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THE FUEL – MAIZE PRICE NEXUS AND SPATIAL PRICE TRANSMISSION BETWEEN MAIZE MARKETS IN GHANA

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The Fuel – Maize Price Nexus and Spatial Price Transmission between Maize Markets in Ghana

BY

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THESIS 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 IN AGRICULTURAL ECONOMICS

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DECLARATION

I, Albertina K. Jarawura, author of this thesis titled "The Fuel – Maize Price Nexus and Spatial Price Transmission between Maize Markets in Ghana" do here by declare that with the exception of the references duly quoted, this work was written by me from August, 2016 to October, 2017 in the Department of Agricultural and Resource Economics, University for Development Studies, Nyankpala. I do hereby declare that, this work has not been submitted in part or whole for a degree or diploma in this University or anywhere.

Date: ----------------------------

Albertina K. Jarawura

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

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Date: ----------------------	Date: ----------------------
Dr. JOSEPH AMIKUZUNO	Mr. ISAAC G. K. ANSAH
(Major supervisor)	(Co-supervisor)

DEDICATION

To

My entire family

ACKNOWLEDGEMENT

Most thanks and praise to the almighty God for this achievement I could not have done it without good health and life. My family has been the most supportive ever and I could not have asked for a better family. I thank my siblings and husband for the financial and moral support. I pray that we grow together in unity and in good health.

I most grateful to my supervisors Dr. Joseph Amikuzonu and Mr. Isaac Ansah for the immense knowledge, advice and friendship you have given me. I wish you the best in life and look forward to working with you in the future.

Mr. Amadu Yakubu (Carlos) thank you for the great tutoring in time series analysis, am forever thankful. To all the institutional bodies that provided data for the study, I say thank you and keep up the good work. God bless everyone who contributed directly and indirectly to this study.

ABSTRACT

Stable and affordable food commodity prices are important for food security. Higher food prices reduce a family's expenditure on other life sustaining expenditures such as health and education. In 2007/8, the world experienced an unexpected rise in both food commodity prices and fuel (petroleum products) prices, which drew the attention of world leaders and researchers. The effect of this continues increases in gasoline prices on the price of maize have implications for Ghanaians and food/ agricultural policies. This effect is further influenced by price transmission mechanism that exists among major maize markets in the country. This thesis seeks to determine the dynamics and extent of maize price transmission and responses to fuel pricing in different markets of Ghana. To achieve this, data on monthly maize prices was collected from MOFA for the period, January 2000 to December 2015. Monthly data on gasoline prices was also collected from ACEP for the same period. Models used are trend analysis, and cointegration, threshold autoregressive model (TAR) and impulse response function analysis. Generally maize prices in all four markets under study moved in the same direction as gasoline prices over the years and months. Prices in all markets were integrated with significant thresholds above which prices responded to. Also prices in all markets over the years studied experienced an immediate sharp rise in maize prices when gasoline prices are raised. This effect, the study realized is permanent and never leads to a nominal fall in maize prices. It is therefore recommended that policies on fuel pricing should be sensitive to its effect on maize pricing. Also MOFA and all actors in the agricultural sector should provide transportation infrastructure to lessen the effect of gasoline prices on maize prices

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LIST OF ACRONYMS

ACEP-	African Center for Energy Policy
ACF-	Autocorrelation Function
ADF-	Augmented Dickey Fuller
AIC -	Akaike Information Criterion
APT -	Asymmetric Price Transmission
ARDL -	Auto Regressive Distributedd Lag
AVECM -	Asymmetry Vector Error Correction Model
BIC -	Bayesian Information Criterion
BRM-	Bivariate Regression Model
CPI-	Consumer Price Index
CS -	Coastal Savannah
DF-	Deciduous Forest
ECM-	Error Correction Model
ECT-	Error Correction Term
EPA-	Economic Partnership Agreement
FAO-	Food and Agriculture Organization
FASDEP I-	Food and Agricultural Sector Development Policy I
FASDEP II-	Food and Agricultural Sector Development Policy II
FIFO-	First in First Out

LIFO-	Last In First Out
GADS I-	Gender and Agricultural Development Strategy I
GADS II-	Gender and Agricultural Development Strategy II
GADS II-	Gender and Agricultural Development Strategy II
GFDC-	Ghana Food Distribution Corporation
GSS-	Ghana Statistical Service
HQIC-	Hannan-Quinn Information Criterion
ICT-	Information Communication Technology
KPSS-	Kwiatkowski, Philips, Schmidt and Shin
LIFO-	Last-In-First-Out
LOP-	Law of One Price
METASIP-	Medium Term Agricultural Sector Investment Plan
MOFA-SRID-	Ministry of Food and Agriculture–Statistical Research Information Directorate
NAFCO-	National Food Buffer Stock Company
NPA-	National Petroleum Authority
NS-	Northern Savannah (Guinea and Sudan Savannah)
OLS-	Ordinary Least Squares
OMCs-	Oil Marketing Companies
PACF-	Partial Autocorrelation Function

PBM-	Parity Bound Model
PP-	Philip Perron
RF-	Rain Forest
SRM-	Switching Regime Model
TAR-	Threshold Autoregressive Model
TZ-	Transitional Zone
VAR-	Vector Authoregression
VECM-	Vector Error Correction Model
WTO-	World Trade Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Stable and affordable food commodity prices are important for food security. This is because rising food prices have both immediate and long term devastating impacts on people, especially the rural and urban poor. With rising food prices, households might forego other important life sustaining expenses such as health care and education.

Despite these expenditure substitutions, many poor households may still end up going hungry as food prices increase (Yaro, 2012). Consequently, political and social unrest may arise, since a higher food price erodes consumer purchasing power and people may become angry or frustrated. A case in point was observed in Senegal, where food crises in April, 2008 led to rioting in Dakar (Benzie, 2015). A classical case is the Arab spring in 2011 where continues increases in food prices led to a chain of political unrest throughout the region.

The global food price shock in 2007-2008 was a major recent force that drew the attention of researchers and policy makers to the underlying causes and implications. Food price shocks occur when a country or region experiences sharp and sudden increases in food prices (Badolo et al., 2015). When applying appropriate policy options, for development and investment opportunities, policy makers and investors often question the factors influencing the agricultural commodity markets/prices especially in developing countries.

Research has evidenced the food price crises, especially the 2007-2008 episode, to be caused by multiple factor interactions, including higher oil prices (Fowowe, 2016), unusual weather, changing food demand patterns, biofuel policies, depreciation of the US dollar and world agricultural trade and government trade policies (Abbot et al., 2008; 2009). The 2007-2008 crises invoked a rise in staple food prices such as rice, maize, cassava, cowpea and groundnut. The impacts of this and other similar shocks drew the attention of world leaders to the issues of volatile food prices. Following this event, many nations have been considering and instituting measures to prevent their economies from such future shocks.

The food commodity under focus is maize. This is because maize is the primary source of food both produced and consumed by Ghanaians. It is also one of the most traded food commodities in the country which is vastly influenced by shocks in the domestic prices of gasoline due to trade linkages. This is because traders transport maize from producer market(s) to consumer market(s) and each of these markets are in different locations. It is therefore not surprising to hear news reports on the rise of transportation fares leading to a general increase in maize prices immediately domestic gasoline prices increase.

The effect of changes in gasoline prices on maize prices is further exacerbated by the rudimentary nature of production in the country. Agricultural production is highly dependent on climatic factors which are unpredictable and transportation cost which is highly influenced by the domestic price of gasoline.

Among the many food crops grown in Ghana, maize is the most widely and intensively cultivated and traded in the country. Due to this, over the years maize has often recorded the highest total land area in terms of cultivation. For example, in 2014, a total land area of 1,025 hectares was used to cultivate maize with an output of 1,769 (FAF, 2014). This figure is about six times more than the land area used to cultivate other food crops. The southern part of Ghana alone produces more than 40% of maize output, probably due to the two growing seasons in this part of the country (Cudjoe et al., 2010).

The differences in growing seasons, between the northern and southern parts of the country lead to varying production capacities and durations. Each agro-ecological zone is usually characterized by different climatic conditions; hence the difference in growing seasons. This indicates that, weather shocks in a given agro-ecological zone could adversely affect the availability of a particular crop in that zone and also overall prices of the commodity. Furthermore, through trade, the effect of this shock can be transmitted to nearby and distant trading markets (or zones), which could affect overall price levels.

Historically, agriculture has been an energy-intensive sector and therefore one can draw a direct and indirect linkage from oil prices to agricultural commodity prices (Saban and Ugur, 2011). Increases in oil prices lead to an increase in input costs which in turn causes agricultural prices to rise. Another link between oil prices to agricultural commodity prices is through the exchange rates, which is an indirect cause. The appreciation/ depreciation of local currency, in return, influences local maize prices directly through transportation fares and indirectly through the cost of spare parts for transportation vehicles.

Price transmission between different zones and markets is vastly influenced by the level of information flow between them. Transforming technological advancements have greatly influenced how and when trade is undertaken. Information flow between traders in different zones used to be limited; however, with the advent of telephones and mobile phones, information is easily and immediately shared among traders in different locations (Abdulai, 2000; Amikuzunu, 2009).

Aside verbal communications, documents are shared among traders who are more technologically advanced via emails and other social networks such as WhatsApp and other social platforms. The introduction of mobile money by telecommunication providers has further increased and motivated trade between traders in different markets. Most traders do not necessarily move to other locations to trade but rather communicate with their trading partners and the goods are delivered. Also, banking services are becoming readily available in Ghana there by promoting easy transactions needed for trade.

1.2 Problem statement

In relation to food prices and gasoline prices, not enough studies have been conducted in the Ghanaian context. However studies have been conducted on agricultural food pricing and energy pricing especially after the food crises in 2008. Nazlioglu and Soytas (2010) investigate the direct and indirect effects of world oil prices on Turkish agricultural commodity prices (wheat, maize, cotton, soybeans, and sunflower). They utilized Toda and Yamamoto (1995) procedure which showed that oil prices affect individual agricultural prices in Turkey neither directly nor through the exchange rates. The generalized impulse response analyses, that are robust to the ordering of variables in the system, support the neutrality of agricultural commodity prices to world oil prices in the short run. The neutrality of all agricultural prices in Turkey to world oil price changes may be due to the relatively low energy intense production processes.

Also, in Ghana fuel prices determine direction and extent of food commodity prices either directly or indirectly. Food commodities are usually transported from farms in rural areas by traders. When the price of gasoline or diesel increases, transporters increase the fares to cover cost and make profits. The rise in transport fares is however transferred by the traders to end users through various pricing mechanisms, which is a direct effect. Oil price volatility, which is often reflected in domestic fuel prices, leads to sharp increases in food commodity prices in Ghana (Adam, 2009).

Like any other net oil importer, Ghana's problem of oil price volatility does not seem to end any time soon since fuel price hikes are also influenced by international factors (Adam, 2009). It is therefore important to study the price movement between markets and domestic gasoline prices.

Maize production in Ghana is mostly for domestic consumption as there is little and unrecorded trade between some border towns and the neighboring countries. Maize crop in Ghana is grown in rural areas with bad road infrastructure linking major market(s). This therefore acts as a hindrance to trade. According to Winter et al. (2004) transfer costs is usually caused by poor transportation infrastructure such as roads, rails and vehicles which are usually high in developing countries as price signals that are passed on to consumers are completely different from the producer price.

Information on price movement within a country or region is imperative to development since it provides empirical analysis of how changes in prices from one domestic market can affect prices of the same commodity in another domestic market as well as its output, consumption and the economic and social welfare of people within the zones or markets where trade exists.

Also knowledge on price movements between markets and the degree to which prices are transmitted is of economic significance as it provides forecast information on how producers and consumers in the domestic markets will react to price changes. Studies of price transmission can provide important information on how prices are transmitted and how markets are integrated. This will also help inform agricultural marketing policy for intervention and implementation to improve market efficiency (Alderman, 1993).

The trend of food pricing in Ghana is continually changing as all of these forces increase across agro-ecological zones in the country. Price transmission of food prices in Ghana has been studied by some researchers at the national level. Previous studies have examined price transmission between regions and markets but without a fuel component. For instance, Cudjoe et al. (2012) used rice and maize as an index to understand tradable and non-tradable food prices in Ghana. Other studies have also used some staple foods as the reference commodities, while others examined the effects of macroeconomic factors or climate impacts on food prices. While previous studies have examined the general trends of price volatility on the macro scale, empirical studies on the fuel -maize price nexus has received limited attention.

Domestic fuel price shocks exacerbate the effects of information transfer and transportation infrastructure on maize pricing. Undoubtedly, ecological differences of markets may interact at some point in time with fuel pricing to influence food price levels, thereby complicating the issues of consumer vulnerability to price shocks; these dynamics are not known.

This study hopes to bridge these gaps in literature by studying the fuel – maize price nexus i.e. the influence of fuel pricing on maize prices in Ghana. It will as well explore the effects of price transmission which may be important determinants of food prices in Ghana. Finally, the study will examine the potential effect of fuel pricing on food price development.

1.3 Research Questions

The main research question is what are the dynamics and extent of maize price transmission and responses to fuel pricing in Ghana? To address this main question, the following specific questions will be studied in the process.

i. What has been the trend of maize prices across markets in Ghana from the 2000 to 2015?

ii. Does seasonal price variation of maize exist among markets in Ghana?

iii. What is the relationship of maize prices between different markets in Ghana?

iv. What is the dynamic relationship between domestic fuel prices and maize prices across markets in Ghana?

1.4 Research Objectives

The main objective of the study is to determine the dynamics and extent of maize price transmission and responses to fuel pricing in different markets of Ghana.

The specifics include the following,

i. Examine the trend of maize prices across markets in Ghana from the 2000 to 2015.

ii. Determine the seasonal variation of maize price in Ghana.

iii. Examine the relationship between maize prices across different markets in Ghana.

iv. Determine the dynamic relationship between domestic fuel prices and maize prices across markets in Ghana.

1.5 Justification

Ghana presents an interesting case of study because of its interesting location. Its diverse agricultural zones with different kinds of foods suited for each region in Ghana is therefore suited for this study because the variation in types of food suited in these zones will be reemphasized by empirical evidence to inform project implementers and policy makers.

Affordable food or stable food commodity prices are an imperative for sustenance in Ghana. Food prices as a source of income for many Ghanaians who are mostly peasant farmers. Over the years, ecological differences have had adverse effects on food production coupled with continues rise in domestic fuel prices which increases food prices. This study will contribute to empirical evidence in this area.

Ghana has experienced continuous rise in domestic fuel prices over time. However the full cost was not being paid by consumers since government was subsidizing the prices. But since 2016, the government has removed all subsidies on fuel and rather imposed taxes. This difference in policy hopefully will be captured. And inferences made on the effects of the new policy.

1.6 Organization of the study

The study is categorized into five main chapters.

Chapter one is an introduction to the study. It comprises of the research background, problem statement, objectives and significance and organization of the study. Chapter two is the review of literature. Related publications on topics related to this study are discussed and methods used in time series analysis. Chapter three outlines the methodology employed in carrying out this research. Chapter four comprises of the analysis and discussion of results obtained. Chapter five consists of conclusions and recommendations made from the study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction to chapter

This chapter provides an overview of the concepts that will furnish this research with more insight into the topic under consideration. The chapter discusses the maize market and food policies in Ghana. Price transmissions, models used in its studies as well as similar works are discussed by the chapter.

2.1 Food markets in Ghana

Maize is Ghana's most important cereal crop produced by a vast majority of households in all parts of the country. Ghana is covered by five main agro ecological zones: Rain Forest (RF), Deciduous Forest (DF), Transitional Zone (TZ), Coastal Savannah (CS) and Northern Savannah (Guinea and Sudan Savannah) (NS) (FAF, 2014). Each of these zones has different kinds of food commodities grown and also differs in their responses to weather shocks. Cash crops and food crops are the two main crops grown in Ghana. The northern savanna zone of Ghana accounts for 70% and 60% of rice and Millet produced respectively. Maize however, is widely produced and consumed within the northern region (SZ) and Brong Ahafo (TZ) accounting for a larger proportion of the output.

The cropping system and production technologies vary between the remaining four agro-ecological zones where significant quantities of maize are produced. The transitional zone, which includes Brong Ahafo and parts of Ashanti and Eastern regions of Ghana, accounts for a higher percentage of maize produced in Ghana (WABS, 2008). The Ghanaian maize market comprises of the yellow maize which is mostly used in the poultry industry and the white maize used for human consumption, industrial use and Same as used in poultry industry.

Maize prices are often high due to the high agricultural cost of production, high transaction costs of buying maize from the many scattered small scale farmers. The prices exhibit considerable fluctuations caused largely by seasonal production and inadequate and poor storage facilities. Prices are generally low during major harvest seasons and increase dramatically until it peaks in the lean seasons just before the next harvest.

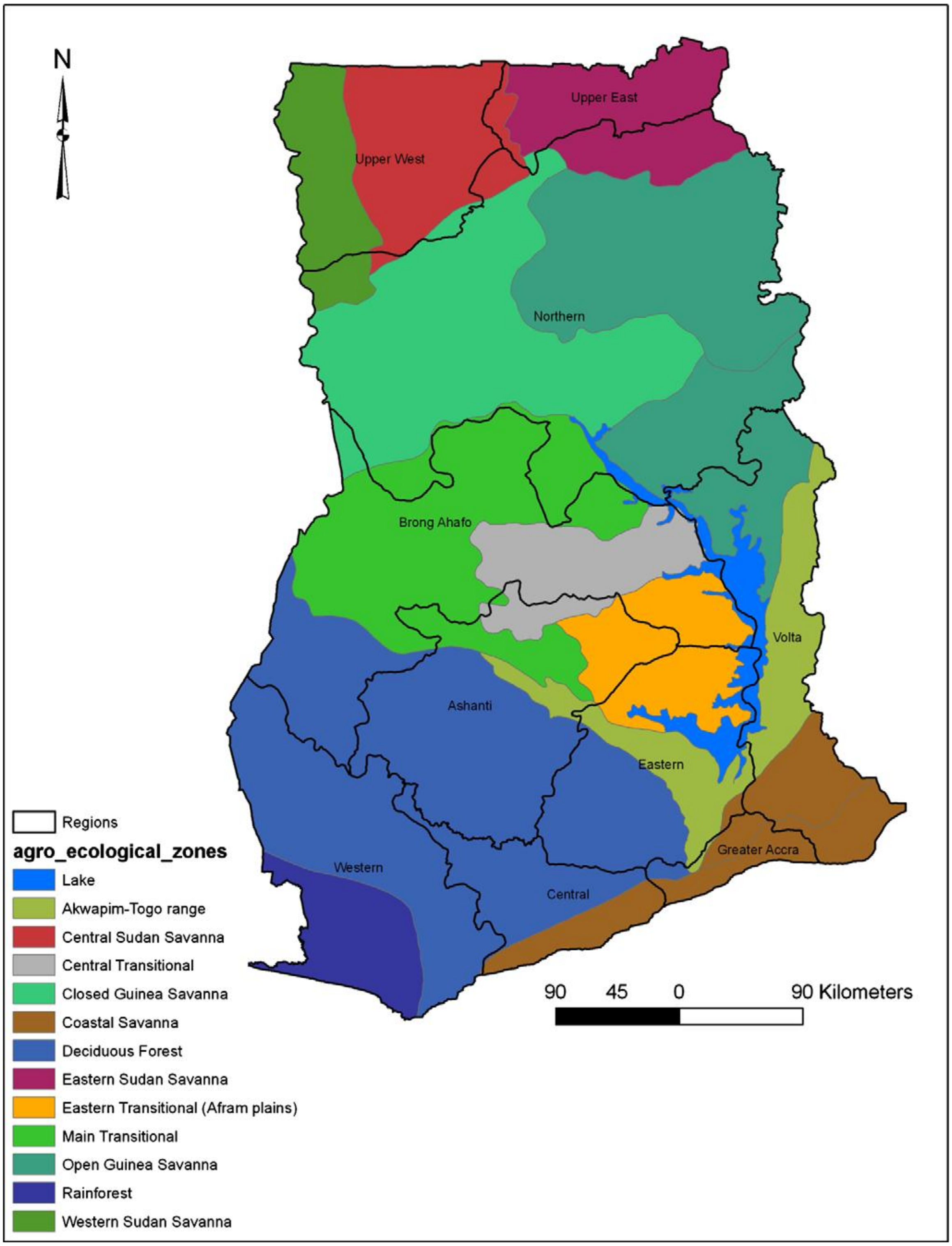
In the major production regions, maize has minor and major harvesting seasons where prices are low during the major harvesting season when farmers generally sell their output immediately after harvest, usually from August to October to meet their cash needs. The minor season harvest occurs in January and February which is sometimes stored and sold between May and July when prices are very high (Armah and Asante, 2004). The northern regions however have only one growing season from May with the harvest period occurring in October and November (Gage et al., 2012).

Maize marketing in Ghana is traditionally a private sector system which takes place in formal and informal markets. In the rural areas farmers sell to local assemblers who also sell to wholesalers or commission agents. These wholesalers often hold large stock of grains in the urban centers and hence have some control on when and how much to release into the market for retailers who also sell to consumers (this inventory behavior is also hampered by the uneven distribution of maize across time caused by seasonal factors and inadequate storage facilities). The local assemblers and commission agents often act individually while the wholesalers organize themselves into associations under the leadership of market queens who sometimes influence the conduct of the market (Langyintuo, 2010).

Alderman and Shively (1996) indicate the maize market appear to be sufficiently competitive to prevent traders from enjoying excess margin; prices are generally determined through private negotiation between purchasers and traders (Abdulai, 2000). Spatial arbitrage between regions is often the task of wholesalers in the maize market. In major maize production areas, wholesalers sometimes buy directly from farmers with whom they have long lasting relationship (Abdulai, 2000), sometimes to the extent of giving farmers credit for maize production.

According to Cudjoe et al. (2010), the different ecological zones have different varieties and species of food commodities. Indigenous groups in every zone have unique food consumption patterns which greatly influence the prices of food commodities in that area. The forest and coastal savannah vegetation is characterized by two rainy seasons which enables the production of food commodities, especially maize. This gives it a higher availability of maize compared to the northern savannah zone.

Root tubers such as yam and cassava are widely grown in each zone though different species are cultivated. The much preferred species commands higher prices. With the exception of rice, Ghana is self-sufficient in staple foods. Ghana is experiencing an open economy with the implementation of an ad valorem tariff rate of 20% (Cudjoe et al., 2010). In May 2008, the government waived tariffs on the importation of rice, wheat, yellow corn and vegetable oil. Also, Cudjoe et al. (2010), asserted that, intra country and cross bounder trade between Ghana and its neighbors do exist while most trade goes unrecorded.



Adopted from Cudjoe et al. (2014)

Fig. 2.1. Ghana's agro-ecological zones and administrative regions.

2.2 Food Polices in Ghana

Ghana, since independence, has created some policies with the aim of improving agricultural output, pricing and food security for both farmers and consumers. The development of the agricultural sector has been a priority of the Ghanaian government with great emphasis on increased output and prices for farmers as well as reasonable prices for consumers. “vision 2020” was launched in 1995 and envisions Ghana as the first developed country in Africa by 2039 (UN country specific report, 2015). To achieve the goal of good pricing for both producers and consumers, the national buffer stock company was established in 2010 to buy products during gluts at a minimum price to ensure price stability. However the UN 2015 country specific report specifies that, NAFCO since its establishment has not achieved its goal of price stability in the maize, rice and soya bean market.

Ghana is one of the founding members of the ECOWAS which aims at integrating the economic policies of the region. However, the country implements some policies which does not augur well for policy integration in the region. For instance in 2015, the UN reported that, Ghana banned the importation of rice through any other border except the Tema, Accra and Tarkoradi ports. Also the Ghana export promotion was established to promote trade with the world.

2.3 Linkage between Fuel prices and maize prices in Sub-Saharan Africa

The link between Fuel and maize prices has not been studied vastly hence there is very limited research available for review.

A study by Dillon and Barret, 2013 examined the linkage between fuel and maize prices in four countries, Ethiopia, Kenya, Tanzania and Uganda. The study revealed that, though global oil prices exert no identifiable effect on global maize prices, the sub-national maize market prices are however affected through the impact of global oil prices on transport fuel prices in all countries.

The average elasticity of local maize prices with respect to global oil prices is low compared to the average elasticity of local maize prices with respect to global maize prices. In the four markets under study, which are farthest from the coastal ports, changes in transport costs have larger effects on maize prices than do changes in the global market price of the grain itself.

Also, oil price shocks on the world market transmit much more rapidly throughout fuel markets in the region than do global maize price shocks. The policy recommendation therefore is that, when oil and maize prices co-move on global markets, policies to intervene directly in grain markets will have the desired impact if they are coupled with policies to address rising transport costs.

2.4 Overview of the petroleum subsector in Ghana

The National Petroleum Authority (NPA) was established in 2005 by an act of parliament (NPA Act 2005, ACT 691) (NPA, 2017). The duty of the authority is to regulate the petroleum downstream industry in Ghana. These duties include regulating, overseeing and monitoring activities in the petroleum downstream industry. This is to help establish a Unified Petroleum Price Fund (UPPF) and ensure an efficient, profitable and fair industry as well as ensuring that consumers receive value for money.

To further strengthen the petroleum subsector in Ghana, the government of Ghana's strategic policy for the sector is to expand the capacity of the existing infrastructure by attracting private sector investment to these structures. The focus will be on the licencing the private sector to build and own refineries and depots. This will be achieved using a combination of administrative and regulatory changes anchored on a pricing framework that aims at full-cost recovery based on the following phrases (Acheampong and Ackah, 2015).

i. "Ex-refinery prices of petroleum products will continue to be based on import parity prices of petroleum products

ii. Transportation and distribution charges for petroleum products will be regulated to ensure reasonable profit margins for transporters and distributors

iii. Cross-subsidies between petroleum products will be applied, as necessary, to achieve specific national development objectives

iv. Uniform national prices for petroleum products would be maintained"

2.5 Pricing of Petroleum (Gasoline) in Ghana

The national petroleum authority (NPA) regulates the importation of petroleum products in to the country by bulk distribution companies (BDC). The aim is to ensure full cost recovery, government revenue generation and uniformity of prices via the Unified Petroleum Price Fund (UPPF). The IPP benchmark refers to the cost of refined fuel at the port gate of Ghana; this includes the international price for refined fuel freight charges, exchange rate, customs and port duties, insurance and losses. The rationale behind the IPP benchmark is to have a strong relationship with the actual costs of fuel imports into Ghana taking into account global developments (Acheampong and Ackah, 2015).

To arrive at the ex-pump price, NPA has a two week period, where the average of FBO prices of petroleum products is calculated. The average of the dollar figures within the two weeks window is calculated in to the pricing framework. Other charges like port duties are also added to arrive at the ex-refinery price in Ghana pesewas. To arrive at the ex-pump price, other charges such as taxes or subsidies approved by parliament and OMC distribution cost are finally added (Franklin, 2016). The Ex-pump price is the price at which the public buys fuel at the fuel stations. According to Acheampong and Ackah 2015, fuel taxes and margins typically make up about 35-40% of ex-pump fuel prices in Ghana. The figure below further elaborates the constituents of fuel (gasoline) pricing in Ghana.

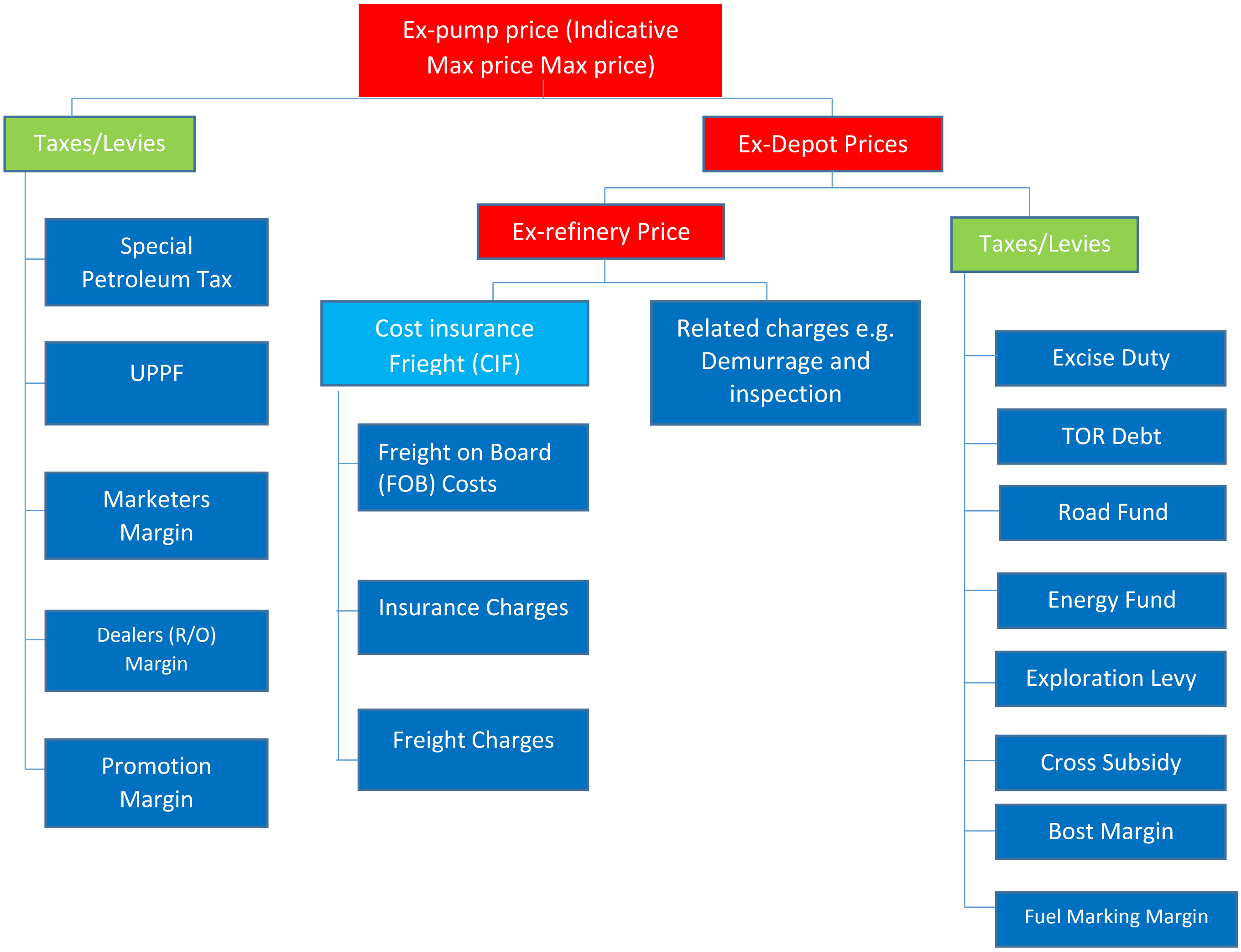


Fig. 2.2 Breakdown of the Petroleum Pricing Regime in Ghana, adopted from Acheampong and Ackah, 2015.

2.6 Market Integration and Price transmission

Market integration occurs when prices in spatially separated markets have the same patterns over a long time period. Cointegration methods are usually used to study how markets are integrated. Market integration has been considered to relate to the flow of goods and information between markets or regions that are distantly situated. Thus, in discussing market integration the prerequisite is the existence of two or more separate regions or countries, each of which is characterized by its own supplies and demands for a range of commodities under autarkic conditions. In Barrett and Li (2002), market integration is defined as the tradability and contestability between markets which includes market clearance process where demand, supply and transaction costs in distinct markets determine prices and trade flows jointly, and the transmission of price shocks from one market to the other. In the tradability view, trade flows are sufficient to signal spatial market integration but not necessarily implying price equalization and hence consistent with Pareto-inefficient distribution (Barrett, 2005). Thus, two markets can be integrated by belonging to a network or by a state institution that fixes prices adjusted to regional or national shocks making it possible for prices to be transmitted even in the absence of trade (Cirera and Arndt, 2006).

Market integration is considered to be a desirable phenomenon because it improves welfare by fostering competition, improving security of supply and providing better signals for consumers and producers to make optimal decisions. Through these processes, market integration influences economic growth, induces structural change and has the potential to change the location of economic transactions (Vollrath and Hallahan, 2006). Spatial market integration is of high relevance to agriculture, as agricultural products are often bulky and/or perishable and that production may be concentrated in one location while consumption is concentrated in the other which may imply expensive transportation cost (Sexton et al., 1991).

Prince transmission and market integration are theories guiding this research (Ansah, 2012). The Law of one price is usually considered the core of price transmission studies. The spatial arbitrage conditions ensures that, for a homogeneous product the price differences between regions in a competitive market that trade with each other should equal the transaction cost, while at autarky price differences between two regions is less than or equal to the transaction cost (Tomek and Robinson, 2003). If price differences exceed the transfer cost, arbitrage is created and profit seeking merchants will purchase commodities from low price surplus markets and sell in the high price deficit market (Katengeza, 2009). Prices between two spatially separate markets P_1 and P_2 are said to be integrated if price in the two markets are equal, corrected by the transport cost T_t,

thus $T_t = P_1 - P_2$ 2.1

An appropriate measure to evaluate whether two markets are integrated is to explore if a possible cointegrating relationship exists between them. In a cointegration framework, sharing long-run information is an important prerequisite. The long-run information means there exists one and the only integrating factor that may be common to all price series. In analyzing market integration, great advances have been made in methodology from the use of simple correlation coefficients to more sophisticated econometric approaches, such as bivariate models, cointegration and error correction models. Our focus will be confined to threshold autoregressive model.

2.7 Models for Estimating price transmission and Spatial Market Integration

In the analysis of market integration, it is often preferred if all possible information such as prices and quantities produced and traded, data on costs or transaction costs are utilized to infer demand and supply mechanisms. However, due to data unavailability, researchers rely on assumptions guided by economic theory to make use of price based techniques such as price transmission econometrics or parity bound models that utilize more than price data in equilibrium representation (Abunyuwah, 2007). Some of these techniques relevant to the maize price transmission study are discussed below.

2.7.1 Static Price Correlation and Regression Models

The study of market integration started with the use of static price correlations to test for spatial market integration in agricultural markets. This approach involves the estimation of bivariate correlation and regression coefficients of homogeneous goods in distinct markets (Hossain and Verbeke, 2010). The intuition behind this approach is that there is co-movement of prices between integrated markets. Thus, high/low correlation coefficient is interpreted as market integration/segmentation. For instance, if P_t^i and P_t^j are two contemporaneous price series in markets i and j connected by trade for a homogenous commodity, the correlation coefficient, r, is obtained by:

$$r = \frac{\sum_{k-1}^{n}\left[(P_t^i - \overline{P}^i)(P_t^j - \overline{P}^i)\right]}{\sqrt{\sum_{k-1}^{n}(P_t^i - \overline{P}^i)^2 \sum_{k-1}^{n}(P_t^j - \overline{P}^j)^2}} \qquad 2.2$$

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

The bivariate regression models (BRM) of price transmission and market integration are commonly specified as:

$$P_t^i = \beta_0 + \beta_1 P_t^j + \beta_2 T_t + \beta_3 R_t + \varepsilon_t \qquad 2.2.1$$

Where P_t^i and P_t^j may be in their first-difference or logarithmic forms, T_t is transaction cost, R_t denotes other factors influencing prices. The β_is are the coefficients to be estimated and ε_t is the error term. Even though the static models are easy to estimate using only price data, their assumption of stationary price behaviour and fixed transactions costs make them underestimate the extent of market integration (Barrett, 1996; Baulch, 1997). Recent developments in time series econometrics allow economist to test a more general notion of spatial market integration by analyzing long-run co-movement of prices leaving the LOP a testable hypothesis.

The static approach though simple, represents significant weakness and hence faces inferential dangers in drawing conclusions from parameter estimates. The principal weakness is that correlation does not imply causality (Cirera and Arndt, 2006). Timmer (1974) recognized that inter-seasonal flow reversals, which are common in areas with poor infrastructure make price spread observations unreliable indicators of market integration or competition because the spreads vary seasonally. Bivariate correlation analysis also masks the presence of certain factors such as government policy effects and general inflation (Golleti et al., 1995). The approach assumes instantaneous price adjustment and hence cannot capture the dynamic nature of the prices. Prices may tend to move together even in the absence of market integration and this has the tendency for spurious market integration (Ravallion, 1986) which can be influenced by general inflation, seasonality or autocorrelation. This simple correlation analysis also fails to recognize the presence of heteroscedasticity common in price data. Also correlation test may overestimate lack of market integration if lag in price response is created by lags in market information (Barrett, 1996). It is limited to only a pair wise market analysis and cannot be used to evaluate the entire marketing system.

2.7.2 Delgado Variance Decomposition Approach

In an attempt to correct for some of the numerous problems in the bivariate correlation approach to measuring market integration, an alternative model was developed by Delgado (1986). The Delgado approach, according to Negassa et al. (2003), is a variance decomposition approach that tests market integration for the whole marketing system instead of a pair-wise test. Prior to the test for market integration, common trends and seasonality present in price series are removed and transport and transaction costs are assumed to be constant. Then, the equality of spatial price spreads between pairs of markets for a given season gives an indication of spatial integration. The problem with this approach is that it is based on contemporaneous price relationships and does not allow dynamic relationships for a given pair of distinct markets.

2.7.3 The Ravallion Dynamic Model

The Ravallion (1986) approach became the most prominent technique for measuring spatial market integration, which distinguished between short-run and long-run market integration and segmentation after controlling for seasonality, common trend and autocorrelation (Negassa et al., 2003). The motivation behind this model is due to the sluggish nature of agricultural markets when a shock is invoked, that may require considerable time lags. The incorporation of dynamic considerations in this model helps avoiding the inferential danger pointed out in the static model discussion.

The Ravallion model rules out the possibility of inter-seasonal flow reversals and assumes constant inter-market transfer cost. If the transfer costs are complex or time varying, inference will be biased in favour of failing to reject the hypothesis of segmented markets (Barrett, 1996; Cirera and Arndt, 2006). This method posits a radial spatial market structure between a group of local markets and a single central market where local price formation is dominated by trade with the central market. Assuming P_{1t} and P_{2t} represent local and central markets prices respectively, the model can be expressed as:

$$P_{1t} = \sum_{j-1}^{n} \alpha_j P_{1t-j} + \sum_{j-0}^{n} \beta_i P_{1t-j} + \gamma X_t + \varepsilon_t \qquad 2.3$$

j is the lag lengths and X represents the constant, seasonal, time and policy variables. From the above model, the restriction $\beta_i = 0$ for all j indicate complete market segmentation, short-run integration is tested from the restriction and for j = (1,...n). Failing to reject this hypothesis implies that changes in the central market are completely transmitted to the local market in a single time period. Since price changes in spatially distinct agricultural markets may take time to influence other markets, Ravallion tests the long-run integration from the restriction, $\sum \alpha_j + \beta_j = 1$; thus price shocks in the central market take more than a single time period to be transmitted to the local market which may be due to inadequate infrastructure.

2.7.4 Cointegration Models

One characteristic of price series used for testing market integration with the use of conventional measures is that the series are often non-stationary and hence tests are invalid. As a result of this problem, Engle and Granger (1987), and Engle and Yoo (1987) introduced the concept of co-integration and defines it as the existence of long-run relation among different series. The absence of co-integration between two market price series indicates market segmentation, otherwise is an indication of market interdependence. The analysis of co-integration involves determining the order of integration using the appropriate unit root test, constructing the co-integration regression if price series are integrated of the same order and finally testing for stationarity of the residuals from the co-integration regression. The absence of stochastic trend in the residuals indicates the existence of long run relationship between the two series (Negassa et al., 2003). The Engle and Granger approach does not allow testing for all possible cointegrating vectors in a multivariate system which led to the development of the Johansen (1988) cointegration approach.

The Johansen method uses maximum likelihood to test for cointegrating relationships among several economic series. In evaluating the short-run dynamics, Engle and Granger (1987) suggest the use of error correction models, if there is the existence of cointegration relation between variables under consideration. The error correction representation sheds more light on the adjustment process in both short-run and long-run responsiveness to price changes which generally reflects arbitrage and market efficiency (Abunyuwah, 2007). The use of cointegration and error correction models help to explore further notions such as completeness, speed and asymmetry of price relationships as well as the direction of causality between two markets.

Barrett (1996) indicates that co-integration among price series is neither necessary nor sufficient for market integration. According to Negassa et al. (2003) and Barrett (1996), if transaction costs are nonstationary, failure to find cointegration between two markets' price series may be completely consistent with market integration. Co-integration is insufficient because a negative coefficient of the central market price implies divergence instead of co-movement as indicated by the concept of market integration. The magnitude of the cointegration coefficient may be implausibly far from unity which contradicts the intuition behind market integration. Also, market segmentation can result from either market margins been larger than or less than transfer costs which both implies the absence of efficient arbitrage; however co-integration tests identify only the former (Barrett 1996; Goletti et al., 1995). It is worth noting that all the above models of market integration ignore the significant role of transaction costs. Recognition of transaction costs data permits substantial improvement in market integration modeling techniques. This led to the use of models often referred to as switching regime models in recent analysis of market integration.

2.7.5 Switching Regime Models (SRM)

Usually, prices are related nonlinearly, contrary to the assumption in much of the premier price transmission literature that linear price relationships exist. The realisation that price relationships may be nonlinear due to transactions costs motivated the introduction of a class of models collectively called switching regime models (SRM). Four classes of SRM are widely used in the literature for price transmission analysis. These include the error correction models (ECM), threshold autoregressive (TAR) models; parity bound models (PBM) and Markov-switching models (MSM).

2.7.6 The Error Correction Models (ECM)

The ECM is an extension of the cointegration model. If P_t^i and P_t^j are cointegrated, then the equilibrium relationship between them can be specified as:

$$P_t^i - \beta P_t^i - \beta_0 = \varepsilon_t \qquad 2.4$$

. If ε_t (the error term) is assumed to follow an autoregressive (AR) process, then $\varepsilon_t = \alpha\varepsilon_{t-1} + e_t$. This means the equilibrium relationship between P_t^i and P_t^j can be expressed as:

$$P_t^i - \beta P_t^i - \beta_0 = \alpha \varepsilon_{t-1} + e_t \qquad 2.4.1$$

The above equation implies that the long run relationship (cointegration) between P_t^i and P_t^j is a function of the autoregressive process ε_{t-1}, where ε_{t-1} is the deviation from long run equilibrium, and called the error correction term (ECT), while α measures the response of P_t^i and P_t^j to deviation from equilibrium. The standard ECM has been extended to asymmetric error correction (EC), vector EC and switching vector EC models.

2.7.7 Parity Bound Models (PBM)

Early studies that developed the PBM were Spiller and Haung (1986) and Spiller and Wood (1988). This was further developed and applied by other researchers such as Sexton et al. (1991), Barrett and Li (2002), Baulch (1997) among others. According to Abunyuwah (2007), the development of the parity bound model represents an attempt to utilize all available market data (prices, transfer cost, trade flows and volumes) to describe markets along their long-run conceptual settings. The model assumes that transaction costs determine the price efficiency band (parity bounds) within which the prices of a homogenous good in two spatially distinct markets can vary independently (Baulch, 1997; Barrett and Li, 2002).

The PBM assesses the extent of market integration by distinguishing among three possible trade regimes. Regime I occurs at the parity bound where inter-market price differential equals transfer costs. In this case, trade will cause prices between the two markets to move on a one-for-one basis and spatial arbitrage conditions are binding when there are no impediments to trade between the two markets. Regime II is inside the parity bound where inter-market price differential is less than the transfer costs.

This implies that trade will not occur and spatial arbitrage conditions are not fulfilled. Regime III is outside the parity bound where inter-market price differential exceeds the transfer costs; spatial arbitrage conditions are violated whether trade occurs or not (Baulch 1997; Sanogo, 2008).

The model determines the probability that an observation will fall into one of the three regimes and hence requires establishing the upper and lower parity bounds for spatial arbitrage conditions between the designated markets. The model relies on exogenous transaction cost data to estimate the probability of attaining inter-market arbitrage conditions and the use of the maximum likelihood based estimator copes well with trade discontinuities and time varying transaction cost (Barrett, 1996). Though the PBM model attempts to improve the measurement of market integration by incorporating exogenous transactions costs, there still come with it certain weaknesses. According to Barrett (1996), transaction costs can be difficult to measure.

There are significant unobservable components to trading margins, and in the presence of nontrivial risk premia or positive profits, transaction costs can be underestimated which biases the PBM results away from finding market segmentation. Baulch (1997) also recognizes that since only contemporaneous spreads are used in estimation, accounting for the lagged price adjustment postulated by causality and Ravallion models is hardly attainable. Also the violation of spatial arbitrage condition indicates lack of market integration but do not point out its causes.

2.7.8 Threshold Autoregressive Models (TAR)

The use of threshold autoregressive models in the study of price transmission mechanisms is often based on the assumption that, the models recognize thresholds which are caused by transaction costs that deviations must exceed before provoking equilibrating price adjustments which lead to market integration (Goodwin and Piggot, 1999). Unlike the Engle and Granger (1987), and Johansen (1988) approach which assumes a linear adjustment relationship between variables, the dynamic responses arising from the threshold effects may be nonlinear in nature. The threshold effects occur when shocks above some critical threshold bring about different response than shocks below the threshold. The thresholds are normally thought of as a function of transaction and adjustment costs or economic risks that prevent agents from continuously adjusting to changes in markets (Rapsomanikis and Karfakis, 2007).

The notion of nonlinear threshold time series according to Goodwin and Piggot (1999) and Hassouneh et al. (2012) was introduced by Tong (1978). Tsay (1989) proposed the method to test for threshold effects and modeling threshold autoregressive processes while Balke and Fomby (1997) extended the threshold autoregressive models to cointegration framework. The use of threshold vector error correction model was proposed by Goodwin and Holt (1999). Variants of threshold models have been used in empirical studies such as the Enders and Granger (1998), and Enders and Siklos (2001). The Enders and Siklos approach is based on a one threshold, two regime model while other studies may employ a multiple threshold modeling approach. Though this approach is an improvement in the techniques for measuring market integration by recognizing transaction cost constraint, it still presents some weaknesses.

The limitation is the assumption of constant transaction costs which imply a fixed neutral band over the period under study (Abdulai, 2007). Attempts to address this weakness involves the inclusion of time trend in both the threshold and adjustment parameter and then modeling the threshold as a simple linear function of time (Van Campenhout, 2007). Otherwise, the introduction of different sub-samples to represent the changing policy and economic environment to capture potential variation in transaction costs as a result of different policy regimes (Abdulai, 2007).

The threshold autoregressive models as mentioned earlier account for potential nonlinearities and asymmetries in the price adjustment process and provides more information regarding the data dynamics (Abdulai, 2007). It also provides a measure of the degree to which the market violates spatial arbitrage condition as well as a measure of the speed with which it eliminates these violations (Fackler and Goodwin, 2001). Asymmetries in price adjustment have generated greater interest by different groups of people. For instance, consumers are concerned about why traders respond differently to positive and negative shocks of market prices (downstream and upstream prices). According to Manera and Frey (2005), economic theory offers limited number of justifications for price asymmetries. A limitation worth noting of all the approaches discussed is that, they assess the nature and degree of price transmission without addressing the underlying causes of the degree of transmission.

2.8 Asymmetry in Price Transmission: Evolution, Types and Causes

When the response of market at one level responds differently to a decrease and increase in price at a different level, then asymmetry exist. Asymmetry could exist in the magnitude or the speed of adjustment or both. In the former, short-run elasticities of price transmission differ according to the sign of the initial change while in the latter, long-run elasticity differ (von Cramon-Taubadel, 1998). Asymmetry can also be classified more positive (when one price responds fully or quickly to an increase in another price than to a decrease, thus price movement that squeezes the margin is transmitted more rapidly and/or completely than the movement that stretches the margin). Otherwise, negative (when one price responds fully or quickly to a decrease in another price than to an increase; thus rapid and/or complete transmission to price movements that stretch the margin). This determines the direction of welfare transfer (Meyer and von Cramon-Taubadel, 2004). Asymmetry can also be considered to be vertical if determined along the food supply chain (e.g. from farm level to wholesale level) or spatial when determined between two geographically separated markets.

Asymmetric price transmission has long been associated with agricultural prices with the idea starting from Tweenten and Quance (1969) that used dummy variable to split input prices into increasing and decreasing input prices. Following this, studies such as Wolfram (1971), Houck (1977) and Ward (1982) used variants of the variable splitting technique to capture asymmetry in price transmission. These studies, however, predated the development of cointegration and did not consider the problems related to nonstationary series (Hassouneh et al, 2012). Granger and Lee (1989) therefore incorporated the variable splitting technique into the error correction representation to correct for the problem of nonstationarity. Since then, variants of this approach have been used extensively in applied work (Von Cramon-Taubadel and Fahbusch, 1994; von Cramon-Taubadel and Loy, 1996).

Other studies (Engle and Granger, 1998; Enders and Siklos, 2001 and Abdulai, 2000) also have captured asymmetry using threshold models, where price movements above or below certain thresholds trigger different response. A number of potential but limited causes have been attributed to asymmetries in price transmission. Among studies addressing this issue include Meyer and von Cramon-Taubadel (2004), Frey and Manera (2005) and Abdulai (2000). Some of the potential causes of asymmetry discussed in literature include market power.

Market power refers to the ability of an enterprise or a group of enterprises to raise and maintain price above or below a competitive level (Amonde et al., 2009). In non-competitive market structure where there is considerable degree of market power, market agents react quickly and/ or more completely to shocks that squeeze their marketing margin than to corresponding shocks that stretches them, resulting in positive asymmetry. Positive asymmetry is, however, not the only resulting effect of market power. Ward (1982) indicates that oligopolists can be reluctant to increase market prices for the risk of losing market share. The positive asymmetry appears to be reasonable in pure monopoly while both positive and negative asymmetries are conceivable in the more common oligopolistic context (Meyer and von Cramon-Taubadel, 2004).

Another similar argument by Frey and Manera (2005) is the case of tacit collusion in oligopolistic markets. When wholesale prices increase, firms signal their competitors by quickly increasing their selling price to show they are adhering to the tacit agreement. However, when wholesale prices fall, price adjustment is slow due to the risk of signaling that it is cutting its margins and diverging away from the agreement.

Another cause of asymmetry is adjustment/menu costs. Adjustment cost refers to costs a firm incur when it changes its quantities and/or prices of inputs and/or outputs. If the costs are associated with price changes, then such adjustment costs are termed menu costs (Meyer and von Cramon-Taubadel, 2004). Menu cost includes the cost of changing nominal prices, printing catalogues, inflation cost and dissemination of information about price changes. Such costs may be asymmetric with respect to increasing and decreasing prices. For instance traders may not adjust prices when input costs decrease due to the menu costs associated especially when the input costs changes are perceived to be temporary (Kovenock and Widdows, 1998). Menu cost can cause asymmetry in the presence of inflation (Ball and Mankiw, 1994). Under these conditions, Abdulai (2000) indicates that shocks that increase a firms desired price leads to larger responses than shocks that decrease it since firms will take advantage of the positive shocks to correct for accumulated and anticipated inflation.

Inventory management or stock behavior of traders is a potential cause for asymmetry in price transmission in many markets. Firms usually increase inventory in periods of low demand instead of reducing prices while in periods of high demand, prices are rather increased. In combination with asymmetry in costs related to high and low inventory stocks and the fear of stock out may lead to positive asymmetry (Reagan and Weitzman, 1982). Frey and Manera (2005) also argue that asymmetry could arise due to the accounting principle used by firms. For instance, the First In First Out (FIFO) accounting criteria does not allow firms to adjust output rapidly to cost changes until inventory is depleted whiles the Last In First Out(LIFO) criteria allows firms to adjust prices rapidly in response to changes in input costs. Hence the accounting principle has influence on the speed of adjustment since FIFO results in longer lags than the LIFO principle.

Consumers incur cost such as transportation or fuel cost and cost in terms of the time taken when searching for competitive prices, such costs are termed search costs. Imperfect market characterized by information asymmetry may result in asymmetry in price adjustment (Cutts and Kirsten, 2006). Due to the presence of search costs, consumers may have no option than to accept prices offered to them or to search for alternative prices in their locality. Since consumers may have limited knowledge of prices offered by firms elsewhere, sellers exploit them by adjusting quickly when prices rise and slowly when prices fall. Meyer and von Cramon-Taubadel (2004) indicate the role perishability of a product plays in causing asymmetry in price transmission. Ward (1982) argues that traders might hesitate to raise prices for perishable products for fear of spoilage which leads to negative asymmetry. Another counter argument from Heien (1980) is that changing prices is more of a major problem for products with long shelf life than the perishable ones. This is because with the former, changing prices brings about higher time cost and loss of good will.

Another factor causing asymmetry in price transmission is the interventionist role of the Government. This is much evident in political intervention in the form of price support in the agricultural sector mostly introduced as floor price (Kinnukan and Forker, 1987). The resultant asymmetry occurs if retailers or wholesalers are made to believe that the intervention is for an extended period, then downstream price increases are passed on quickly and completely by traders while decreases are passed on slowly (Uchezuba et al., 2010).

2.9 Review of Past Studies on Cointegration in Agricultural Markets

Cudjoe et al. (2010) used threshold cointegration to study price transmission between regional markets in Ghana. Their results showed that, price transmission is high between regional producer markets and markets located in the country's largest cities, and the distance between producer and consumer markets and the size of consumer markets matter in explaining the price transmission. They therefore concluded that the distance between markets and the size of markets play a key role in explaining price transmission in Ghana. The implication for policy interventions during the food price crises is that small populated towns and towns far from major staple production areas need to be given particular attention. More generally, improving road networks and storage facilities will increase price transmission and thus improve incentives for producers in more remote locations to supply food to urban areas.

Ankamah-Yeboah (2012) also studied regional maize price transmission in Ghana using threshold cointegration. His results showed that, regional maize markets are integrated. Bidirectional market interdependence was found between market pairs both in the short and long run. Also, long run causality of his study, was however heterogeneous with respect to positive and negative shocks. The study realized that, the expansion in communication infrastructure motivates regional market integration, implying that resources should be allocated to transportation development which is the main hindrance to trade. Ayeduvor (2014) studied spatial price transmission and market integration among maize markets in Ghana using a VECM. The Johansen Maximum likelihood cointegration test was used to test the cointegration between the market pairs. It was found that all five market pairs were cointegrated. The proof of cointegration is also evidence for a common domestic maize market in Ghana, where inter-market prices adjust to achieve long-run market equilibrium.

In a similar study as those discussed above, Abdualai (2000) utilizes the threshold cointegration approach to examine price linkages between the principal maize markets in Ghana. Results indicate that wholesale maize prices from 1980 to 1997 in the local markets (here Accra and Bolgatanga) respond more swiftly to central market price increases than decreases. Also, Accra market reacts faster than Bolgatanga market to changes in Techiman market prices. Henry (2012) also analyzed the long-run equilibrium relationship between retail and wholesale Ghanaian maize prices. Using the Enders-Siklos asymmetric cointegration tests, he found that the retail and wholesale prices are cointegrated with threshold adjustment. Furthermore, the adjustment process is asymmetric when the retail and wholesale prices adjust to achieve the long-term equilibrium. There is also faster convergence for negative deviations from long-term equilibrium than for positive deviations. These results imply that price increases tend to persist whereas decreases tend to revert quickly towards equilibrium.

Muyatwa (2001) examined if regional markets have become spatially integrated following the liberalization of the maize market in Zambia. The study employed cointegration analysis and error correction model using monthly whole price data from 1993 to 1997. The outcome of the test indicates that the magnitude of market integration and the speed of price transmission between the regional markets have been very limited. Also, even with the rapid emergence of private traders, the rate of filling in the gap left by the state has been slow while private participants are constrained with inadequate finance, lack of storage facilities, lack of access to market information and poor transportation infrastructure. The efficient operation of the maize market would therefore need the government providing an enabling environment for trading.

Van Campenhout (2007) used a threshold cointegration approach where he introduced a time trend to the threshold and the adjustment parameter to examine price transmission in the Tanzania maize market using weekly prices from seven markets. The result from this study reveals that the model disregarding transaction cost and time trend has higher half-lives ranging from 3.9 to 22 weeks. Observing the nonlinearities caused by transaction cost, the half-lives reduces to 4 to 11 weeks, and introducing the time trend to the TAR model reduced the half-lives further to 1.5 to 5 weeks. Also, transaction costs have decreased between the market pairs over time; however, integration of individual routes shows considerable heterogeneity.

Franklin 2016, examined the influence of the political economy of Ghana on pricing of petroleum products. The study show power struggles among actors in the pricing of fuel. The Import Parity Method components; the ex-refinery price, taxes and distribution margins as well as the platt methods were revealed as the processes and methods involved in determining the prices of petroleum products in Ghana. He revealed that the petroleum price deregulation policy has positive and negative implications on the Ghanaian economy. Positively, it brings more profit, improves the financial situation of the domestic market and increases the regular supply of petroleum products into the country. Negatively, the deregulation of fuel pricing brings unpredictable prices, and the time for implementing the policy was revealed as unfavorable. His study recommended that government build the capacity of the key players so as to ensure healthy competition and stability in the pricing of petroleum products.

Saban and Ugur (2011) examined the dynamic relationship between world oil prices and twenty four world agricultural commodity prices accounting for changes in the relative strength of US dollar in a panel setting. They employed panel cointegration and Granger causality methods for a panel of twenty four agricultural products based on monthly prices ranging from January 1980 to February 2010. The empirical results provide strong evidence on the impact of world oil price changes on agricultural commodity prices. Contrary to the findings of many studies in the literature that report neutrality of agricultural prices to oil price changes, they find strong support for the role of world oil prices on prices of several agricultural commodities.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Chapter outline

The section presents an introduction to the study area, type and source of data and the empirical method of the study.

3.1 The study Area

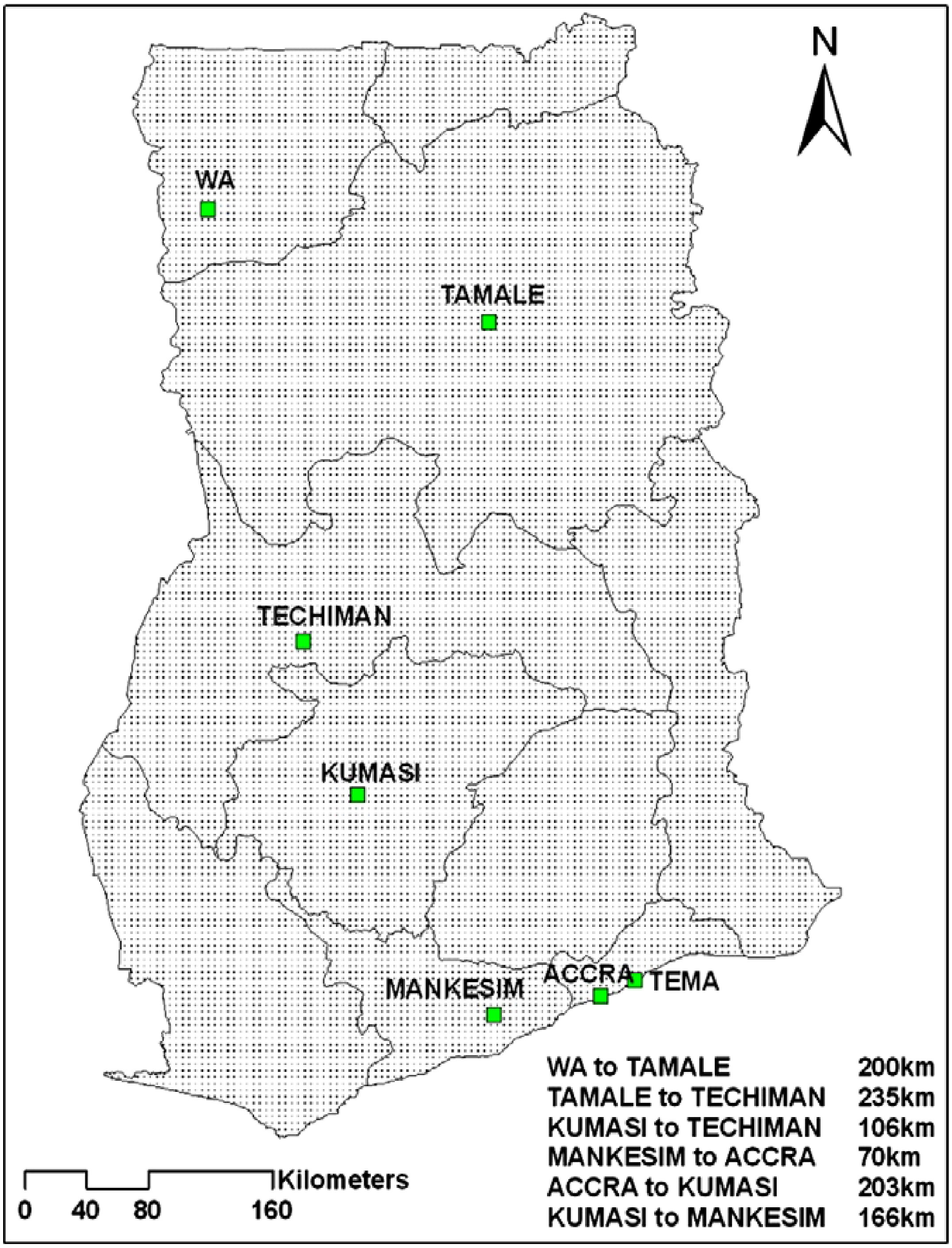
The study is conducted using prices of four major maize markets and gasoline prices in Ghana. These markets are Tamale, Techiman, Kumasi and Accra. The Tamale and Techiman markets are among the leading producers of maize in Ghana based on a 3-year average production from 2012 to 2014 (MOFA-FAF, 2014).

Ghana's land area of 23.9 million hectares (AGRICINGHANA, 2013) is made of the five ecological zones (FAF, 2014) which are based on their different climatic conditions and soil compositions. The natural vegetation varies in each zone due to different climatic conditions and soil types. Each zone under study is characterized by different influencing factors (climate, culture, taste and preference) and hence pricing of food might be different in each zone. The NZ experiences only one wet season while the TZ, DF, RF and NS do experience two wet seasons in a year. Among the zones, TZ serves as the hub for the production and distribution of maize in Ghana. This is due to its ecological conditions especially suitable for the production of maize all year round. The TS and NS respectively serve as the production arears of maize. Table 1.1 shows the varieties of food commodities grown in each ecological zone. It is clear that maize is grown in all zones however, the intensity vastly varies.

Table 3. 1 Major crops grown in agro-ecological zones

Major crops grown in agro-ecological zones					
Zone	**Cereals**	**Starchy crops**	**Legume**	**Vegetables**	**Tree crops**
High Rain Forest	Maize, Rice	Cassava, Cocoyam, Plantain		Pepper, okra, eggplant	Citrus, coconut, oil palm, rubber
Semi-Decidous Rain Forest	Maize, Rice	Cassava, Cocoyam, Plantain	Cowpea	Pepper, okra, eggplant, tomato	Citrus, oil palm, coffee, cocoa
Forest Savannah Transition	Maize, Rice, Sorghum	Yam, Cocoyam, Plantian, Cassava	Cowpea, Groundnut	Tomato, pepper, eggplant, okra,	Citrus, coffee, cashew
Guinea Savannah	Maize, Rice, Sorghum, Millet	Yam, Cassava	Cowpea, Groundnut, Bambara	Tomato pepper	Sheanuts, cashew
Sudan Savannah	Maize, Rice, Sorghum, Millet	Sweet potato	Cowpea, Groundnut, Bambara	Tomato, onion	
Coastal Savannah	Maize, Rice	Cassava	Cowpea	Tomato, shallot	coconut

Source: FAO, 2005, (Gerken et al., 2001)



Source: Adopted from Cudjoe et al

Fig. 3.1. Map of Ghana's major markets.

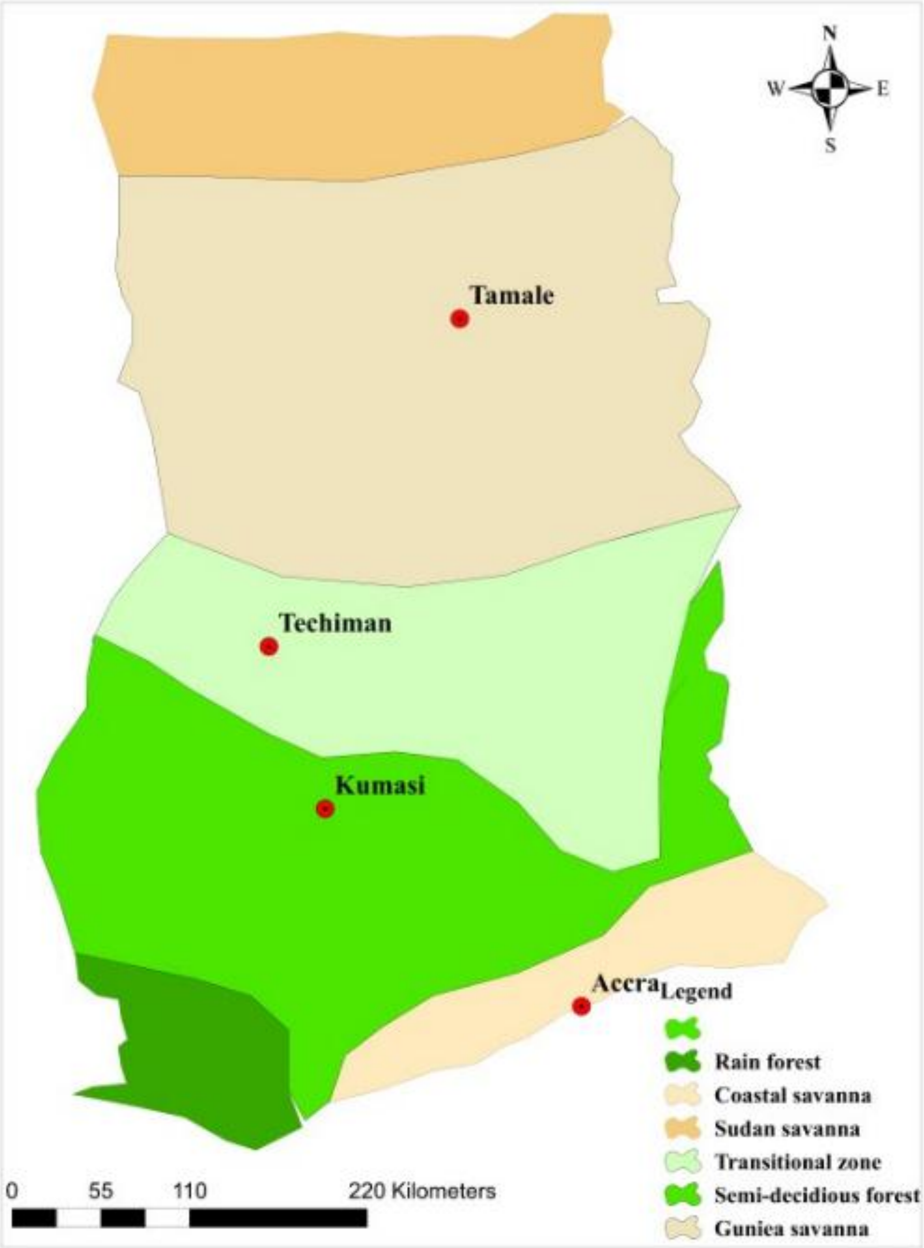


Figure 3.2 Map of the Study Area

3.2 STUDY DESIGN AND DATA

Bivariate time series techniques are used in the study. The study examines past trends of maize prices in markets, the relationship between these markets and the national domestic fuel prices as well as causality between these series of prices.

3.2.1 Type and source of data

The variables under study are maize prices of markets and domestic fuel prices. Secondary data on whole sale prices of white maize from January 2000 to December 2015 are used for the analysis. Monthly data on maize prices was sourced from the Ministry of Food and Agriculture, Statistical Research and Information Division (MoFA-SRID). The price series from MOFA-SRID are in GHS per 100kg of white maize. Data on domestic fuel prices was also obtained from the African Centre for Energy Policy (ACEP) for the same period of time. Domestic fuel price series are in GHS per litter. The period under study yielded 192 observations. The empirical analysis of the data was based on the logarithmic transformation of the data. However, since the series of maize prices under consideration are of the same level, there was need to deflate it, nominal values are used. Prices of gasoline were not deflated either. All prices are expressed in Ghana Cedi and analysis done with logarithmic transformation of the prices. The data for this research was analyzed with STATA, EViews and Minitab statistical packages.

3.2.2 Theoretical framework

To understand the spatial interaction of prices in geographically separated markets, market integration analysis is used. Spatial integration stipulates that, under competitive conditions, the difference in prices of a homogeneous commodity in two or more economic markets will approximately equal the inter-market transaction costs.

The Law of One Price (LOP) is assumed as the epicenter of price transmission. The law states that price of a homogenous product should only differ by transportation cost of the product from one location to the other. This situation is usually referred to as a strong form of the law of one price. Where a strong form of LOP exits, an equilibrium condition is attained where price differences among markets evolve over time toward the transactions costs (Barrett, 2001). This usually happens in the long run. However, prices can deviate from equality in the short run due to different kinds of shocks. When such a disequilibrium situation occurs, price signals will elicit the movement of products between surplus and deficit markets, thus restoring the long run equilibrium.

Empirically, cointegration analysis is used to interpret the equilibrium situation as long run and short run equilibrium (Alderman, 1993). The existence of such a relationship implies a stationary term which is interpreted as the temporal and stochastic deviations from the equilibrium. The central characteristic of such a stationary series is that it frequently crosses its mean value. Such behavior closely corresponds to the economic understanding of equilibria, which is a long run concept.

3.3 The Econometric Techniques

Bivariate time series methods will be used for the data analysis. First, trend analysis and graphs were employed to examine the trend of food commodity prices across the markets under study and gasoline prices. The maize prices, and domestic gasoline prices were the main variables under study. Trend analysis, unit root test, cointegration, threshold autoregressive model, and impulse response functions are used for the study.

3.3.1 Trend Analysis

The trend of a series reflects the long term growth or decline of the time series over time. Time series variables may exhibit different types of trends, for example the linear, quadratic, linear constant growth and quadratic constant growth trend models among others. This study employs a graphical method where the movement of the prices is analyzed and explained using policy and natural events that occurred.

3.4 Test for stationarity and unit roots

3.4.1 Unit Root Test

It is essential to establish the presence or absence of unit root in time series data. Usually stationarity of data is assumed by most econometric theory. However, the existence of non-stationarity usually leads to spurious regression (Dickey and Fuller, 1981). Also, according to Verbeek (2004), stationarity means that the distribution of the variable of interest does not depend on time. A regression is spurious when it has a high R-squared and the Durbin-Watson statistic close to 0 or 4 but with insignificant coefficients of the independent variables (Gujarati, 2003).

The presence or absence of unit roots helps to identify the nature of the processes that generates the time series data and to investigate the order of integration of a series (Dickey and Fuller, 1981). This is because, contemporary econometrics has indicated that, regression analysis using non-stationary time series variables produce spurious regression since standard results of OLS do not hold: $E(P_t) = E(P_{t-l}) = \mu$ which is a constant and $cov(P_t, P_{t-l}) = \gamma_l$ which depends only on the lag l but not on time, t.

If there exist no unit root, the time series fluctuates around a constant long-run mean with finite variance which does not depend on time. There are several proposed quantitative methods of testing for stationarity of a time series variable however the Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test are considered for this study.

3.4.1.1 Augmented Dickey Fuller (ADF) Unit Root Test

This study employed the Augmented Dickey-Fuller (ADF) test to determine whether the individual prices contained a unit root (non-stationary) or were covariance stationary. The ADF test proposed by Dickey and Fuller (1979) is an upgrade of the Dickey-Fuller (DF) test. This test is based on the assumption that the series follow a random walk with model;

$$P_t = \phi P_{t-1} + \mu_t \qquad 3.1$$

and tests the hypothesis:

$H_O : \phi = 1$ (Non-stationary) against

$H_1 : \phi < 1$ (Stationary)

where ϕ is the characteristic root of an AR polynomial and u_t is an uncorrelated white noise series with zero mean and constant variance σ^2. When $\Phi_1 = 1$, $\phi_1 = 1$ equation (3.1) does not satisfy the weakly stationary condition of an AR (1) model hence the series becomes a random walk model known as a unit root non-stationary time series. Subtracting P_{t-1} from both sides of equation (3.1) gives

$$\Delta P_t = \varphi P_{t-1} + \mu_t \qquad t = (1, \ldots, T) \qquad 3.2$$

where $\varphi = \phi - 1$ and $\Delta P_t = P_t - P_{t-1}$. For estimating the existence of unit roots using equation (3.2), we test hypothesis $H_0: \varphi = 0$ against $H_1: \varphi \neq 0$. Under H_0, if $\varphi = 0$, then $\Phi = 1$, thus the series has a unit root hence is non-stationary. The rejection or otherwise of the null hypothesis, H_0 is based on the t-statistic critical values of the Dickey Fuller statistic. The Dickey Fuller test assumes that the error terms are serially uncorrelated, however, the errors terms of the Dickey Fuller test do show evidence of serial correlation. Therefore, the proposed ADF test includes the lags of the first difference series in the regression equation to make u_t a white noise. The Dickey and Fuller's (1979) new regression equation is given by;

$$\Delta P_t = \varphi P_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta P_{t-j} + \mu_t, \qquad t = (1, \ldots, T) \qquad 3.3$$

If the intercept and time trend $(\beta + \alpha t)$ are included, then equation 3.3 is written as;

$$\Delta P_t = \beta + \alpha t + \varphi P_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta P_{t-j} + \mu_t, \qquad t = (1, \ldots, T) \qquad 3.4$$

where β is an intercept, α defines the coefficient of the time trend factor, $\sum_{j=1}^{p} \gamma_j \Delta P_{t-j}$ defines the sum of the lagged values of the response variable ΔP_t and p is the order of the autoregressive process. If φ of the Augmented Dickey Fuller model is zero (0), then there exist a unit root in the time series variable considered, hence the series is not covariance stationary. The choice of the starting augmentation order depends on the periodicity of the data, the significance of γ_i estimates and the white noise residuals series u_t. The ADF test statistic is given by;

$$F_t = \hat{\varphi} / SE(\hat{\varphi}) \qquad 3.5$$

where $\hat{\varphi}$ is the estimate of φ and $SE(\hat{\varphi})$ is the standard error of the least square estimate of $\hat{\varphi}$. The null hypothesis (H_0) is rejected if, the $p - value <$

α (significance level). If the series is not stationary, it is transformed by differencing to make it stationary and stationarity tested again. If the time series is not stationary but its first difference is stationary, then the series is said to be an integrated process of order one (1) or simply an $I(1)$ process.

3.4.1.2 Phillip-Perron (Phillip and Perron, 1988) Unit Root Test

Although the Augmented Dickey-Fuller test includes lags of the first difference of the variable to correct for serial correlation of the residual term, the problem of conditional heteroscedasticity in the residuals may still create a problem. Phillips (1987) therefore proposed an approach that corrects the original ADF unit root test to allow for a wide class of time series with heterogeneously and serially correlated errors. The Phillips and Perron (1988) semi-parametric approach for testing for the presence of unit root is an extension of the Phillips (1987) approach which corrects for any serial correlation and heteroscedasticity in the residual error term, u_t, non-parametrically. The test is therefore viewed as a Dickey-Fuller test that have been made robust to serial correlation and conditional heteroscedasticity by using the Newey and West (1987) heteroscedasticity and autocorrelation consistent covariance matrix estimator. The PP statistics test the pair of hypothesis;

H_O: unit root,

against

H_1: stationary about deterministic trend

The PP test involves estimating the model;

$$P_t = \beta + \rho P_{t-1} + \mu_t \qquad 3.6$$

When we exclude the constant β and include a time trend t, the model is given as;

$$P_t = at + \rho P_{t-1} + \mu_t \qquad 3.7$$

The PP test consists of two (2) statistics known as Phillips Z_ρ and Z_t tests given as;

$$Z_\rho = n(\hat{\rho}_n - 1) - \tfrac{1}{2}\frac{n^2\sigma^2}{s_n^2}(\hat{\lambda}_n - \hat{\gamma}_{0,n}) \qquad 3.8$$

$$Z_t = \sqrt{\frac{\hat{\gamma}_{0,n}}{\hat{\lambda}_n^2}} \times \frac{\hat{\rho}_n - 1}{\hat{\sigma}} - \frac{1}{2}(\hat{\lambda}_n^2 - \hat{\gamma}_{0,n})\frac{1}{\hat{\lambda}_n}\frac{n\hat{\sigma}}{s_n} \qquad 3.9$$

$\hat{\gamma}_{j,n} = \frac{1}{n}\sum_{i=j+1}^{n}\hat{\mu}_i\hat{\mu}_{i-j}$ when $j=0$, then $\hat{\gamma}_{j,n}$ is a maximum likelihood estimate of the variance of the error terms, whiles for $j > 0$, $\hat{\gamma}_{j,n}$ is an estimate of the covariance between two error terms j periods apart.

$\hat{\lambda}_n^2 = \hat{\gamma}_{0,n} + 2\sum_{j=1}^{q}(1 - \frac{j}{q+1})\hat{\gamma}_{j,n}$ if there is no autocorrelation between the error terms, $\hat{\gamma}_{j,n} = 0$ for $j > 0$, then $\hat{\lambda}_n^2 = \hat{\gamma}_{0,n}$. Replacing, $\hat{\lambda}_n^2 as \hat{\gamma}_{0,n}$ in Z_t, it reduces to;

$Z_t = \frac{\hat{\rho}_n - 1}{\hat{\sigma}}$ which is a *t*-statistic in the standard Dickey-Fuller (DF) equation. Hence if there is no autocorrelation between the error terms, the PP test is equal to the DF statistic with constant and time trend.

Also, when the covariance are equal, then, $\hat{\lambda}_n^2 = \hat{\gamma}_{0,n}$, the error terms have the constant variance property (homoscedastic), therefore $Z_\rho = n(\hat{\rho}_n - 1)$ is the same as the DF test.

3.5 Test for Cointegration

In evaluating spatial market linkages as is done in this study, some of the methods that exist are developed by Engle and Granger (1987) and Engle and Yoo (1987).

Cointegration is said to exist when a linear combination of a set of time series is stationary, given that the individual series are non-stationary (Engle and Granger, 1987). Cointegration of two or more variables suggests that there is a long-run or equilibrium relationship between them. Two conditions must be satisfied for variables to be co-integrated. First, the series for the individual variables must be non-stationary. Second, a linear combination of the non-stationary variables from a static regression involving levels of the variables must be stationary (Ama, 2003). This study employed the Johansen's (1988) and Johansen and Juselius (1990) maximum likelihood co-integration concept to determine if there exist a long run equilibrium relationship between the series of prices considered.

A $(k \times 1)$ time series vector, $P_t = (P_{1t},..., P_{kt})'$ each of an $I(1)$ process are said to be co-integrated if there exist a $(k \times 1)$ vector β_i such that $\beta' P_t$ is a trend stationary vector ($I(0)$); thus, P_t is said be co-integrated of order (1, 0) with co-integrating vector β. The parameters in β are the parameters in the co-integrating equation. If there exist y of such linearly independent vectors, $\beta_i, i = 1,..., y$, then P_t is said to be co-integrated with co-integrating rank y. This means, a set of time series variables P_t are co-integrated if there exists a $(k \times 1)$ vector $\beta = (\beta_1,..., \beta_k)'$ such that;

$$\beta' P_t = \beta_1 P_{1t} + ... + \beta_k P_{kt} \sim I(0) \qquad 3.10$$

If some elements of β are equal to zero, then only the subset of the time series in R_t with non-zero coefficients are co-integrated. The linear combination $\beta' R_t$ is often called the long-run equilibrium relationship. The implication is that $I(1)$ time series variables with a long-run equilibrium relationship cannot drift too far apart from the equilibrium because economic forces will act to restore the equilibrium relationship.

If the $(k \times 1)$ vector P_t is co-integrated, there may be $0 < y < k$ linearly independent co-integrating vectors with $k-1$ non-stationary $(I(1))$ common stochastic trends. Co-integration analysis uses the first difference in the VAR (p) process given by;

$$\Delta P_t = \sum_{j=1}^{n=1} \pi_j \Delta P_{t-j} + \pi P_{t-n} + \mu_t \qquad 3.11$$

where P_t is lag length $k\ (p \times 1)$ $k(p \times 1)$ endogenous vector, π_j is a short term adjusting coefficient to describe short-term relationship, π is long term shock vector that includes long term information hint in the regression to test those time series variables' whether there exist long term equilibrium relationship or not.

To examine the vector rank that tests how many non-zero characteristic roots exist in the vector, we use the trace statistic test given as;

$$\lambda_{trace}(y) = -T\sum_{i=y+1}^{k} \ln(1-\hat{\lambda}_i)$$

where $\hat{\lambda}_i$ is the estimated characteristic root. It tests the hypothesis:

$H_0 : rank\ (\pi) \ \leq y$ (at most y integrated vector) against

$H_1 : rank\ (\pi) > y$ (at least $y + 1$ integrated vector)

If the test fails to reject H_0, then the time series variables have at most y co-integrated vectors. Johansen‘s testing starts with the test for zero co-integrating equations (a matrix of zero ranks) and then accepts the first null hypothesis that is not rejected, which means variables have y co-integrated vectors. We fail to reject H_0 if the trace statistic is less than the critical value.

3.6 Threshold Autoregresssive Model

Analyzing market integration based on price data alone while neglecting the role of transaction costs in influencing the direction of trade is often critiqued, this study therefore endeavored to overcome this critique. By applying the Threshold

Autoregressive model, the study accounted for the effects of transaction costs in price transmission without relying on transaction cost data directly. The Threshold Autoregressive model was used to fit the economic requirements for the analysis of price adjustment. It also presented the ability of capturing potential symmetric price adjustment processes between markets based on the assumption of a constant transaction costs.

The TAR model is used to determine if there is price transmission between selected maize markets in Ghana from the year 2000 to 2015. The price difference between a net consumer market P^c, and a net producer market, P^s, is given by $m_t = P_t^c - P_t^s$.

The TAR model, allows the price adjustment process to vary depending on the price difference at time, i.e., if it the price is below or above a threshold, τ^{cs} which is a proportional measure of the transaction costs between markets (Amikuzuno,et al, 2011). The relationship is given as follows:

$$\Delta m_t = \begin{cases} \rho^{out} m_{t-1} + \varepsilon_t, & if \ m_{t-1} > \tau \\ \rho^{in} m_{t-1} + \varepsilon_t, & if \ -\tau \leq m_{t-1} \leq \tau \\ \rho^{out} m_{t-1} + \varepsilon_t, & if \ m_{t-1} < -\tau \end{cases} \quad 3.12$$

where ρ^{in} is the speed of price adjustment when the price difference is below τ and ρ^{out} is the speed of price adjustment when the absolute value of the price difference exceeds τ. Theory assumes that there is no adjustment when the price difference is below τ i.e. $\rho^{in} = 0$. With this assumption, the TAR model actually estimated is:

$$\Delta m_t = \begin{cases} \rho^{out} m_{t-1} + \varepsilon_t, & if \ m_{t-1} > \tau \\ \varepsilon_t & if \ -\tau \leq m_{t-1} \leq \tau \\ \rho^{out} m_{t-1} + \varepsilon_t, & if \ m_{t-1} < -\tau \end{cases} \quad 3.13$$

The estimation process involves identifying the τ^{cs} through a grid search for the threshold that maximizes the sum of squared residuals.

3.7 Impulse Response Function (IRF) Analysis

The Granger and instantaneous causality tests introduced are quite useful to infer whether a time series variable helps predict another one. However, these analyses fall short of quantifying the impact of the impulse time series variable on the response variable over time. The impulse response analysis is used to investigate these kinds of dynamic interactions between the endogenous time series variables and is based upon the Wold's moving average representation of a VAR (*p*) process. From the error correction models, impulse-responses were calculated to determine the length of time needed to complete transmission of a price shock; often represented graphically. This length of time may vary depending on the direction of the shock in the case of asymmetric relationship between market pairs.

IRF enables us to determine the response of one time series variable to an impulse or a shock in another time series variable in the system that involves a number of further variables as well. If there is a reaction of one time series variable to an impulse in another variable, then the latter is causal for the former. However, the effect of a unit shock in any of the variables dies away quite rapidly due to stability of the system. If there is a reaction of one time series variable to an impulse in another variable, then the latter is causal for the former. However, the effect of a unit shock in any of the variables dies away quite rapidly due to stability of the system. The Wold representation is based on the orthogonal errors η_t given by;

$$P_t = \mu + \theta_0\eta_{t-1} + \theta_2\eta_{t-2} + \ldots$$

where Θ_0 is a lower triangular matrix. The impulse responses to the orthogonal shocks η_{jt} are;

$$\frac{\partial R_{i,t+s}}{\partial \eta_{j,t}} = \frac{\partial R_{i,t}}{\partial \eta_{j,t-s}} = \Theta_{ij}^{s} \quad i,j = 1,2,\ldots,k, s > 0 \tag{3.14}$$

where Θ_{ij}^{s} is the $(i,j)th$ element of Θ_0. For k variables there are k^2 possible IRF.

CHAPTER FOUR

ANALYSIS AND DISCUSION OF RESULTS

4.0 Introduction to chapter

In this chapter, the variability and trend of prices of maize in different markets are discussed as well as the cointegration and long term relationship that exist between them. The responses of each market to shocks in gasoline prices are also discussed.

4.1 Descriptive, Trend and Seasonal variation of maize prices

Spatial price differences are usually influenced by differences in production levels resulting from differences in weather/climatic-factors and in soil fertility. Changes in agricultural policies, transportation infrastructure and policies also play a major role in influencing spatial price disparities. The influence of consumer behavior cannot be ignored in the pricing of maize across locations with different production capacities. It is therefore necessary to understand the price variation across each market and the linkages between them.

4.1.1 Descriptive analysis of markets

Table 4.1 shows the descriptive statistics for each of the four markets under study. Among the markets, Accra recorded the highest price of GH¢ 198.40 per 100kg of maize, while the minimum price of GH¢4.20 per 100kg was recorded in the Tamale market. The Accra market also recorded the highest average price of GH¢53.60 while Techiman recorded the lowest average price of GH¢36.66. The Tamale market experienced the highest variation in prices of 83.35 percent as indicated by the coefficient of variation while the Techiman market experienced the lowest of 75.85

percent. The variations in prices were however approximately close except for the Tamale market.

Also, the average price for the Accra and Kumasi show a significant variation from the Tamale and Techiman markets. Variation of prices is relatively high for all markets especially the Tamale market, which indicates that the producer is highly susceptible to changes in prices which greatly affect his income and ability to farm during the next season. Similar studies by Ayeduvor (2014) and Ankamah-Yeboah (2012) reached similar conclusions. These variations are not desirerable since this ultimately affects the consumers of maize since maize is a staple food across the country (per capita consumption of 45kg/year in 2010). Also expenditure on food constitutes a large proportion of income so these variations mean some consumers are spending more on food as compared to others all other things equal.

Table 4. 1: Descriptive statistics of prices of maize in markets

Statistic	Accra	Kumasi	Techiman	Tamale	Gasoline
Mean	53.600	50.890	36.660	38.140	1.167
Maximum	198.400	166.000	190.000	160.000	3.947
Minimum	6.300	6.250	4.400	4.200	0.118
Std. Dev	41.760	39.570	27.810	31.790	0.928
Coef. Var	77.920	77.750	75.850	83.350	79.540
Kurtosis	0.920	0.160	7.300	2.920	0.580
Observations	192.000	192.000	192.000	192.000	192.000

Source: computed from monthly data obtained from MOFA-SRID on maize prices from 2000 to 2015

The supply of maize in Accra especially is highly influenced by Tamale and Techiman. Tamale at all times experiences the lowest price and this is expected because Tamale is located in the NSZ which is a major producer of maize in the country with just one rainy season in a year but trades a lot with Techiman which is also a major supplier of maize with two rainy seasons. The Techiman market thus, plays an influencing role on the prices of maize in all the markets. Accra however, has the highest mean price because it is not a producer of maize but rather a consumption city and transportation and other transaction costs do influence its prices.

4.1.2 Annual Trend of Maize and gasoline prices

As seen in fig. 4.1, nominal prices in each market varied over the years under study and portrayed trends and seasonal patterns. Fig. 4.1 shows that prices in each market generally moved together in the same direction while increasing over time. Prices were at their highest level in 2015 however, there were some exceptional hikes in 2005, 2008/9 and 2012. Gasoline prices however experienced a steep rise during the years. It is worth noting that whenever there is a rise in gasoline prices, maize prices tend to reach a peak in all markets as seen in 2005, 2008/9, 2012 and 2015.

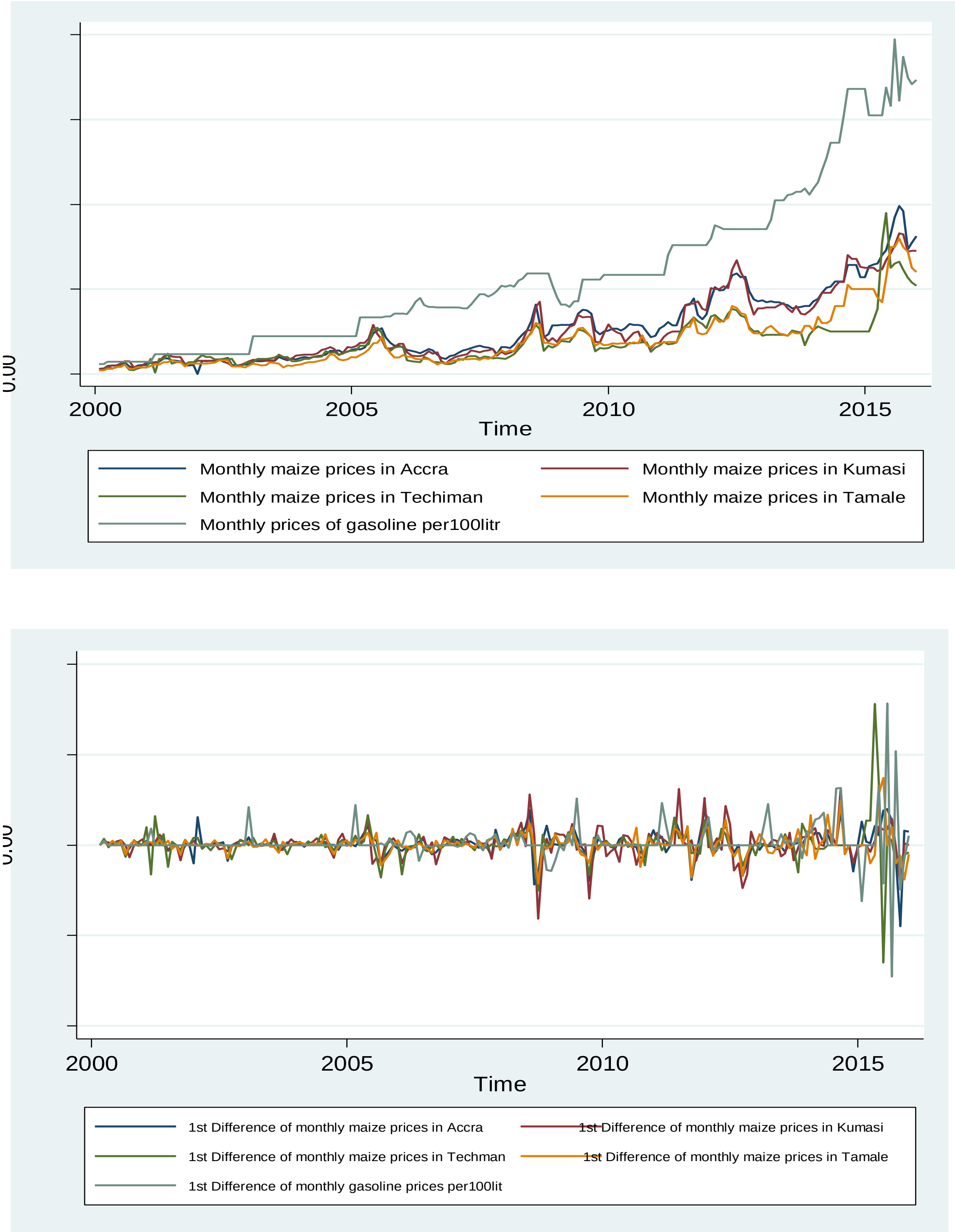


Figure 4. 1: Annual trend of maize market prices and gasoline price in Ghana

Source: computed from monthly data obtained from MOFA-SRID on maize prices from 2000 to 2015

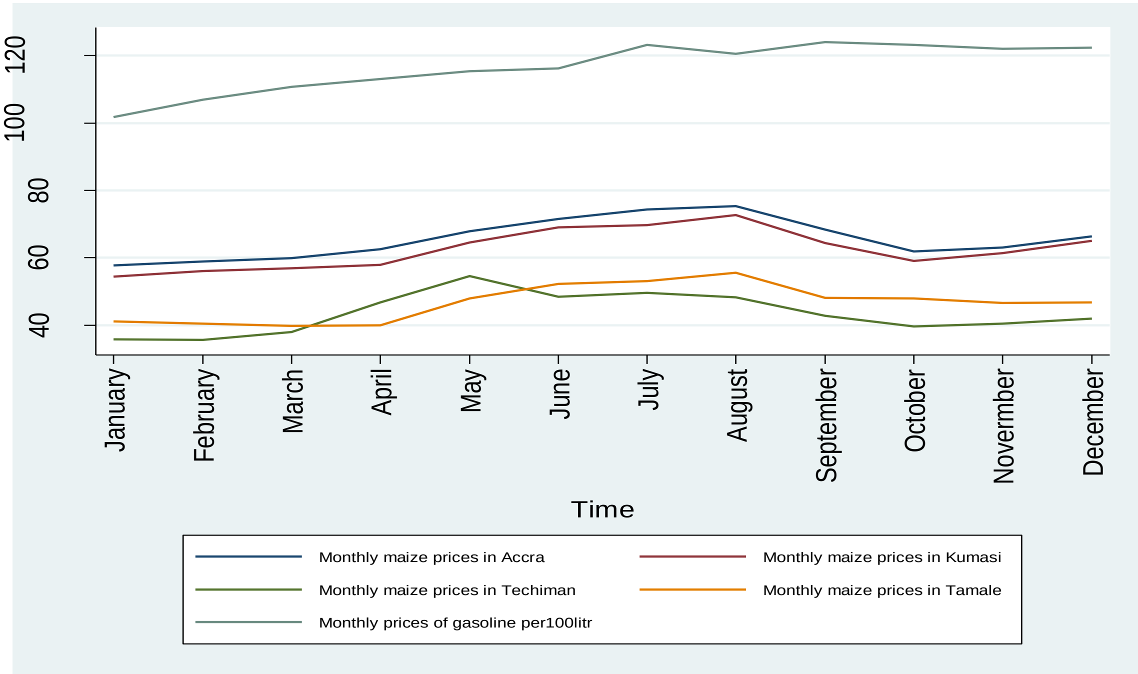
The price hike in 2008/9 was attributed to the influence of the world food and financial crises in that period and increases in fuel prices. During this period, the government of Ghana temporally waived tariffs on some food imports to help stabilize food prices during the crises and this trend is indicative of its effect. However, prices started to rise again by the mid of 2011 until 2013 with the Accra market experiencing the highest prices. Thereafter, prices fell in all markets and stayed relatively stable until 2014 where prices began to rise relatively high again. Generally, the highest price series was recorded in the Accra market with Tamale and Techiman recording the lowest. The high prices in Accra is expected because Accra is mainly a consumer market while Techiman and Tamale are producer markets.

The rise in prices are attributed to supply and demand factors. Supply factors were adverse weather conditions (poor rainfall and floods), increasing fuel prices (gasoline) and high cost of fertilizer which led to the reintroduction of the fertilizer subsidy program in 2008 by the Government of Ghana. A study by Cudjoe et al. (2014) realized a similar trend in the development of wheat and rice prices in Ghana from the year 2004 to 2008. Also studies by Ankamah –Yeboah (2012) and Ayedevor (2014) reported similar trends in maize prices over the years.

Some of the demand factors that could have contributed to the trend observed include, a continuous growth in population, income growth and the world food crises experienced in 2008. Unstable food prices have the potential to render a country or region food insecure hence the right policies should be developed to help prevent such a catastrophe.

4.1.3 Seasonal Trend of Maize and gasoline prices

Usually in rain fed agriculture, agricultural prices tend to fluctuate seasonally. This leads to lower prices during the harvest season and very high prices during the lean season. Fig. 4.2 shows the average monthly prices from January to December of all markets under study. In fig. 4.2, the seasonal trend of prices across all markets under study seem to follow the same pattern. The highest prices are experienced from April to July which is the major farming season throughout the country. Gasoline prices also tend to undulate with a peak in July. Gasoline prices also tend to be at its highest during this period, which further excoriates the plight of both consumers and farmers by increasing production and transportation cost and the price in general. However, during the harvest period prices start to fall as most farmers are selling off some or all of their produce creating a glut from August to January.



Source: computed from monthly data obtained from MOFA-SRID on maize prices from 2000 to 2015

Figure 4. 2: Seasonal trend of maize prices in markets

In January, harvest from the Techiman area come in to further push down prices until the start of the farming season in May. Similar studies by Ayeduvor (2014), Ankamah-Yeboah (2012) also realized that the seasonal nature of the producing markets greatly influence the pricing of maize in the country. Amikununo et al. (2011) also attributed the pricing of tomato in Ghana to seasons. This further emphasizes the need for policy interventions targeting enhanced storage and value addition during this period. Also increases in fuel prices should be avoided during these periods since it further reduces the income of the farmers. These results reflect the influence of the wet and dry season's on food pricing and changes in gasoline pricing.

4.2 Unit Root Test on Levels of the Series

A stationarity test was conducted on all levels of the data to determine the order of integration of each rate measured over time. The time series plot of prices in the market indicate that, prices do not fluctuate with constant variation about a fixed point, which gives an indication of non-stationarity in the levels of the series. This is indicated by the ACF and the PACF of each market as shown in Appendix B. The individual ACF plots also show a slow decay and their PACF plot have a very significant spike at lag one (1). Graphically, these gave an indication that the levels of the series are non-stationary.

Augmented Dickey Fuller (ADF) and Phillip Peron unit root test (PP) were conducted and represented in Table 4.2. The test statistic failed to reject the null hypothesis of a unit root in level data for all regions.

Table 4. 2: Augmented Dickey Fuller and Philip Peron Test, Lag 4

	ADF-Test		PP-Test	
1%: -3.480 5%: -2.884				
	Levels	Fist Differenced	Levels	Fist Differenced
Accra	0.053	-9.212***	-0.167	-10.992***
Kumasi	-0.508	-8.22***	-0.667	-12.188***
Techiman	-1.425	-8.325***	-1.964	-12.532***
Tamale	-0.692	-8.134***	-0.608	-11.995***
Gasoline	1.206	-6.776***	1.177	-21.227***

Source: computed from monthly data obtained from MOFA-SRID on maize prices from 2000 to 2015

However, the null hypothesis was rejected at 1 percent significance level after the first difference for both the ADF and PP tests. The price series are therefore a first-difference stationary process which implies that they have unit root or are integrated of order one, I (1). In a similar study by Ansah (2012) wheat price series in markets of Ethiopia were also integrated of order one. This implies that, all price series under study have a similar stochastic process and can exhibit the tendency toward long-run equilibrium. This instigated a test for cointegration.

4.3 Cointegration Analysis

From the stationarity test, all price series under study are integrated of order one hence using the Johansen's approach, a cointegration test was conducted to investigate the dynamic relationship between each market pair. The cointegration test results are presented in table 4.3. The results provide evidence of cointegration between the maize market pairs under study.

Table 4. 3: Johansen's Cointegration Test

Market pair	Rank	Parameters	Eigenvalues	Trace statistic	5% critical value
Tamale-Accra	1	17	0.08179	1.4966	3.76
Tamale-Kumasi	1	17	0.08104	1.5547	3.76
Tamale-Techiman	1	17	0.10482	1.633	3.76
Techiman-Accra	1	17	0.08772	1.0226	3.76
Techiman-Kumasi	1	17	0.09006	1.8306	3.76
Accra-Gasoline	0	14		14.7453	3.76
Kumasi- Gasoline	1	17	0.07872	0.5977	3.76
Techiman-Gasoline	1	17	0.10509	0.1602	3.76
Tamale-Gasoline	1	17	0.08901	0.3136	3.76

Source: computed from monthly data obtained from MOFA-SRID on maize prices from 2000 to 2015

The null hypothesis, $r = 0$ i.e. an absence of a cointegration relation is rejected for all the market pairs at 5% significance level. However, the alternative hypothesis of one cointegration relation that is $r = 1$ between pairs of markets cannot be rejected.

There exists at least one stationary cointegration relation between the pairs of markets considered. At 5% critical value, all four markets under study are cointegrated with gasoline prices except the Accra market. This means that all price series under study have a long-run relationship with gasoline prices.

These findings show that, there is a similar stochastic process between market pairs and that, there is efficient information flow between markets which drives prices (Amikuzuno et. al. 2011). This shows that, maize prices do not drift apart in the long run. Cointegration is a proof that there exist a common maize market in Ghana where inter market prices adjust to achieve long-run, market equilibrium. Since all markets under study are connected by the West African high way which is of good quality, it will be delusional to assume that all maize markets in Ghana are conintegrated since most rural-urban roads are linked by poor roads or poor river transportation systems. The evidence of a cointegrating relationship between the market pairs provides a basis to use a threshold autoregressive model to analyze the nature of price transmission and market integration between the market pairs (Amikuzuno et. al. 2011). Studies by Abdulai on maize markets in Ghana also showed maize markets are cointegrated.

4.4 Threshold Autoregressive Modeling Results

The TAR model is used to determine whether there is threshold cointegration between the market pairs. In Table 4.4 the estimated threshold (ϕ) above which the price differences between the market pairs must exceed before necessitating a price adjustment is measured in Ghana cedi's. The price difference between Tamale-Accra and Tamale-Kumasi must exceed a threshold of approximately 50% to cause an adjustment. A threshold of 40% must be exceeded to create an adjustment process between Tamale and Techiman. The lowest threshold of 30% is between Techiman and Kumasi. On average, a threshold of 40 must be exceeded among all market pairs to create an adjustment.

There is fast adjustment speed between market pairs under study which are significantly different from zero at 1% significance level. Tamale-Kumasi and Techiman-Kumasi recorded the lowest speed of adjustment of 20% and 30%, whereas Tamale-Techiman and Techiman-Accra experienced a fast speed of adjustment of about 60%. The Tamale-Accra pair experiences the fastest speed of adjustment of about 70%. On average, there is a 50% speed of adjustment between the market pairs.

Table 4. 4: Threshold Autoregressive Model Results

Market pair	Distance km	Adjustment parameter(ρ)	Threshold(ϕ)	Half-lives (λ)
Tamale-Accra	614	-0.67346***	0.4766	0.619
Tamale-Kumasi	385	-0.2167***	0.4647	2.838
Tamale-Techiman	260	-0.57539***	0.3754	0.809
Techiman-Accra	367	-0.583***	0.5216	0.792
Techiman-Kumasi	126	-0.3121***	0.2921	1.853

Source: computed from monthly data obtained from MOFA-SRID on maize prices from 2000 to 2015

The time needed for half of the price deviations from equilibrium to be adjusted was fairly different for all market pairs. The Tamale-Accra market pair adjust half of the deviations from equilibrium within two weeks (0.619) which is the fastest among all markets under study. The next fastest pair is the Tamale-Techiman pair with a half-life of about three weeks (0.809). Tamale-Kumasi and Techiman-Kumasi obviously have the longest period of two months and three weeks (2.838), and one month and three weeks (1.853) respectively to adjust half of the deviations to equilibrium. On average, all market pairs under study will have six weeks (1.3) within which half of the deviations from equilibrium will be corrected.

The TAR results show that there is cointegration among market pairs under study and that these markets are highly integrated. The integration of maize markets is consistent with the view that the period is characterized by well-functioning agricultural commodity markets (Alderman and Shively, 1996). Price transmission does exist among them indicating the existence of market integration in the local maize market. In spatial price transmission, it is hypothesized that due to transaction costs traders will only respond to a deviation from the long-run equilibrium between two markets if the deviation exceeds a certain threshold value. The estimated threshold value therefore serves as a proxy for transaction costs. Similar results were achieved by Abdulai 2000 Ayeduvor (2014), Ankamah-Yeboah (2012) about the maize market in Ghana. Amikuzuno et al (2011) also found similar resuts about the tomato market in Ghana.

4.5 Impulse Response Analysis

The dynamic relationship between domestic gasoline prices and maize prices in different markets is examined by the use of impulse response functions. A Vector Autoregressive model was fitted for all market pairs from which the impulse response functions were developed. The VAR results are presented in Appendix A. Impulse response functions give additional information about the long-run dynamic interrelationships that exist among market pairs such as the time path needed to take the system back to equilibrium.

The response to a price shock is dependent of the history of the time series and the sign and magnitude of the postulated shock. Positive shocks here, refer to shocks that affect the profit margins of those involved in the maize market positively (i.e. a decrease in gasoline price) while negative shocks are shocks that affect the profit margin of traders negatively, thus reducing the profit margins (i.e. an increase in gasoline price). To understand the time period it takes for a unit shock in gasoline price to be eliminated, impulse response was estimated from a VAR model. The nonstationarity of price data and VAR properties may allow shocks to elicit responses that are temporary (such that there is a return to the initial time path of the variables) or permanent (such that there is persistent shift in the time path).

In fig.4.3, twelve-period (twelve month) IRFs for each market is presented. The impulse is a one standard deviation positive shock from gasoline price and the response relates to each market price affected by the shock. The IRFs show that, a positive shock to gasoline prices leads only to permanent and negative effects on the various markets.

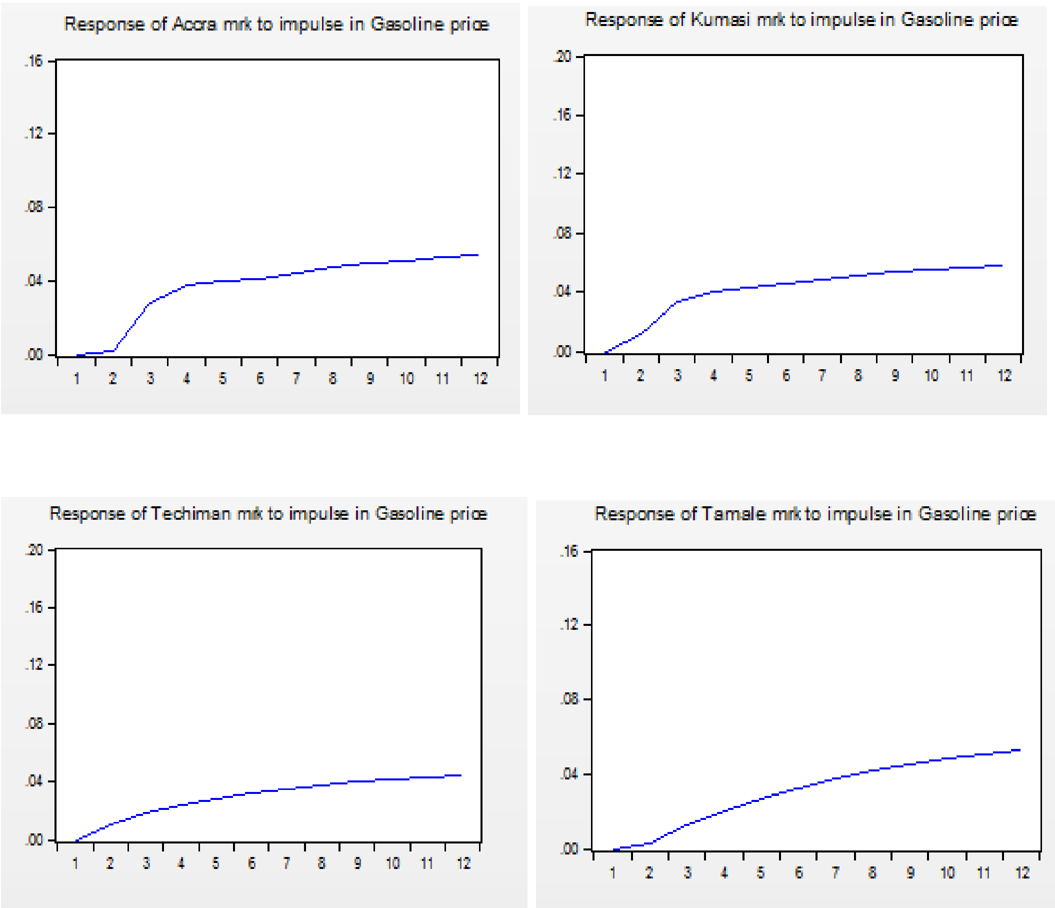


Figure 4. 3: Impulse response graphs showing response of markets to an impulse in gasoline prices

Source: computed from monthly data obtained from MOFA-SRID on maize prices from 2000 to 2015

All markets respond immediately to a one-standard-deviation positive shock in gasoline prices within two weeks of implementation. All markets under the study respond negatively to the positive shocks however, their individual responses and magnitudes differ. In the Accra market, maize prices respond by, increasing gradually during the first six weeks and then, escalating thereafter and never goes back to equilibrium. The Kumasi market however experiences an immediate sharp rise in maize prices after about two weeks of a shock. The Tamale market also responds after about two weeks of the shock but after which it continues to rise slowly without stabilizing. In the Techiman market the response is however lower than the rest of the markets. All markets experience the shock which remains positive thereafter.

Hence, in the long-run shocks from gasoline prices lead to a permanent increase in the average prices of maize in all markets under study. The IRFs also show that the Accra, Kumasi and Techiman markets have the largest response to shocks in gasoline prices. Thus, according to the analysis, in the long-run unexpected shocks in gasoline prices will have a permanent effect on average prices in the markets under study. This means that market efficiency in these markets has not been achieved yet. This also means that any time fuel prices are increased in Ghana; in the long run it causes an ever increasing rise in maize prices. Similar results were reached by Mawejje (2016) that energy prices are a main driver of food prices in Uganda.

The practice of 'petroleum-price-response' by Ghana's informal transport sector where transport fares would increase at the slightest increase in prices of petroleum products with no decrease even when prices go down, comes across as practices that is in to stay (Joynews, 2015). Transportation services in Ghana are practically provided and ruled by the private sector which is mainly profit motivated. Increases in gasoline prices are immediately transferred to the directly through transportation of maize to the markets or through the rise in input prices. This makes the effect severe since it is uncontrollable by the farmer, middle person or the final consumer. This effect is further exacerbated by the poor state of roads leading the rural producers to the urban consumers.

Gasoline prices have had a spiraling effect on maize markets in Ghana as its prices increases. This shows that both Agricultural and energy policies have not considered the effect of fuel pricing on maize pricing thus its effect on both production and consumption. Policies such as FASDEP I AND II (METASIP) and GADS I and II have not had a complimenting policy or strategy on fuel pricing. Thus leaving an important influencer not tackled. Over years of the government of Ghana subsidized the cost of gasoline but is gradually fading it out. This means the new sources of energy especially renewable will have to be developed and adapted by Ghana.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction to chapter

In this chapter, the main findings in the study are summarized and conclusions made based on the main findings of the study. Recommendations are then drawn from the conclusions reached. Finally, the limitations and challenges encountered during the research are discussed.

5.1 Summary

This study was designed to investigate the dynamics and extent of maize price transmission and responses to fuel prices in Ghana. The relationship among maize markets in Ghana and their individual responses to shocks in domestic gasoline prices was studied. To achieve this goal, data on maize prices of four selected markets from the year 2000 to 2015 was sourced from the Ministry of Food and Agriculture, Statistical Research and Information studies (MOFA-SRID).

The descriptive analysis of the data showed that the market with the highest average values for monthly wholesale prices was Accra while Techiman had the lowest. The variability in wholesale maize market prices as determined by the coefficient of variation was on the average approximately 79 percent. The high fluctuations in mean wholesale prices indicated that maize prices were unstable. Also, the seasonal variation indicated that prices generally decline rapidly after harvest which happens in July for the southern sector of the Ghana until April/May where prices begin to rise again. Also, the seasonal trend of gasoline prices recorded the highest numbers during the months in which maize prices were the highest, especially in July. This indicated that, maize prices generally, move along the trend of gasoline prices. The seasonal trend analysis in all markets, shows that, prices were lowest in January and highest in June.

The study showed that the Tamale and Techiman as producer markets experienced relatively lower level prices in all seasons as compared to the Accra and Kumasi markets. The general trend also shows a general increase in price of maize over the years with peaks in 2005, 2008/9, 2012 and 2015. Gasoline prices however showed a showed a gentle rise over the years of study with prices of maize in all markets moving up with the smallest rise in gasoline prices.

Bivariate time series techniques were employed in the study. Unit root tests were conducted using the Dickey-Fuller and Phillip Peron test. These test showed that all price series were non-stationary but were all integrated of order one meaning that similar stochastic processes generated these series, thus providing a bases for possible cointegration. The Johansen's cointegration tests predicted all market pairs have a long-run relationship among them. The market pairs examined showed that their prices series do not diverge at equilibrium thus exhibiting spatial price linkage. The results complement earlier studies of market integration in the Ghanaian market, which potentially can be attributed to the non-interventionist role of the government, improvement in communication infrastructure and the different degrees of self-sufficiency of the producer markets that create arbitrage between the maize markets.

A standard TAR model was then estimated for each market pair. The parameters showed that, all market pairs exhibited market integration and hence price transmission. In spatial price transmission, it is hypothesized that due to transaction costs traders will only respond to a deviation from the long-run equilibrium between two markets if the deviation exceeds a certain threshold value. The estimated threshold value therefore serves as a proxy for transaction costs. There was a fast adjustment speed between market pairs under study which are significantly different from zero at 1% significance level. The Tamale-Kumasi pair experienced the fastest speed of adjustment with a threshold of GHS0.5 even though it took about 10 weeks for half of the deviations to return to equilibrium. The lowest threshold of GHS.0.20 was between Techiman and Kumasi which was expected because this pair has the shortest distance between them. On average, a threshold of GHS0.40 must be exceeded among all market pairs to create the need for an adjustment.

The time needed for half of the price deviations from equilibrium to be adjusted was fairly different for all market pairs. The Tamale-Accra market pair adjust half of the deviations from equilibrium within two weeks was the fastest among all markets under study. The next fastest pair, was the Tamale-Techiman pair, Tamale-Kumasi and Techiman-Kumasi obviously had the longest period to adjust half of the deviations to equilibrium. On average, all market pairs under study will have six weeks within which half of the deviations from equilibrium will be corrected.

Impulse response functions were also used to analyze the dynamic relationship between gasoline prices and maize prices in different markets. All markets responded positively to a shock from gasoline prices. Maize prices in all markets especially that of Accra and Kumasi within two weeks of the shock, sharply rose, and then gradually kept rising. This shows that increases in Gasoline prices permanently increased Maize prices there by reducing the profit margins of the farmers (producers and retailers) and further exacerbating the plight of the poor. Furthermore, shocks from gasoline prices renders efforts towards sustained food security in the country null.

5.2 Policy Recommendations

Maize is a staple food for most Ghanaians; hence policies on gasoline pricing should be consciously designed and implemented to avoid worsening the welfare of both citizens and residents. The current pricing system led by NPA is promising since the OMCS autonomy to follow the world market prices however; these companies should be well monitored to ensure that reductions in prices are reflected in the domestic prices of fuel. Majority of people spend a great proportion of their income on food and hence the effect being described here has a bigger impact especially on the poor. Increases in gasoline prices should be avoided during the lean season as it can greatly cause an increase in maize prices.

The development and adaption of renewable energy by the ministry of Energy and MOFA will help reduce over reliance on fossil fuel and mitigate its vast negative effect on the agricultural sector. Solar and wind energy is being adopted by most developed countries around the world as these are more sustainable than fossil fuel for operating on farm machinery and processing equipment. As the ministries adopt new forms of energy sources other supporting ministries such as Transport should priorities the development of transport facilities especially those linking rural and urban places. This can be achieved effectively through the effective implementation of the countries long term development plans without political disruptions.

Also, the pricing of petroleum products in Ghana need to be revised. The deregulation initiative by the government and NPA is laudable however, the various components of the pricing system need to revise. For instance taxes such as the TOR Debt Recovery Levy and Exploration Levy need to be removed. These taxes further increase the prices of gasoline with its spillover effects on transportation and expenditure on food.

Agricultural policies and their implementation plans have over the years inadequately considered the effect of gasoline (fuel) pricing policies on the prices of maize. FASDEP I and II, METASIP, GSGDA II and GADS have all failed to make reference to the possible dumping effect of gasoline prices on the prices of the produce of the famers (beneficiaries of these policies) and the overall welfare of the peasant farmer. Policy makers especially in the agricultural sector should incorporate the negative effect of fuel pricing policy on these policies there are or have planned on implementing. The most recent is the Planting for Food and Jobs (PFJ) flagship initiative which hopes to boost food production in the country yet very little consideration is given to the pricing of gasoline. The national petroleum authority (NPA) should advice the design of the policies in order to create an all-inclusive policy for the benefit of citizens.

Energy policies in Ghana are expected to have significant impacts on the agricultural sector prices. This implies that policies to stabilize agricultural prices need to account for developments in the pricing of fuel. Also, in order to identify the causes of inflation in agricultural prices policy makers must not focus only on supply and demand dynamics within the agricultural sector, since agricultural prices respond to shocks in the fuel pricing. The study therefore recommends that the effect of gasoline on maize pricing be included in agricultural policies and ways of reducing its effect considered.

The high variability of prices indicates that prices of maize fluctuate across all seasons of production in all markets analyzed. This translates into unstable producer incomes with deleterious effects on production (planning). The high variability in prices demands an improvement in basic marketing information especially in relation to prices.

Collection, collation and dissemination of time series data need to be improved by the Ministry of Food and Agriculture (MOFA) and other institutions such as ESOKO and the Energy commission of Ghana.

There is the need for the provision of logistics of modern standards to the Statistics, Research and Information Division of Ministry of Food and Agriculture in terms of finance, logistics and capacity building to enable them work effectively thereby generating reliable and robust data history. A regular and wide dissemination of price and market supply information will lead to effectiveness of arbitrage among markets, it will reduce uncertainties in market supplies in different locations and lead to a reduction in the risks associated with inter-market trade. Doing this will lead to an efficiently functioning market network where very few markets are segmented and maize is delivered to consumers at competitive price. Also, such a market network with very high proportion of the markets linked in the long-run disallows exploitative tendencies by market agents and actors.

Price transmission between maize markets have improved over time due to improved road networks, transport and market infrastructure as well as information technology (mobile phones) leading to a decline in transaction costs in the distribution level of maize supply chain however, this may not be the case for all maize producing communities throughout the country.

There is still evidence that several roads linking the producer (rural) and consumer (urban) markets are in a bad condition which hampers the rate of price transmission and for that matter trade flow between the consumer and the producer markets. It is therefore recommended that policy initiatives be directed towards ensuring efficient transportation networks to aid the movement of agricultural commodities across markets. These include investment in both private and government owned transporting vehicles, rail/road construction and maintenance. These may contribute to reducing transaction costs and subsequently improving market integration and the imperfection observed in the maize market in Ghana. Unstable prices should therefore be considered as an emergency situation hence policy should focus on initiatives that would encourage stable food prices.

5.3 Limitations of the study and Suggestions for Future Research

A limiting concern of the study is that, data on food commodity and gasoline prices are currently difficult to come by and this makes researchers frustrated as well as limits research in this area. MOFA and the energy commission should create an online portal where researchers and students can easily access data on output and prices of food commodities. The process of generating price data need to be taken serious by appropriate bodies in charge of collecting agricultural price data, that is well trained and qualified personnel's should be used in collecting such information since it has several policy implications on both consumers and producers.

Future studies can consider breaks in the data with regard to the implementation of different polices at different times to better inform policy.

REFERENCES

Agriculture in Ghana. (2013, 05 14). Retrieved from agric in ghana .com: http://agricinghana.com/2013/05/14/agriculture-in-ghana-country-brief/

Abdulai, A. (2000). Spatial price transmission and asymmetry in the Ghanaian maize market. *Journal of development economics*, *63*(2), 327-349.

Adam Mohammed Amin (2009), Petroleum Products Pricing In Ghana – Economics Or Politics? https://www.ghanaweb.com/GhanaHomePage/features/Petroleum-Products-Pricing-In-Ghana-Economics-Or-Politics-171021

Ministry of Agriculture, (2014). *Agriculture in Ghana:Facts and Figures.* Accra .

Ahene, A. A. (2003). *Effect of Climate Change on Maize Supply in Ghana.Master's Thesis*.

Alderman, H., & Shively, G. (1996). Economic reform and food prices: Evidence from markets in Ghana. *World Development*, *24*(3), 521-534..

Alderman, H., & Shively, G. (1991). *Prices and markets in Ghana*. Washington, DC: Cornell Food and Nutrition Policy Program.

Alderman.H. (1993). Intercommunity Price Transmittal: analysis of food markets in Ghana. *Policy Research Working Papar Series 884.The world Bank, W. DC.*

Amikuzuno, J. (2010). Spatial Price Transmission and Market Integration Between Fresh Tomato Market in Ghana:Any Benefits from trade Liberalization? *University for Development Studies*.

Amikuzuno, J. (2010). Spatial Price Transmission and Market Integration Between Fresh Tomato Market In Ghana:Any benefits from trade Liberalization?

A Amonde, T., McDonald, L., & Barrett, K. (2009). An economic enquiry into the causes the perceived asymmetric price transmission in markets for specific consumer goods in Jamaica. *The Fair Trading Commission (FTC) of Jamaica, April*.

Amonde, T., McDonald, L., & Barrett, K. (2009). An economic enquiry into the causes of the perceived asymmetric price transmission in markets for specific consumer goods in Jamaica. *The Fair Trading Commission (FTC) of Jamaica, April*.

Ansah, I. G. (2012). Analysing the Relationship Between World Market Prices ans Local Prices Of heat in African Markets. *A case of Wheat in Ethiopia.Master's Thesis*.

Ayeduvor, S. (2014). *Spatial Price Transmission and Market Integration Analysis: The Case of Maize Market in Ghana*(Doctoral dissertation, University of Ghana).

Barrett, C. (1996.). Market Analysis Methods:are our enriched toolkits well suited to enlivened markets? *American Journal ofAgricultural Economics,*, 78,825 -9.

Benzie, M., Hedlund, J., & Carlsen, H. (2016). Introducing the Transnational Climate Impacts Index: Indicators of country-level exposure–methodology report. *Stockholm: Stockholm Environment Institute*.

Barrett, C. B. (1996). Market analysis methods: are our enriched toolkits well suited to enlivened markets? *American journal of agricultural economics*, *78*(3), 825-829.

Cramon-Taubadel, S. V. (1998). Estimating asymmetric price transmission with the error correction representation: An application to the German pork market. *European review of agricultural economics*, *25*(1), 1-18.

Cutts, M. a. (2006). Asymmetric Price Transmission and Market Concentration:an Investigation into four South African Agro- Food Industries. *South African Journal Of Econonmics, 2*(74), 323 -333.

Dercon, S. (1995). On Market Integration and Liberalization:method and Application to Ethiopia. *Journal of Development Studies, 3*(4), 112 -143.

Dickey, D. F. (1979). Distribution of the stimators for autoregressive time series with a unit root. *Journal of American Statistics Association*, 74,427-431.

Ender, W. G. (1998). Unit - root tests and asymmetric adjustment withan example using the term structure of interest rates. *Journal of Business and Economic Statistics*, 16, 304 - 11.

Enders, W. S. (2001). Cointegration and threshold adjustment. *Journal of Business and Economic Statistics, 19*, 166 - 176.

Fackler, Paul and Barry K. Godwin (2001). *Spatial Price Analysis,In Handbook of agricultural Economics. Gardener and G.Rausser,Amsteerdam:Elsevier.* (Second Edition ed.).

Franklin Akosa (2016). The Political Economy Of Petroleum Pricing In Ghana. Master's Thesis, University of Ghana.

Fwowe., B. (2016). Do oil Prices Drive Agricultural Commodity Price? Evidence From South Africa.Energy Economics,Elsevier.Energy. p. 149e 157.

Granger, C. W. J., & Lee, T. H. (1989). Investigation of production, sales and inventory relationships using multicointegration and non- symmetric error correction models. *Journal of applied econometrics*, *4*(S1).

Heien, D. (1980). Markup Priceing in Dynamic Model of the Food industry. *American Journal Of Agricultural Economics, 62*, 10-18.

Houck, J. P. (1977). An approach to specifying and estimating nonreversible functions. *American Journal of Agricultural Economics*, *59*, 570-572.

Iddrisu, S. M. (2015, 08 13). *Ghana | Myjoyonline.com*. Retrieved 10 04, 2017, from http://www.myjoyonline.com/opinion/2015/August-13th/deregulation-sanitising-ghanas-downstream-petroleum-sector-or-business-as-usual.php

Isaac, A.Y (2012), Spatial Price Transmission in the Regional Maize Markets in Ghana, MPRA Paper No. 49720, posted 11 September 2013 11:33 UTC

Jarawura, F. X., & Smith, L. (2015). Finding the right Path: Climate change and migration in Northern Ghana. In *Environmental Change, Adaptation and Migration* (pp. 245-266). Palgrave Macmillan, London.

Leybourne, S. N. (2004). Behaviour of Dickey - Fuller Unit Root Tests Under Trend Misspecification. *Journal of Time Series Analysis*, 755-764.

Manera, G. F. (2005). Econometric Models of Asymmetric Price Transmission. *Department of Statistics, University of Milan-Bicocca and Fondazione Eni Enrico Mattei*.

Marno., V. (2004). *A Guide to Modern Econometric Methods* (Second Edition ed.). John Wiley & Sons Inc.

Mawejje, J. (2016). Food Prices,Energy and Climate Shocks in Uganda:Agricultural and Food Econonmics,. *A Springer Open Journal*.

Musaka., A. N. (2015). Empirical Essays On the Economics of Food Price Shocks. *Micro Economic Evidence from Uganda*.

Muyatwa, V. (2001). The Liberalization and Integration of Regional Maize Markets in Zambia. *PhD.Thesis*.

Nations, F. a. (2005). Fertilizer use by Crop in Ghana. *1*. Organisation, F. a. (2005). Retrieved from ftp://ftp.fao.org/docrep/fao/008/a0013/a0013e00.pdf

Phillips P.C.B. (19987). *Time Series Regression with A Unit Root.Econometrica.*

Phillips, P. B. (1988). *Testing for a Unit Root in Time Series Regression.Biometrika* (Vol. 75).

R., W. (1971). Posiitvistic Measure of Aggregate Supply Elasticities-some new Approaches:some critical Notes. *American Journal of Agricultural Economics* .

Reagan, P. a. (1982). Asymmetries in Price and Quantity Adjustments By the Competitive Firm. *Journal Of Economic Theory* , 27, 410 -420.

S.Fahlbusch, S. v.-T. (1994). Identifying asymmetric price transmission with error correction models. *Poster session EAAE European seminar in reading*.

Soytas, S. N. (2010). World Oil Prices and Agricultural Commodity Prices. *Evidence from an Emerging Market,Energy Econimics,Elsevier the State of Food Security in the World*.

Soytas, S. N. (2011). Oil Price,Agricultural Commodity Price and the Dollar. *A Panel Cointegration and Causlaity Test,Ernergy Economics,Elsevier*.

Theophilus A, and Ishmael A, MPRA Paper no. 66116,posted 15 August 2015. https://mpra.ub.uni-muenchen.de/66116/1/MPRA_paper_66116.pdf

Tinsae Demise, V. N. (2016). Empirical Investigation into Spatial Integration Without Direct Trade:Comparative Analysis Before and After the Establishment of the Ethiopian Commodity Exchange,. *The Journal of Development Studies* .

Van Campenhout, B. (2007). Modelling trends in food market integration: Method and an application to Tanzanian maize markets. *Food Policy*, *32*(1), 112-127.

Von Cramon - Taubadel, S. (1998). Estimating Asymmetric Price Transmission With The Error Correction Representation:An Application to the German Pork Market. In *European Review Of Agricultural Economics*.

Winter, B. a. (2004). Trade Liberation and Poverty: the Evidence so Far . *Journal of Economic Literature* , 42,72-115.

Appendix A

A1.Threshold Autoregressive Model

A1.1 TAR, Tamale-Accra

```
. TARestR2 diff, movar(movar) tssetvar(Time)
        time variable:  Time, 1960m2 to 1976m1
                delta:  1 month
(1 missing value generated)
(1 missing value generated)
(1 missing value generated)
ESTIMATED THRESHOLD: .4766413867473602
```

indouttab	Freq.	Percent	Cum.
-1	39	20.42	20.42
0	151	79.06	99.48
1	1	0.52	100.00
Total	191	100.00	

Source	SS	df	MS
Model	12.8044537	1	12.8044537
Residual	23.9110035	190	.125847387
Total	36.7154572	191	.192227525

```
Number of obs =      191
F(  1,    190) =   101.75
Prob > F      =   0.0000
R-squared     =   0.3487
Adj R-squared =   0.3453
Root MSE      =   .35475
```

dependent	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
intvarout	-.6734645	.0667661	-10.09	0.000	-.8051627	-.5417664

A1.2 TAR, Tamale-Kumasi

```
. TARestR2 diff, movar(movar) tssetvar(Time)
        time variable:  Time, 1960m2 to 1976m1
                delta:  1 month
(1 missing value generated)
(1 missing value generated)
(1 missing value generated)
ESTIMATED THRESHOLD: .4647816717624664
```

indouttab	Freq.	Percent	Cum.
-1	42	21.99	21.99
0	149	78.01	100.00
Total	191	100.00	

Source	SS	df	MS
Model	.645117461	1	.645117461
Residual	4.93925376	190	.025996072
Total	5.58437122	191	.029237546

Number of obs	= 191
F(1, 190)	= 24.82
Prob > F	= 0.0000
R-squared	= 0.1155
Adj R-squared	= 0.1109
Root MSE	= .16123

dependent	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
intvarout	-.2167041	.0435012	-4.98	0.000	-.3025115	-.1308967

A1.3 TAR, Tamale-Techiman

```
. TARestR2 diff, movar(movar) tssetvar(Time)
        time variable:  Time, 1960m2 to 1976m1
                delta:  1 month
(1 missing value generated)
(1 missing value generated)
(1 missing value generated)
ESTIMATED THRESHOLD: .3754351139068604
```

indouttab	Freq.	Percent	Cum.
-1	26	13.61	13.61
0	152	79.58	93.19
1	13	6.81	100.00
Total	191	100.00	

Source	SS	df	MS
Model	4.95973253	1	4.95973253
Residual	13.7231328	190	.072227015
Total	18.6828653	191	.097816049

Number of obs =	191
F(1, 190) =	68.67
Prob > F =	0.0000
R-squared =	0.2655
Adj R-squared =	0.2616
Root MSE =	.26875

dependent	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
intvarout	-.5753865	.0694353	-8.29	0.000	-.7123497	-.4384234

A1.4 TAR, Techiman-Accra

```
. TARestR2 diff, movar(movar) tssetvar(Time)
        time variable:  Time, 1960m2 to 1976m1
                delta:  1 month
(1 missing value generated)
(1 missing value generated)
(1 missing value generated)
ESTIMATED THRESHOLD: .5216047763824463
```

indouttab	Freq.	Percent	Cum.
-1	41	21.47	21.47
0	148	77.49	98.95
1	2	1.05	100.00
Total	191	100.00	

Source	SS	df	MS
Model	14.3267984	1	14.3267984
Residual	35.4622119	190	.18664322
Total	49.7890103	191	.260675447

```
Number of obs =     191
F(  1,    190) =   76.76
Prob > F      =  0.0000
R-squared     =  0.2878
Adj R-squared =  0.2840
Root MSE      =  .43202
```

dependent	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
intvarout	-.5830124	.0665441	-8.76	0.000	-.7142725	-.4517524

A1.5 TAR, Techiman-Kumasi

```
. TARestR2 diff, movar(movar) tssetvar(Time)
        time variable:  Time, 1960m2 to 1976m1
                delta:  1 month
(1 missing value generated)
(1 missing value generated)
(1 missing value generated)
ESTIMATED THRESHOLD: .2921364307403565
```

indouttab	Freq.	Percent	Cum.
-1	89	46.60	46.60
0	97	50.79	97.38
1	5	2.62	100.00
Total	191	100.00	

Source	SS	df	MS
Model	2.84943166	1	2.84943166
Residual	14.5407215	190	.076530113
Total	17.3901531	191	.091047922

Number of obs =	191
F(1, 190) =	37.23
Prob > F =	0.0000
R-squared =	0.1639
Adj R-squared =	0.1595
Root MSE =	.27664

dependent	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
intvarout	-.3121541	.0511571	-6.10	0.000	-.4130629	-.2112452

A1.6, Halve-lives

Ln(0.5)	Lamda	1-/lam/	LN (C)	HL
-0.69315	0.673465	0.326536	-1.11922	0.619
-0.69315	0.216704	0.783296	-0.24424	2.838
-0.69315	0.575387	0.424614	-0.85658	0.809
-0.69315	0.583	0.417	-0.87467	0.792
-0.69315	0.3121	0.6879	-0.37411	1.853

A2. Vector Autoregressive Model

A2.1 Accra-Gasoline

```
Vector autoregression

Sample:  1960m4 - 1976m1                      No. of obs      =       190
Log likelihood = -73.01718                    AIC             =  .8107072
FPE            =  .1317086                    HQIC            =  .8383982
Det(Sigma_ml)  =  .1262773                    SBIC            =  .8790656
```

Equation	Parms	RMSE	R-sq	chi2	P>chi2
LNAccra	4	.359156	0.8416	1009.56	0.0000

LNAccra	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
LNAccra						
LNAccra						
L1.	.3040215	.0708627	4.29	0.000	.165133	.4429099
L2.	.2130885	.0703531	3.03	0.002	.0751989	.3509781
LNgasoline	.4361112	.0767081	5.69	0.000	.2857661	.5864563
_cons	1.857055	.2957538	6.28	0.000	1.277388	2.436722

A2.2 Kumasi-Gasoline

Vector autoregression

Sample: 1960m4 - 1976m1		No. of obs	= 190
Log likelihood =	84.83399	AIC	= -.8508841
FPE =	.0250031	HQIC	= -.8231931
Det(Sigma_ml) =	.0239721	SBIC	= -.7825257

Equation	Parms	RMSE	R-sq	chi2	P>chi2
LNKumasi	4	.156485	0.9607	4649.027	0.0000

LNKumasi	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
LNKumasi						
LNKumasi						
L1.	1.041094	.0713775	14.59	0.000	.9011965	1.180991
L2.	-.1979943	.0708224	-2.80	0.005	-.3368037	-.059185
LNgasoline	.1235703	.0324788	3.80	0.000	.059913	.1872276
_cons	.6039007	.1380037	4.38	0.000	.3334184	.8743829

A2.3 Techiman-Gasoline

Vector autoregression

Sample: 1960m4 - 1976m1		No. of obs =	190
Log likelihood =	-22.61273	AIC =	.280134
FPE =	.0774799	HQIC =	.307825
Det(Sigma_ml) =	.0742848	SBIC =	.3484924

Equation	Parms	RMSE	R-sq	chi2	P>chi2
LNtechman	4	.275468	0.8516	1090.172	0.0000

LNtechman	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
LNtechman						
LNtechman						
L1.	.4927541	.069993	7.04	0.000	.3555704	.6299378
L2.	.2748833	.0694049	3.96	0.000	.1388522	.4109145
LNgasoline	.1469525	.0440398	3.34	0.001	.0606362	.2332688
_cons	.8263571	.1930285	4.28	0.000	.4480282	1.204686

A2.4 Tamale-Gasoline

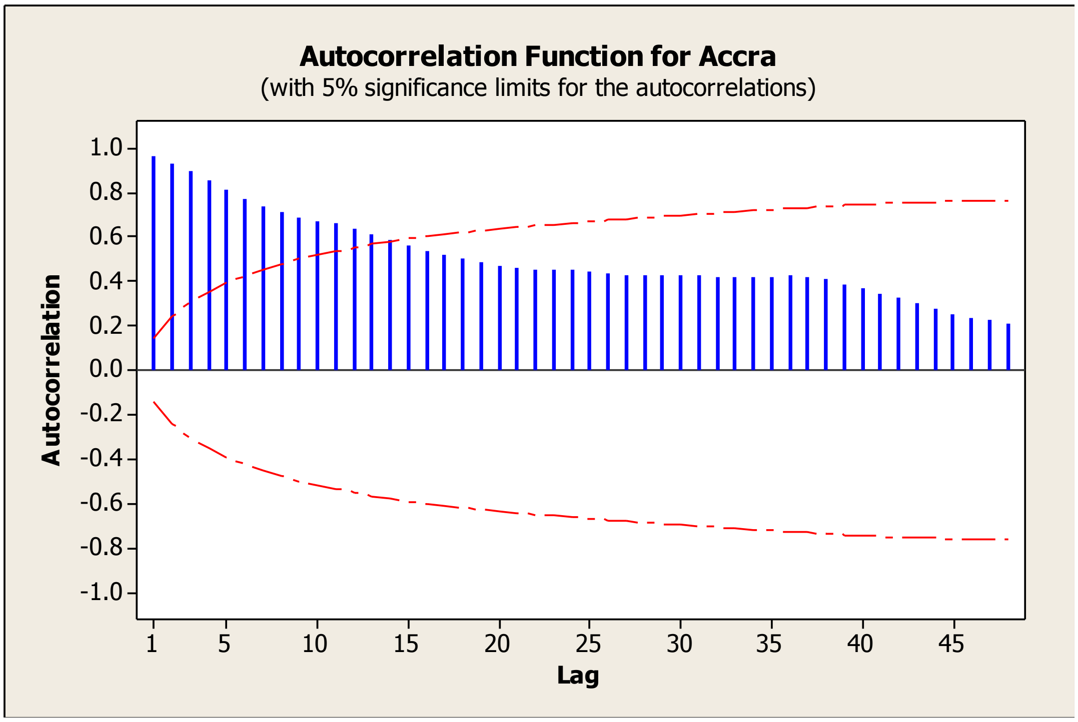
Vector autoregression

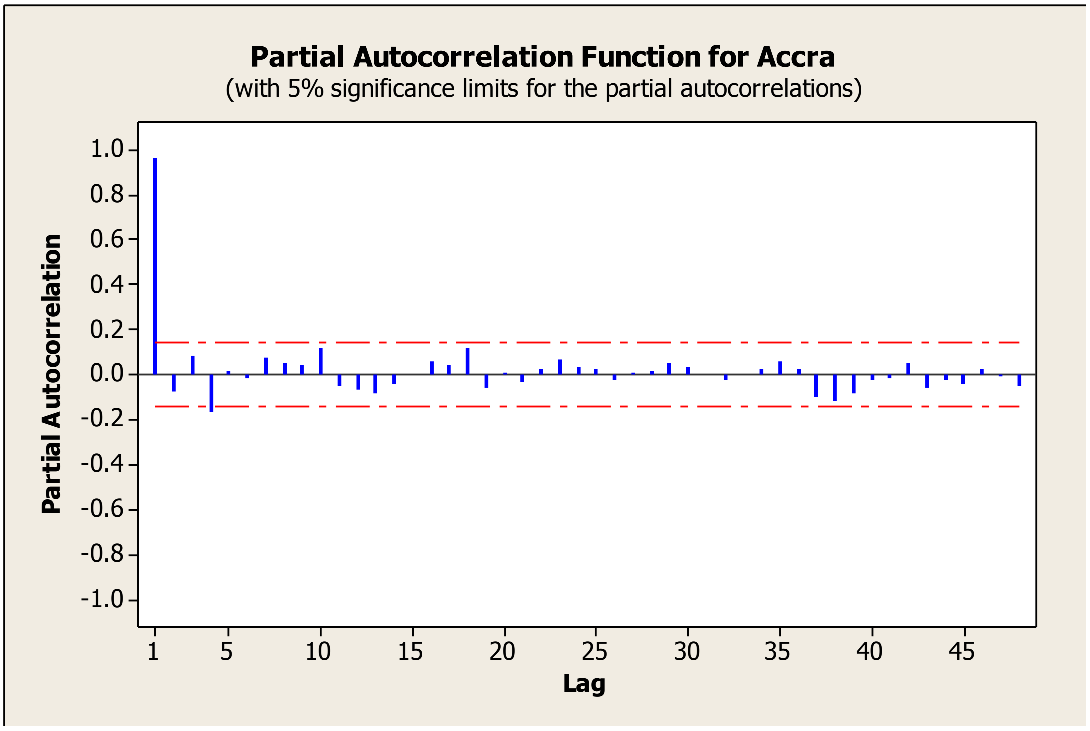
Sample: 1960m4 - 1976m1		No. of obs	= 190
Log likelihood	= 90.56668	AIC	= -.9112282
FPE	= .0235389	HQIC	= -.8835372
Det(Sigma_ml)	= .0225683	SBIC	= -.8428698

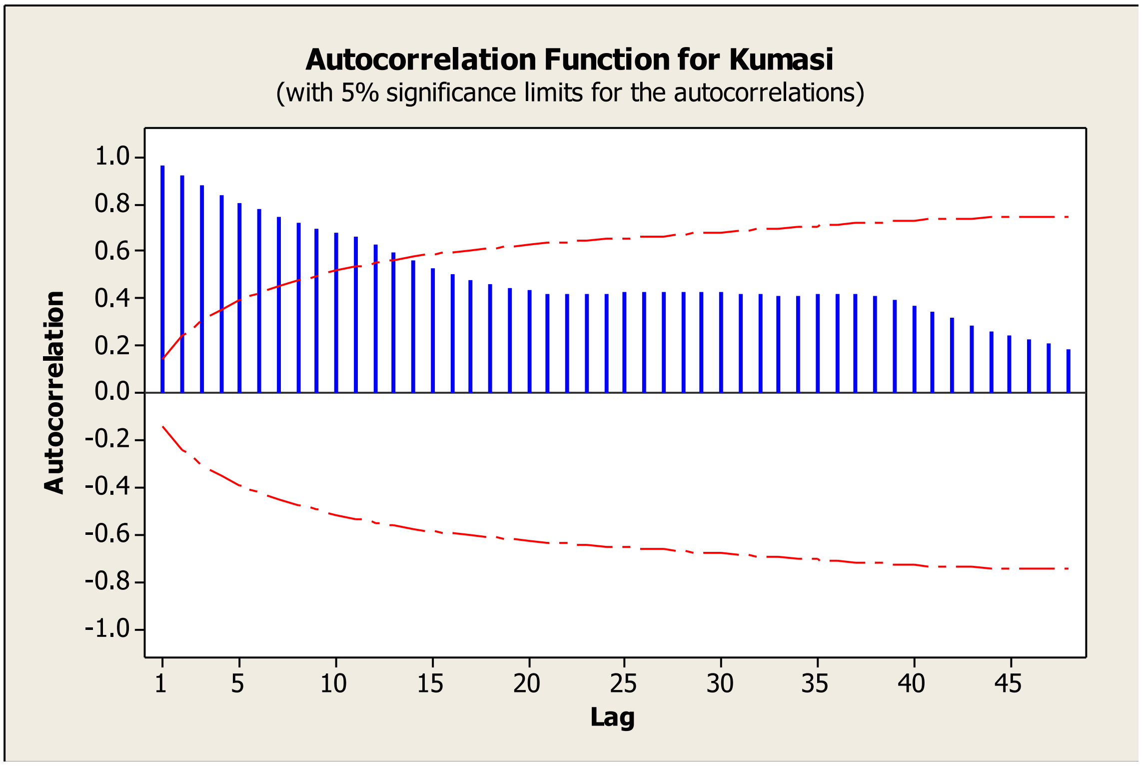
Equation	Parms	RMSE	R-sq	chi2	P>chi2
LNTamale	4	.151834	0.9641	5095.498	0.0000

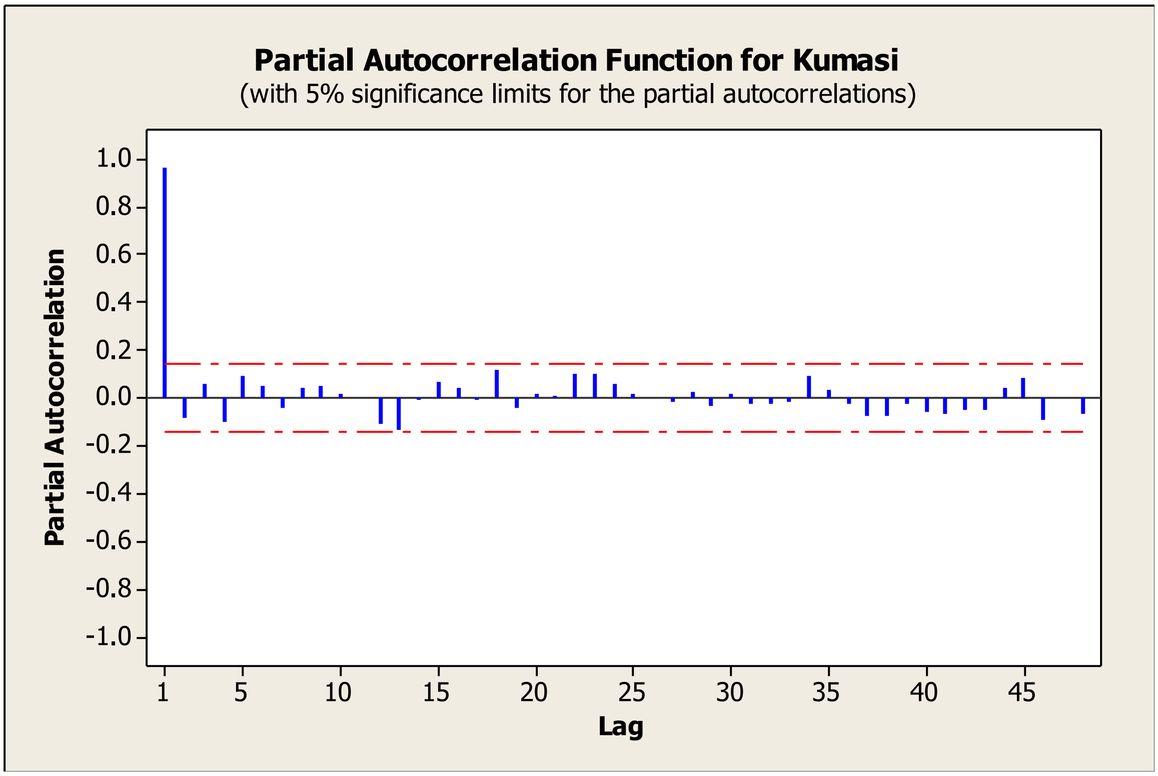
LNTamale	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
LNTamale						
LNTamale						
L1.	.8909147	.0730053	12.20	0.000	.7478269	1.034003
L2.	-.0240916	.0715616	-0.34	0.736	-.1643498	.1161666
LNgasoline	.1066465	.0321945	3.31	0.001	.0435464	.1697466
_cons	.4785954	.1242501	3.85	0.000	.2350697	.7221212

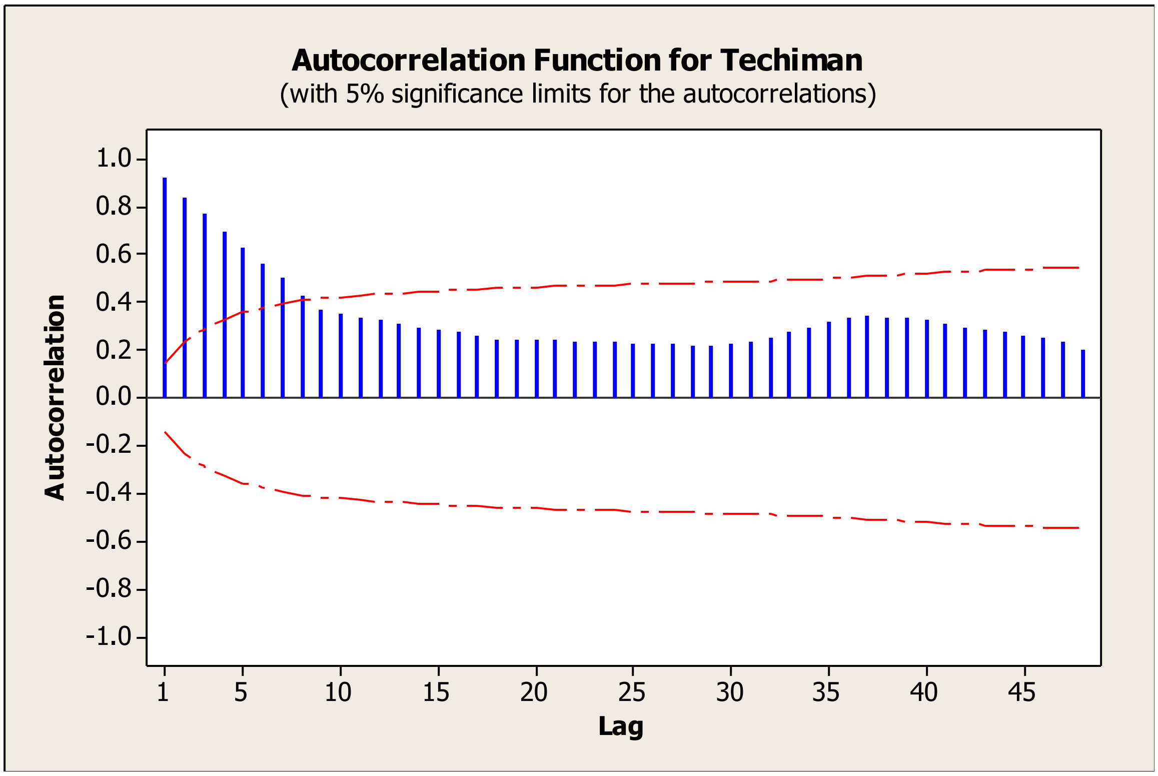
Appendix B

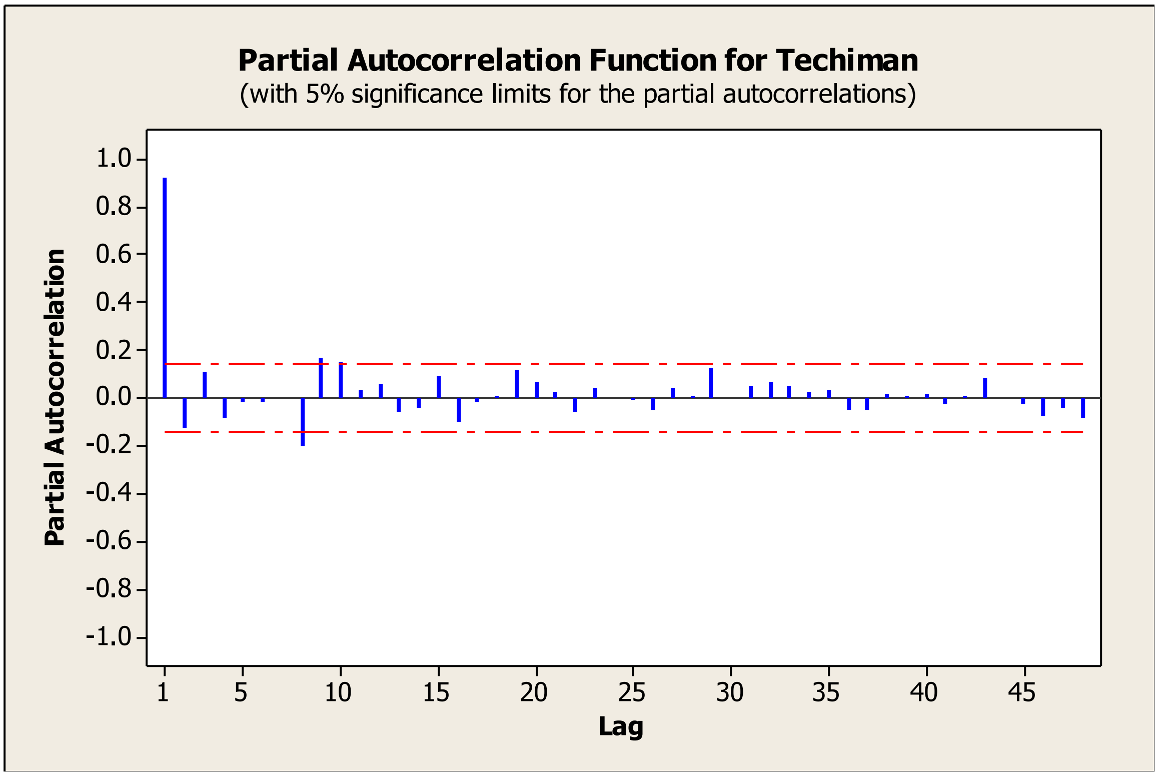

Autocorrelation Function for Accra
(with 5% significance limits for the autocorrelations)
Autocorrelation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
1
5
10
15
20
25
30
35
40
45
Lag

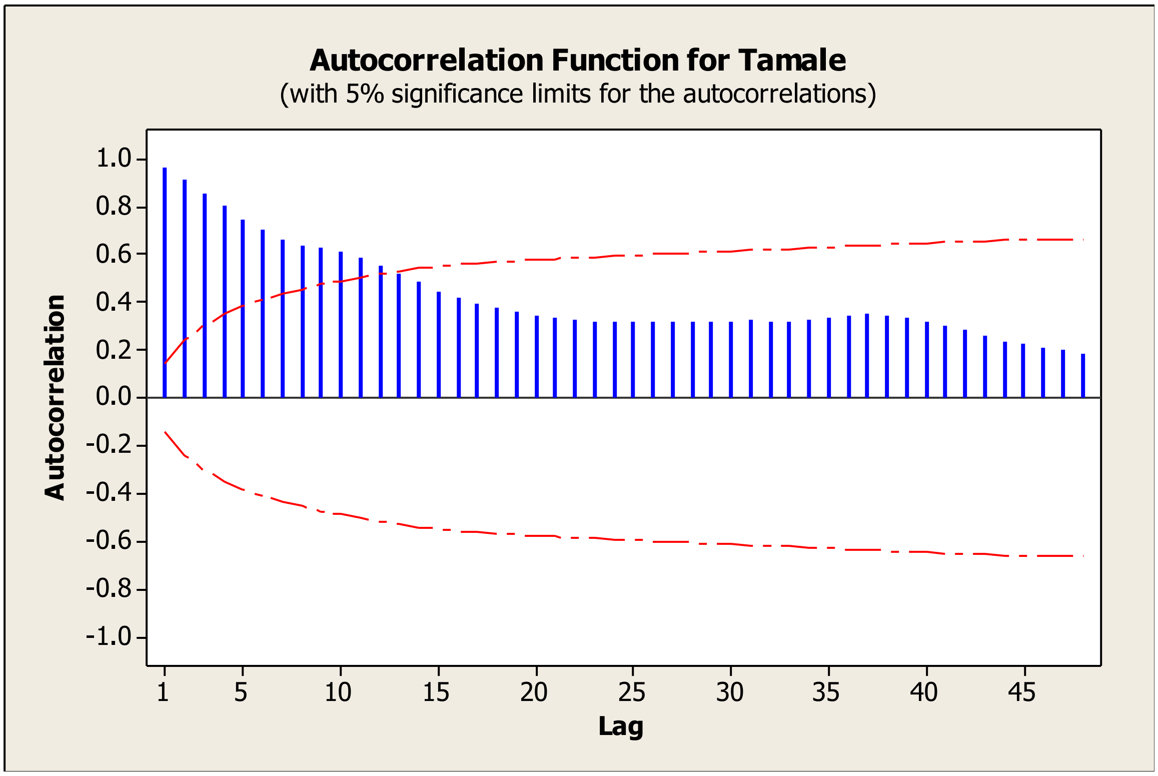

Partial Autocorrelation Function for Accra
(with 5% significance limits for the partial autocorrelations)
Partial Autocorrelation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
1
5
10
15
20
25
30
35
40
45
Lag

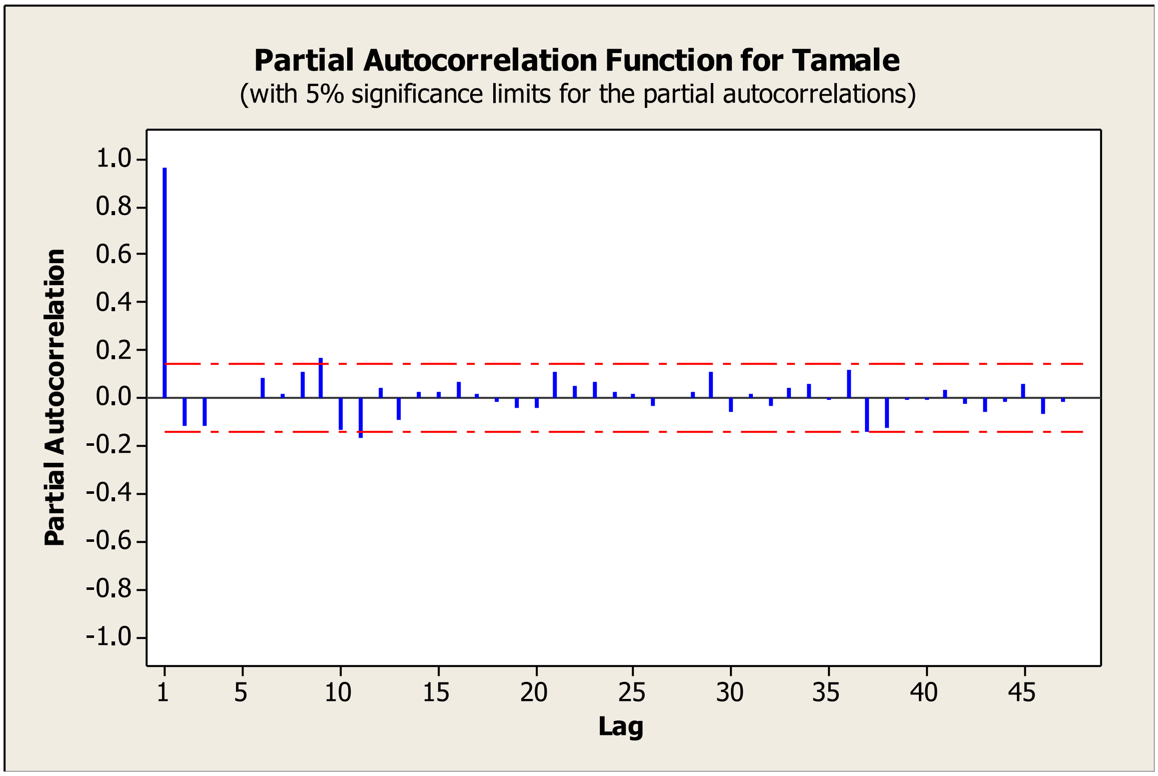

Autocorrelation Function for Kumasi
(with 5% significance limits for the autocorrelations)
Autocorrelation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
1
5
10
15
20
25
30
35
40
45
Lag

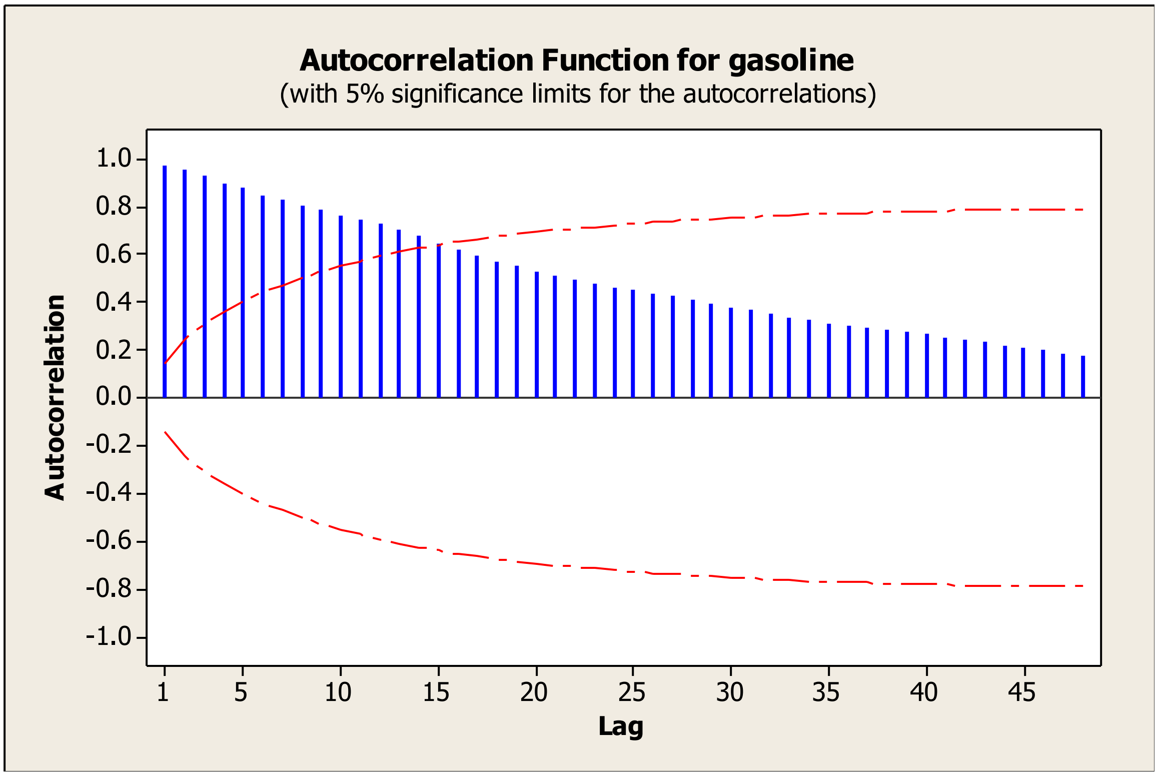

Partial Autocorrelation Function for Kumasi
(with 5% significance limits for the partial autocorrelations)
Partial Autocorrelation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
1
5
10
15
20
25
30
35
40
45
Lag

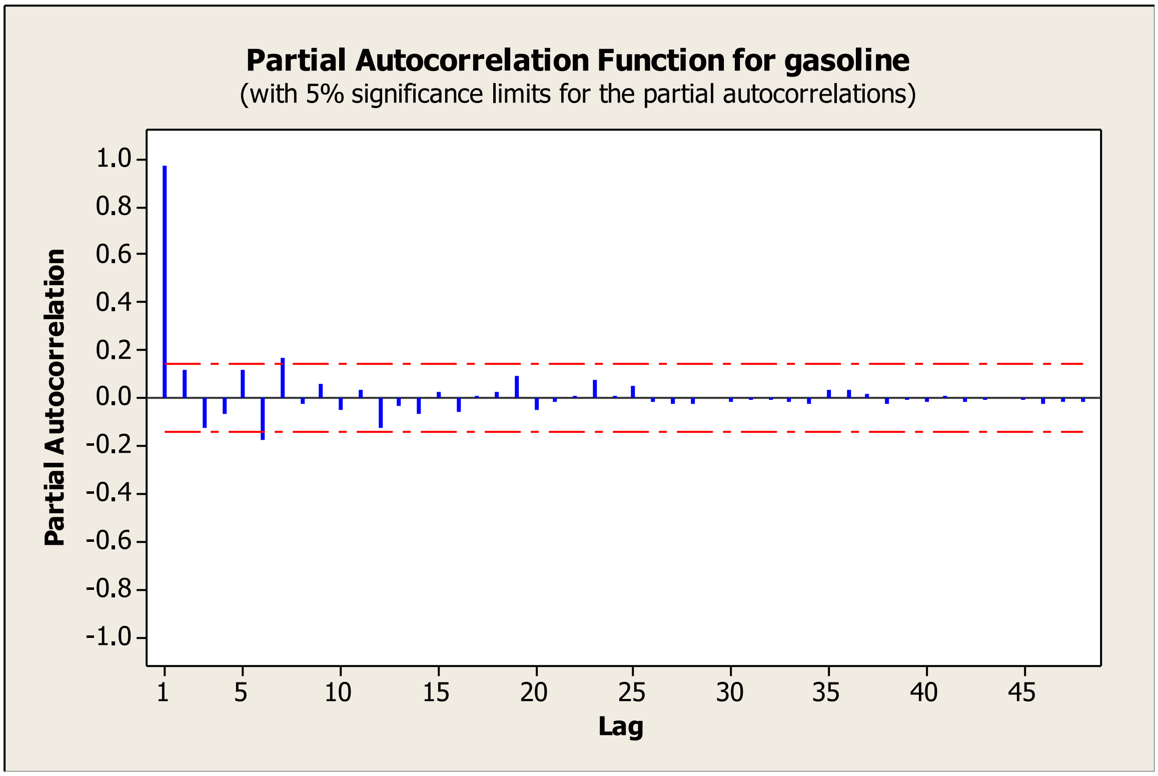

Autocorrelation Function for Techiman
(with 5% significance limits for the autocorrelations)
Autocorrelation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
1
5
10
15
20
25
30
35
40
45
Lag


Partial Autocorrelation Function for Techiman
(with 5% significance limits for the partial autocorrelations)
Partial Autocorrelation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
1
5
10
15
20
25
30
35
40
45
Lag


Autocorrelation Function for Tamale
(with 5% significance limits for the autocorrelations)
Autocorrelation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
1
5
10
15
20
25
30
35
40
45
Lag


Partial Autocorrelation Function for Tamale
(with 5% significance limits for the partial autocorrelations)
Partial Autocorrelation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
1
5
10
15
20
25
30
35
40
45
Lag


Autocorrelation Function for gasoline
(with 5% significance limits for the autocorrelations)
Autocorrelation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
1
5
10
15
20
25
30
35
40
45
Lag


Partial Autocorrelation Function for gasoline
(with 5% significance limits for the partial autocorrelations)
Partial Autocorrelation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
1
5
10
15
20
25
30
35
40
45
Lag

Autocorrelation Function: Accra

Lag	ACF	T	LBQ
1	0.964474	13.36	181.41
2	0.925105	7.58	349.18
3	0.893017	5.79	506.35
4	0.851134	4.75	649.88
5	0.809785	4.07	780.50
6	0.771416	3.58	899.67
7	0.738065	3.22	1009.34
8	0.710245	2.94	1111.46
9	0.686011	2.72	1207.25
10	0.671742	2.57	1299.60
11	0.656891	2.43	1388.40
12	0.636493	2.28	1472.23
13	0.613434	2.14	1550.54
14	0.587586	2.01	1622.79
15	0.561032	1.88	1689.02
16	0.537188	1.76	1750.10
17	0.515229	1.67	1806.60
18	0.501245	1.60	1860.38
19	0.485945	1.53	1911.22
20	0.472174	1.47	1959.51
21	0.462231	1.42	2006.05
22	0.454242	1.38	2051.26
23	0.450474	1.36	2095.98
24	0.447292	1.33	2140.34
25	0.442538	1.31	2184.02
26	0.436262	1.28	2226.73
27	0.429179	1.25	2268.31
28	0.425028	1.22	2309.34
29	0.424109	1.21	2350.44
30	0.424541	1.20	2391.88
31	0.424153	1.19	2433.50
32	0.421508	1.18	2474.86
33	0.419080	1.16	2516.01
34	0.419232	1.16	2557.44
35	0.421720	1.15	2599.63
36	0.425043	1.16	2642.77
37	0.419828	1.13	2685.13
38	0.405684	1.09	2724.93
39	0.387997	1.03	2761.58
40	0.368153	0.98	2794.80
41	0.346583	0.91	2824.43
42	0.326674	0.86	2850.93
43	0.302909	0.79	2873.86
44	0.277783	0.72	2893.28
45	0.254653	0.66	2909.72
46	0.237310	0.62	2924.08
47	0.223273	0.58	2936.89
48	0.206729	0.53	2947.94

Partial Autocorrelation Function: Accra

Lag	PACF	T
1	0.964474	13.36
2	-0.073147	-1.01
3	0.087325	1.21
4	-0.171335	-2.37
5	0.016810	0.23
6	-0.014883	-0.21
7	0.076371	1.06
8	0.049405	0.68
9	0.038313	0.53
10	0.120762	1.67
11	-0.046838	-0.65
12	-0.066513	-0.92
13	-0.083111	-1.15
14	-0.042438	-0.59
15	0.003649	0.05
16	0.057839	0.80
17	0.039652	0.55
18	0.116376	1.61
19	-0.055417	-0.77
20	0.008154	0.11
21	-0.033994	-0.47
22	0.026097	0.36
23	0.065386	0.91
24	0.035697	0.49
25	0.024672	0.34
26	-0.023482	-0.33
27	0.006390	0.09
28	0.017136	0.24
29	0.047033	0.65
30	0.034758	0.48
31	0.000958	0.01
32	-0.024570	-0.34
33	0.002159	0.03
34	0.024021	0.33
35	0.055280	0.77
36	0.024308	0.34
37	-0.103007	-1.43
38	-0.117641	-1.63
39	-0.082491	-1.14
40	-0.025181	-0.35
41	-0.014500	-0.20
42	0.051069	0.71
43	-0.061096	-0.85
44	-0.022852	-0.32
45	-0.039844	-0.55
46	0.028888	0.40
47	-0.010908	-0.15
48	-0.049323	-0.68

Autocorrelation Function: Kumasi

Lag	ACF	T	LBQ
1	0.961722	13.33	180.37
2	0.918645	7.54	345.81
3	0.881273	5.73	498.87
4	0.838451	4.71	638.16
5	0.802715	4.06	766.50
6	0.774138	3.62	886.52
7	0.743093	3.26	997.69
8	0.716169	2.98	1101.52
9	0.695425	2.77	1199.96
10	0.675491	2.59	1293.34
11	0.656342	2.43	1381.99
12	0.630605	2.27	1464.28
13	0.593467	2.08	1537.57
14	0.555921	1.90	1602.24
15	0.524792	1.77	1660.20
16	0.497817	1.65	1712.65
17	0.473503	1.55	1760.37
18	0.460163	1.48	1805.70
19	0.445132	1.42	1848.36
20	0.430611	1.36	1888.52
21	0.420950	1.32	1927.11
22	0.417131	1.29	1965.24
23	0.418385	1.28	2003.82
24	0.421839	1.28	2043.27
25	0.423308	1.28	2083.24
26	0.423345	1.27	2123.45
27	0.422984	1.26	2163.84
28	0.424006	1.25	2204.67
29	0.423347	1.24	2245.63
30	0.423556	1.23	2286.88
31	0.420948	1.21	2327.87
32	0.414129	1.18	2367.80
33	0.407458	1.15	2406.69
34	0.410104	1.15	2446.34
35	0.415910	1.16	2487.38
36	0.419333	1.16	2529.37
37	0.416662	1.15	2571.09
38	0.405793	1.11	2610.91
39	0.390297	1.06	2648.00
40	0.370548	1.00	2681.65
41	0.346102	0.93	2711.20
42	0.318977	0.85	2736.46
43	0.287964	0.77	2757.19
44	0.259771	0.69	2774.17
45	0.241112	0.64	2788.90
46	0.222267	0.59	2801.51
47	0.205651	0.54	2812.37
48	0.186721	0.49	2821.39

Partial Autocorrelation Function: Kumasi

Lag	PACF	T
1	0.961722	13.33
2	-0.083421	-1.16
3	0.057905	0.80
4	-0.103297	-1.43
5	0.089985	1.25
6	0.049336	0.68
7	-0.039966	-0.55
8	0.040539	0.56
9	0.051755	0.72
10	0.015953	0.22
11	-0.000328	-0.00
12	-0.107596	-1.49
13	-0.137665	-1.91
14	-0.012253	-0.17
15	0.063411	0.88
16	0.041586	0.58
17	-0.008369	-0.12
18	0.118449	1.64
19	-0.043496	-0.60
20	0.014705	0.20
21	0.011040	0.15
22	0.097377	1.35
23	0.097288	1.35
24	0.055651	0.77
25	0.015205	0.21
26	-0.002269	-0.03
27	-0.016131	-0.22
28	0.023820	0.33
29	-0.037453	-0.52
30	0.016663	0.23
31	-0.021123	-0.29
32	-0.027957	-0.39
33	-0.019627	-0.27
34	0.088085	1.22
35	0.037508	0.52
36	-0.027863	-0.39
37	-0.072404	-1.00
38	-0.073758	-1.02
39	-0.026450	-0.37
40	-0.059412	-0.82
41	-0.064038	-0.89
42	-0.047513	-0.66
43	-0.053043	-0.73
44	0.038296	0.53
45	0.081153	1.12
46	-0.095740	-1.33
47	0.002224	0.03
48	-0.070601	-0.98

Autocorrelation Function: Techiman

Lag	ACF	T	LBQ
1	0.922531	12.78	165.97
2	0.832915	7.02	301.97
3	0.766078	5.25	417.64
4	0.697110	4.21	513.92
5	0.626994	3.48	592.22
6	0.562520	2.94	655.59
7	0.504295	2.53	706.79
8	0.422319	2.05	742.90
9	0.365003	1.73	770.02
10	0.347115	1.62	794.68
11	0.334148	1.54	817.65
12	0.325193	1.48	839.54
13	0.312487	1.41	859.86
14	0.295268	1.32	878.10
15	0.286204	1.26	895.34
16	0.273253	1.20	911.14
17	0.260549	1.13	925.59
18	0.243974	1.05	938.33
19	0.238821	1.03	950.61
20	0.240453	1.03	963.13
21	0.238219	1.01	975.49
22	0.235497	1.00	987.64
23	0.233909	0.98	999.70
24	0.232034	0.97	1011.64
25	0.229694	0.96	1023.41
26	0.225531	0.93	1034.82
27	0.226126	0.93	1046.36
28	0.220873	0.91	1057.44
29	0.221443	0.91	1068.65
30	0.226495	0.92	1080.44
31	0.235822	0.96	1093.31
32	0.253996	1.03	1108.33
33	0.273135	1.10	1125.81
34	0.295916	1.18	1146.45
35	0.319498	1.27	1170.67
36	0.337265	1.32	1197.83
37	0.340057	1.32	1225.62
38	0.336037	1.30	1252.93
39	0.333154	1.27	1279.95
40	0.327206	1.24	1306.19
41	0.310734	1.17	1330.00
42	0.294178	1.10	1351.49
43	0.283262	1.05	1371.55
44	0.271733	1.00	1390.14
45	0.260418	0.96	1407.32
46	0.247216	0.90	1422.91
47	0.230365	0.84	1436.54
48	0.202487	0.73	1447.15

Partial Autocorrelation Function: Techiman

Lag	PACF	T
1	0.922531	12.78
2	-0.121851	-1.69
3	0.112254	1.56
4	-0.079494	-1.10
5	-0.020699	-0.29
6	-0.013408	-0.19
7	-0.002441	-0.03
8	-0.202775	-2.81
9	0.165258	2.29
10	0.148627	2.06
11	0.029704	0.41
12	0.058265	0.81
13	-0.055338	-0.77
14	-0.042377	-0.59
15	0.090012	1.25
16	-0.101755	-1.41
17	-0.019203	-0.27
18	0.011640	0.16
19	0.114255	1.58
20	0.066646	0.92
21	0.021402	0.30
22	-0.059130	-0.82
23	0.038260	0.53
24	-0.001077	-0.01
25	-0.010913	-0.15
26	-0.046894	-0.65
27	0.044393	0.62
28	0.004960	0.07
29	0.125769	1.74
30	-0.000108	-0.00
31	0.053167	0.74
32	0.063879	0.89
33	0.050071	0.69
34	0.025264	0.35
35	0.035436	0.49
36	-0.053957	-0.75
37	-0.047584	-0.66
38	0.013032	0.18
39	0.012222	0.17
40	0.013976	0.19
41	-0.022146	-0.31
42	0.012311	0.17
43	0.083884	1.16
44	0.000083	0.00
45	-0.022851	-0.32
46	-0.079230	-1.10
47	-0.045887	-0.64
48	-0.080982	-1.12

Autocorrelation Function: Tamale

Lag	ACF	T	LBQ
1	0.959183	13.29	179.42
2	0.910636	7.49	341.99
3	0.854204	5.58	485.79
4	0.798603	4.53	612.15
5	0.745202	3.84	722.76
6	0.701118	3.36	821.21
7	0.661955	3.00	909.43
8	0.635016	2.75	991.06
9	0.624363	2.61	1070.41
10	0.608229	2.45	1146.12
11	0.581056	2.27	1215.60
12	0.554274	2.11	1279.17
13	0.517889	1.93	1334.98
14	0.481240	1.76	1383.45
15	0.446094	1.61	1425.32
16	0.416674	1.48	1462.07
17	0.390198	1.37	1494.47
18	0.372562	1.30	1524.19
19	0.357380	1.23	1551.69
20	0.339622	1.16	1576.67
21	0.330516	1.12	1600.46
22	0.324122	1.09	1623.48
23	0.319974	1.07	1646.04
24	0.317222	1.06	1668.36
25	0.316573	1.05	1690.71
26	0.314328	1.04	1712.88
27	0.314350	1.03	1735.19
28	0.316685	1.03	1757.96
29	0.321750	1.04	1781.62
30	0.321434	1.04	1805.38
31	0.323071	1.04	1829.52
32	0.320112	1.02	1853.38
33	0.321606	1.02	1877.61
34	0.327483	1.03	1902.89
35	0.334417	1.05	1929.42
36	0.346107	1.08	1958.03
37	0.348579	1.08	1987.23
38	0.343011	1.06	2015.68
39	0.333137	1.02	2042.70
40	0.320226	0.98	2067.83
41	0.305023	0.92	2090.78
42	0.284414	0.86	2110.87
43	0.260797	0.78	2127.87
44	0.235596	0.71	2141.84
45	0.222573	0.67	2154.39
46	0.210994	0.63	2165.75
47	0.198650	0.59	2175.89
48	0.184846	0.55	2184.73

Partial Autocorrelation Function: Tamale

Lag	PACF	T
1	0.959183	13.29
2	-0.117495	-1.63
3	-0.116537	-1.61
4	-0.003631	-0.05
5	0.002744	0.04
6	0.080566	1.12
7	0.013179	0.18
8	0.104955	1.45
9	0.165684	2.30
10	-0.132525	-1.84
11	-0.169317	-2.35
12	0.045900	0.64
13	-0.090864	-1.26
14	0.021608	0.30
15	0.028430	0.39
16	0.067871	0.94
17	0.016734	0.23
18	-0.013482	-0.19
19	-0.042792	-0.59
20	-0.042840	-0.59
21	0.104833	1.45
22	0.054060	0.75
23	0.064616	0.90
24	0.027052	0.37
25	0.020429	0.28
26	-0.030724	-0.43
27	-0.001574	-0.02
28	0.024195	0.34
29	0.111591	1.55
30	-0.059614	-0.83
31	0.019326	0.27
32	-0.030863	-0.43
33	0.041523	0.58
34	0.060828	0.84
35	-0.004531	-0.06
36	0.116426	1.61
37	-0.139074	-1.93
38	-0.126330	-1.75
39	-0.010092	-0.14
40	-0.005840	-0.08
41	0.033207	0.46
42	-0.025291	-0.35
43	-0.062440	-0.87
44	-0.018667	-0.26
45	0.059359	0.82
46	-0.070574	-0.98
47	-0.014971	-0.21
48	-0.002370	-0.03

Autocorrelation Function: gasoline

Lag	ACF	T	LBQ
1	0.973071	13.48	184.65
2	0.953150	7.76	362.76
3	0.926106	5.91	531.79
4	0.898004	4.91	691.56
5	0.876249	4.28	844.50
6	0.844151	3.78	987.20
7	0.824972	3.45	1124.23
8	0.801190	3.16	1254.17
9	0.783010	2.94	1378.96
10	0.764022	2.75	1498.43
11	0.744497	2.58	1612.49
12	0.723769	2.42	1720.89
13	0.698455	2.27	1822.41
14	0.673206	2.13	1917.25
15	0.646651	2.00	2005.24
16	0.619636	1.88	2086.50
17	0.592386	1.76	2161.19
18	0.568172	1.66	2230.30
19	0.548567	1.58	2295.09
20	0.528632	1.51	2355.61
21	0.509015	1.43	2412.04
22	0.490975	1.37	2464.86
23	0.476030	1.31	2514.81
24	0.462568	1.27	2562.25
25	0.449749	1.22	2607.36
26	0.436896	1.18	2650.19
27	0.422682	1.13	2690.52
28	0.408822	1.09	2728.48
29	0.394019	1.04	2763.96
30	0.380073	1.00	2797.17
31	0.365543	0.95	2828.09
32	0.351005	0.91	2856.77
33	0.336609	0.87	2883.31
34	0.322162	0.83	2907.78
35	0.310705	0.80	2930.68
36	0.300575	0.77	2952.26
37	0.291945	0.75	2972.74
38	0.283260	0.72	2992.15
39	0.274258	0.70	3010.46
40	0.264890	0.67	3027.65
41	0.254881	0.64	3043.68
42	0.244252	0.62	3058.49
43	0.232529	0.58	3072.01
44	0.221136	0.56	3084.31
45	0.209137	0.52	3095.40
46	0.196739	0.49	3105.27
47	0.184429	0.46	3114.01
48	0.172217	0.43	3121.68

Partial Autocorrelation Function: gasoline

Lag	PACF	T
1	0.973071	13.48
2	0.118257	1.64
3	-0.129165	-1.79
4	-0.066000	-0.91
5	0.115947	1.61
6	-0.176135	-2.44
7	0.170679	2.37
8	-0.021920	-0.30
9	0.058744	0.81
10	-0.050556	-0.70
11	0.034704	0.48
12	-0.121414	-1.68
13	-0.035918	-0.50
14	-0.065849	-0.91
15	0.024748	0.34
16	-0.058911	-0.82
17	0.011977	0.17
18	0.027738	0.38
19	0.093107	1.29
20	-0.052862	-0.73
21	-0.017190	-0.24
22	0.005654	0.08
23	0.072472	1.00
24	0.005957	0.08
25	0.046175	0.64
26	-0.018201	-0.25
27	-0.022130	-0.31
28	-0.022162	-0.31
29	-0.003073	-0.04
30	-0.018973	-0.26
31	-0.011829	-0.16
32	-0.010751	-0.15
33	-0.012555	-0.17
34	-0.025147	-0.35
35	0.035792	0.50
36	0.034441	0.48
37	0.012692	0.18
38	-0.023025	-0.32
39	-0.009138	-0.13
40	-0.015398	-0.21
41	0.005383	0.07
42	-0.014063	-0.19
43	-0.012010	-0.17
44	-0.004154	-0.06
45	-0.010238	-0.14
46	-0.027302	-0.38
47	-0.012697	-0.18
48	-0.016933	-0.23

Appendix C

Nominal Wholesale Maize Price Data (2000-2015) From SRID-MOFA

Date	Accra	Kumasi	Techiman	Tamale
2000-01	6.30	6.25	4.40	4.20
2000-02	6.34	6.67	4.40	4.50
2000-03	9.54	8.33	8.00	6.00
2000-04	9.83	10.00	6.80	6.00
2000-05	9.86	10.00	8.00	8.30
2000-06	12.10	12.22	10.00	8.50
2000-07	13.26	15.00	11.20	11.00
2000-08	9.10	15.00	4.80	6.00
2000-09	7.30	8.33	4.40	6.00
2000-10	10.10	8.33	6.80	8.30
2000-11	10.64	10.00	8.00	8.00
2000-12	10.78	13.33	8.00	8.00
2001-01	13.09	13.30	18.00	9.73
2001-02	13.70	13.33	1.81	11.20
2001-03	14.30	15.00	18.00	11.00
2001-04	18.21	20.83	18.00	14.00
2001-05	18.53	24.00	24.00	14.00
2001-06	15.92	20.83	12.00	16.40
2001-07	15.60	20.00	14.00	14.40
2001-08	15.04	20.00	14.00	14.40
2001-09	10.08	11.67	11.00	9.00
2001-10	9.76	13.33	14.00	12.00
2001-11	10.44	13.33	14.00	12.00
2001-12	0.22	15.83	18.00	12.50
2002-01	15.80	15.74	22.00	12.00
2002-02	15.25	15.74	20.00	12.00
2002-03	15.80	15.74	20.00	12.80
2002-04	15.45	15.74	17.00	13.25
2002-05	16.80	17.05	17.00	16.00
2002-06	17.75	14.68	18.00	16.00
2002-07	19.20	13.00	18.00	16.27
2002-08	10.50	9.48	18.00	9.00
2002-09	9.80	9.35	10.00	9.00
2002-10	10.80	10.56	9.00	8.76
2002-11	11.00	12.95	12.00	8.00
2002-12	11.40	15.18	14.00	10.00
2003-01	15.70	16.67	14.00	12.00
2003-02	14.90	16.67	18.00	11.00
2003-03	14.90	16.67	18.00	10.00
2003-04	15.83	16.41	18.00	10.84

2003-05	15.83	16.32	18.50	14.00
2003-06	15.83	16.32	19.69	13.00
2003-07	20.00	22.64	22.00	12.20
2003-08	18.00	19.88	20.00	8.00
2003-09	16.00	17.33	20.00	9.97
2003-10	17.55	18.10	15.00	9.54
2003-11	17.10	21.48	15.00	10.36
2003-12	19.00	22.33	16.00	11.30
2004-01	20.00	23.05	17.97	12.90
2004-02	19.00	22.57	17.86	13.68
2004-03	20.00	22.92	20.07	14.00
2004-04	21.00	24.73	20.00	15.17
2004-05	21.80	28.61	20.83	15.90
2004-06	23.00	29.77	26.60	17.17
2004-07	27.30	31.53	25.30	23.33
2004-08	27.50	29.35	25.45	22.10
2004-09	27.70	22.20	22.70	17.00
2004-10	25.00	25.20	23.70	16.00
2004-11	26.40	31.50	26.80	17.40
2004-12	28.60	31.27	27.30	20.00
2005-01	29.30	32.60	27.90	19.40
2005-02	28.70	36.66	33.15	22.45
2005-03	31.00	36.69	33.15	24.95
2005-04	37.50	41.89	35.25	29.00
2005-05	48.00	57.86	51.90	36.00
2005-06	51.20	47.50	54.50	36.80
2005-07	53.80	40.50	48.38	43.67
2005-08	43.00	30.41	30.50	32.33
2005-09	36.50	29.93	27.30	24.25
2005-10	33.40	31.79	31.11	19.40
2005-11	33.40	35.60	32.20	19.40
2005-12	31.24	35.60	32.48	22.00
2006-01	28.20	25.40	16.15	20.75
2006-02	27.05	21.75	14.91	20.00
2006-03	25.90	21.21	14.37	17.67
2006-04	24.65	20.88	14.04	17.00
2006-05	26.58	22.00	20.19	18.00
2006-06	29.73	26.70	17.90	17.33
2006-07	27.85	23.93	14.43	15.25
2006-08	22.75	25.40	13.70	11.00
2006-09	18.65	14.82	13.49	13.50
2006-10	17.75	12.50	11.55	12.15
2006-11	21.08	16.74	11.60	14.75
2006-12	22.00	19.60	13.10	16.00

2007-01	25.00	21.17	17.72	16.00
2007-02	27.90	22.53	16.95	17.75
2007-03	28.90	23.40	20.35	17.00
2007-04	30.38	27.68	20.98	18.00
2007-05	32.50	26.93	20.95	18.00
2007-06	33.30	25.60	18.10	16.50
2007-07	31.70	27.25	20.39	19.00
2007-08	30.95	27.90	20.00	18.00
2007-09	29.75	29.30	18.28	20.00
2007-10	23.50	21.70	18.85	23.50
2007-11	32.00	26.00	18.20	28.00
2007-12	31.50	23.50	17.69	25.75
2008-01	30.75	25.00	20.83	28.00
2008-02	34.25	27.50	23.27	27.00
2008-03	41.67	33.16	29.72	36.00
2008-04	46.50	39.50	34.73	36.00
2008-05	52.00	52.00	42.60	43.50
2008-06	62.25	51.30	49.21	47.75
2008-07	81.60	79.30	58.09	60.00
2008-08	59.75	85.00	52.69	58.25
2008-09	43.50	44.35	27.50	37.00
2008-10	46.50	38.55	33.27	36.50
2008-11	57.40	42.20	31.30	34.80
2008-12	57.50	38.00	33.70	34.25
2009-01	58.00	44.50	38.80	40.40
2009-02	57.88	50.13	38.30	41.45
2009-03	57.75	55.75	37.79	42.50
2009-04	59.50	58.00	45.00	44.00
2009-05	71.20	69.60	52.15	53.60
2009-06	75.80	67.00	51.40	54.50
2009-07	75.25	67.25	48.27	49.50
2009-08	71.40	67.60	43.29	43.20
2009-09	51.50	38.00	26.65	33.25
2009-10	46.80	37.20	30.70	36.60
2009-11	50.00	48.00	29.83	34.00
2009-12	51.50	58.50	30.75	34.75
2010-01	53.40	52.40	33.20	36.00
2010-02	53.25	49.00	32.00	35.75
2010-03	51.00	47.25	31.00	36.00
2010-04	54.25	38.00	32.25	36.25
2010-05	58.80	43.60	36.80	35.60
2010-06	58.00	48.50	36.25	37.25
2010-07	58.00	50.00	36.90	36.00
2010-08	56.75	39.00	37.13	45.75

2010-09	49.75	35.50	37.38	33.75
2010-10	43.40	29.80	26.20	32.00
2010-11	45.25	36.00	31.00	36.00
2010-12	53.50	37.00	33.25	36.00
2011-01	56.60	43.80	37.80	37.20
2011-02	61.25	47.75	35.00	38.00
2011-03	57.25	50.00	35.50	38.00
2011-04	57.25	50.00	37.25	38.00
2011-05	72.50	50.00	52.50	47.50
2011-06	80.75	81.00	56.25	55.00
2011-07	82.00	83.00	61.50	55.75
2011-08	89.00	83.00	67.00	66.25
2011-09	69.75	85.75	62.50	48.25
2011-10	64.50	77.00	59.00	47.00
2011-11	70.25	75.25	54.25	48.00
2011-12	89.00	101.25	68.00	57.00
2012-01	102.25	100.00	69.75	67.00
2012-02	98.25	100.00	64.50	61.00
2012-03	99.25	103.75	62.00	63.00
2012-04	105.25	101.25	71.00	66.00
2012-05	116.50	122.75	77.00	80.00
2012-06	118.50	134.00	75.00	78.00
2012-07	114.25	120.00	68.75	72.00
2012-08	114.50	110.00	66.75	70.00
2012-09	97.50	86.25	55.25	53.00
2012-10	87.75	70.00	50.00	48.00
2012-11	85.50	77.50	50.75	48.00
2012-12	87.00	77.50	45.00	48.00
2013-01	84.50	78.75	46.00	54.00
2013-02	85.50	78.75	46.00	56.50
2013-03	84.75	78.25	46.00	52.50
2013-04	84.50	81.25	46.00	48.00
2013-05	82.25	83.75	46.00	46.50
2013-06	81.25	77.50	45.00	45.00
2013-07	77.50	73.00	51.00	49.75
2013-08	78.50	80.00	50.00	48.00
2013-09	79.00	71.50	49.00	48.00
2013-10	80.25	70.00	34.00	56.75
2013-11	80.25	74.25	46.00	56.75
2013-12	85.50	78.75	52.00	51.00
2014-01	88.75	86.25	56.00	67.50
2014-02	95.50	95.50	54.00	60.00
2014-03	102.00	96.00	52.00	60.00
2014-04	103.25	95.50	50.00	63.00

2014-05	109.25	103.75	50.00	80.00
2014-06	109.25	108.75	50.00	80.00
2014-07	109.25	108.75	50.00	80.00
2014-08	128.50	140.00	50.00	105.00
2014-09	128.50	136.00	50.00	100.00
2014-10	128.50	136.00	50.00	100.00
2014-11	114.00	126.25	50.00	100.00
2014-12	114.00	125.00	50.00	100.00
2015-01	127.00	125.00	50.00	100.00
2015-02	129.00	125.00	63.50	100.00
2015-03	130.00	121.25	77.00	90.00
2015-04	140.50	123.75	155.00	84.50
2015-05	146.00	134.00	190.00	112.80
2015-06	165.00	142.50	125.00	150.00
2015-07	185.00	151.25	130.00	150.00
2015-08	198.40	166.00	132.40	160.00
2015-09	192.00	165.00	122.75	150.00
2015-10	147.00	144.00	113.40	144.00
2015-11	155.00	145.00	108.00	125.00
2015-12	162.50	145.00	104.00	120.00

Nominal Pump Price of Gasoline (2000-2015) From ACEP, Ghana

Date	Gasoline Price per 100 liters
2000-01	11.80
2000-02	11.80
2000-03	14.20
2000-04	14.20
2000-05	14.20
2000-06	14.20
2000-07	14.20
2000-08	14.20
2000-09	14.20
2000-10	14.20
2000-11	14.20
2000-12	14.20
2001-01	14.20
2001-02	23.33
2001-03	23.33
2001-04	23.33
2001-05	23.33
2001-06	23.33
2001-07	23.33
2001-08	23.33
2001-09	23.33

2001-10	23.33
2001-11	23.33
2001-12	23.33
2002-01	23.33
2002-02	23.33
2002-03	23.33
2002-04	23.33
2002-05	23.33
2002-06	23.33
2002-07	23.33
2002-08	23.33
2002-09	23.33
2002-10	23.33
2002-11	23.33
2002-12	23.33
2003-01	44.44
2003-02	44.44
2003-03	44.44
2003-04	44.44
2003-05	44.44
2003-06	44.44
2003-07	44.44
2003-08	44.44
2003-09	44.44
2003-10	44.44

2003-11	44.44
2003-12	44.44
2004-01	44.44
2004-02	44.44
2004-03	44.44
2004-04	44.44
2004-05	44.44
2004-06	44.44
2004-07	44.44
2004-08	44.44
2004-09	44.44
2004-10	44.44
2004-11	44.44
2004-12	44.44
2005-01	44.44
2005-02	66.67
2005-03	66.67
2005-04	66.67
2005-05	66.67
2005-06	66.67
2005-07	66.67
2005-08	67.78
2005-09	67.78
2005-10	71.11
2005-11	71.11

2005-12	71.11
2006-01	70.67
2006-02	77.44
2006-03	85.17
2006-04	89.70
2006-05	81.04
2006-06	79.12
2006-07	79.12
2006-08	78.34
2006-09	78.34
2006-10	78.34
2006-11	78.34
2006-12	78.34
2007-01	78.34
2007-02	77.49
2007-03	77.49
2007-04	82.03
2007-05	88.59
2007-06	94.00
2007-07	94.00
2007-08	91.20
2007-09	93.91
2007-10	97.78
2007-11	103.92
2007-12	102.92

2008-01	104.65
2008-02	103.25
2008-03	109.95
2008-04	112.61
2008-05	118.53
2008-06	118.53
2008-07	118.53
2008-08	118.53
2008-09	118.53
2008-10	118.53
2008-11	104.83
2008-12	90.50
2009-01	82.00
2009-02	82.00
2009-03	79.27
2009-04	85.70
2009-05	85.70
2009-06	111.41
2009-07	111.41
2009-08	111.41
2009-09	111.41
2009-10	111.41
2009-11	116.98
2009-12	116.98
2010-01	116.98

2010-02	116.98
2010-03	116.98
2010-04	116.98
2010-05	116.98
2010-06	116.98
2010-07	116.98
2010-08	116.98
2010-09	116.98
2010-10	116.98
2010-11	116.98
2010-12	116.98
2011-01	116.98
2011-02	140.37
2011-03	152.07
2011-04	152.07
2011-05	152.07
2011-06	152.07
2011-07	152.07
2011-08	152.07
2011-09	152.07
2011-10	152.07
2011-11	152.07
2011-12	159.87
2012-01	175.48
2012-02	173.00

2012-03	170.80
2012-04	170.80
2012-05	170.80
2012-06	170.80
2012-07	170.80
2012-08	170.80
2012-09	170.80
2012-10	170.80
2012-11	170.80
2012-12	170.80
2013-01	170.80
2013-02	182.19
2013-03	204.96
2013-04	204.96
2013-05	204.96
2013-06	211.11
2013-07	212.11
2013-08	214.73
2013-09	214.73
2013-10	218.64
2013-11	211.29
2013-12	219.00
2014-01	226.00
2014-02	240.00
2014-03	255.00

2014-04	273.00
2014-05	273.00
2014-06	273.00
2014-07	304.50
2014-08	336.00
2014-09	336.00
2014-10	336.00
2014-11	336.00
2014-12	336.00
2015-01	305.00
2015-02	305.00
2015-03	305.00
2015-04	305.00
2015-05	337.67
2015-06	316.30
2015-07	394.70
2015-08	322.10
2015-09	374.00
2015-10	349.30
2015-11	341.60
2015-12	346.80

Monthly maize and gasoline prices

Month	Accra	Kumasi	Techiman	Tamale	Gasoline per 100 liters
January	57.80	54.46	35.72	41.08	101.80
February	58.91	56.03	35.55	40.37	107.00
March	59.87	56.89	37.88	39.76	110.80
April	62.60	57.96	46.69	39.93	113.10
May	67.85	64.59	54.50	47.93	115.40
June	71.60	68.95	48.39	52.25	116.20
July	74.30	69.64	49.50	53.12	123.20
August	75.40	72.70	48.18	55.55	120.60
September	68.30	64.30	42.75	48.15	124.00
October	61.93	59.10	39.67	47.92	123.20
November	63.08	61.44	40.38	46.58	122.10
December	66.30	65.01	42.01	46.79	122.40