UNIVERSITY FOR DEVELOPMENT STUDIES

EFFECTS OF RICE IMPORTATION ON THE PRICING OF DOMESTIC RICE IN NORTHERN REGION OF GHANA

MOHAMMED TANKO

DISSERTATION SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS, FACULTY OF AGRIBUSINESS AND COMMUNICATION SCIENCES, UNIVERSITY FOR DEVELOPMENT STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN AGRICULTURAL ECONOMICS

2015

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2015

Declaration

I hereby declare that this dissertation is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere:

Candidate's Signature: ..... Date: 13/08/2015

Name: Mohammed Tanko

Supervisor

I hereby declare that the preparation and presentation of the dissertation was supervised in accordance with the guidelines on supervision of dissertation laid down by the University for Development Studies.

Supervisor's Signature: ..... Date: 17/08/2015

Name: Dr. Joseph Amikuzuno

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Name: Dr. S. A. Donkoh

Abstract

The agricultural sector plays a major role in Ghana's economy, contributing 21.5% to the Gross Domestic Product [GDP], employing about 69% of the labour force and serving as a source of income and food security to the poor. Given the importance of the agricultural sector in the economy, if governments and policy makers are to take adequate measures to ensure food security, they need to have a good understanding of the functioning of their markets (price transmission). This research analysed secondary data of two categories of rice prices (imported and domestic) at the same district market in eight selected districts of Northern region of Ghana collected from the Ghana Ministry of Food and Agriculture (MoFA) to analyse the price dynamics of the two rice brands. The first chapter explained rice importation, domestic rice marketing and its effects. The methodology applied to this work starts from the verification of co-integration property between the two prices using Johansen method after applying Augmented Dickey-Fuller (ADF), Phillip Peron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests of stationarity. Granger causality is applied to find the causal relationship between imported rice prices in Tamale market as the regional market and domestic rice prices of other district markets. Finally, Vector error correction model (VECM) applied to determine the speed of adjustment of the two prices when equilibrium is to restore. The application of the above mentioned models proved that prices of the two rice brand co-move in the long run, and that, imported rice has significant effect on the marketing of domestic rice and vice versa. The VECM results show a bi-respond to price shocks. To know the time duration that 50% of deviations from equilibrium will be corrected, half-lives are calculated from the speed of adjustment and the Tamale market appears to correct one-half of deviations from equilibrium in a shorter time period relatively. The results are presented in both quantitative and qualitative forms.

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This work is dedicated to my wife, Ibrahim Adamu and to our lovely son Mohammed Aijaz Mpagya

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Acronyms

APT	Asymmetric Price Transmission
COCOBOD	Cocoa Board
DRP	Domestic Rice Price
EPA	Environment Protection Agency
ERP	Economic Recovery Program
FAO	Food and Agricultural Organisation
FAOSTAT	Food and Agricultural Organisation Statistics
FASDEP	Food and Agricultural Sector Development Policy
GDP	Gross Domestic Product
GFDC	Ghana Food Distribution Corporation
GLSS	Ghana Living Standard Survey
GNA	Ghana News Agency
GPRS	Growth and Poverty-Reduction Strategy
IFPRI	International Food policy Research Institute
IMF	International Monetary Fund
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
LOP	Law of One Price
MAFAP	Monitoring African Food and Agricultural Policies
MDG	Millennium Development Goals
MI	Market Integration
MOFA	Ministry of Food and Agriculture
MRP	Imported Rice Price
NGO	Non-Governmental Organisation

CHAPTER ONE
INTRODUCTION

1.1 Background

Rice alongside maize is the most widely traded agricultural commodity in Ghana and self-sufficiency in rice production is an issue of national pride, rice is Ghana's largest cereal import commodity, costing the country about $500M in foreign exchange to import annually (deGrassi, 2007; Atengdem, 2009). In 2013 alone, Ghana spent US$1.5 billion in importing consumable goods among which rice ranked highest by constituting US$374 million (state of the nation's address, 2014). Ghana is presently only about 30% self-sufficient in rice production, producing only about 150,000MT compared to a prevailing consumption requirement of about 700,000MT (MoFA, 2014). To meet the supply deficit, Ghana imports about 70% of its rice consumption requirement from Asia viz. China, Thailand and Vietnam, and the USA. A combination of increasing urbanization, consumers' income and preference of Ghanaians for imported ("perfumed/polished") rice are driving rice imports to unprecedented high levels. Ghana's 70% deficits in rice output have several apparent causes. These include low productivity (MT/Ha of paddy), high production cost including cost of credit, farm inputs, improved seed as well as efficient processing facilities, and as a consequent of the last cause, low demand for locally produced rice (MoFA, 2011).

Over the period 2000 to 2011, imported rice increased from 187,256MT to 543,465MT representing about 190 percent increase in imports. Over the same period, the import bill increased from US$65.03 million to US$391.17 million (MoFA, 2013; Makafui, 2014). As a

result, the government has initiated a number of policies; increasing tariff on rice, (FASDEP I, II, METASIP, etc) and established the Ghana Rice Inter-professional Body (GRIB).

The high per capita consumption level of imported rice, i.e. 26 kg per annum (SRID-MoFA, 2012) has attracted the attention of many stakeholders and policy maker, as it may has effects on the marketing and production of domestic rice in Ghana.

The notable underlying causes of low productivity and demand for Ghana's locally produced rice notwithstanding, public opinion in the last two decades of Ghana's agricultural market liberalization, i.e. the reduction in government involvement in marketing, price regulation, and control of international trade, has always blamed as the challenges in the domestic rice sector on the high competiveness, quality and marketability of rice imported from Asian and American markets (hereafter called imported rice).

Opponents of Ghana's agricultural market liberalisation argue that huge imports of rice has destroyed the domestic market for locally produced rice (here after called local rice), leading to additionally unprecedented levels of rice imports into Ghana. The opponents believe that through its high competitiveness, quality and taste, and relatively low prices, imported rice compared to local rice is more marketable, and this reduces the parity price for local rice, and distorts intermarket transmission of price signals in the domestic scene. In Ghana, negative media propaganda, hectic parliamentary debates, strong NGO advocacy campaigns and numerous formal and informal campaigns from rice farmers against rice imports is a common, daily phenomenon. These conflicts have been termed "Ghana's rice wars" in the media (Amikuzuno, *et. al.*, 2013).

Due to public criticisms and discontent arising from and inflaming the so called rice war, Ghana's government has often thought of getting directly involved in the regulation of rice imports and prices. For instance, an increase of the tariff on rice imports from 20% to 25% was considered in 2003 in response to an import surge, an option that was eventually dropped for various reasons including government willingness to comply with conditions of the World Bank and IMF (BMOS AGRO-CONSULT, 2003 in Lancon, 2007). Again, in the peak of the global food price crises in 2008, the government of Ghana removed the import tariff of 20% on rice imports in response to the rising food prices, but indicated in its 2011 budget statement to review the import duty exemption for rice (Republic of Ghana, 2010; USAID, 2009). The objective here too was to satisfy the concerns of local rice farmers and other stakeholders in the domestic rice industry. In 2014, the government put some temporary ban on rice importation, to boost domestic rice production. This was intending to reduce the prices of domestic rice and encourage the consumption of made in Ghana goods.

The above interventions among others, have always been proposed to merely satisfy lobbyists including farmers, politicians and NGOs, but have often lacked the guidance of any empirical evidence. While the ability of the domestic markets of a country to function efficiently - i.e. to transmit price signals and information between themselves and across the country's borders - is a panacea for producers and consumers to benefit from liberalised marketing systems (Alam, *et. al.*, 2010; McCulloch, *et. al.*, 2004), whether import liberalisation can be solely blamed for the production constraints, low demand, marketability and volatile prices of local rice and the resultant decreasing profitability of local rice producers in Ghana is highly contestable.

1.2 Problem Statement

Rice is not a traditional Ghanaian staple food, but it is becoming an important part of the daily Ghanaian menu, both in terms of its caloric value and share of the household budget. Ghanaians, especially urban and suburban dwellers eat rice not only as a source of calories but also as a convenient food. It is therefore not surprising that rice is one of five staple crops recommended by Ghana's Food and Agricultural Development Sector Policy II (FASDEP II) for productivity improvements in order to accelerate Ghana's pace towards attaining the MDG 1 - i.e. to end poverty and hunger.

The Millennium Development Goals (MDG) of the United Nations (UN) for instance call for the halving of the number of people living below the poverty line of less than a US 1$ per day by 2015. The WTO on the other hand in its Doha Development Agenda has urged fair trade with the expectation that this will have a positive impact on economic development and poverty reduction. Expanded trade with Ghana and other sub-Saharan African countries for poverty reduction is the goal of the USA's African Growth and Opportunity Act (AGOA) and other institutions such as Economic Partnership Agreement (EPA) initiatives, which allow African countries to export a wider variety of products to the two regions duty free or at lower tariff rates. In Ghana, a Growth and Poverty-Reduction Strategy (GPRS II) was implemented in the 2005 as a policy package for transforming the economy through promoting agriculture, economic growth, good governance, the development of the private sector and potentially poverty alleviation. As part of the strategy, the country plan to double local rice production by the year 2018 so as to contribute to food security and increased income in rice production (NDPC, 2005.)

Despite the above efforts, observations reveal that many regions of the world have gained far less from globalization and for that matter trade liberalization. About 19% of the world's population still lives on only 1.3% of the world's income. About 52% of the population of SSA lives on less than two dollars per day in 1987 purchasing power parity (PPP) and on just 12% of the regions wealth (Roe et al., 2006). Data collected by Sala-i-Martin reveals that there are still 350 million of the world's population subsisting on less than US$1 per day and almost one billion on less than US$2 per day (WIDER, 2003).

To reduce poverty and better the life of Ghanaians, the Government of Ghana put a Policy interventions which include input subsidies (fertilizer, machinery), impose import duty of 20% (temporarily removed in 2008 and reinstated during the course of 2009) as well as other taxes and levies and rice farmers received price incentives under the prevailing cost structure in the value chain up to year 2009. These measures were put in place with intended aim of curving the effects of market inefficiencies on farmers.

FAO (2013) asserts that rice importation is a disincentive when they exist; arise from price dynamic, taxes and levies and transport and handling costs. To FAO actions to be taken to reduce the disincentives could include carrying out a review of existing taxes, duties and levies, carrying out a review on all costs affecting transport and handling for both imported and domestic rice and In-depth assessment of existing programmes supporting rice and coherence with policy objectives.

The government of Ghana has stated that, from 2015 a stimulus package will be given to rice and poultry farmers, to boost their production capacity and to meet the demands of the domestic market. In view of this, a proposed budget of GH¢50 million is made available as a special support to these sectors of agriculture, to increase production, drastically reduce the importation of those commodities and create sufficient jobs for those who would be engaged in their production. This policy intervention is to support other policies such as taxes and levied to reduce rice importation which affects domestic market. The effects of liberalisation for that matter rice importation are viewed to trickle to domestic market through price transmission (GNA, 2014).

Based on the perception that rice importation has an inverse impact on the marketing of domestic rice which led to low income accruing to rice farmers and subsequently affecting rice farmers and sellers' poverty status attracts much attention. As a result, a series of studies have examined the impact of higher food prices on the marketing, income and poverty level.

Minot and Reno (2013) uses household survey data for Ghana to explore the impact of domestic price changes on the real income of different types of households. Not forgetting that, the study of market integration has attracted a lot of empirical research interests on spatial price relationships in agricultural markets to examine the underlying factors likely to drive (asymmetric) spatial price dynamics. For example, von Cramon-Taubadel (1998), Abdulai (2000), Meyer and von Cramon-Taubadel (2004) study the implications of market power on asymmetric price transmission (APT).

Villafuerte (2011) stated that the price transmission between markets was mostly interpreted as providing insights into the market's infrastructure efficiency and transaction costs. Amikuzuno (2010) wrote on how spatial price transmission or market integration (MI) measures the degree to which markets at geographically separated locations share common long-run price or trade information on a homogenous commodity. His research dwelled on five main markets in Ghana and not across borders. Amikuzuno and Rico (2011) again, assessed boarder effects of market integration and price transmission of perishable goods in Sub-Saharan Africa by studying Ghanaian market with that of Burkina-Faso. Though, their research was on cross boarder but their investigation pay much to bi-modal market and also studies perishable commodity-tomatoes.

This study seeks to analyse relevant secondary database from the Ministry of Food and Agriculture (MoFA), the Ghana Statistical Service (GSS) and Tamale Metropolitan Assembly (TMA) to examine the effects of rice importation on the pricing of domestic rice in Northern Region of Ghana. The analysis is based on the price transmission between imported rice and domestic produced rice with an intended aim of addressing the following questions:

1.3 Research questions

- ✓ What is the long-run relationship between prices of imported rice and prices of local production of the same commodity?
- ✓ Do imported rice markets lead local rice markets in the price determination process or vice versa?

- ✓ What is the extent of price linkage between imported rice and local produced rice in Northern Region of Ghana?

1.4 Objectives of the Study

1.4.1 General Objective

This study seeks in the general context to examine the pricing implications of rice importation in

Ghana using a multi-empirical analysis of data obtained from relevant institutions in Ghana.

1.4.2 Specific Objectives

Specifically, the study seeks to:

Examine the long-run relationship between the prices of imported rice and local rice prices in Northern Region of Ghana.

Determine whether imported rice markets lead local rice markets in the price determination process or vice versa.

Examine the extent of the linkage between imported rice and locally produced rice prices in Northern Region of Ghana.

1.5 Justification

Agriculture is a critical area for poverty analyses. The reasons are that farming constitutes a major source of livelihood for a majority of the working poor and food accounts for a major share of their expenditure. Also, the importance of agriculture for poverty reduction is well established; it affects not only those directly engaged in the sector, but also artisans and petty

entrepreneurs in small shops and firms in developing countries. In the global scene, agricultural markets are the most distorted since both developed and developing countries maintain high levels of protection (McCullock, *et. al.*, 2001).

The effects of trade policies on capital owners and workers have been studied by trade theorists for centuries, but applying their findings to the real world turns to be a complex empirical task. This is because the economic linkage between trade and poverty is complex, diverse and not easily measurable ; data for measuring the two is often scarce, poverty is multidimensional and cannot be held as a direct denominator of trade per se, while every country and hence the context of its liberalization policy is unique.

It has also been revealed that the economy-wide effects of trade policies depend on the shares of household incomes from different productive factors such as labour and land, their expenditure shares on different products, the quality of political and economic institutions and infrastructure, the efficiency of domestic markets and other geographical factors of a country (WIDER, 2003).

In this case, it is difficult to generalize a priori or even in the face of empirical modelling results, the welfare-effects of trade liberalization on marketing of local rice. This makes individual and country specific studies and this study for that matter imperative.

Policy research and analysis as prerequisite for policy decisions is an elementary and obvious fact. Sound trade policies require research findings for their successful formulation and implementation. Policy makers need to know the net production and consumption of the poor of

the goods liberalized, as well as the details of rural labour markets and demand patterns in order to implement complementary policies to ensure increase pro-poor effects of reforms and the filtering of agricultural incomes down to the poor (Tiepoh, 2000).

Being already neck-deep in liberalized trade policy, and tied by the need for foreign aid, loans and debt relief, whose conditions include a full participation of the beneficiary country in globalization, the study cannot suggest that Ghana reverts her policy decision, but will suggest a new set of alternative and appropriate domestic policies and institutions in the face of liberalized trade regarding what investments can aid the supply response of farm households, improve domestic agricultural production and marketing competitiveness as well as increase the chances of rural producers to benefit from the trade reforms (FAO, 2007).

The study expects to generate useful information on price transmission between imported rice and domestic rice of the same district market and from these offer recommendations to enable farm households market their produce more efficiently, even in the face of rice import liberalization. A vibrant though “contraband” commodity trade already exists in the West African Sub-region. The findings of the study will also fill the gap of increasing but still limited empirical work on the effect of trade liberalization on marketing and households' income in developing countries with large rural economies.

1.6 Organization of the Study

The study is put in to five chapters. Chapter one includes the background of the study, problem statement, research questions, research objectives and justification. Chapter two consists of

literature review. Chapter three embodies the setting of the study area - the location in Ghana and the land size, specifically, farm land and the methodology that applied in the work starts from the verification of integration between the two study variables - price of imported rice and price of locally produced rice. Chapter four covers results and discussion and the final Chapter includes major findings, recommendations and conclusion.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Literatures relevant to the issues raise in the problem statement and related works done by other researchers are reviewed. This cut across two thematic areas- the field of marketing and price transmission, specifically, rice marketing, importance, price among others. Key concepts relating to market integration are defined for easy understanding of the study.

In this chapter, literature on the connection between trade liberalization, price transmission and market integration are reviewed, particularly the possible ways in which trade liberalization policy affects market performance. Finally, the chapter discusses empirical findings of previous studies about the underlying factors that often influence price transmission and market integration in developing country agricultural markets.

Theoretical and Conceptual Framework

2.2.1 Price transmission and market integration

There is no universally accepted definition of marketing, indicating the variety of opinions, which exist concerning the subject. Terpstra (1978) offers a very broad definition of marketing as “the collection of activities undertaken by the firm to relate profitability to its markets”. Kempner (1976) is similarly vague. “Marketing is the process in a society by which the demand for economic goods and services is anticipated or enlarged, and satisfied through the conception, physical distribution and exchange of such goods and services”. Kotler (1972) gives a very concise definition, in so much as “marketing is the set of human activities directed at facilitating and consummating exchange”. Kotler suggests that there are three elements, which must be

present in order to define a marketing situation. These are: two or more parties potentially interested in exchange; each party possesses things of value to the other(s); each party is capable of communication and delivery.

According to Barker (1981) marketing is an emotive subject, with a wide range of viewpoints concerning its scope and importance. It is the collective term used to describe exchanges between buyers and sellers, who are attempting to maximize profit or subjective utility. It may be thought of quite simply as the process of making goods available for consumption.

Rodger (1971) offers a definition of marketing which is applicable to most marketing systems. “Marketing is the primary management function which organises and directs the aggregate of business activities involved in converting consumer purchasing power into effective demand for a specific product or service and in moving the product or service to the final customer or user so as to achieve company-set profit or other objective”.

Agricultural marketing is often regarded by observers as having a certain associated mystique. The definition of marketing, which is most applicable to agriculture, is given by Kohls (1968). “Marketing is the performance of all business activities involved in the flow of goods and services from the point of initial agricultural production until they are in the hands of the ultimate consumer”.

Kohls and Uhl (1990) have narrowed it down to food marketing as “the performance of all business activities involved in the flow of food products and services from the point of initial agricultural production until they are in the hands of consumers”. According to them, food

marketing is the physical and economic bridge which links raw material production and consumer food purchases. It involves a set of interdependent decisions, investments, institutions, resource flows and physical and business activities.

Abbot (1987) also defined marketing as "the business activities associated with the flow of goods and services from production to consumption". According to him, the marketing of agricultural products begins on the farm, with the planning of production to meet specific demands and market prospects. Marketing is completed with the sale of the fresh or processed product to consumers. Agricultural marketing also includes the supply, to farmers, of fertilizers and other inputs for production.

Abbot (1987) asserts that enterprises must be able to arrange assembly from farms; packing and presentation in appropriate containers; sorting according to buyers' requirements; transport to buyers' depots or markets which they attend; storage to extend the availability of seasonal commodities and processing to extend the time and range of sales outlets. Marketing tasks and responsibilities may be summarized as follows: finding a buyer and transferring ownership; assembling and sorting; sorting, packing and processing; providing the finance for marketing and risk-taking; assorting and presenting to consumers.

Market integration is considered as a measure of the degree of flow of homogenous tradable commodities, information, standard measures, trading habits and prices over form, space and time between markets linked directly or indirectly by trade (Lutz et al., 1994; Barrett, 1996). In this sense, price transmission analysis measures the relationship between prices of a homogenous commodity in

spatially or vertically separated markets in a country, or between world prices and a country's domestic prices of the commodity.

Price transmission refers to the effect of prices in one market on prices in another market. It is generally measured in terms of the transmission elasticity, defined as the percentage change in the price in one market given a one percent change in the price of another market. Although the markets could be for related commodities (such as maize and soybeans) or for products at different points in the supply chain (for example, wheat and bread), we focus on the case of markets for the same commodity in the same locations but different brands. For a pair of markets that trade with each other, competitive market equilibrium between them only exists if their prices obey the LOP i.e. the inter-market prices differ only by the value of the transaction costs incurred in moving the commodity between the markets. In a similar sense, the physical connectivity of arbitrage processes between markets may not constitute market integration. This is a case of market segmentation or uncorrelated inter-market prices that occurs whenever the inter-market price differential equals (is less than) the transactions costs and traders are indifferent about participating in arbitrage. Since both phenomena implies the LOP, empirical results of spatial price transmission could be similar under markedly different market regimes (Baulch, 1997; Barrett and Li, 2002; Stephens *et. al*., 2008).

Horizontal and vertical integration

Listorti and Esposti (2012) assert that integrated markets are trading centre that have a high price correlation, this can be horizontal or vertical integration. In business, horizontal integration is a strategy where a company creates or acquires production units for outputs which are alike - either complementary or competitive. One example would be when a company acquires competitors in the same industry doing the same stage of production for the creation of a

monopoly. Another example is the management of a group of products which are alike, yet at different price points, complexities, and qualities. This strategy may reduce competition and increase market share on by using economies of scale. This research follows the defined path of horizontal integration as it deals with the same commodity (rice) but with different price levels. Vertical integration is the opposite of horizontal integration, where companies integrate multiple stages of production of a small number of production units (David and Henry, 2003.)

Vertical price transmission refers to price linkages along a given supply chain, with horizontal price transmission we mean the linkage occurring among different markets at the same position in the supply chain. The notion of horizontal price transmission usually refers to price linkages across market places *(spatial price transmission). Lato sensu,* however, it can also concern the transmission across different agricultural commodities *(cross-commodity price transmission)* (Esposti and Listorti, 2011), from non-agricultural to agricultural commodities (notably, from energy/oil prices to agricultural prices) (Serra, *et. al*., 2008; Hassouneh, *et. al*., 2011), and across different purchase contracts for the same commodity (typically, from futures to spot markets and *vice versa;* Baldi, *et. al.*, 2011).

As detailed below, the key underlying theoretical explanation of spatial price transmission is the spatial arbitrage and the consequent Law of One Price (LOP). On the contrary, for cross-commodity price transmission, the co-movement of prices is mostly driven by the substitutability and complementarily relations among the products (Saadi, 2011), while transmission from nonagricultural to agricultural commodities is prevalently due to the underlying production technology and cost structure, but also due to the complex drivers (expectations, speculative behaviour, etc.) of financial markets which also underlies the linkage between spot and futures

prices. However, though the background theory differs, the empirical framework and the econometric implications of these different cases of horizontal price transmission are the same.

If we limit the notion of horizontal price transmission to the co-movement of prices of a given product in different locations (spatial price transmission), the *spatial arbitrage condition* is the key theoretical concept. It implies that the difference between prices in different market places will never exceed transaction costs; otherwise the profiting opportunities would be immediately exploited by arbitrageurs. The consequence of spatial arbitrage is the *Law of One Price* (LOP), as already derived by Marshall (1890; see also Fackler and Goodwin, 2001): in markets linked by trade and arbitrage, homogeneous goods will have a unique price, when expressed in the same currency, net of transaction costs.

Two other familiar theoretical concepts complement those of spatial arbitrage and the LOP. In this context, *market efficiency* indicates the capacity of markets to minimize costs when they match supply and demand. In a competitive market with perfect information, arbitrage will ensure that price differentials will reflect all marketing costs. The concept of *market integration* refers rather to the tradability of products between spatially distinct markets, irrespective of the presence or absence of spatial market equilibrium and efficiency (Barrett and Li, 2002; Thompson, *et. al.*, 2002).

2.2.2 Market Efficiency and Segmentation

Cointegration techniques have been used extensively to examine the relationship between macroeconomic phenomena and market integration. However, few have applied these methods to market integration in Africa, despite the increasing importance of these emerging markets.

Several studies address the emerging markets of East and South East Asia, although this region includes a mix of well-established and much newer stock markets. ADF and KPSS test and Johansen methodology is used to investigate the world price of rice integration with that of selected regional local rice prices (Amikuzuno, *et. al.,* 2013).

Maysami *et. al.* (2000) examines possible interactions between the Singapore market and those of Japan and the US. The initial time series are tested for stationarity, both in levels and in first differences, using standard augmented Dickey Fuller (ADF) and Phillips Perron unit root tests. Then, the series are analysed using Vector Auto regressions (VAR), to construct a Vector error correction model (VECM). Phylaktis (1999) investigates Pacific Basin countries to determine the influence of the US and Japan, using a similar approach, except with the addition of impulse response functions, in which the variables within a specially constructed VAR are subjected to external shocks. The resulting response times are compared and those with the shortest response times are considered to be the most highly integrated. While Phylaktis (1999) used standard ADF tests and VAR methodology, this was adapted to account for small samples and, crucially, for each individual period, pre and post any structural breaks in the underlying data that result from the Asian securities market crisis. Finally, Huang, *et. al.,* (2000) investigated equity market integration between several South East Asian countries, including two recently established markets in China, the Shenzhen and Shanghai Exchanges. The Huang, *et. al.,* (2000) study was based on an adaptation of a unit root test and associated residual based tests for cointegration, following the work of Zivot and Andrews (1992). This approach requires the inclusion of a dummy variable to account for structural breaks in data, and deviations from the underlying stochastic data generating process resulting from an endogenous break. The addition of this variable avoids any potential pre-testing bias that may result from alternative methods of dealing

with structural breaks by using assumptions of exogeneity, such as those proposed by Perron (1989, 1992). Although focusing on the European Stock Markets that have a very different market structure to those of either Asia or Africa, research by Corhay (1993) uses cointegration methods with relatively large samples, and both standard Dickey Fuller tests for unit roots as well as VAR analysis.

The absence of market integration is called market segmentation. This occurs when supply and demand conditions fail to affect trade and hence prices of a homogenous commodity between markets. If the markets for a homogenous commodity are not spatially integrated, it is expected that the benefits or losses of any policy changes affecting some markets in the system may not necessarily accrue to those markets of the system outside the direct impact of the policy and disequilibrium in the marketing system as a whole may not be restored. The reason is that the impact of the shock is not transmitted throughout the system but rather absorbed by the particular market receiving the impact (Amikuzuno, 2009).

2.2.3 The Law of One Price (LOP)

The law of one price (LOP) is the cornerstone of most empirical studies of market integration. The LOP in its strong form, expressed as $P^j - P^i = C^{ij}$ **,** asserts that for a single homogenous commodity, if efficient arbitrage occurs and competitive equilibrium holds between two markets linked by trade, then a price change in one of the markets will be translated on a one-for-one basis (instantaneously) to the other market. A weaker form of the LOP allows for temporary deviations from equilibrium following a price shock, with the tendency however to return to this equilibrium in the long run.

Analysis of the LOP assume that market agents have all the relevant information required to undertake optimal arbitrage and there are no impediments to trade (Jensen, 2007). Since this

assumption is rarely the case in practice, using the LOP as a measure of market integration is only idealistic. As noted in McNew (1996), the LOP is just a necessary condition for spatial price efficiency since it holds only when there are no obstacles to trade or when transportation costs between markets is insignificant. A strong LOP condition is met, when trade flows from market j to i until the price differential between both markets equals the inter-market transfer costs.

Most empirical works in this field essentially aim at assessing whether the LOP holds true. As a matter of fact, it is well recognized that the universal validity of this 'law' can be easily questioned, as its assumptions are quite restrictive and unlikely to hold in practice. The LOP is a static concept while, in reality, economic processes are dynamic and may show temporary deviations from equilibriums. Assuming that prices are always in equilibrium is not realistic. Indeed, temporary arbitrage opportunities (disequilibrium) might co-exist with long-run equilibrium conditions. Moreover, it is clear that many factors can prevent or slow down price convergence (see Miljkovic, 1999; Conforti, 2004).

Notably, *transaction costs* are relevant in agriculture if compared to the unit value of the commodities considered (Fackler and Goodwin, 2001; Barrett, 2001). Prices might still not move together if transaction costs are large and volatile or might move together only when their difference is high enough, with respect to transaction costs, to make arbitrage convenient. In addition to conventional transaction costs, other factors may prevent the validity of the LOP: domestic and border regulation policies, market power, product heterogeneity and perishability, exchange rate risks, imperfect flow of information and expectations are some of the factors that interfere with spatial arbitrage, and then with price transmission (Miljkovic, 1999; Graubner, *et. al.*, 2011; Rezitis and Stavropoulos, 2010; Santeramo and Cioffi, 2010).

As these sources of deviations from the LOP are often unobservable, in many empirical models they are not explicitly considered and are therefore implicitly captured by disturbance terms. This leads to three major consequences for the empirical analysis. First of all, the assumptions on disturbances imply strong assumptions on how these drivers behave. Secondly, the estimated parameters sum up the combined effect of a whole set of factors affecting price transmission, not only the LOP. Thirdly, all the knowledge and information about these drivers are helpful in finding the appropriate empirical specification and interpretation of the estimation results (Fackler and Goodwin, 2001).

Previous Research on Price Transmission

Research on price transmission has been motivated largely by the belief that co-movement of prices in different markets can be interpreted as a sign of efficient, competitive markets, while lack of co-movement is an indication of market failures, including lack of information, poor infrastructure, or uncompetitive markets. A large number of studies examine the degree of price transmission between markets within a country, including several for Sub-Saharan Africa (see Abdulai, 2000 for Ghana; Rashid, 2004 for Uganda; Lutz, Kuiper and van Tilburg, 2006 for Benin; Negassa and Myers, 2007 for Ethiopia; Van Campenhout, 2007 for Tanzania; Myers, 2008 for Malawi; and Moser, Barrett and Minten, 2009 for Madagascar). Here, we focus on methodological advances and the empirical studies that examine the transmission of prices from one brand of a commodity to a different brand of the same commodity in the same district markets.

Early studies of price transmission used simple correlation coefficients of contemporaneous prices. A high correlation coefficient is evidence of co-movement and was often interpreted as a sign of an efficient market. Another early approach was to use regression analysis on contemporaneous prices, with the regression coefficient being a measure of the co-movement of prices. For example, Mundlak and Larson (1992) estimated the transmission of world food prices to domestic prices in 58 countries using annual price data from the FAO. They found very high rates of price transmission: The median elasticity of transmission was 0.95, implying that 95 percent of any change in world markets was transmitted to domestic markets. The static regression approach has been criticized for assuming instantaneous response in each market to changes in other markets. In fact, there is generally a lag between the price change in one market and the impact on another market due to the time it takes traders to notice the change and respond to it. A change in world prices may take more than a month to be reflected in domestic prices. These dynamic effects can be captured by including lagged world prices as explanatory variables in the regression analysis (Ravallion, 1986).

In the 1980s, researchers became aware of the problem of non-stationarity. Standard regression analysis assumes that the mean and variance of the variables are constant over time. This implies that the variable tends to return toward its mean value, so the best estimate of the future value of a variable is its mean value. However, in the analysis of time-series data, prices and many other variables are often non-stationary, meaning that they drift randomly rather than tending to return to a mean value. One implication of this "random walk" behaviour is that the best estimate of the future price is the current price. When standard regression analysis is carried out with non-stationary variables, the estimated coefficients are unbiased but the distribution of the error is non-normal, so the usual tests of statistical significance are invalid. In fact, with a large enough

sample, any pair of non-stationary variables will appear to have a statistically significant relationship, even if they are actually unrelated to each other (Granger and Newbold, 1974; Phillips, 1987).

However, the first difference ($\Delta x = x_t - x_{t-1}$) of a non-stationary variable may be stationary. If so, the original variable (x_t) is said to be integrated to degree 1 or I (1). Because the first difference is stationary, it can be estimated econometrically without the problems described above. Furthermore, two non-stationary variables may be related to each other by a long-term relationship even if they diverge in the short run. If two non-stationary variables move together in the long run, they are said to be cointegrated. In this case, an error correction model (ECM) is appropriate to deal with the problems of dynamic effects and non-stationarity (Engle and Granger, 1987.)

Using an inappropriate method can have dramatic effects on the results. For example, Quiroz and Soto (1995) repeated the analysis of Mundlak and Larson (1992) with similar data but using the error correction model. Where Mundlak and Larson found an average of 95 percent price transmission, Quiroz and Soto found no relationship between domestic and international prices for 30 of the 78 countries examined. Even in countries with a relationship, the convergence was very slow in many of them.

Conforti (2004) examined price transmission in 16 countries, including 3 in Sub-Saharan Africa, using the error correction model. In Ethiopia, he found statistically significant long-run relationships between world and local prices in four out of seven cases, including retail prices of wheat, sorghum, and maize. In Ghana, there was a long-run relationship between international

and local wheat prices but no such relationship for maize and sorghum. And in Senegal, he found a long-run relationship in the case of rice but not maize. In general, the degree of price transmission in the Sub-Saharan African countries was less than in the Asian and Latin-American countries.

Even statistical models that take non-stationarity into account face another problem. The lack of price integration does not necessarily imply inefficient markets or policy barriers to trade. As pointed out by Harris (1979), Baulch (1997), and Barrett and Li (2002), transport costs create a range over which a given price is not affected by the price in another market. In this research, the transportation cost has been taken care of, so there is no need transportation can cause such a problem.

Current research dwelled on the impact of world prices on local/domestic prices of the same commodity. Now the question is how do changes in world prices affect domestic prices? The import price of a commodity in the domestic market P^m may be stated as:

$$P^m = P^w R(1 + tm) + C^{ij} \quad \text{.....(1)}$$

Where P^w is the world market price of the commodity, R is the exchange rate, tm is a proportional import tariff or tax, and C^{ij} is the transfer costs of importing the commodity from the foreign market i to the domestic market j. The P^m and P^w are assumed to be expressed in a common currency.

Alternatively, the local price of an exportable commodity P^i can be expressed as:

$$P^1 = P^w R(1 - t_x) - C^{ij} \quad \text{.....(2)}$$

Where t_x is the proportional export tariff or tax, and the other variable notations are as already defined above.

In a liberalised economy for a given commodity, a price shock on P^w first triggers, through the commodity's border price, changes in the import price (P^m) of the commodity in markets close to the country's ports, borders and hub of market information such as urban markets with highly organised network of traders and reliable telecommunication facilities. These markets then lead the commodity's prices in interior markets in the price discovery or market clearing process. The rate of price discovery however depends on whether price transmission mechanisms within the country for the commodity are strong or weak (Badiane and Shively, 1997).

For a price shock on P^1, the effect is first transmitted through border prices of the commodity to its international price. The rate of transmission of price shocks in this case also depends on the degree of integration between domestic and border markets for the commodity. The interdependency between the world and domestic prices of the given commodity is particularly more pronounced if the supply chains for the commodity (grades) in the domestic scene are not mutually exclusive.

Our analysis examines price linkages at the domestic level but within a liberalised trade context. We state, following the Law of One Price (LOP) and the Enke-Samuelson-Takayama-Judge (ESTJ) model, the contemporaneous relationship between two prices, P_t^m and P_t^1 r espectively for imported and local grades of rice as:

$$P_t^m = P_t^1 + D_t^{ml} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where D_t^{ml} is the price differential between imported and local rice and is equivalent to C^{ji} The price differential represents the difference in the attributes of the two grades of rice as a result of consumers adjusting for quality. According to the LOP, perfect price transmission across the two grades of rice holds only if (3) is met. The connection between the prices is transmitted through producer incentives to influence rice output at the farm level.

2.3 Importance of Rice in an Economy

Rice as a highly consumption food crop in Africa and Asian countries performed a lot of functions. Brown (1993) wrote that the boosting of the rice industry in Malaysia has been an important source of foreign exchange savings as well as a means of channeling wealth to a poor sector of society and of providing against a rice shortage in the event of regional or national political crisis.

Francesco (1994) in a study about self-sufficiency in rice production notes that the growth of the Bangladeshi rice production and market development has induced positive outcomes such as the relatively stable food grain price environment and the declining incidence of poverty in the Bangladeshi economy. He further notes that the incidence of malnutrition has also shown improvement.

Rice, according to Singh (1985), is the foremost food of the developing world. It provides about 4/5 of the calories of the more than two billion people of Asia and 1/3 the calorie intake of the nearly one billion people of Africa and Latin America. Singh further notes that food self-sufficiency and food security in majority of the Asian countries largely depends on rice self-sufficiency and rice security. Many countries including Bangladesh, Thailand, Pakistan and

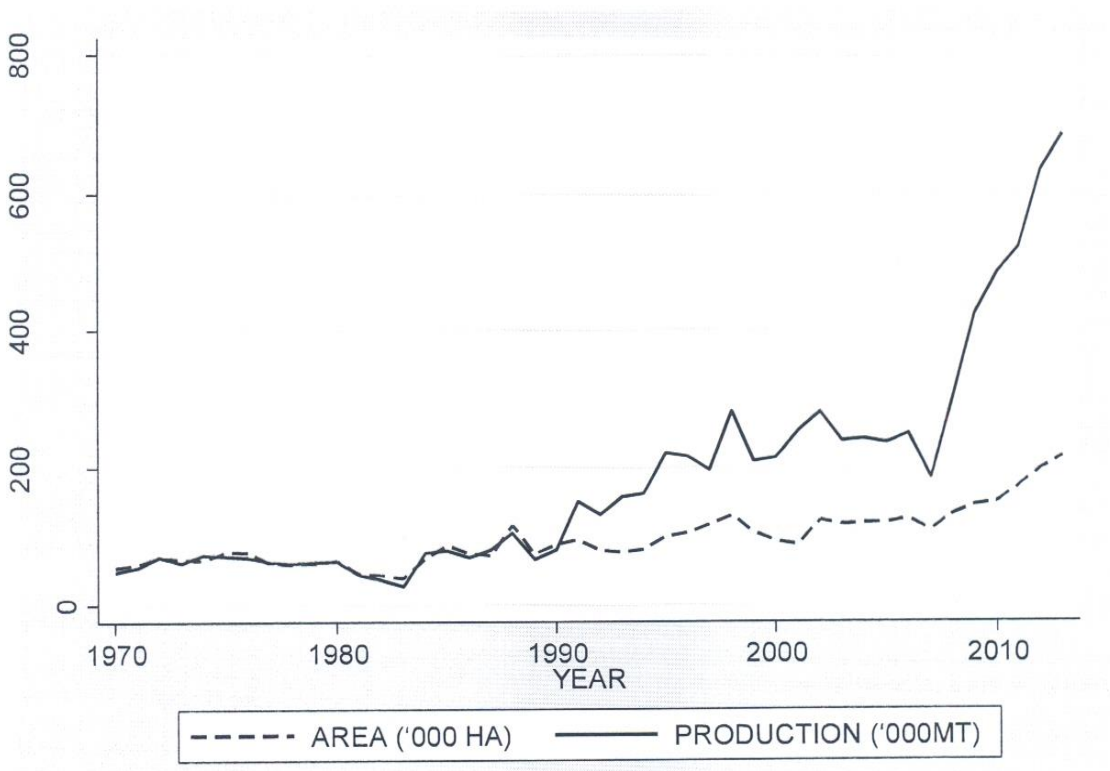
Vietnam have their economies sustained largely through rice production. Such countries earn foreign exchange from the export of rice.

2.4 Rice production in Ghana

The main rice types produced in Ghana are *oryza sativa* and *oryza glaberima* (ODI, 2003). From 2000 to 2010 there is an evolution of production, area and yield for rice in Ghana, This lead to an increase in rice production from 0.09 and 0.16 million hectares while yields fluctuated between 1.7 and 2.7 tonnes per hectare. It however appears that from 2007, rice production has been on the increase with 2010 production levels being more than double 2007 levels (from 185 300 tonnes in 2007 to 491 600 tonnes in 2010) with average annual growth of more than 15 percent over the period 2005-2010, despite the production drop experienced in 2007. Reasons for this increase could be attributed to the favourable rain patterns as well as the 2008 fertilizer subsidy programme, the Block Farm programme of 2009 which are also contemplated in the Ghana Rice Strategy (MoFA, 2011)

Again, the trend in rice production in Ghana over the years has been influenced by changes in both the area cultivated and productivity. Below, in figure 2.1, is the trend over the period 1970 to 2013:

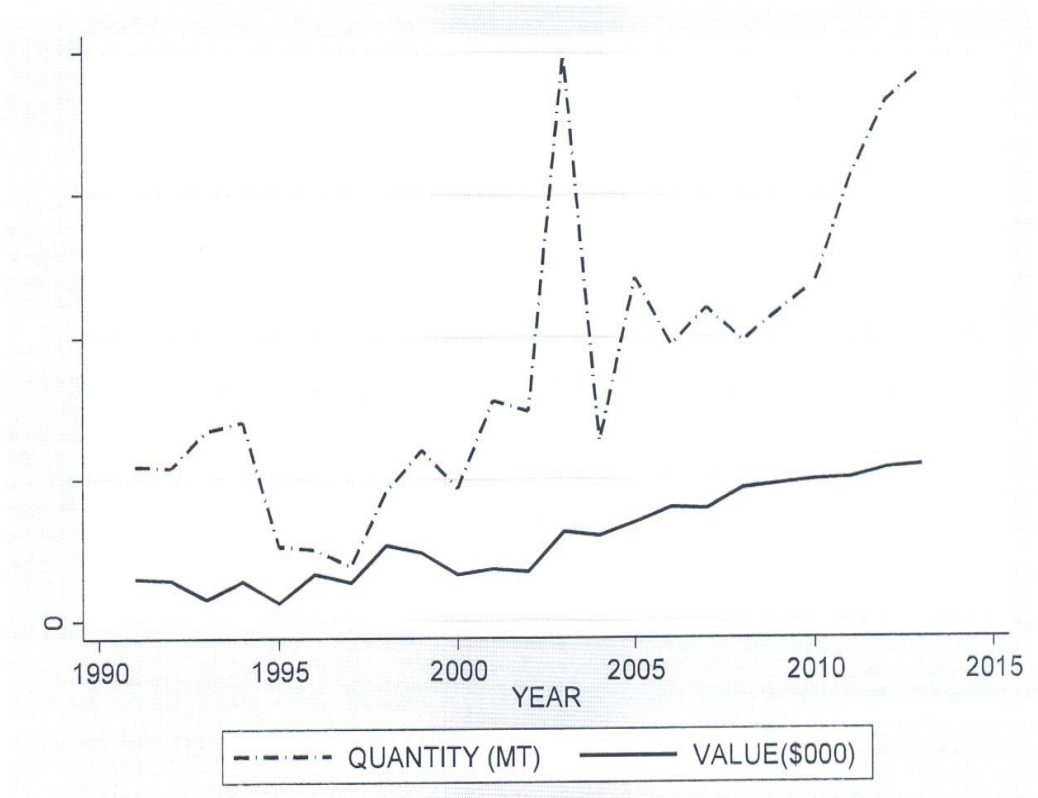
Figure 2.1 Areas and Production of Rice in Ghana 1970 – 2013



Source: Author`s Plots using MOFA-Ghana data (1970 to 2013)

During the seventies, rice production was relatively stable with a peak of 73.2MT in 1974. In the early eighties, production dropped steeply but from 1984, production increased reaching a peak of 689.2MT in 2013. In spite of appreciable level of increases in the production of rice over the years, its importation or consumption has also increased leading to an increase in its importation as shown below in Figure 2.2:

Figure 2.2 Quantities and Value of Rice Imports



Source: Author's Plots using MOFA-Ghana data (1970 to 2013)

Currently, the country has a self-sufficiency level of 30%. This is in part due to the present low national average rice yield of 2.4Mt/Ha compared to the achievable yield of 6.5Mt/Ha (MoFA, 2014). This low self-sufficiency level has caused the nation to depend on large imports to meet domestic demand.

Domestic production of rice in Ghana has been consistently less than consumption needs. Demand for rice has outstripped supply due to population increase and improved standard of living, as well as poor production and marketing arrangements on the supply side. Also, due to changing tasks; shifting from maize to other stable to rice. Consequently, government imports up

to 200% of local rice production to compensate for the short fall in supply with the consequence of draining the country's scarce foreign exchange (Dogbe, 1996).

Again, in USAID (2012), it is stated that, the top-three regions (Northern, Upper East and Volta) accounted for nearly 80% of total national output and 73% of total production area in 2010. These three regions also fall in three of the country's six agro-ecological zones - Coastal savannah, Guinea savannah and Sahel savannah. Average yield of 2.96 MT/Ha in these three regions exceeds the national average of 2.71 MT/Ha but is significantly lower than the average yield of 5.48 MT/Ha in the Greater Accra region, suggesting that the right technologies and policies could enhance yields and output. The opportunities are even higher when 2010 yields of 4.10 MT/Ha, 4.07 MT/Ha and 3.36 MT/Ha in neighbouring countries of Senegal, Benin and Mali are considered. Domestic paddy rice production in Ghana increased by 165% between 2007 and 2010 while yield increased by 59%, results that may be attributable to the focused attention that both the Government of Ghana and its development partners have brought to rice production in the last few years. Despite the observed growth in production, Ghana has been importing significantly larger quantities of rice to address quality and quantity differences between local production and demand.

In Ghana, most rice production, similarly to other crops, is done by smallholder farmers, most of them having farms of less than one hectare in size. It is estimated that more than 80 percent of agricultural production is done by smallholder farmers (AGRA, 2012). Most of the rice is cultivated from low-quality seed with mixed varieties, which brings about uneven maturity at harvest and wide variations in the size and shape of rice grains. Generally, this results in a gap between the quality of local and imported rice.

Rice production is undertaken in three different ecologies: lowland rain-fed ecology, which includes rice planted in the receding waters of the Volta and other rivers (78 per cent of production); upland rain-fed ecology (6 per cent), and irrigated ecology (16 per cent) (CARD, 2010). Lowland production is mainly practiced by women in lowland areas, and is often done without supplementary irrigation. Rain-fed rice production contributes 84 per cent of total current production, generating average paddy yields of 1.0 - 2.4 metric tonnes per hectare while irrigated production accounts for just about 16 per cent of production but produces the highest average paddy yields of 4.5 MT per hectare (CARD, 2010). Rain fed lands and swampy areas producers are able to plant rice in two seasons as the rainfall pattern in these areas is bimodal in nature from between March to July and September to November.

2.5 Rice Marketing System in Ghana

Even though rice is a politically-sensitive and a priority crop for self-sufficiency in Ghana, government does not regulate the import flow of rice. On the contrary, current policies of Ghana's government pragmatically favour the importation of rice into the country (USAID, 2009).

Ghana's rice marketing system has two major supply chains - the local rice supply chain and the imported rice supply chain. Trade liberalisation played a significant role in creating the current structure of the rice market. From government regulation and distribution in the pre-liberalisation 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.

The local rice supply chain involves a host of indigenous rice millers/processors, and sedentary final consumer. To meet their cash needs, most smallholder rice farmers (about 94%) begin selling their produce after harvesting to small scale indigenous, processors/millers, who are usually individual women or women associations.

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.

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 local and imported rice are sold on urban markets, however due to the irregularity in supply of local rice, imported rice dominates the scene. A 2003 study conducted by the ODI in 32 rice producing villages in Ghana revealed that most farmers receive price information for rice from traders or "market women", who dictate the prices. With the introduction of mobile technology

in the country however, there have been pilot projects conducted by a price information company known as Esoko that allows farmers to receive both wholesale and retail market prices, thus enabling farmers to have a better bargaining power (FAO, 2013).

The market women, who often offer access to capital and credit for input purchase as well as transportation for farmers, operate an oligopolistic system, which constrains the market and limits innovation (ODI, 2003). Market price for rice is subject to fluctuations in the market. Market women also present another challenge to farmers; this pertains to measurement of rice. Paddy rice is sold in sacks of 82kg weights in Ghana. Due to a lack of standard measurements, market women's sometimes bring larger sacks than the standard 82kg to collect the paddy from farmers at harvest time (ODI, 2003).

Imported rice on the other hand is sold either to wholesalers, retailers, or directly to consumers for instance at the local ports in Tema and Takoradi where consumers can directly purchase goods from importers, although middle men are often used to link wholesalers to consumers. In comparison to locally produced rice, imported rice is packaged in smaller packs of 50kg, 25kg, 10kg and 5kg bags. Marketing of imported rice (in particular rice from the US) is done through television, radio and print media advertisement all over the country (ODI, 2003). Grade 1 rice accounts for about 6% of total imports while grade 2 holds a share of 51% of total imports. There is no grade 1 rice produced in Ghana, while grade 2 rice represents only 4% of total production. Most of the domestic production (83%) is of grade 5 (USAID, 2009).

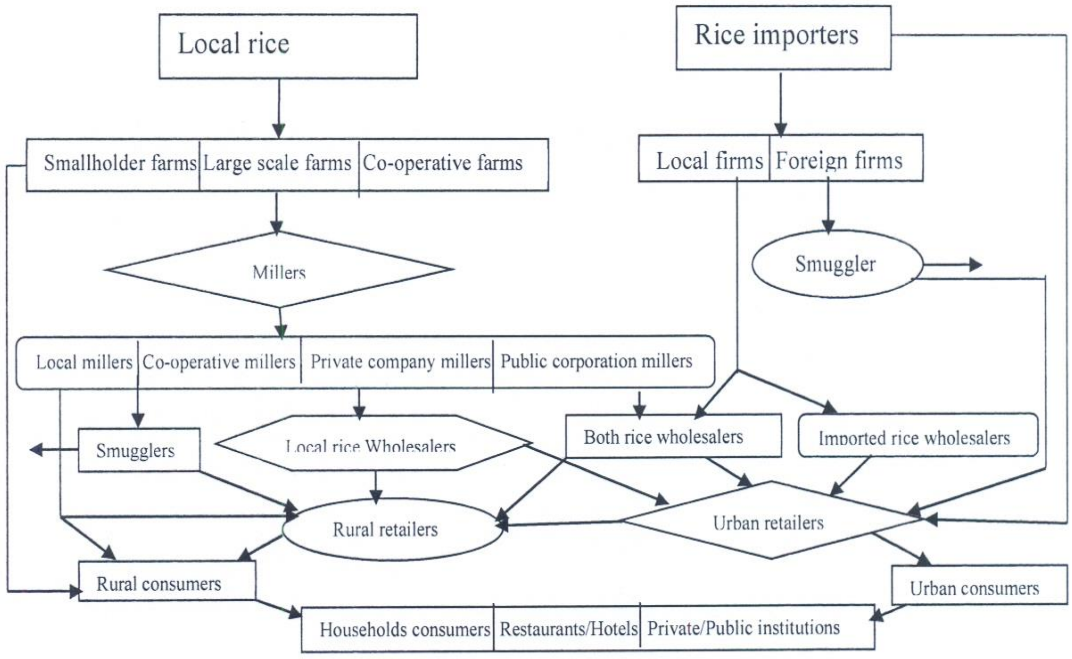
According to USAID (2012), the leading rice exporting countries to Ghana are the U.S., Thailand, Viet Nam, China, Pakistan, India and Korea. Equation (1) describes imported rice

price (P_F) as technically determined by purchase price plus freight and insurance to transport it to a Ghanaian port (Pc), excise, custom and other government-mandated fees (T_E), internal transportation and distribution *(F)* and other transaction costs (T_1) and importers' margin (π), that is:

$P_F = P_c + T_E + F + T_I + \pi$ .... (4)

Imported rice price differences are, thus, defined by differences in *Pc* (which will reflect quality differences) and the expected margin if all other costs are assumed to equal. Importers may distribute their products through wholesalers who sell to urban and rural retailers or distribute directly to retailers themselves, depending on the size of the retailer. Unlike importers who handle only imported rice, wholesalers may handle only imported rice or both local and imported rice. The wholesalers who handle only imported rice tend to be large and generally serve large urban retailers, who not only serve urban consumers but may also supply smaller urban and rural retailers with their imported rice needs.

Figure 2.3: Rice distribution network in Ghana



Source: Author`s design, 2014

Local rice producers tend to be small scale, although some *medium* and *large* scale producers are emerging in the Ghana rice industry. These producers will generally use a processing plant or mill to process their rice while the small producers use traditional threshing and winnowing techniques and sun drying on mats and concrete floor to process their rice. These small local rice producers distribute their marketed products directly to rural consumers, rural retailers or small wholesalers/retailers (essentially "*middlemen*" who would often travel to rice producing areas to assemble production from numerous small producers).

The fragmented structure of the rice markets (as many other commodity markets in Ghana) concentrates a lot of market power at the wholesale level. As such, whole price has

significant influence on both consumer and producer prices. Wholesalers determine how much they are willing to pay producers based on their expectations about the retail market prices.

Poor market information makes it difficult for small retailers and small producers to exercise much power in their transactions with wholesalers. Importers' relative size, capital position and access to relevant and timely information generally provide them with a power advantage in this market. Indeed, most importers also provide wholesale services.

Okoso-Amaa (1975) after conducting a study of rice market power and concentration of the business in Ghana indicated that there was some degree of concentration and oligopolistic pricing at the wholesale level. Nyanteng (1976) also noted that in general, there was not much vertical or horizontal integration in the rice market in Ghana. However there were some attempts at collusion, discriminatory and monopolistic pricing. Ardayfio (1977) also asserted that when the norms of a perfect market and perfect competition were used as the measuring standard or criterion, the marketing system for rice in the country appeared inefficient both in terms of markets and pricing.

Derigubaa (1979) conducted a study into rice marketing in selected areas of the then Upper region. He noted that in Wa and Lawra, mainly women dominated the rice and paddy market but in Bolgatanga mainly men were the wholesalers. In describing the marketing channels and systems, he wrote that the sequence of market channels through which paddy and rice passed from producer to consumer was found to depend on a number on factors. These factors included: the scale of production of the farmer, social and educational position, distance from urban

centres, availability of transport and storage facilities and other financial commitments. He identified three systems:

(i) Traditional bartering of paddy,

(ii) State trading agencies — these provided financial and credit and/or technical assistance to farmers who agreed to sell their produce to them at government stipulated prices,

(iii) The private sector — middlemen buy the paddy, mill it and then retail it.

On storage, he identified three methods. The first involved weaving heads (or ears) of paddy together into bundles and hanging them over heaths and sitting rooms. Most peasants to store their rice seed for the next season used this method. In the second method, the grains were threshed and put into granaries and pots. Sometimes wood ash was added as a preservative. The third method involved packing the paddy into jute sacks and storing in sheds and barns.

In the study into rice production and marketing in Ghana, Praka-Asante and Nyanteng (1979) projected that Ghana could have been about 90 percent self-sufficient in rice production in 1980 and should have been a net exporter of rice by 1985, assuming the expansion of cropped area and yield increases had continued as in the early 1970s. This projection, however, did not materialize as noted by Asuming-Brempong (1987) and is evident to all. The country could not achieve the projections made by Praka-Asante and Nyanteng and Goodman (1985) stated that up to 1985, Ghana was able to produce one-third of its total rice requirement and rice had to be imported to fill the “food gap”.

Studying the effects of commercial rice imports on Ghana’s rice production, Yelibora (1996) concluded that imported rice lowers the price of local rice. He identified three channels through

which local producers market their rice. The first is through the rice mills to retailers who on-sell to the final consumers. From the rice mills local rice is also sold to the erstwhile Ghana Food Distribution Corporation, restaurants and hotels. The second channel for marketing local rice is through the Ghana Food Distribution Corporation. The third is through paddy buyers who in turn market it through the rice mills and retailers.

The SOFRECO/GLG study (1997) into rice marketing in Ghana thought that the market for the local Glaberima rice was separate from that of the imported rice, as the price varied greatly matching the supply characteristics of the variety. The Sativa varieties, on the other hand, are seen as substitutes for imported varieties, so that price variation due to seasonality is less, due to the dampening effect of imports. The study also felt that there was little distinction in the market between parboiled and non-parboiled rice.

2.6 Rice consumption level in Ghana

According to FAOSTAT rice produced in Ghana (average 2000-2007) goes mainly to food consumption with an average waste of 6 percent. Less than 1 percent of rice in Ghana is processed. Rice is also not reported to be used as feed in the country to the best of our knowledge.

In Ghana, rice is considered to be among the main staples with rice consumption in 2011/12 estimated to reach 62, 000 MT (CARD, 2010). Per capita consumption of rice in 2010/2012 is pegged at about 28 kg with urban areas accounting for about 76 percent of total rice consumption (CARD, 2010). In urban areas, rice is preferred over other staples as it is easy and convenient to prepare and it allows for a wide variety of dishes. In addition, the rising number of fast food

restaurants and vendors in the major cities has increased the demand for rice. Rice consumption in rural areas is much lower than in urban areas and thus less vulnerable to price fluctuations.

Although rice displays a high income elasticity of demand, over the last ten years, per capita rice consumption has raised by over 35 percent due to changes in food consumption patterns driven by urbanization (FAO, 2006). Rice consumption is highest around the festive seasons of Christmas and Easter.

High quality white rice is consumed on a regular basis in urban areas where the concentration of people with a stable income is higher. According to the Ministry of Food and Agriculture just about 20 percent of locally cultivated rice is consumed in urban areas due to consumer preferences for long grain aromatic rice which is principally imported from Vietnam and Thailand.

At present there are no local types of rice which can be considered as substitutes of the imported rice. Without an increase in quality, the urban population who typically consumes more rice than rural consumers due to the convenience will continue to buy imported rice. Furthermore, in Ghana, the milling techniques applied to locally produced rice vary considerably. Most of the processing is done manually especially by small rice producers (USAID, 2009), which in turn results in end products of different quality. For instance in Tamale, in the Northern region of Ghana, the whole stem is cut and is only roughly separated from the grain when most rice is harvested. The processed rice is brown in colour and with a lot of dirt particles. In Bolgatanga, in the Upper East region, however, the panicle is severed directly and much less extraneous matter

gets into the processed product. The resulting rice is white and can sometimes be passed as the imported type (Winrock International, 2011).

Quality improvement has been promoted but almost exclusively at the production and on-farm processing but significant investment in processing facilities would be needed to produce rice competitive with imported rice in quality (USAID, 2009).

After conducting an econometric analysis of the demand for cereals in Ghana (1970-1999), Glover (2001) concluded that the general trend in local rice consumption has been increasing in quantity. There has been an increase in quantity from 48800MT to 281100MT over the 1970 - 1999. According to Glover, the increase can be attributed to the influence of the price of imported rice on the quantity of local rice demanded. As the price of imported rice keeps increasing, the demand for imported rice declined, so the quantity of local rice demanded has been increasing.

Aderibgbe (1996) undertook a study on behalf of WARDA into rice marketing in Nigeria. After interviewing 200 consumers, he found that the order in which consumers rated importance of factors in buying rice were as follows:

- cooking quality (notably expansion and speed of cooking)
- absence of stones
- taste
- colour
- percentage broken
- absence of mould

- aroma

Timmins (1991) goes so far as suggesting that locally produced rice can in some respects be regarded as a different commodity to imported rice. In the north, the parboiled rice is preferred for "waache" and can "satisfy" the consumer in a way that the polished raw white rice does not. Informal surveys by Timmins showed a preference for the locally produced rice amongst rural inhabitants, northerners and lower income groups.

According to Buabeng (2009), Majority of consumers (89%) indicated preference for white rice and so generally rated imported rice to be of superior quality. All the respondents rated imported rice superior with regards to the absence of foreign materials. With regards to the percentage of broken grains, majority (78%) indicated preference for rice with low percentage of broken grains and so rated imported rice as being superior to local rice. Labelling or branding is practically almost non-existent with regards to local rice. This introduces a source of operational inefficiency and therefore leads to poor performance. For this study, almost all the farmers marketed their produce themselves and do not lead to increased efficiency, hence lower performance. The range of products is limited with regards to local rice and hence has performed poorly.

2.7 Trade liberalization Policy and Implication in Ghana

According to Asuming-Brempong (1998), Ghana has comparative advantage in the production of paddy rice over the other countries in the sub-region. However, it has a disadvantage in the processing and distribution of rice, due to the high cost of processing and poor transportation systems and is therefore uncompetitive on the market when compared with imported rice.

Analysis of the competitiveness of domestic rice production since the mid-1980s, suggest that the liberalization policies under the Structural Adjustment Programme have affected the competitiveness of rice in Ghana (Asuming-Brempong, 1998).

The erosion of rice profitability in the mid-to late 1980s is demonstrated by the rice-fertilizer price ratio. From 1989, when the liberalization policy was affected, the nominal price of fertilizer increased much faster than the increase in the price of rice. In effect, the liberalization policy negatively affected farmers' incentives to produce rice in Ghana (Asuming-Brempong, 1998).

The theory of trade liberalization policy has a long history. However, the form of trade liberalization or free trade of concern in this study emerged in the early 1980s, when most developing countries, under the supervision of the World Bank and IMF, abandoned their then restrictive, foreign trade policies and liberalized domestic marketing channels from hitherto controlled distribution systems. Import trade liberalization means opening the market of a country to foreign goods, services and capital by minimizing the country's physical and policy trade barriers, and reducing export subsidies and import tariffs.

Liberalized trade in Ghana involved a systematic dismantling of the barriers to trade and allowing market forces to generate competition and guarantee efficiency in resource allocation, improve producer incentives and integrate the countries into the world economy (McCullock, *et. al*., 2001 and Hertel *et. al*., 2003).

The nature and degree of a country's liberalization is a measure of its openness to international trade in particular and economic openness in general. It is however worth noting that liberalised trade is only

one of the several indicators of economic openness and one that often weighs lightly in the overall result of a country's economic success (Winters, *et. al*., 2004).

The connection between the concepts of trade liberalization on the one hand, and price transmission and market integration on the other cannot be overstated. As stated earlier, the transmission of prices of a country's commodities between its domestic markets and across its borders is needed for realizing the welfare-impact of trade liberalization. There is much empirical evidence to prove that well-functioning markets are necessary for trade liberalization to achieve most of its welfare effects, including the creation of more markets (Winters, *et. al*., 2004). Therefore, any analysis of market performance in developing countries with hitherto restrictive trade policies needs to be done in the context of the trade policy changes.

The following section outlines the history of trade liberalization policy in Ghana. The aim is to provide reasons for Ghana's subscription to this policy and present some facts on the performance of Ghana's economy and domestic market following the implementation of liberalization policy.

Economic reforms and trade liberalization policy in Ghana commenced in 1982; and was reworked into a "fundable" format in 1983. The reforms became necessary due to economic crises in West Africa between 1981 and 1983. The crises resulted in the then poor performance of Ghana's economy viz. decade-long declining exports, deteriorating infrastructure, high inflation rate, a severe drought and the repatriation of about one million Ghanaian immigrants from Nigeria in 1983. Based on the belief that the poor economic indicators mentioned above emanated from Ghana's government's excessive control of domestic markets, and to enable the country to qualify for foreign development aid and loans to meet budget constraints, the government undertook economic reforms following recommendations from the IMF, World Bank and other international donors (World Bank 1986 in Acquay 1992; Berry, 1997).

The agricultural sector in the pre-liberalization period was subjected to a range of restrictive and distortionary interventions by the state with the aimed of raising the production of both arable and cash crops. Among these interventions were agricultural price controls, assembling and selling of marketable crop output by the Ghana food distribution corporation (GFDC), as well as distribution of subsidized fertilizer, seed and credit to smallholder farmers through the rural inputs and financial services commission. On the foreign scene, high export tariffs were placed on cocoa and export commodities to generate income for the government, while high import tariffs, quotas and bands were used to protect local industry (Ackah and Appleton, 2007; Alderman and Shively, 1991).

The implementation of trade liberalization meant the removal of the above interventions and the adoption of liberalised market policy. In the agricultural sector for instance, the Ghana cocoa produce buying company (COCOBOD) was reorganized to allow for competition with private firms in buying cocoa from farmers.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 The Study Setting

The study covers selected districts in Northern region of Ghana because of the level of production and consumption of rice and the region being ranked as the third poorest region in Ghana. The target districts comprised of eight in number, namely; Nanumba North, West Gonja, Gushegu, East Gonja, Savelgu, Tamale, West Mamprusi and Yendi. These districts are selected based on availability of continuous time series data.

3.1.1 Location and size

The Northern Region, which occupies an area of about 70,383 square kilometres, is the largest region in Ghana in terms of land area. It shares boundaries with the Upper East and Upper West Regions to the north, Brong Ahafo and Volta Regions to the south, and two neighbouring countries, the Republic of Togo to the east, and La Cote d' Ivoire to the west.

The land is mostly low lying except in the north-eastern corner with the Gambaga escarpment and along the western corridor. The region is drained by the Black and white Volta and their tributaries, Rivers Nasia, Daka, etc.

3.1.2 Soil Type

Soils in the region are fine in texture. The soils types are savannah Ochrosols, which develops under rainfall average between 800mm and 1500mm. There are predominantly medium sandy barns in the upland and valley respectively. There are also patches of gravel to stony land. Along

the cultivation of many food crops such as soybean, yam, cassava, maize, rice, cowpea etc. The soils have lower soil horizons and have slightly heavier textures varying from coarse sandy loams to clays. Many soils contain abundant coarse materials which affect their physical properties, particularly their water holding capacity. Most lowlands get flooded at the peak of the rainy season marking it temporally inaccessible. Farmers are advised to study their lowlands very well before selecting the variety to plant.

3.1.3 Staple Crops Grown in the Region

The major staple crops cultivated in the region include maize, cassava, rice, Cowpea, Millet and yam. Below is a table containing the various yield figures of the major crops cultivated in northern region and Ghana at large.

Table 3.1: Major Crops and the Potential Yields Grown

CROP	Potential Yield	N/R	GHANA	
MAIZE	5.0	1.2	1.6	
RICE	6.5	1.7	2.0	
SORGHUM	2.0	0.79	1.0	
MILLET	2.0	0.90	0.8	
YAM	20.0	9.57	12.5	2012
GROUNDNUT	2.0	0.74	0.9	PRODUCTION
COWPEA	1.5	0.85	0.8	
CASSAVA	28.0	8.07	12.4	

MOFA, Northern Region-Tamale (2013)

From the table above, it is clear that rice is the third staple crop in terms of high yield after yam and cassava in Northern Region and Ghana at large. This shows the country opportunity in improving the cultivation of rice.

3.1.4 Crop production

Crop production is the dominant agricultural activity in the region. It accounts for 70-85% of agricultural output. The table below illustrate the major crops produced in Northern Region of Ghana and major areas it cultivation takes place.

Table 3.2: Major crops produced in the region

CROP	MAJOR AREA OF PRODUCTION
Maize	All 20 Districts (now 26)
Cassava	West Gonja, Kpandai, East Gonja, Central Gonja, Nanumba North, Nanumba South, Yendi.
Yam	Zabzugu/Tatale, Kpandai, East Gonja, Central Gonja, Nanumba North, Nanumba South, Yendi.
Groundnut	Gusheigu, Karaga, West Mamprusi, East Mamprusi, Sabol Savelugu/Nanton
Cowpea	Gusheigu, Karaga, West Mamprusi, East Mamprusi, Sabol YendiSavelugu/Nanton
Mango	Savelugu/Nanton, Karaga, Gusheigu
Soybean	Saboba, Chereponi, Yendi, Savelugu, West Mamprusi, Karaga, Gusheigu, West Gonja
Vegetables	Savelugu/Nanton, West Mamprusi, Tolon/Kumbungu, Central Gonja
Nerica Rice	Central Gonja, West Gonja, Tolon/Kumbungu
Irrigated Rice	TolonKumbungu
Rice	All 20 Districts (now 26)

MOFA, Northern Region-Tamale (2014)

Again, from the table above, it indicates that, all the districts in Northern Region produce rice and the promotion of rice production in the area will be a welcome idea.

3.1.5 Rice Farming System

The main rice producing regions in Ghana are Northern, Volta and Upper East regions, which produce between 45 000-60 000 tonnes per year each. The Northern region is the main producer with about 63 000 tonnes in 2009 (USAID, 2009).

Rice cultivation in the region is done mainly by three categories of farmers, the smallholder farmers and the medium to large scale group. Because of the availability of land and mechanization services some farmers use this advantage to cultivate on large scale, however the small and medium holdings are in the majority. Majority of rice cultivation is done under rain fed conditions, though there is the potential for irrigation, rice cultivation under this system is limited but could be exploited to enhance production.

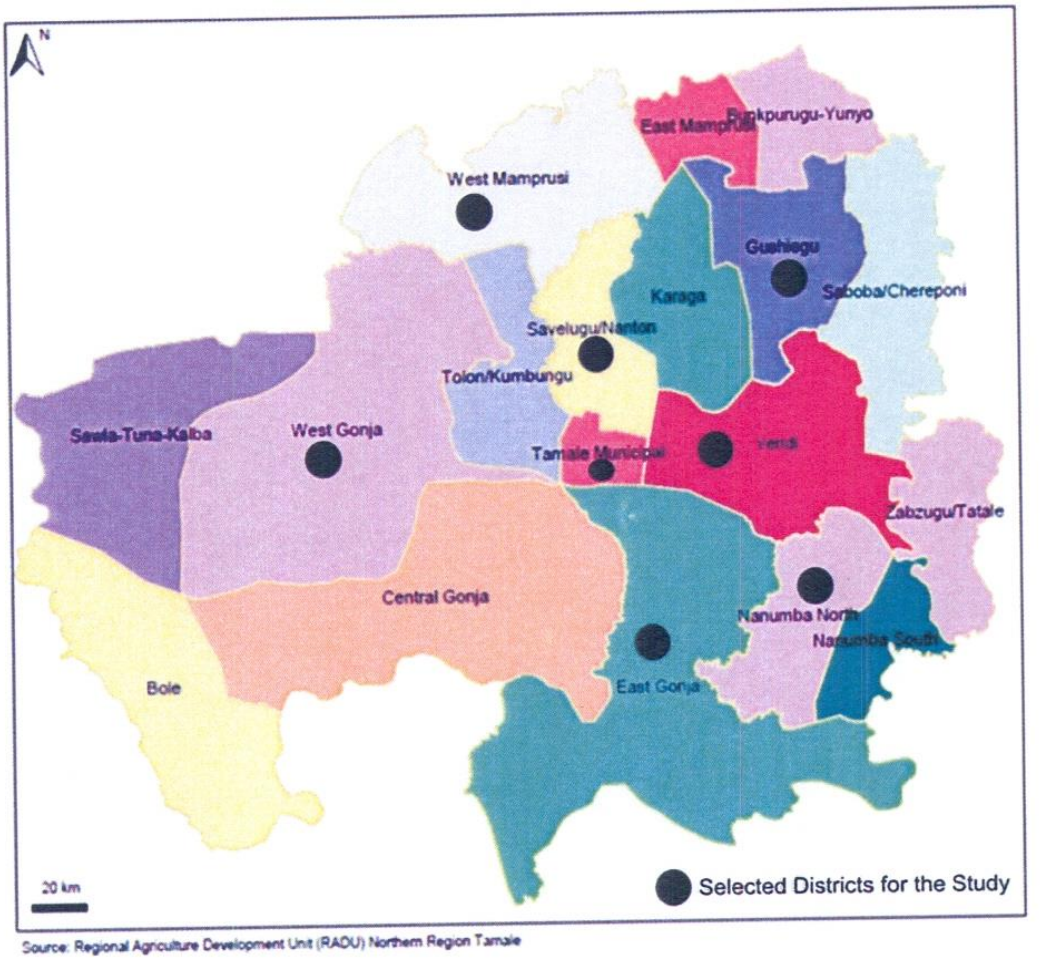
Table 3.3: Rice Growing Ecologies for 2012 production

Rice Ecologies	Area in hectares	Farmer Population	Percentage (%) of farmers	Average Farm Size(ha)
Rain Fed Lowland/Upland	72,854	170,177	99.5	2.3
Irrigated	535	823	0.5	1.5
Total	73,389	171,000	100	

MOFA, Northern Region-Tamale (2013)

The target districts in this study are indicated in the map of Northern region of Ghana below as Fig. 3.1

Figure 3.1: Map of Northern region of Ghana



Source: Regional Agriculture Development Unit (RADU) Northern Region Tamale

Nationally, the main industries are Agriculture (52.0%), Wholesale and Retail Trade (15.0%) and Manufacturing 01.0%). The main industrial activity in the Northern Region is Agriculture (70.9%) comprising largely of farming, animal husbandry, hunting and forestry. There is very limited manufacturing (7.1%) in the region. Wholesale and retail trading also accounts for only (7.5%) of all industrial activity, only about (0.7%) of the population are engaged in mining and

quarrying activities. A variety of other enterprises in the industry sector, such as fishing and others comprise 10.0 per cent of the total industrial activity of the region.

The proportion of the population in Agriculture is smallest in the Tamale municipality (31.3%). In the other districts, the figure ranges between 62.2 per cent in Savelugu-Nanton to 87.2 per cent Zabzugu-Tatale. The industry sector, (Manufacturing), accounts for less than 10.0 per cent of economic activity in all districts except the Tamale municipality (14.4%), Savelugu-Nanton (14.8%), and Yendi (10.2%). There are very limited mining and quarrying activities in any of the districts. The highest proportion is recorded in Gushiegu-Karaga (1.0%), Bole (1.1%), East Mamprusi (1.0%) and Tamale (1.0%) (Tamale Metropolitan Assembly, 2013).

The marketing of rice in Northern region of Ghana is not different from the rice distribution system in Ghana. Local rice usual purchase from farmers at the farm gate price by processors who intend sell the rice to middle men (wholesalers and retailers) and the middle men also sell the rice to final consumer. Sometimes deviations like smuggling takes place either after production or processing. Also, imported rice usual made available to consumer by local retail sellers after buying the goods from northern or southern wholesalers.

3.2 The Analytical Method

3.2.1 Data and definitions of variables

We used monthly wholesale prices of domestic and imported rice for selected markets in the Northern Region of Ghana for the analysis. The data covered the period from January, 2005 to June, 2014. This period is selected on the basis of availability of a continuous time series data for the entire set of the price variables considered, the period spans the global food price crises and

thus useful for this exercise. Data is collected from the regional office of Ministry of Food and Agriculture (MOFA) in Tamale.

The main part of the analysis in this study used the Johansen method of cointegration, Granger causality and Vector Error Correction models to determine the long term connectivity between the prices of imported and local rice respectively. The study uses the bivariate approach of Johansen cointegration analysis. This is because of the two variables (price of imported rice and that of local rice) analysis that we are concerned with in this study.

3.2.2 Test for Stationary

Before the cointegration model is applied, the first step in this study is to investigate the integration properties of the data. If the variables are integrated (non-stationary), then the issue is to what degree they are integrated. If all variables in the data are integrated of order one, *I(1),* we proceed to test whether they are cointegrated using Johansen methodology. Stationary time series is the one with constant mean and variance over a period.

Testing to know whether time series is stationary or not is critical in regression analysis involving time series data, a non- stationary time series behaviour can be study only for the period under consideration making the time series to have little if not no practical value, especially in forecasting purposes. Also, two or more non-stationary time series regression analysis may lead to spurious - obtaining a high R^2 value and some or the entire regression coefficients may be statistically significant on the basis of t and F tests which are not reliable (Gujarati, 2012.)

Based on the reasons stated above, it is critical to test time series stationarity. The stationarity can be tested using graphical analysis, autocorrelation function and correlogram as well as unit root test. But the research will dwell on the unit root test of stationarity.

Unit root test is considered as an appropriate technique in testing for stationarity. This is use by Lavan and Paul (2004) to help in model building. Also, if it is known that a series has a unit root, the series can be differenced to render it stationary. But, the difference between a trended series and a difference-stationary series may be extremely difficult to see in small samples.

To increase precision, the test for unit root test is performed on single time series of price pairs of imported rice and domestic rice for the selected markets. The unit root test for the pair of prices for Dickey-Fuller test can be express below:

$$\Delta P_t = \beta_1 + \beta_{2t} + \beta_3 P_{t-1} + \mu_t \quad \text{.....(5)}$$

Where $\Delta P_t = P_t - P_{t-1}$, that is, the first difference of the pair of prices, is the drift, subscript till is the time taking the value of 1, 2, till the end of the sample and is the error term.

We will take the regression of the first difference of the pair of the prices on the time variable and the one-period lagged value of the prices. The hypothesis is stated as: The null hypothesis is that β_3, the coefficient of P_{t-1} is zero. This is usual known as the unit root hypothesis (null hypothesis). The alternative hypothesis is that $\beta_3 < 0$; that is, the time series is stationary (no

unit root). A non-rejection of the null hypothesis would suggest that the time series under consideration is non-stationary — no unit root.

Practically, equation (5) is estimated with the help of OLS and the calculated t-value of the coefficient of the P_{t-1} is compared with the DF critical. If β_3 t-calculated is greater than the DF critical value, we reject the null hypothesis — we conclude that the time series under consideration is stationary.

According to Gujarati (2012) the DF test can be perform in three different forms namely; the random walk without drift, random walk with drift and random walk with drift around a deterministic trend. The random walk without drift is appropriate if the time series fluctuates around a sample average of zero, random walk with drift is use when the time series fluctuates around a sample average that is non-zero and random walk with drift around a deterministic trend is appropriate for time series that fluctuates around a linear trend which some time the trend could be quadratic.

We have used Augmented Dickey—Fuller (ADF) and Philip Peron (PP) test to test the null hypothesis of non-stationarity and not the usual t-test, because the t-test is only valid if the time series under study is stationary.

Also, Augmented Dickey-Fuller (ADF) model will be appropriate as prices are not stable at given time and the error term usual correlates. The ADF test is conducted by "augmenting" the three methods stated above by adding the lagged values of the dependent variable as follows:

$\Delta P_t = \beta_1 + \beta_2{}^t + \beta_3 P_{t-1} \sum \alpha_i \Delta P_{t\text{-}1} + \varepsilon_1$ ……………………………………..(6)

Where ε_1 is a pure white noise error term, m is the maximum length of the lagged dependents variable and $\Delta P_{t\text{-}1}$ is change in price of time t less i term. The number of lagged difference terms to include is often determined empirically, the idea being to include enough terms so that the error term in equation (6) is serially uncorrelated. In ADF we still test whether $\beta_3 = 0$ and the ADF test follows the same asymptotic distribution as the DF statistic, so the same critical values can be used. This study also employs the Philip Peron test (1988). The regression equation for the PP test is given by

$\Delta P_t = \alpha + \phi P_{t\text{-}1} + \varepsilon_t$ .... *(7)*

Both the ADF and PP test carry out to test the null hypothesis of non-stationarity or there is unit root against the alternative of stationarity or there is no unit root. However, the KPSS test is the opposite. It tests the null hypothesis of stationarity against the alternative of non-stationarity.

A Kwiatkowski - Phillips - Schmidt - Shin (KPSS) test for unit root is used to confirm the ADF and PP test. In econometrics, Kwiatkowski – Phillips – Schmidt - Shin (KPSS) tests are used for testing a null hypothesis that an observable time series is stationary around a deterministic trend. Such models were proposed in 1982 by Alok Bhargava in his Ph.D. thesis where several John von Neumann or Durbin - Watson type finite sample tests for unit roots were developed (Bhargava, 1986). Later, Denis Kwiatkowski, Peter C. B. Phillips, Peter Schmidt and Yongcheol Shin

(1992) proposed a test of the null hypothesis that an observable series is trend stationary (stationary around a deterministic trend). The series is expressed as the sum of deterministic trend, random walk, and stationary error, and the test is the Lagrange multiplier test of the hypothesis that the random walk has zero variance. KPSS type tests are intended to complement unit root tests, such as the Augmented Dickey—Fuller tests. By testing both the unit root hypothesis and the stationarity hypothesis, one can distinguish series that appear to be stationary, series that appear to have a unit root, and series for which the data (or the tests) are not sufficiently informative to be sure whether they are stationary or integrated.

3.2.3 Testing for Cointegration

Regression of a unit root time series on another unit root time series is the beginning of testing for cointegration. When price of domestic rice at time t $(P_t{}^d)$ and price of imported rice at time t (P_t^m) are integrated of the same order, i.e., if $P_t{}^d \approx I(1)$ and $P_t{}^m \approx I(1)$, the research proceeds to test for cointegration properties and examines causality between and P_t^d and $P_t{}^m$ in a cointegration, causality and error correction framework.

There are several approaches that allow investigating the integration properties if two (or more) variables are likely to have a long run relationship. Engle and Granger (1987) have introduced a methodology which can be applied to investigate if there exists a cointegration relation between two variables $P_t{}^d$ and $P_t{}^m$. The procedure contains the following two steps. Firstly, a regression equation below will be run

$X_t = \beta Y_t + \mu_t$ …… (8)

If the residuals, μ_t are *1(0),* then X_t and Y_t, are said to be cointegrated. Then, Johansen and Juselius approach of testing for cointegration relationships, ***r,*** will be implemented since it allows

for the presence of multiple cointegration relationships. Consider the following basic vector auto regressive (VAR) model of order *p:*

$$Y_t = A_1Y_{t-1} + \ldots + A_pA_{t-p} + \mu_1 \ldots\ldots \quad (9)$$

Where Y_t is a vector of non-stationary variables, in this study a 2 x 1 vector containing the natural logarithm of a monthly whole sales price of imported rice and that of domestic produced rice, A_i *is* a 2 x 2 matrix of parameters, and μ_1 is i.i.d. (independently and identically distributed) *k* dimensional Gaussian error term with $\mu_1 \sim (0, \sum \mu)$. Since Y_t is *I(1),* the VAR can be written in the first differenced error-correction (EC) form by subtracting Y_t - *1*from both sides of equation (9) and rearranging terms such as:

$$\Delta Y_t = \Gamma \Delta Y_{t-1} + \ldots \Gamma_{p-1} \Gamma \Delta Y_{t-1+1} + \Pi \Gamma \Delta Y_{t-1} + \mu_1 \ldots\ldots \quad (10)$$

Where

$$\Gamma_I = -(Ai_{+1} + \ldots + A_p) \text{ and } \pi = -(I_k - A_t - \ldots - A_p), \text{ for i} = 1\ldots, p-1$$

Because ΔY_t does not contain stochastic trends by the assumption that all variables are at most I(1), it follows that ΠY_{t-1} is the only term that includes I(1) variables. Hence, ΠY_{t-1} must be I(0) and as a result it contains the cointegration relations. The Γj's (j – 1… *p* – 1) are often referred to as short-run parameters, and ΠY_{t-1} is referred to as containing the long-run parameters. The model in equation (10) will be abbreviated as VECM *(p* -1). The focus of the Johansen and Juselius technique is on the parameter matrix Π, which contains information about the long-run relationship among the variables in the data vector.

The rank r of this matrix Π, rk(Π), determines the number of cointegration vectors in the VAR system. If matrix Π has a full rank, i.e., rk(Π)= k, the vector Yt is stationary. Instead, if matrix Π has a rank that equals zero, rk(Π)=0, then Π is a null matrix and equation 4 corresponds to a traditional VAR model in first difference. Finally, if matrix Π has a reduced rank ($0 < r < 2$ in this case), then there exists $k \times r$ matrices α and β, each with rank r such that $\Pi = \alpha \beta`$ and $\beta`Y_t$ are $I(0)$ even though Y_t itself is $I(1)$. r is the number of cointegration relations and each column of β is the cointegration vector. The matrix α contains the weights attached to the cointegration relations in the individual equations of the model and sometimes is referred to as the loading matrix. In this case, equation (10) is a vector error-correction model of order p-1, VECM (p-1).

Several extensions of the VECM in equation (10) are usually necessary to represent the main characteristics of a data set of interest. Including deterministic terms such as a constant, a linear trend term, and seasonal and other dummy variables, may be required for a proper representation of the process. A general VECM that includes all such terms is:

$$\Delta Y = \Gamma_1 \Delta Y_{t-1} + \ldots + \Gamma_{p-1} \Delta Y_{t-p+1} + \alpha\beta Y_{t-1} + \Phi D_t + \mu_t \ldots\ldots\ldots\ldots (11)$$

Where D_t contains all regressors associated with deterministic terms and Φ is a matrix of parameters. In the presence of cointegration, Granger Causality concerns the influence of the Γ and α parameters on the levels of the endogenous variables, i.e., P_m *and* P_d.

Granger causality can be investigated in the framework of the VECM in equation (11). For example, the VECM in equation 10 with P level lags and one cointegration relation, has the following short-run parameter matrices, Γ_j, and long-run parameter matrix, $\alpha\beta`$:

$$\Gamma_j = \begin{bmatrix} \Gamma_{j,11}\Gamma_{j,12} \\ \Gamma_{j,21}\Gamma_{j,22} \end{bmatrix} and \alpha\beta` = \begin{bmatrix} \alpha_{11} \\ \alpha_{12} \end{bmatrix} \times \begin{bmatrix} \beta_{11} & \beta_{12} \end{bmatrix} = \begin{bmatrix} \alpha_{11} ec_{1,t-1} \\ \alpha_{21} ec_{1,t-1} \end{bmatrix} \ldots\ldots\ldots (12)$$

Where sub-index j is the lag length of the VECM (j = 1, …, p - 1), and $ec_{1,t-1}$ is the error correction term lagged one period . Granger causality from LP_m to LP_d (imported rice price influence domestic rice price hypothesis) in the presence of cointegration is determined by testing the following null hypothesis:

$$\Gamma_{1,12} = \Gamma_{2,12} = ... = \Gamma_{j,12} = \alpha_{11} ec_{1,t-1} = 0 \quad \text{[LX does not Granger cause LY (} LX \rightarrow LY \text{)]}$$

By rejecting the null hypothesis, one can conclude that LP_m Granger-causes LP_d. The above test differs from SGC tests since it includes an error correction term, $ec_{1,t-1}$, that accounts for cointegration among the variables. It is worth mentioning that, if there is a cointegration relation among the variables, there must also be Granger causality in at least one direction, i.e., one of the coefficients of the error correction terms must be significantly different from zero. Similarly, Granger causality from LP_d to LP_m (price of domestic rice cause price of imported rice hypothesis) can be determined by testing the following null hypothesis:

$$\Gamma_{1,21} = \Gamma_{2,21} = ... = \Gamma_{j,21} = \alpha_{21} ec_{1,t-1} = 0 \text{ [LY does not Granger cause LX (} LY \rightarrow LX \text{)]}$$

The Johansen and Juselius (1990) cointegration technique allows estimation of the cointegration relationships among the *I(1)* variables (*LPm*, *LPd*) using a maximum likelihood (ML) procedure that tests for the rank of Π and estimates the parameters of β.

For cointegration analysis in this research, we have chosen Johansen (1988) maximum likelihood estimators over Engle and Granger (1987) two-step procedure which is easy to use but has several important limitations and can, sometimes, provide misleading results. The Johansen approach circumvents the two-step procedure and can check for multiple cointegration vectors.

Johansen (1988) relies heavily on the relationship between the rank of a matrix and its characteristic roots. The Johansen procedure is a multivariate generalization of the Dickey-Fuller test. The formulation is as follows:

$$\Delta P_{it} = A_1 P_{it-1} - P_{it-1} + \varepsilon_t \quad \text{……………………………………………………….. (13)}$$

$$\Delta P_{it} = (A_1 - I)P_{it-1} + \varepsilon_t$$

$$\Delta P_{it} = \Pi P_{it-1} + \varepsilon_t$$

Where P_{it} and ε_t are (nx1) vectors; A_1 = an (nxn) matrix of parameters;

I = an (nxn) identity matrix; and $\Pi = (A_1 - I)$ matrix.

Rank of $(A_1 - I)$ matrix equals the number of cointegration vectors. The crucial thing to check is whether $(A_1 - I)$ consists of all zeroes or not. If it does, that implies all the $\{\Delta P_{it}\}$ in the above VAR are unit root processes, and there is one linear combination of $\{P_{it}\}$ which is stationary, and hence the variable are not cointegrated. The rank of matrix Π is equal to the number of independent cointegration vectors.

Trace and Maximum Eigenvalue test is used to determine the presence of cointegration relationship between the price series. Using the estimates of the characteristic roots, the test for the number of characteristic roots that are insignificantly different from unity was conducted using the following statistic:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}) \quad \text{……………………………………. (14)}$$

Where $\hat{\lambda}$ = the estimated values of the characteristic roots (Eigen values) obtained from the estimated Π matrix; and T = the number of usable observations. The second statistical test is the maximum Eigenvalue test $(\lambda_{\max})$ that is calculated using the formula

$$\lambda_{\max}(r, r+1) = -T \ln\left(1 - \hat{\lambda}_{r+1}\right) \quad \text{..... (15)}$$

The test of cointegration is based on the null hypothesis of no cointegration (H_0: r=0) against the alternative of at least one cointegration (H_A: r=1)

3.2.4 Testing For Granger Causality

Following the logic that the existence of cointegration between two markets implies at least unidirectional Granger causality, we extend the cointegration tests to test for Granger causality. This test will verify whether price dynamics of the two brands of rice exhibit well-defined paths i.e. whether price shocks start around producer markets and spread to consumer markets or vice versa or both hold true. To explain the Granger causality test, we will consider the often asked question in macroeconomics: Is it price of imported rice that "causes" the price of domestic rice to change ($P_t^m \rightarrow P_t^d$) or is that domestic rice price leads imported rice price in price dynamics ($P_t^d \rightarrow P_t^m$), in which the arrows give causality direction. The assumption of the Granger causality test is that the information relevant to the prediction of the respective price variables is contained solely in the time series data on these variables. Granger-causality tests examines the degree to which both current and past price changes in one market explain current prices changes in another (Baulch, 1997). The test involves estimating the following pair of regressions:

$$P_t^d = \sum_{i=1}^{n} \alpha_i P_{t-i}^m + \sum_{i=1}^{n} \beta_j P_{t-j}^d + \varepsilon_{1t} \quad \text{..... (16)}$$

$$P_t^m = \sum_{i=1}^{n} \lambda_i P_{t-i}^m + \sum_{i=1}^{n} \delta_j P_{t-j}^d + \varepsilon_{2t} \quad \text{..... (17)}$$

Where the disturbances ε_{1t} and ε_{2t} are assumed to be uncorrelated.

Granger causality has possible four cases:

1. *Unidirectional causality from imported rice prices at time t (P_t^m) to domestic rice prices at time t (P_t^d)* is indicated if the estimated coefficients on the lagged P_t^m in equation (16) are statistically different from zero as a group (i.e. $\sum \alpha_i \neq 0$) and the set of estimated coefficients on the lagged P_t^m in equation (17) is not statistically different from zero (i.e. $\sum \delta_j = 0$).

2. Conversely, *unidirectional causality from domestic rice prices at time t (P_t^d) to imported rice prices at time t (P_t^m)* exists if the set of lagged P_t^m coefficients in equation (16) is not statistically different from zero (i.e. $\sum \alpha_i = 0$) and the set of the lagged P_t^d coefficients in equation (17) is statistically different from zero (i.e. $\sum \delta_j \neq 0$).

3. *Feedback,* or *bilateral causality,* is suggested when the sets of *imported rice prices at time t (P_t^m)* and *domestic rice prices at time t (P_t^d)* coefficients are statistically significantly different from zero in both regressions (i.e. $\sum \alpha_i \neq 0$ and $\sum \delta_j \neq 0$).

4. Finally, *independence or no causality* is suggested when the sets of *imported rice prices at time t (P_t^m)* and *domestic rice prices at time t (P_t^d)* coefficients are not statistically significant in both the regressions (i.e. $\sum \alpha_i = 0$ and $\sum \delta_j = 0$).

The steps involved in implementing the Granger causality test are as follows.

Firstly, estimation of restricted and unrestricted model for the two equations, this is follow by the estimation of F-test given by

$$F = \frac{(RSS_R - RSS_{UR}) / m}{(RSS_{UR}) / (n - k)} \quad \ldots\ldots (18)$$

which follows the *F* distribution with *m* and (n- *k)* degrees of freedom. In the present case *m* is equal to the number of lagged terms, *k* is the number of parameters estimated in the unrestricted regression, RSS_R is the residual sum of squares from the restricted model and RSS_{uR} is residual sum of squares from the unrestricted model. Since we have two variables, we are dealing with bilateral causality. Equation (16) postulates that current domestic rice price is related to past values of itself as well as that of imported rice price, and (17) postulates a similar behaviour for imported rice price.

A unidirectional Granger causality of $P_t^m \rightarrow P_t^d$ or $P_t^d \rightarrow P_t^m$ is proved by an F-test on the null hypothesis that the coefficients of P_{t-1}^m in equation (16) and P_{t-j}^d, in equation (17) equal zero. *i.e.* $\alpha_1 = \sigma_j = 0$, while the alternative hypothesis states that; at least one of the coefficients is not equal to zero. When computed F-value is greater than the F-tabulated value, we reject null hypothesis, explaining causality relationship.

Granger and Elliot (1967) first used Granger causality to examine price relationship of 18th century prices of wheat in England. Alexander and Wyeth (1994) used Granger causality tests within the context of cointegration to evaluate the spatial integration of Indonesian rice markets. The author discovered that Granger causality tests enrich the empirical analysis of market integration.

Empirical weakness of Granger causality tests includes their sole dependence on the statistical difference of the coefficients of the lagged exogenous variables in the models to infer the

relationship between the contemporaneous and lagged prices. According to Fackler and Goodwin (2001), a statistically significant relationship that is inconsistent with the conventional notions of market integration could exists and be mistaken as evidence of market integration. Granger causality tests are also sensitive to omitted variable biases. Hence the result is used with a greater care.

3.2.5 Vector Error-correction model (VECM)

After indicating that P_t^d and P_t^m are cointegrated using Johansen (1988) cointegration; that is, there is a long term, or equilibrium, relationship between the two prices. Though, in the short run the $P_t^d \approx I(1)$ may be disequilibrium. The VECM is estimated. The model takes the following general form:

$$\Delta P_t = \alpha + \Pi P_{t-1} + \sum_{k=1}^{q} \Gamma_k \Delta P_{t-k} + \varepsilon_t \quad \text{..... (19)}$$

Where P_t is an n x 1 vector of n price variables;

Δ is the difference operator, so $\Delta P_t = P_t - P_{t-1}$;

ε_t is an n x 1 vector of error terms;

α is an n x 1 vector of estimated parameters that describe the trend component;

Π is an n x n matrix of estimated parameters that describe the long-term relationship and the error correction adjustment; and

Γ_k is a set of n x n matrices of estimated parameters that describe the short-run relationship between prices, one for each of q lags included in the model.

The VECM tests for the effect of changes in each price variable on each other. In the context of this study, the two-variable VECM tests the effect of changes in imported rice prices on domestic

rice prices as well as the effect of changes in domestic rice prices on imported rice prices at the same district market . The VECM is therefore presented as follow:

$$\begin{pmatrix}\Delta P_t^d \\ \Delta P_t^m\end{pmatrix} = \alpha + \begin{pmatrix}\theta^d \\ \theta^m\end{pmatrix}(P_{t-1}^d - \beta P_{t-1}^m) + \delta \Delta P_{t-1}^m + \rho \Delta P_{t-1}^d + \varepsilon_t \quad \text{..... (20)}$$

where P_t^d is the log of domestic rice price ;

P_t^m is the log of imported rice price;

Δ is the difference operator, so $\Delta P_t = P_t - P_{t-1}$;

$\alpha, \theta^d, \theta^m, \beta, \delta$ and ρ are estimated parameters; and

ε_t is the error term.

As indicated above, if the price series are I(1), then the first differences (ΔP) will be stationary, or I(0). The coefficients in the error correction model can be interpreted as follows:

Since the prices are expressed in logarithms, the cointegration factor (β) is the long-run elasticity of the domestic rice price with respect to the imported rice price and vice versa. Thus, β is the long-run elasticity of price transmission. The expected value for imported rice price is $-1 < \beta < 1$. Thus, if β = 0.8, this implies that there is a strong long run cointegration relationship between imported rice price and domestic price of the same commodity. The error correction coefficients (θs) reflect the speed of adjustment. It expected to fall in the range of $-1 < \theta < 0$. The term in parentheses represents the deviation or "error" between the prices in the previous period and the long-run relationship between the two prices (IFPRI Paper 01059, 2011).

If the error is positive (the domestic rice price is too high given the long-term relationship), then the negative value of θ helps "correct" the error by making it more likely that the ΔP_t^d is

negative. The larger θ is in absolute value (that is, the closer to -1), the more quickly the domestic rice prices (P_t^d) will return to the value consistent with its long-run relationship to the imported rice prices (P_t^m).

The coefficient on change in the imported rice prices (δ) is the short-run elasticity of the domestic rice prices relative to the imported rice prices. In this case, it represents the percentage adjustment of domestic rice prices one period after a one percent shock in the imported rice prices. The expected value ranges $0<\delta<\beta$. The coefficient on the lagged change in the domestic rice prices (ρ) is the autoregressive term, reflecting the effect of each change in the domestic rice prices on the change in domestic rice prices in the next period. The expected value is $-1<\rho<1$.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1: Descriptive Statistics of Price Series

Descriptive statistics are used to describe the basic features of the data in the study. The descriptive statistics are presented in a quantitative form and help us to simplify large amounts of data in to sensible way as well as provide a powerful summary that may enable comparisons across units.

The summary statistics for the two price categories- imported and domestic rice are presented in Tables 4.1 and 4.2. The Tables indicate the number of observation, mean, standard deviation, minimum and maximum prices in the eight (8) district markets. Table 4.1 represents summary statistics for the average monthly wholesale prices of domestic rice as follow:

Table 4.1: Average Monthly wholesale prices of domestic rice (GH¢/50kg bag)

Variable	Obs	Mean	Std. Dev.	Min	Max
Nanumba North	114	54	25	17	123
West Gonja	114	45	24	17	93
Gushegu	114	35	14	17	98
East Gonja	114	45	25	15	100
Savelgu	114	44	23	14	93
Tamale	114	41	22	16	93
West Mamprusi	114	54	27	14	100
Yendi	114	44	26	12	96

Source: Own computations using MOFA-Ghana data (January.2005 to June, 2014)

The Table above indicates the summary statistics of 114 observations (price data of domestically produced rice from Jan, 2005 to June, 2014). It can be seen that the minimum and maximum average monthly wholesale prices per 50kg bag for domestic rice from January, 2005 to June, 2014 among the eight selected districts markets are GH¢12 in Yendi market and GH¢123 in Nanumba North market respectively. Nanumba North seems to have the highest maximum price

among the eight districts because; the district concentrates in the cultivation of tuber crop such as yam at the expense of cereal crop like maize. However, the population is dominated by low income people who tend to consume more local rice than imported rice. Averagely, the wholesale price for the domestic rice prices since January, 2005 to June, 2014 range from GH¢36 to GH¢55 per 50kg bag with a minimum standard deviation of 14.00.

The summary statistics for imported rice prices from January, 2005 to June, 2014 for eight selected markets in Northern region of Ghana is shown in Table below. The table presents the average, minimum, maximum and standard deviation of imported rice prices for the districts as well as the sample size used for the study.

Table 4.2: Average Monthly wholesale prices of imported rice GH¢/50kg bag

Variable	Obs	Mean	Std. Dev.	Min	Max
Nanumba North	114	70	31	20	156
West Gonja	114	71	19	45	130
Gushegu	114	71	47	28	153
East Gonja	114	75	36	26	180
Savelgu	114	63	40	31	184
Tamale	114	69	52	30	217
West Mamprusi	114	78	21	34	110
Yendi	114	71	28	34	135

Source: Own computations using MOFA price data (January.2005 to June, 2014)

Again, the statistics shows that, GH¢20 in Nanumba North market and GH¢217 in Tamale market are the minimum and maximum average wholesale prices for imported rice among the selected districts of Northern region. Savelgu recorded the lowest yearly average price for the imported rice price amounted to GH¢63 and the highest is recorded by West Mamprusi by an amount of GH¢78. Relatively, there is limited price variability in Savelgu market over all the other markets leading to the district accounting for the lowest average price while Tamale market

experienced high demand for imported rice resulting in the highest average price among the eight selected districts. Tamale is the regional capital characterized by high income population with high taste for imported rice and equally high demand. Thus it is expected that prices for imported rice is higher for this major consumer's market.

4.2 Test of Stationarity of price series for domestic and imported rice

Before the test of Unit root, the two graphs in appendix F give clue to the nature of the time series. Both graphs in the eight series are trending upwards after deflating the prices suggesting non-stationarity of the time series at levels. In testing the price series for stationarity, Augmented Dickey Fuller (ADF), Phillip Peron test (PP) and KPSS tests are used with the help of Stata 11.0 and JMulti. The results are presented in Table 4.3 below.

Table 4.3: Results of Unit root test of variables (ADF, PP and KPSS test)

Districts	Variables	Level			First difference		
		ADF Test	PP Test	KPSS Test	ADF Test	PP Test	KPSS Test
Nanumba North	DRP	-3.776**	-2.719	4.4670***	-9.223***	-7.825***	0.0749
	MRP	-2.119	-2.678	4.3974***	-8.473***	-12.597***	0.1033
West Gonja	DRP	-3.962**	-5.266***	3.5522***	-9.668***	-15.478***	0.0196
	MRP	-3.933**	-6.406***	2.9393***	-13.695***	-19.610***	0.0201
Gushegu	DRP	-1.925	-2.118	1.9467***	-7.407***	-11.969***	0.0678
	MRP	-1.268	-1.493	2.9799***	-9.114***	-15.230***	0.1657
East Gonja	DRP	-1.851	-1.928	5.1834***	-7.206***	-10.590***	0.2006
	MRP	-3.230	-5.264***	2.5909***	-11.623***	-17.768***	0.0605
Savelgu	DRP	-2.813	-3.482**	2.9482***	-11.399***	-14.384***	0.0286
	MRP	-1.281	-1.884	1.3930***	-12.658***	-15.452***	0.1674
Tamale	DRP	-2.006	-2.231	3.5737***	-9.233***	-12.366***	0.1144
	MRP	-1.810	-2.179	2.4301***	-9.915***	-13.690***	0.1299
West Mamprus	DRP	-2.613	-2.442	5.2771***	-7.234***	-9.460***	0.0922
	MRP	-2.245	-2.018	1.4878***	-8.876***	-10.402***	0.2526
Yendi	DRP	-2.028	-2.211	4.6460***	-7.089***	-12.014***	0.0565
	MRP	-1.662	-1.663	1.7815***	-7.596***	-10.484***	0.1200

Source: Own computations using MOFA-Ghana data (January, 2005 to June, 2014)

NB: DRP and MRP denotes domestic rice price and imported rice price. *** 1% and ** 5% critical values for both the ADF and PP test are -4.036 and -3.448 while the KPSS test has ***1%, **5% and *10% critical values of 0.739, 0.347 and 0.463 respectively.

The time series is tested for stationarity through the Augmented Dickey-Fuller, Phillip Perron and KPSS tests. The result showed that the time series is stationary, with the ADF and PP statistic being significant at the 1% level at the first difference. This is confirmed by the KPSS test which is significant at level 1% significant level. The ADF, PP and KPSS results confirmed the graphical test of stationarity. Though, prices of imported and domestic rice in West Gonja market as well as domestic rice price in Nanumba North seems to be stationary at level, the research take in to consideration the first difference.

Since there is enough evidence to show that the two pairs of rice prices (domestic and imported) are stationary for KPSS at level and first difference for ADF and PP test in all the eight (8) selected district markets, we continue to test for bivariate cointegration using Johansen (1988) cointegration test for the non-stationary pair of prices in each district market.

4.3 Cointegration test

Trace and Maximum Eigenvalue test are used to determine the presence of a cointegration relationship between the price series. Using the estimates of the characteristic roots, the test for the number of characteristic roots that are insignificantly different from unity was conducted. The test of cointegration is based on the null hypothesis of no cointegration (H_o: *r = 0)* against the alternative of at least one cointegration *(H_a: r =1)*

Research shows that, the power of corresponding maximum eigenvalue and trace tests is very similar. A Monte Carlo comparison shows, however, that there may be slight differences in small

sample size. The trace tests tend to have more distorted sizes where as their power are in some situations superior to that of the maximum eigenvalue tests.

The results of Johansen cointegration using strata 11.0 are presented in Table 4.4 below. The result shows both the trace and Eigen value statistics.

Table 4.4: Results of Johansen test of Cointegration for price pairs (Trace and Eigenvalue test statistic)

Market differenc e	Trace Statistic		No. of Lags	Max Statistics	
	Ho: r=0	H_A: r=1		H0: r=0	HA: 1=1
Nanumba North	19.6052*	2.8594	2	16.7458*	
West Gonja	18.2821*	3.5669	2	13.7152*	2.8594
Gushegu	19.8598*	1.8627	1	17.9972*	3.5669
East Gonja	48.8648**	0.0126	1	48.8521**	1.8627
Savelgu	20.3499**	0.3419	5	20.0081**	0.0126
Tamale	23.8645**	2.1846	1	21.6798**	0.3419
West Mamprusi	9.0968	0.8776	1	8.2192	2.1846
Yendi	11.0806	0.5986	1	10.4820	0.8776
					0.5986
	** 1% and *5% Critical values are 20.04 and 15.41	** 1% and *5% Critical values are 6.65 and 3.76		** 1% and *5% Critical values are 18.63 and 14.07	** 1% and *5% Critical values are 6.65 and 3.76

Source: Own computations using MOFA-Ghana data (January.2005 to June, 2014)

Note: The asterisks ** and * denote non acceptance of the null hypothesis of no cointegration at the 1% and 5% levels. Lag selection is based on the suggestion of a maximum lag criterion, but much attention is given to the Hannan-Quinn criterion as it ensures there is no asymptotically overestimating the lag order (Ltttkepohl and Kratzig 2004, 111.)

The results show that prices of imported rice in Nanumba North, West Gonja, Gushegu, East Gonja, Savelgu and Tamale markets are cointegrated with domestic rice prices of their respective market pairs, but no significant cointegration seems to exist between imported rice price and domestic rice price in West Mamprusi and Yendi markets even at 5% significant level. The null hypothesis of no cointegration ($H_0 : r = 0$) is therefore rejected in the six different markets. The rejection of the null hypothesis indicates an evidence for a long-run equilibrium relationship. However, the alternative hypothesis of at least one cointegration vector between the two pairs of price could not be rejected at the given levels (1% and 5%). We then proceed with the analysis considering only the six market pairs for which a significant long-run equilibrium is found.

The present of cointegration among the six market pairs suggest that, there is a long run relationship or interaction between prices of imported rice and prices of domestically produced rice in the six market pairs. For West Mamprusi and Yendi markets, there is no evidence of cointegration. This indicates market segmentation — absent of long run association between the prices of the two rice categories.

4.4 Granger causality test

After establishing by the use of Johansen procedure, that the two price series, P_t^d and P_t^m of rice in each market are cointegrated; we conducted Granger (1969) causality test to find out the order and direction of long-term equilibrium relationships. Whether prices of domestic rice (P_t^d) Granger cause prices of imported rice (P_t^m) or vice-versa. The long run causality test verifies price leadership between imported rice prices in Tamale as a regional market vis-a-vis domestically produced rice prices in the other districts markets.

It must be mentioned here that the Granger Causality test determines the effect of lagged values of explanatory variables on the current values of the dependent variable and does not indicate the instant causality or transmission. Due to this disadvantage, the results of Granger causality are use with caution. The test is carried out based on the null hypothesis of no causality; the arrows in the table below illustrate causality direction. The econometrics analysis with the support of JMulTi for causality or price leadership produced the results in Table 4.5.

Table 4.5: Results of Granger causality between market pairs

Market difference	Granger Causality		
	T- stats.	P. value	Decision
Tamale ⟶ Nanumba North	7.2171	0.0009	causality
Nanumba North ⟶ Tamale	1.4077	0.2471	No causality
Tamale ⟶ West Gonja	2.6722	0.0715	No causality
West Gonja ⟶ Tamale	0.0306	0.9699	No causality
Tamale ⟶ Gushegu	0.8504	0.4287	No causality
Gushegu ⟶ Tamale	1.2085	0.3007	No causality
Tamale ⟶ East Gonja	5.6007	0.0043	causality
East Gonja ⟶ Tamale	2.2721	0.0869	No causality
Tamale ⟶ Savelgu	4.3223	0.0248	causality
Savelgu ⟶ Tamale	5.3397	0.0055	causality

Source: Own computations using MOFA-Ghana data (January.2005 to June, 2014)

The results indicate that the null hypothesis of no Granger causality of imported rice prices in Tamale as a regional market to domestic rice prices at the various district markets is not rejected

in all the cases, except Tamale — Gushegu and West Gonja cases and its reverse. The test statistic of 7.2171, 5.6007 and 4.3223 are then compared to the critical value corresponding to a 5% level of significance. The Probability values are less than 0.05 shows that the test values are greater than the respective critical value not shown in the table, and so we reject the hypothesis that imported rice prices in Tamale market do not Granger-cause domestic rice prices in Nanumba North, East Gonja and Savelgu markets. For P values higher than 0.05 (e.g. in the case of Tamale — West Gonja and Gushegu), we fail to reject the no-causality hypothesis. In the three causality proves, only one (i.e. Tamale — Savelgu) indicates a bilateral causality — given evidence that domestic rice prices in the district market leads imported rice prices in the regional market in price determination and vice versa. This implies, arbitrageurs of domestic rice in the named districts markets above are both price takers and price makers. They use information of imported rice prices in their price determination and arbitrageurs of imported rice at the regional market (Tamale) sometimes also use information on domestic rice prices in their price decision making. As Francis (2009) prefers the term predictive causality, we will conclude by saying that imported rice prices in Tamale market has a predictive causality on domestic rice prices in Nanumba North, East Gonja and Savelgu markets and the reverse is not generally true. This is in conformity with (Cudjo et al., 2008) in Ghana grain product market that prices in Accra as a national capital market Granger causes Techiman and Wa prices.

4.5 Test of Vector Error Correction Model (VECM)

After indicating that P_t^d and P_t^m are cointegrated using Johansen (1988) cointegration; that is, there is a long term relationship between the two prices. We estimate the VECM in order to evaluate the long run properties of the cointegrated series.

The VECM tests for the adjustment of each price variables on the other price when there is a shock. In the context of this study, the VECM tests the effect of imported rice prices shocks on domestic rice prices as well as the effect of the domestic rice prices shocks on imported rice prices. Since the study concerns price transmission of two brands of rice (domestic and imported) at the same district markets, there is the need to test the response of domestic rice prices to price shocks and also imported rice prices to shocks in the respective markets.

Applying the vector error correction model (VECM) to our analysis gives Table 4.6 which provides the results for the two price pairs for six different districts markets in Northern Region of Ghana: Nanumba North, West Gonja, Gushegu, East Gonja, Savelgu and Tamale.

The results from the error correction model gives the speed of price transmission between imported rice ($\hat{\theta}^m$) and that of local or domestic rice ($\hat{\theta}^d$). The error correction parameters are transformed to half-lives ($\hat{\alpha}^d$ and $\hat{\alpha}^m$) to indicate how many unit of time are required to correct 50% of a deviation from the long run equilibrium. Also, the long run elasticity coefficients were obtained as the prices were in their natural logarithms ($\hat{\beta}$)' form. The elasticity illustrates the long term effects of local to imported rice and vice versa in the various markets, while the adjustment parameters indicates how equilibrium will be restored when there is distortions in the studied markets. The Table below shows the results for adjustment parameters; cointegration elasticity coefficient and computed half-lives for those adjustment parameters that are significant.

Table 4.6: Estimated speed of price transmission and long run effects

Market difference	Variables Pairs	$\hat{\theta}^d$	$\hat{\alpha}^d$	$\hat{\theta}^m$	$\hat{\alpha}^m$	$\hat{\beta}$
Nanumba North	DRP –MRP	-0.150*** [-3.492]	4.01	0.018 [0.354]	-	-1.004*** [-6.036]
Nanumba North	MRP –DRP	0.151 *** [3.492]	4.00	-0.018 [-0.354]	-	-0.996*** [-7.791]
West Gonja	DRP –MRP	-0.159** [-2.412]	3.78	-0.052 [-1.065]	-	0.787 [1.372]
West Gonja	MRP –DRP	-0.125** [-2.412]	4.82	-0.041 [-1.065]	-	1.271** [2.497]
Gushegu	DRP –MRP	-0.155 *** [-3.269]	3.88	-0.060 [-1.021]	-	-0.552*** [-3.906]
Gushegu	MRP –DRP	-0.186*** [-3.269]	3.24	0.033 [1.021]	-	-1.812*** [-4.660]
East Gonja	DRP –MRP	-0.009 [-0.781]	-	0.203*** [3.870]	2.96	-2.496*** [-5.206]
East Gonja	MRP –DRP	0.022 [0.781]	-	-0.106*** [-3.870]	5.68	-0.401*** [-3.652]
Savelgu	DRP –MRP	-0.088 [-1.368]	-	0.093** [2.529]	6.47	-0.541*** [-2.721]
Savelgu	MRP –DRP	0.047 [1.368]	-	-0.115** [-2.529]	5.24	-1.847*** [-3.939]
Tamale	DRP –MRP	-0.461*** [-4.906]	1.31	0.158*** [3.311]	3.81	-0.828*** [-4.972]
Tamale	MRP –DRP	0.008 [0.182]	-	-0.113*** [-3.311]	5.32	-1.207*** [-5.173]

Source: Own computations using MOFA-Ghana data (January.2005 to June, 2014)

The results of the cointegration elasticity coefficient indicate that an increase in the price of imported in Tamale market by 1% will result in a decrease in domestic rice price in the same market by 0.83%. Conversely, the figure for West Gonja depicts that a 1% increase in the price of imported rice will

induce domestic rice price to also increase by 0.787% and vice versa, however, the change is statistically insignificant. It is only the long run connectivity between domestic rice and imported rice prices in the West Gonja market parameter that is not significant, the rest of the parameters are significant. Also, the Nanumba North and East Gonja markets depicts 1.004% and 2.496% respectively long term inverse price transmission between imported and domestic rice. The negative and positive signs are anticipated based on the factors affecting demand and supply. Again, Savelgu has the lowest elasticity considering the inducement of imported rice price to domestic rice price — a 1% increase in imported rice price will affect the change in domestic rice price by 0.541% negatively. This can link to the low patronage or consumption of imported rice relative to the other selected districts.

Also, a prior expectation sign for the adjustment parameters are met and both negative and positive sign are expected to restore the equilibrium. This is critical because, for price adjustment to attain equilibrium the positive price adjustment of one brand must be accompany by a negative price adjustment of the other brand. The adjustment parameters ($\hat{O}^d$ and $\hat{O}^m$) denotes estimated margins of price adjustment of one price to ensure the formation of equilibrium. The coefficient shows deviations from the long run equilibrium relationship. The coefficients called the loading or adjustment parameters are the elasticity of price transmission or the speeds of price adjustment by the domestic and imported rice price respectively. The closer a value approaches one in absolute terms; the faster deviations from equilibrium become corrected. For instance, the results in Tamale domestic rice price adjustment speed between domestic and imported rice prices of -0.461 corrects deviation from equilibrium faster compared to the imported rice price adjuster in Savelugu market which valued 0.093. The fact is that, in absolute value, the domestic rice price adjustment parameter in Tamale is closer to one (1) than the imported rice adjustment parameter in Savelugu market.

The speed of transmission involving imported rice price $\hat{O}^m$ in Tamale market corrects error significantly by -0.113% towards the attainment of equilibrium. This implies 11.3% changes of domestic rice prices are transmitted to imported rice prices as a result of shocks. But in general, 10.6% or more changes in domestic rice prices are transmitted to imported rice prices for equilibrium to be restored. On the other hand, a speed of transmission from imported rice prices to domestic rice prices in all the six market for an error to correct towards the attainment of equilibrium is 15% or more. This means, 15% or more of the changes in imported rice prices are transmitted to domestic rice prices based on demand and supply shocks. The values at the bottoms of the estimated parameters are the test statistics.

From observation, the half-lives of domestic price adjustment suggest that, prices need a minimum of 1.3 months to correct half of the deviations from price equilibrium following market shocks as against 2.69 months require by imported rice to correct one half of the deviations. Though, domestic and imported rice prices both respond to price shocks. Domestic rice prices respond faster than imported prices and have higher adjustment parameters relatively. On average, the speed of adjustment of domestic rice prices is -0.231 (23.1%) which corresponds to a half- life of 2.6 months compared to an average of -0.111(11.1%) of imported rice price speed of adjustment which corrects half of deviations from equilibrium within 5.4 months.

In conclusion, the VECM results show that, domestically produced rice prices response significantly to price shocks at a faster rate while imported rice prices do not react significantly in re-establishment of equilibrium in Nanumba North, West Gonja and Gushegu markets. The

reverse is true in the case for the pair in East Gonja and Savelgu. Tamale market domestic and imported rice prices is exceptional case in that, the adjustment parameters for the two pair are correct error significantly, but domestic rice half-life of 1.31 proves to correct 50% deviations faster approximately by a month while imported rice corrects half of deviation to equilibrium by 4 months approximately. Generally among the markets, Tamale market seems to restored equilibrium by solving one half of deviations faster as both domestic and imported rice prices have lower half-lives. This can be attributed to the larger nature of the market and the free flow of information about the prices of the two rice brands.

The response to prices shock by both domestic rice prices and imported rice prices may seems to be new. This is thus possible as Greb et al. stated in the paper No. 125 (2012) on price transmission from international to domestic market that, in most cases, domestic prices adjust to deviations from the long run price relationship, but international prices do not. The only notable exception to this rule is rice. There is evidence of a statistically significant reaction by international prices to disequilibrium between domestic and international prices in 121 market pairs of which 111 involve rice. Roughly 40% of all rice prices are affected. To Greb *et. al*., most countries are price takers on wheat and maize markets, but their evidence for rice market is mixed.

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Introduction

The main findings of the study are summarized in this chapter and a conclusion is drawn. Based on the conclusion, some recommendations are presented for policy making.

5.2 Summary

The study examine the long-run relationship between the prices of imported rice and the prices of local rice in Northern Region of Ghana, the extent of price linkage and investigate the causality relationship as well as the extent of linkage of the two prices. The following are the summaries and conclusion of the findings:

In agricultural economics, price transmission elasticity is frequently applied in finding out the interaction between various markets, but studies on the rice markets are scarce. Due to the relatively scarce access to some of the data we have processed. The fact that Ghana is such a principal and large importer of rice on the global scene, made us do the studies in Ghana and Northern Region in particular because of its potential in producing local rice.

There are several interesting results of this thesis; the findings of this study provide strong evidence of long run relationships between imported and domestic rice prices in Northern Region of Ghana based on the selected markets in the study. This means that over the long run, the two price categories co-move and may be driven by common factor(s) including both domestic and possibly imported rice prices.

that matter Ghana can use as a proxy to link domestic rice market to imported rice market. The connection of the two markets can occur through product improvement and standardization.

Protection of domestic rice producers and sellers based on the perception that, rice importation affects the marketing of domestically produce rice might not be the right decision. Rather integrating domestic rice prices to the imported rice prices by directly encouraging quality improvement of domestic rice through modern processing techniques and consequently enhancing competition between the two grades of rice at the domestic scene must be a key concern of government. Domestic rice sellers are not only price takers, but are in a mixed position of making and taking prices.

Domestic rice sellers are critical in price determination process; hence, local producers and sellers should be place on equal ground with imported rice sellers to compete. This gave domestic producer opportunity to grab positive price shocks from the imported rice market by increasing their output and quality of their produce to competitive level. This is especially necessary since global food prices have since 2007 has been rising.

5.3 Conclusion

In conclusion, we can say that imported rice and domestic rice prices at the same market has a long run association. Imported rice prices alone is not the only factor that Northern region for

that matter Ghana can use as a proxy to link domestic rice market to imported rice market. The connection of the two markets can occur through product improvement and standardization.

Protection of domestic rice producers and sellers based on the perception that, rice importation affects the marketing of domestically produce rice might not be the right decision. Rather integrating domestic rice prices to the imported rice prices by directly encouraging quality improvement of domestic rice through modern processing techniques and consequently enhancing competition between the two grades of rice at the domestic scene must be a key concern of government. Domestic rice sellers are not only price takers, but are in a mixed position of making and taking prices.

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5.4 Recommendation

Based on the findings of the study, the following recommendations are worth considering: The introduction of de-stoners in the existing milling machine should be a critical intervention in the rice industry. This could help reduce the presence of stones and other foreign materials in local rice. Along this line, efforts should also be made to improve whole grain; the production of long grain aromatic rice and reduce the multi-coloured nature of some of the local rice. This we

hoped will make local rice more appealing to domestic consumers and widens the market of local in international scene as it can compete with the foreign rice, usual called polished rice.

Efforts should be made at institutionalizing market extension services and improvement in communication system. The Ministry of Food and Agriculture could provide regular and current information about varietal preferences, price levels, and demand and supply situations in the markets so that market participants could make useful decisions by improving the quality of their rice.

Establishment of marketing board to handle the distribution of the product, the board shall be responsible of buying rice from farmer, grade and package the rice in a standard form before sales takes place. This in one way solves the problem of poor packaging and grading of local rice. The board can sometimes give guarantee price to producers of rice to motivate them give their best in the production of rice.

Bank credit to the farmers and marketers should be revisited. Millers could be roped in by the financial institutions to serve as a link between them and the farmers through which credit could be made available to the farmers and marketers of local rice. Credible millers could be screened and given some form of orientation to enable them play this role more effectively. This would make more funds available to the farmers and marketers who need them.

Provision of modern storage facilities such as warehouse could also improve marketing of locally produced rice in Northern region of Ghana and Ghana at large. The poor storage of some local rice leads to their poor quality and multi-coloured nature of them. Adequate storage

facilities will help farmers and distributors to ensure that rice produced is not consumed within the harvesting season alone but spread throughout the year.

Finally, rural areas represent less than a quarter of the total consumption of rice in the country, with around 9 kg/cap/year (IFPRI, 2012). This is as a result of the many reasons the inaccessible and bad nature of the road network leading to those areas. To improve rice marketing, government should priorities the construction of road to rural areas to improve and widen the distribution based of rice in the country.

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Appendices

Appendix A: Average monthly whole sale price of domestic rice (GH¢/50kg bag) for eight selected districts in Northern region of Ghana.

Date	Yendi	Gushegu	Tamale	Savelgu	Damongo	Walewale	Salga	Bimbillah
1/1/2005	12.5	17	16.5	15	17.5	14	15	18
1/2/2005	12	18	17	16	19	14.5	15.5	17
1/3/2005	11.5	18	17.5	16.5	18	16	15.5	17.5
1/4/2005	12	18.5	17	17.5	18.5	17	15	17
1/5/2005		19	16.5	18	18	16	15	17.5
1/6/2005	12.5	19.5	16	16	19.5	18		18.5
1/7/2005	13	19.5	17.5	15.5	20	17	16	18
1/8/2005	12	20.5	17	14	20.5	17.5	16	19
1/9/2005	13	20	17.5	18	21	18.5	16	19.5
1/10/2005	14	20.5	19	20.5	21	19	17	20
1/11/2005	15.5	20.5	20	21.5	21.5		17	20.5
1/12/2005	16	21	20.5			23.5	16.5	21
1/1/2006	17	21.5	21	22.5	21.5	22.5	17	21.5
1/2/2006	17	21.5	21.5	23	17	23		22.5
1/3/2006	18	21.5	20	23.5	17.5	21.5	17	21.5
1/4/2006		21	20	26.5	22.5	23	18	22.5
1/5/2006	18.5	21	21	22.5	27	22.5	19	23
1/6/2006	18.5	21.5	20.5	18	22.5	23	19.5	23
1/7/2006	18.5	21	21.5	21.5	28	21.5	18	23
1/8/2006	17	21.5	21	23	22.5	24	19	22.5
1/9/2006	19.5	22	21	23.5	28	25	19.5	22
1/10/2006	19.5	22	20.5	24.5	22.5		20.5	23.5
1/11/2006	21.5	22	21	26.5	22.5	26.5	21	24.5
1/12/2006	21	22	21	28	32	27	21.5	25
1/1/2007	21.5	22.5	20	27	22.5	26	22	
1/2/2007	21.5		20	32	23	25.5	21.5	27
1/3/2007	23	25.5	24	37	32	28	21	28
1/4/2007	22.5	26	20	26.5	22.5	28.5	22.5	28.5
	22.5					28.5	23	

1/5/2007	22.5	25.5	22	23	22.5	29	22.5	27
1/6/2007		25.5		28	23	26.5	23.5	26.5
1/7/2007	23.5	26	24	28	23	27	24	29
1/8/2007	23.5	26	20		32.5	30	24.5	31
1/9/2007	23.5	26	20	28	32	32	25	32.5
1/10/2007	24.5	26	25	22.5	22.5	32.5	26	33.5
1/11/2007	26.5	26.5	26	37.5	22.5	33.5	27	34
1/12/2007	27	26.5	22	28	32	34	28	34.5
1/1/2008	27	26.5	22	28	22.5	34.5	26.5	36
1/2/2008		26.5	25	33.5	22.5	35.5	27	37.5
1/3/2008	32		24	28	23	36.5	28	38
1/4/2008	27	24	29	33.5	23	37.5	29	39
1/5/2008	32	24.5	37	28	32	38	30.5	39.5
1/6/2008	28	24.5	34	28	26.5	38.5	31.5	41
1/7/2008	28	24.5	34	28	16.5	38	31	42.5
1/8/2008	33.5	24.5	38	37.5	28	39	32	44.5
1/9/2008	36.5	24	34.5	28	32	39.5	32.5	45
1/10/2008	37.5	24	30	23		41	33.5	46.5
1/11/2008	32.5	26.5	26	38	27	41	34	48.5
1/12/2008	39	27	30	33.5	22.5	42	33	49
1/1/2009	33	27.5	31	32.5	22.5	43		49.5
1/2/2009	36	27.5	31	36	33.5	43.5	34	
1/3/2009	36	27.5	30	36	36	44	34.5	50.5
1/4/2009	36	27.5	30	36	52	44.5	36.5	52
1/5/2009	41	32.5	30	34.325	52	45	37.5	54
1/6/2009	46	30	40	50	70	46	38	51
1/7/2009	46	32	38	50	52	47	39	52.5
1/8/2009	47	32.5	36	43.5	52	48	39.5	
1/9/2009	40	32.5	36	43.625	34	49	39	56
1/10/2009		32.5	32	41.25	44	45	39.5	60.5
1/11/2009	36		30	37.875	38	48.5	39	61.5
1/12/2009	36		28	32.875	42.5	49	38.5	

1/1/2010	36	32.5	26	30.25	43		40	63.5
1/2/2010	35	27.5	30	28.625	33.5	51	41	64.5
1/3/2010	33	27.5	30	29.125	37	56	42	66
1/4/2010		31.5	28	27.75	28	61.5	43	67
1/5/2010	39.25	32.5	26	27.5	37.5	62	42.5	67.5
1/6/2010	40		30	27.5	42.5	62	43.5	69
1/7/2010	40	32.5	30	38	55	63	43.5	69.5
1/8/2010	40	32.5	32	35.625	47	63.5	44.5	71.5
1/9/2010	40	32.5	32	35	47.5	64	45	
1/10/2010	40	32.5	40	41.835	27.5	65		73.5
1/11/2010	40	32.5	40	43.5	49	66	46.5	
1/12/2010	40	40	36	43.5	49	65.5	48	71.5
1/1/2011	40	42.5	32	37	49	65	48.5	71.5
1/2/2011	40	42	36	38.5	49	64	47.5	72.5
1/3/2011	40.5	42.5	32	38.5	50	67.5	49.5	73
1/4/2011	50	42.5	40	38.335	50	68	51	73
1/5/2011		42.5	40	38.165	40	69	3.5	72.5
1/6/2011	52	45	48	56.165	50	70.5	55	74
1/7/2011	52		48	46.335	55	71.5	56	74.5
1/8/2011	52	45	48	45.5	55	73.5	58	
1/9/2011	60	45	50	50	60	74	60	76.5
1/10/2011	66	45	54	55.835	60	74.5	61.5	76
1/11/2011	67	44	65	56.665	65	76.5	62	76
1/12/2011	67.5	45	56	59.165	65	78	63.5	76.5
1/1/2012	68.5	46.5	61			79	65.5	77
1/2/2012	65	46.5	62.5	62	66.5	82	67	76.5
1/3/2012	68.5	47.5	62	67	67	82.5	69	76
1/4/2012	72.5	48	65.5	66	67.5	87.5	70.5	76
1/5/2012	74.5	48.5	67	68	68	88	73.5	
1/6/2012	76.5	49	67	69	67.5	90	75	77
1/7/2012	79	49	68		66	90.5	77	78.5
1/8/2012		49.5	64.5	70	68.5	91		

1/9/2012	80	49	68.5	71	69.5			
1/10/2012	81					90	80	79
1/11/2012	84	50	70	71	70	90	80	79
1/12/2012	86			71	70			
1/1/2013	87	50.5	71.5	72	71.5	93.5	82	78
1/2/2013	85	51.5	71.5	74	73.5	96.5	83.5	77
1/3/2013	89.5	51	73	79	76.5	98	87	78.5
1/4/2013	87.5	52	74	77	77			79
1/5/2013	89	51.5	74.5	81.5	76	92.5	87.5	77
1/6/2013	91	53.5	76.5	84.5	80	92.5	86.5	76.5
1/7/2013	91.5	54	74.5	84	82	93.5	88	78
1/8/2013	92	55.5	77	91		91.5		
1/9/2013	91.5	60.5	79.5	86.5	89		87.5	
1/10/2013	93	61.5	76.5	93.335	90	90	89.5	68
1/11/2013	92.5	62	80	93.335	90	90	91	122.5
1/12/2013	93	61	81.5			92.5	91.5	
1/1/2014	94	66	82.5	86	91	91.5	92.5	
1/2/2014	94	66		87	92.5		91.5	
1/3/2014	94.5	67				90		80
1/4/2014	96	67.5	85	88.835	90	100	90	84
1/5/2014		65	92.5	87	90		100	
1/6/2014		66						

Appendix B: Average monthly whole sale price of imported rice (GH¢/50kg bag) for eight selected districts in Northern region of Ghana.

Date	Yendi	Gushegu	Tamale	Savelgu	Damongo	Walewale	Salga	Bimbillah
1/1/2005	34	28	43	32	45	34	29	20
1/2/2005	36	29	44	31	46	34	28	23
1/3/2005	36	30	45	34	47	34	26	24
1/4/2005	37	34	47	36	45	35	29	25
1/5/2005	38	34	49	32	48	36	28	25
1/6/2005	39	34	48	35	50	37	29	25
1/7/2005	39	34	50	36	52	34	32	25
1/8/2005	41	34	50	33	53	35	31	26
1/9/2005	40	35	51	33	54	34	34	26
1/10/2005	41	36	52	33	52	38	35	26
1/11/2005	41	36	53	35	54	39	35	23
1/12/2005	42	36	53				36	26
1/1/2006	43	38	55	37	54	41	37	27
1/2/2006	43	36	54	43	56	42	38	27
1/3/2006	43	37	49	34	53	45	34	32
1/4/2006	42	43	52	35	56	43	38	34
1/5/2006	42	42	50	37	64	46	39	32
1/6/2006	43	36	50	35	45	48	41	34
1/7/2006	42	36	49	36	45	49	43	35
1/8/2006	43	36	57	37	65	51	43	36
1/9/2006	44	37	57	36	65	52	44	37
1/10/2006	44	37	57	35	56	53	45	40
1/11/2006	44	36	56	35		54	46	42
1/12/2006	44	37	56	35	56	58	43	42
1/1/2007	45	36	60	35	56	57	45	42
1/2/2007		36	30	35	56	54	46	42
1/3/2007	51	37	40	35	57	62	47	41
1/4/2007	52	37	40	35	57	64	49	39
1/5/2007	51	36	40	36	57	65	51	42
1/6/2007	51	37		46	75	64	53	42
1/7/2007	52	42	48	45	56	64	54	42
1/8/2007	52	42	48	45	65	67	56	45
1/9/2007	52	44	34	35	64	68	57	35
1/10/2007	52	36	33	54	64		58	37
1/11/2007	53	42	33	54	64	73	57	42
1/12/2007	53	45	48	45	64	74	57	53
1/1/2008	53	35	49	45	57	74	56	42
1/2/2008	53	37	49	45	57	75	55	46
1/3/2008			49	45	57	74	54	48
1/4/2008	48	42	56	45	58	73	57	49

1/3/2009	55	35	70	64	70	93	63	
1/4/2009	55	36	70	64	63	93	63	65
1/5/2009	65	40	70	45	60	87	64	67
1/6/2009	60	45	70	64	60	86	65	68
1/7/2009	64	36	70	54	60	90	64	71
1/8/2009	65	39	80	46	60	85	61	73
1/9/2009	65	34	80	64	60	85	64	75
1/10/2009		54	80	54	63	87	64	73
1/11/2009	65	43	84	45	53	86	68	74
1/12/2009		40	84	34	56	86		74
1/1/2010	65	40	84	35	58	89		
1/2/2010	55	40	80	73	58	91	73	76
1/3/2010	55		80	53	68	90	76	78
1/4/2010	63	45	66	35	66	90	76	79
1/5/2010	65		66	36	56	90	75	78
1/6/2010			70	36	76	87	73	
1/7/2010	65	45	70	63	58	86	78	
1/8/2010	65	45	66	53	130	87	73	
1/9/2010	65		66	43	60	89	79	82
1/10/2010	65	45	66	34	66	88	81	85
1/11/2010	65	45	68	34	96	90	82	83
1/12/2010	80	45	68	53	65	91	84	85
1/1/2011	85	65	70	34	65	91	86	87
1/2/2011	84	65	70	35	70	91	87	88
1/3/2011	85	65	50	35	70		89	86
1/4/2011	85	65	72	55	70		90	88
1/5/2011	85	60	72	35	70		91	87
1/6/2011	90	60	72	54	80	92	87	87
1/7/2011		89	140	44	80	93	89	89
1/8/2011	90	60	95	47	80	93	89	89
1/9/2011	90	80	76	54	80	93	88	87
1/10/2011	90		76	45	80	87	88	93
1/11/2011	88	90	100	45	80	89	87	90

1/12/2011	90	100	98	46	85	98	86	90
1/1/2012	93	112	102			98	89	90
1/2/2012	93	123	105	56	84		89	91
1/3/2012	95	124	109	65	86	96	86	91
1/4/2012	96	126	111	65	86	95	89	93
1/5/2012	97	134	123	71	84	94		95
1/6/2012	98	135	127	75	86	97		94
1/7/2012	98	142	135	78	85	97	90	94
1/8/2012	99		146				91	92
1/9/2012	98	145	154	82	87	95	92	91
1/10/2012				85			93	92
1/11/2012	100	150	160	93	86	95	94	95
1/12/2012		150		90	86	95	120	95
1/1/2013	101	152		97			124	
1/2/2013	103		163	97	88	96	125	95
1/3/2013	102	153	164	101	91	89	125	99
1/4/2013	104	152	167	112	94		128	97
1/5/2013	103	153	173	123	96	99	129	96
1/6/2013	107	151	176	125	97	98	132	96
1/7/2013	108		183	134	99	95	134	
1/8/2013	111	152	187	136	103	96	32	103
1/9/2013	121		189	143	106	96	136	114
1/10/2013	123	152	194	153			138	
1/11/2013	124	150	193	164	108	95	143	120
1/12/2013	122	150	199	163	108	95	143	
1/1/2014	132	152	202		109			125
1/2/2014	132	151	215	184	107		154	129
1/3/2014	134	152		176		104	165	
1/4/2014	135			173				
1/5/2014	130	150	217	178	108	110	170	150
1/6/2014	132	150	213	173	108	110	180	156
				176			181	
		152			107			
						111		

Appendix C: Sample results of Unit root test of ADF, PP and KPSS both in level and first difference (Analysis with Stata and JMulTi)

ADF results with Stata

1. Bimbillah Imported Rice Price in level

Augmented Dickey-Fuller test for unit root — Number of obs = 112

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-2.119	-4.036	-3.448	-3.148

MacKinnon approximate p-value for Z(t) = 0.5356

D.Bimbilla	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Bimbilla						
L1.	-.1283606	.0605852	-2.12	0.036	-.248451	-.0082702
LD.	-.111804	.0980505	-1.14	0.257	-.306157	.082549
_trend	.0148714	.0069851	2.13	0.036	.0010256	.0287172
_cons	2.242757	1.03005	2.18	0.032	.2010189	4.284495

2. Bimbillah Imported Rice Price in first difference

Augmented Dickey-Fuller test for unit root — Number of obs = 111

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-8.473	-4.036	-3.449	-3.149

MacKinnon approximate p-value for Z(t) = 0.0000

D.BimbillaD	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
BimbillaD						
L1.	-1.267017	.1495316	-8.47	0.000	-1.563446	-.970588
LD.	.0655515	.0969235	0.68	0.500	-.126588	.2576911
_trend	.0022194	.0033675	0.66	0.511	-.0044563	.0088951
_cons	.0916822	.2210511	0.41	0.679	-.3465258	.5298902

3. Damongo Domestic Rice Price in level

Augmented Dickey-Fuller test for unit root — Number of obs = 112

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-3.962	-4.036	-3.448	-3.148

MacKinnon approximate p-value for Z(t) = 0.0099

D.Damongo2	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Damongo2						
L1.	-.3438935	.0867954	-3.96	0.000	-.5159371	-.1718499
LD.	-.1955426	.094172	-2.08	0.040	-.3822078	-.0088775
_trend	.0292062	.0091757	3.18	0.002	.0110184	.0473941
_cons	3.409179	.9460356	3.60	0.000	1.533972	5.284386

PP results with Stata

1. Yendi Domestic Rice Price in level

Phillips-Perron test for unit root — Number of obs = 113, Newey-West lags = 1

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(rho)	-9.583	-27.487	-20.752	-17.543
Z(t)	-2.211	-4.036	-3.448	-3.148

MacKinnon approximate p-value for Z(t) = 0.4836

Yendi2	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Yendi2						
L1.	.9073116	.0401317	22.61	0.000	.8277799	.9868433
_trend	.0114811	.0054117	2.12	0.036	.0007564	.0222057
_cons	.7518653	.3185115	2.36	0.020	.1206504	1.38308

2. Yendi Domestic Rice Price in first difference

Phillips-Perron test for unit root — Number of obs = 112, Newey-West lags = 1

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(rho)	-128.477	-27.480	-20.748	-17.540
Z(t)	-12.014	-4.036	-3.448	-3.148

MacKinnon approximate p-value for Z(t) = 0.0000

Yendi2D	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Yendi2D						
L1.	-.1399111	.0947951	-1.48	0.143	-.3277919	.0479697
_trend	.0004078	.0024453	0.17	0.868	-.0044388	.0052544
_cons	.1158567	.1595286	0.73	0.469	-.2003237	.4320372

3. Tamale Imported Rice Price in first difference

Phillips-Perron test for unit root — Number of obs = 112, Newey-West lags = 1

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(rho)	-138.556	-27.480	-20.748	-17.540
Z(t)	-13.690	-4.036	-3.448	-3.148

MacKinnon approximate p-value for Z(t) = 0.0000

TamaleD	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
TamaleD						
L1.	-.2597764	.0926156	-2.80	0.006	-.4433375	-.0762154
_trend	.0103651	.0097987	1.06	0.292	-.0090557	.0297858
_cons	-.3666385	.6362938	-0.58	0.566	-1.627752	.8944751

asymptotic critical values:

10%	5%	1%
0.347	0.463	0.739

value of test statistic: 5.1834

reference: reprinted from JOURNAL OF ECONOMETRICS,

Vol 54, No 1, 1992, pp 159-178, Kwiatkowski et al:

"Testing the null hypothesis of stationarity ...",

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2. Salga Domestic Rice Price in first difference

KPSS test for series: Salga Domestic rice price in first difference

sample range: [2005 M2, 2014 M6], T = 113

number of lags: 1

KPSS test based on y(t)=a+e(t) (level stationarity)

asymptotic critical values:

10%	5%	1%
0.347	0.463	0.739

value of test statistic: 0.2006

reference: reprinted from JOURNAL OF ECONOMETRICS,Vol 54, No 1, 1992, pp 159-178, Kwiatkowski et al: "Testing the null hypothesis of stationarity ...",

Appendix D: Sample results of Johansen Co-integration model (Analysis with Stata)

1. ln_Bimbilla2 (Imported rice price) ln_Bimbilla (Domestic rice price),

Johansen tests for cointegration

Trend: constant — Number of obs = 112
Sample: 3 - 114 — Lags = 2

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value	1% critical value
0	6	346.04117		19.6052*1	15.41	20.04
1	9	354.4141	0.13888	2.8594*5	3.76	6.65
2	10	355.84377	0.02521			

maximum rank	parms	LL	eigenvalue	max statistic	5% critical value	1% critical value
0	6	346.04117		16.7458	14.07	18.63
1	9	354.4141	0.13888	2.8594	3.76	6.65
2	10	355.84377	0.02521			

2. ln_Damongo2 (Imported rice price) ln_Damongo (Domestic rice price),

Johansen tests for cointegration

Trend: constant — Number of obs = 112
Sample: 3 - 114 — Lags = 2

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value	1% critical value
0	6	109.55999		18.2821*1	15.41	20.04
1	9	116.4176	0.11526	4.5669	3.76	6.65
2	10	118.70104	0.03996			

maximum rank	parms	LL	eigenvalue	max statistic	5% critical value	1% critical value
0	6	109.55999		13.7152	14.07	18.63
1	9	116.4176	0.11526	4.5669	3.76	6.65
2	10	118.70104	0.03996			

3. ln_Gushegu2 (Imported rice price) ln_Gushegu (Domestic rice price),

Johansen tests for cointegration

Trend: constant — Number of obs = 113
Sample: 2 - 114 — Lags = 1

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value	1% critical value
0	2	189.79838		19.8598*1	15.41	20.04
1	5	198.79697	0.14723	1.8627*5	3.76	6.65
2	6	199.7283	0.01635			

maximum rank	parms	LL	eigenvalue	max statistic	5% critical value	1% critical value
0	2	189.79838		17.9972	14.07	18.63
1	5	198.79697	0.14723	1.8627	3.76	6.65
2	6	199.7283	0.01635			

Appendix E: A Sample of the Output of the Estimated Vector Error Correction Model (Analysis with JMulTi)

VEC REPRESENTATION

1. **Endogenous variables: ln_Bimbilla (Domestic rice price) ln_Bimbilla2 (Imported rice price)**

Exogenous variables:

Deterministic variables: CONST

Endogenous lags (diffs): 2

Exogenous lags: 0

Sample range: [2005 M1, 2014 M6], T = 110

Estimation procedure: One stage. Johansen approach

Lagged endogenous term:

==========

	d(ln_Bimbilla)	d(ln_Bimbilla2)
d(ln_Bimbilla) (t-1)	-0.257	-0.096
	(0.104)	(0.088)
	{0.013}	{0.276}
	[-2.476]	[-1.089]
d(ln_Bimbilla2)(t-1)	-0.141	0.441
	(0.102)	(0.086)
	{0.165}	{0.000}
	[-1.389]	[5.133]
d(ln_Bimbilla) (t-2)	-0.123	-0.065
	(0.100)	(0.084)

```
                |  {0.219}   {0.439}
                |  [-1.230]  [-0.773]
d(ln_Bimbilla2)(t-2)|  0.058    -0.265
                |  (0.108)   (0.091)
                |  {0.593}   {0.004}
                |  [0.534]   [-2.906]
-------------------------------------------------

Deterministic term:
====================
        d(ln_Bimbilla)  d(ln_Bimbilla2)
---------------------------------------
CONST   |  0.015    -0.035
        |  (0.015)   (0.012)
        |  {0.295}   {0.004}
        |  [1.047]   [-2.853]
---------------------------------------

Loading coefficients:
=====================
        d(ln_Bimbilla)  d(ln_Bimbilla2)
---------------------------------------
ec1(t-1)|  -0.018     0.151
        |  (0.051)   (0.043)
        |  {0.723}   {0.000}
        |  [-0.354]  [3.492]
---------------------------------------
```

Estimated cointegration relation(s):

==========

ec1(t-1)

---

ln_Bimbilla (t-1)| 1.000

| (0.000)

| {0.000}

| [0.000]

ln_Bimbilla2(t-1)| -0.996

| (0.128)

| {0.000}

| [-7.791]

2.endogenous variables: ln_Tamale (Domestic rice price) ln_Tamale2 (Imported rice price)

exogenous variables:

deterministic variables: CONST

endogenous lags (diffs): 2

exogenous lags: 0

sample range: [2005 M5, 2014 M6], T = 110

estimation procedure: One stage. Johansen approach

Lagged endogenous term:

==========

d(ln_Tamale) d(ln_Tamale2)

| [-2.578] [-2.239]

d(ln_Tamale2)(t-1)| 0.119 -0.121

| (0.157) (0.105)

| {0.447} {0.252}

| [0.761] [-1.146]

d(ln_Tamale) (t-2)| -0.111 -0.007

| (0.093) (0.062)

| {0.230} {0.905}

| [-1.200] [-0.120]

d(ln_Tamale2)(t-2)| 0.031 -0.097

| (0.150) (0.101)

| {0.837} {0.335}

| [0.205] [-0.963]

Deterministic term:

==========

d(ln_Tamale) d(ln_Tamale2)

CONST | 0.060 0.006

| (0.021) (0.014)

| {0.004} {0.670}

| [2.911] [0.427]

Loading coefficients:

==========

d(ln_Tamale) d(ln_Tamale2)

---

ec1(t-1)| -0.213 0.008

| (0.064) (0.043)

| {0.001} {0.856}

| [-3.311] [0.182]

Estimated cointegration relation(s):

==========

ec1(t-1)

---

ln_Tamale (t-1)| 1.000

| (0.000)

| {0.000}

| [0.000]

ln_Tamale2(t-1)| -1.207

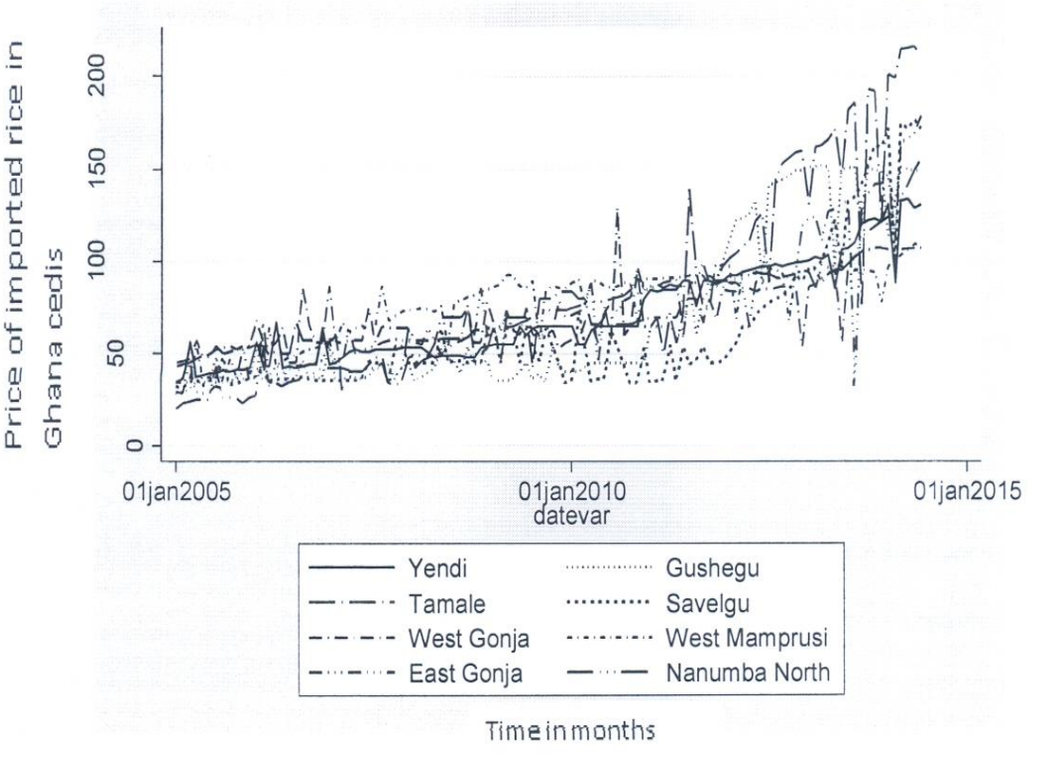
| (0.233)

| {0.000}

| [-5.173]

Appendix F: Graphs of the Price Series for Eight District Markets

Average Monthly Wholesale Prices for Domestic rice (GH¢/50kg bag)



Average Monthly Wholesale Prices for Imported rice (GH¢/50kg bag)