C(5)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	-0.121211	0.049616
C(5)	0.035607	0.336375

Restrictions are linear in coefficients.
Wald Test:
Equation: ERROR2

Test Statistic	Value	df	Probability
t-statistic	-2.742822	113	0.0071
F-statistic	7.523075	(1, 113)	0.0071
Chi-square	7.523075	1	0.0061

Null Hypothesis: C(3)=0

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(3)	-0.254447	0.092768

Restrictions are linear in coefficients.
Wald Test:
Equation: ERROR2

Test Statistic	Value	df	Probability
F-statistic	0.179347	(2, 113)	0.8361
Chi-square	0.358693	2	0.8358

Null Hypothesis: C(4)=C(5)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	-0.002355	0.113007
C(5)	-0.458715	0.766144

Restrictions are linear in coefficients.