PRICE FLUCTUATION AND MARKET INTEGRATION OF SELECTED CEREAL IN NORTH-EASTERN NIGERIA, 2001-2010

BY

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NSUKKA

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BEING A THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL ECONOMICS, FACULTY OF AGRICULTURE, UNIVERSITY OF NIGERIA, NSUKKA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF DOCTOR OF PHILOSOPHY (Ph.D) AGRICULTURAL ECONOMICS

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CERTIFICATION

Taru, Bala a postgraduate student in the Department of Agricultural Economics with registration number PG/Ph.D/09/51326 has satisfactorily completed the requirements of research work for the award of degree of Doctor of Philosophy (Ph.D) in Agricultural Economics, University of Nigeria, Nsukka. The work embodied in this thesis, except where duly acknowledged, is original and has not been previously published or submitted in part or full for any other diploma or degree of this or any other University.

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DEDICATION

To all parents, who despite their non-literate levels were able to sponsor their children to school.

In particular, to mothers who have toiled the soil to sponsor their children to school.

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ABSTRACT

Prices contain information crucial to maximizing the returns to production and marketing investments. At planting time, a farmer's planting decision depends on expected profits, which invariably hinge on the anticipated prices of the crop or mix of crops that would prevail in the market at the time of sale and on the farmer's interpretation of those prices. A trader, in search of profitable arbitrage, reads and translates price signals in deciding on what crops to buy, where to buy, and when to sell. Apart from guiding production and marketing decisions, prices govern the optimal allocation of resources among competing uses. The accuracy, reliability, and promptness of market information are therefore critical in attaining pricing efficiency. Broadly, the study attempted to analyze the price fluctuation and market integration of selected cereal grains in North-eastern Nigeria. The specific objectives of the study were to: (i) estimate the extent of the various components of price; (ii) derive the probability distribution of cereal grain price in the long-run; (iii) determine the existence and level of inter-market price dependency; (iv) examine the speed of price adjustment to long-run equilibrium and (v) examine the Granger Causality among rural and urban cereal grain markets. The study was conducted in North-eastern Nigeria. Purposive sampling technique was used to select two states, of Adamawa and Taraba, from the six states that made up the North-east geopolitical zone. Only secondary data were used in the study. Secondary data on monthly bases for the prices of 100kg of three cereal grains, maize, rice and sorghum in both rural and urban markets in the study area were obtained from Adamawa and Taraba States Agricultural Development Program offices for a period of 10 years (2001-2010). Data were analyzed using descriptive statistics such as price decomposition technique, and inferential statistics such as Markov Chain, Vector Autoregressive and Error Correction Models. The results revealed that, the trend component showed an upward movement for all the three commodities. The seasonal variation had indexes ranged from 198.15 to 52.61, 142.83 to 61.88, and 141.44 to 66.25 for maize, rice and sorghum, respectively. The random and cyclical variations had negligible and insignificant indices with the former having 0.01 all through and the later ranging from 0.93 to 1.26. Probability distribution matrices of the three cereal grains were 0.18, 0.48 and 0.34 for maize, 0.27, 0.68 and 0.05 for rice and 0.48, 0.25 and 0.27 for sorghum. The Augmented Dickey-Fuller unit roots test indicated $I(0)$, $I(1)$ and $I(1)$ for maize, rice and sorghum, respectively. Null hypothesis of б = 1 was rejected against б = 0. Trace statistics for rural and urban markets were not significant ($\rho > 0.05$). Rural and urban prices of maize responded to shocks within and between each market. The speed with which the system adjusted to shocks and restored equilibrium between the short and the long-run were -0.170725 and -0.29517 for urban and 0.592237 and 0.38034 for rural prices of rice and sorghum, respectively. Granger Causality showed that a bi-directional flow of price signals existed between rural and urban prices of maize, while rural prices of rice and sorghum did not Granger-Cause urban prices of rice and sorghum. Also, urban prices of both rice and sorghum did not Granger-cause rural prices of both rice and sorghum. Findings of the study showed an imperfect market integration for North-eastern Nigeria cereal grain markets, this indicate that there may be substantial benefits in developing better infrastructure facilities to effectively link production centers to market centers and in improving market knowledge by providing more relevant, accurate, and timely public market information.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The grain sub-sector plays an important role in the economic development of Nigeria. The output of the sub-sector (Ismaila, Gana, Twanya & Dogara 2010; Okunneye, 2003) constitutes a large proportion of staple food stuffs in Nigeria. Between 1985 and 1995, cereal grain accounted for almost 50 % of the total food supply in Nigeria when expressed in grain equivalent (Akpan & Udoh, 2009; Ukoha). On the other hand, Paulino and Sarma (1988) reported that about 70% of the total food crop area harvested in Nigeria was devoted to cereals and the remaining 30% to non-cereals.

The most important cereal grain crops grown and marketed in Nigeria are maize, rice, sorghum, millet and wheat (Akpan & Udoh, 2009; Global Information and Early Warning System on Food and Agriculture (GIEWS), 2008; Ismaila et al., 2010; Oguntunde, 1989; Wudiri, 1992). Of these, rice, maize, millet and sorghum are the major sources of energy staple food available and affordable in Nigeria, and are the commodities that are of considerable importance for food security, expenditure and income of households in Northern Nigeria (Ismaila et al., 2010; Maziya-Dixon et al., 2004).

In most parts of Asia and Africa, cereal products comprise 80% or more of the average diet, in central and western Europe, as much as 50% and in the United States, between 20 ï 25% (Food and Agriculture Organization, 1996). Also, the increased demand for cereals, as a result of rapid urbanization, means that food crops must increasingly be produced to meet the needs of the rural and urban population (Balarabe, 2003). According to the Central Bank of Nigeria (CBN) (2000), Okunneye (2003) and Ukoha (2005), most Nigerians depended on cereal grains for their daily dietary needs and the price of these grains is one factor that determines the extent to which Nigerians can pay for these food commodities. Cereal grains availability and prices have become a major welfare determinant for the poorest segments of the Nigerian consumers who also are least food secured (Akande, 2001). Also, CBN (2000), Akande (2001) and Akpan and Udoh (2009) have affirmed that, the nominal or producer price of cereal grains have continuously fluctuated over the past years.

Spatial market integration of agricultural products has been widely used to indicate overall market performance (Faminow & Benson, 1990). In spatially integrated markets, competition among arbitragers will ensure that, a unique equilibrium is achieved where local prices in regional markets differ by no more than transportation and transaction costs. Information of spatial market integration, thus, provides indication of competitiveness, the effectiveness of arbitrage, and the efficiency of pricing (Sexton, Kling & Carman, 1991).

If price changes in one market are fully reflected in alternative market, these markets are said to be spatially integrated (Goodwin & Schroeder, 1991). Prices in spatially integrated markets are determined simultaneously in various locations, and information of any change in price in one market is transmitted to other markets (Gonzalez-Rivera & Helfand, 2001). Markets that are not integrated may convey inaccurate price signal that might distort producersô marketing decisions and contribute to inefficient product movement (Goodwin & Schroeder 1991), and traders may exploit the market and benefit at the cost of producers and consumers. In more integrated markets, farmers specialize in production activities in which they are comparatively proficient, consumers pay lower prices for purchased goods, and society is better able to reap increasing returns from technological innovations and economies of scale (Vollrath, 2003). Market integration of agricultural products has retained importance in developing countries due to its potential application to policy making. Based on the information of the extent of market integration, government can formulate policies of providing infrastructure and information regulatory services to avoid market exploitation.

In theory, spatial price determination models suggest that, if two markets are linked by trade in a free market regime, excess demand or supply shocks in one market will have an equal impact on price in both markets. Given the wide range of ways prices may be related, the concept of price transmission can be thought of as being based on three notions, or components (Balcombe & Morisson, 2002; Prakash, 1998). These are:

- co-movement and completeness of adjustment which implies that changes in prices in one market are fully transmitted to the other at all points of time;
- dynamics and speed of adjustment which implies the process by, and rate at which, changes in prices in one market are filtered to the other market or levels; and,
- asymmetry of response which implies that upward and downward movements in the price in one market are symmetrically or asymmetrically to the other. Both the extent of completeness and the speed of the adjustment can be asymmetric.

Within this context, complete price transmission between two spatially separated markets is defined as a situation where changes in one price are completely and instantaneously transmitted to the other price, as postulated by the Law of One Price (LOP). In this case, spatially separated markets are integrated. In addition, this definition implies that if price changes are not passed-through instantaneously, but after some time, price transmission is incomplete in the short-run, but complete in the long run, as implied by spatial arbitrage condition. The distinction between short-run and long-run price transmission is important, and the speed by which prices adjust to their long-run relationship is essential in understanding the extent to which markets are integrated in the short-run. Changes in the price at one market may need some time to be transmitted to other markets for various reasons, such as policies, the number of stages in marketing and the corresponding contractual arrangements between economic agents, storage and inventory holding, delays caused in transportation or processing, or ñprice levelingò practices.

Fluctuation in prices seriously affects cereal productivity in Nigeria (Ismaila et al., 2010). For instance, the demise of poultry and poultry processing companies following the outbreak of avian influenza in Nigeria has adversely affected the demand for maize, a major component of poultry feeds across Nigeria. With last yearôs stock of grains still in the market, serious concern has been raised about the impact of the abundant supplies on prices with the exception of sorghum which is commonly demanded by breweries and other drink manufacturing companies in Nigeria. Conversely, the low demand for maize has discouraged many farmers from maize production and consequently increased the price of maize in 2008.

The Nigerian government realizing the importance of the grain sub-sector had several times intervened in standardizing grain prices through agricultural price policy reformation. Some of the instruments used, as pointed out by Okoh and Akintola (2005) and Akpan and Udoh (2009), included input subsidies, strategic grain reserve scheme of 1976, ban on importation of rice and maize in 1985 and the liberalization of the economy in 1986 among other measures. Despite these lofty attempts, the producer prices of grains continued to fluctuate as presented in Table 1.

It is obvious from Table 1 that the major grain crops in Nigeria showed a broad dispersion in producer prices across the specified policy periods. For instance, between 1970 and

1974, the mean producer price of rice was ₦301.40/ton and 17.12 % coefficient of variability in prices. In 1975 to 1979 the mean price of rice increased by more than 100 % compared to the p tfre-Operation Feed the Nation (OFN) period. The fluctuations were the increasing function of time across the specified policy periods. Similar trends were obtained in the producer prices of maize, millet and sorghum. The highest coefficient of variability was obtained during the Structural Adjustment Programme (SAP) period for all the crops. It was 67.97 % for rice, 69.39 % for maize, 83.97 % for millet and 70.64 % for sorghum.

Table 1.1: Major Grain Prices under Different Agricultural Policy Regimes in Nigeria

Policy Regime	Rice		Maize		Millet		Sorghum	
	Mean price (₦)/ton	CV%	Mean price (₦)/ton	CV%	Mean price (₦)/ton	CV%	Mean price (₦)/ton	CV%
Pre-OFN	301.4	17.12	157.4	14.79	140.0	39.56	148.4	19.27
OFN	604.0	20.12	375.8	28.57	141.0	19.32	274.6	12.14
GR	1423.7	38.85	788.0	21.22	622.7	35.36	582.3	32.80
SAP	7483.1	67.97	2938.3	69.39	2759.6	83.97	2689.9	70.64
Post-SAP	39789.8	24.53	20113.8	37.89	19701.0	35.99	1856.2	33.23
Aggregate CV (%)		134.03		138.99		159.13		48.24

Source: Akpan and Udoh (2009)

It is evident however, that farmers in Nigeria in particular and in Africa in general face dramatic fluctuations in prices of the crops they produce (Akpan & Aya, 2009; Fafchamps, 2000; Nuhu, Ani & Bawa, 2009; Nzomoi, 2008; Simister & Chanda, 2006; Williams, 2009; Zulauf & Roberts, 2008). Because of the fixed character of inputs in agriculture especially land and partly labour force as well as the nature of production, agricultural producers very often are not able to respond in the most economical way to the changes in prices of agricultural products and inputs.

These factors of consequence, which is inelastic demand for most agricultural and food product lead to high fluctuation of agricultural product prices. This further reflects in fluctuation of farmersô incomes leading to deterioration of their welfare (Abdissa & Dereje, 2001; Grega, 2002).

According to Grega (2002), these fluctuations in grain prices make agriculture a risky business. In the opinion of Grega (2002), even if inelastic supply of inputs is eliminated (e.g. there is increased flexibility of using agricultural inputs) still many other factors such as weather, disease and pest would be present. Consequences of the risk in agricultural production are the existence of deviations from the balanced volume of agricultural production demanded by the market leading to price instability of this production (Balarabe, Ahmed & Chikwendu, 2006; Doll & Orazem, 1984; Livingstone & Ord, 1984).

Though some level of price fluctuation provides information signals about market situation and may serve as an instrument for adjustment of supply to demand, high price fluctuation has a deteriorating effect on the whole economy and makes social structure unstable (Grega, 2002). Also, Fafchamps (2002) reported that fluctuation in a single commodity price affects farmers who specialize in that commodity. In practice, many resource poor farmers-though not all-have a diversified crop portfolio and should be relatively isolated against single price changes. But the welfare consequences of even a small drop in revenue might be dire. A large commercial farmer may be able to absorb a one year 50% drop in revenue while the small subsistence farmer may starve as a result of a 5 % drop in revenue. It is therefore not surprising that commercial farmer is typically more specialized than the small holder farmer. Agricultural price fluctuation may affect not only farm revenue but also the price farmers pay for the products consumed (Achanya, 2004). A rise in the world price of rice for instance, tends to raise food prices in rice importing countries not only for rice but for other food products which serve as rice substitutes. Previous studies on the marketing and pricing of staple foodstuffs in different parts of Nigeria have concluded that the marketing and pricing information transmission mechanism are inefficient although there are many buyers and sellers in the market (Anthonio, 1968; Dittoh, 1994; Jones, 1969; Okoh & Akintola, 2005; Thodey, 1969).

Agricultural prices greatly influence the pace and direction of agricultural development. Prices serve as market signals of the relative scarcity or abundance of a given product. Prices also serve as incentives to direct the allocation of economic resources and to a large extent they determine the structure and rate of economic growth (Ariyo, Voh & Ahmed, 2001). Information on agricultural commodity price in both developed and developing countries like Nigeria is important to both producers and consumers. Prices vary among markets and almost throughout the year, and understanding the nature and trend of such variations is essential for good planning by the producers, consumers and policy makers alike (Adegeye & Dittoh, 1985; World Bank, 2000).

1.2 Problem Statement

There have been reports about food insecurity, rising prices and vulnerable population. The World Food Programme (WFP) (2011) has said that the crisis was a silent Tsunami that was threatening to plunge more than 100 million people on every continent to hunger. The increasing commodity prices and the attendant social unrest have not been confined to the developing countries alone. Spain, Israel and South Korea have witnessed demonstrations by consumers protesting increased commodity prices. The rising global food prices pose a serious threat to political stability especially to the developing countries. There have been riots in Burkina Faso, Cameroun, Egypt, Indonesia, Cote dõIvoire, Mauritania, Mozambique, Senegal and Zimbabwe among others. In Haiti, where food prices had risen by 65 % in the last six years, protesters recently took to the street comparing their hunger pangs to the burn of battery acid! In Nairobi, police violently dispersed demonstrators who were agitated by continuous rise in food prices in May 2008. The World Bank has identified 33 countries at risk of public disorder on account of soaring food prices.

According to Akpan and Udoh (2009), agricultural commodities price have experienced unprecedented fluctuations and continuous increases since 2002 until mid-2008. They argued that this has brought about price volatility, food inflation, poverty and hunger. Coupled with inadequate market price transmission, high food prices has increased the levels of food deprivation, droved millions of people into food insecurity, worsening conditions for many who were already food insecure, and threatening long term global food security. This places a tremendous pressure on achieving the Millennium Development Goals (MDGs) on hunger by year 2015 (FAO, 2008).

Fluctuations in food prices might not be rapid, but they create pressure on wages, lower real incomes, rising inflation, unemployment and decreasing demand for non-agricultural products. On the other hand, price decline could lead to a misleading allocation of inputs in agricultural sectors, which could seriously damage production ability and international competitiveness of this industry. Grega (2002) stated that if agricultural product prices were too low, the situation in the sector could be deteriorating by the consequent outflow of qualified labor force to other sectors of the economy and lead to migration of rural population to the urban areas and so, cause the depopulation of the rural areas. Production activities in the grain sub-sector may be retarded due to produce price uncertainty and production risk and marketing inefficiency. Resource use efficiency may also decrease because farmers may have less useful information on prices to guide them in production decision.

Policy formulation has failed to take cognizance of the fact that production and marketing /pricing constitute a continuum and that the absence of development in one retards progress in the other (Okoh & Akintola, 2005). Since the agricultural producer is both a seller of his produce as well as a buyer of agricultural production requisites, agricultural prices cover not only the prices ñreceivedò by farmers (ñoutput pricesò) but also the prices ñpaidò by farmers (ñinput priceò). The farmer is also a buyer of consumer goods for use in his own household, while the second category of purchase can be regarded as ñagricultural pricesò the third category of purchase are not to be regarded as ñagricultural pricesò. The second and third categories of the prices are not, therefore, strictly within the coverage of this study.

There have been researches over the years on the integration of various combinations of Nigerian foodstuff markets, only one has been identified in the north-eastern Nigeria. The principal studies in this area include those of Anthonio (1968, 1988), Jones (1969), Gilbert (1986), Thodey (1969), Hays and McCoy (1977), Delgado (1986), Adekanye (1988), Ejiga (1988), Dittoh (1994), Okoh (1999), Okoh and Akintola (1999), Nuhu et al. (2009), Obayelu and Salau (2010), and Ugwamba and Okoh (2010). These studies covered market integration, price efficiency and pricing conduct of various foodstuffs (gari, rice, cowpea, cassava roots, vegetables, sorghum, and maize) in different regions of Nigeria. The price series used for the various studies were collected weekly or fortnightly by the researchers except for Okoh (1999), and Okoh and Akintola (1999) which used monthly series collected by staff of Agricultural Development Projects (ADPs). With the exception of Dittoh (1994), Okoh (1999), Okoh and Akintola (1999) and Obayelu and Salau (2010), these studies used the classical correlation coefficients and simple static regression equation of the form ($P_1 = A + bP_1$) to draw conclusions about the integration and efficiency of the markets for various foodstuffs.

The findings of these studies are doubtful. This is because the bivariate correlation coefficient and static regression methods are beclouded by problems of overwhelming seasonal and secular trends, as well as the possibility of autocorrelation from a static model calibrated to non-stationary time series, leading to spurious correlations and inferential errors (Blyn, 1973; Delgado, 1986; Granger & Newbold, 1974; Harris, 1979; Iyoha & Ekanem, 2004; Palaskas & Harris-White, 1993; Ravalion, 1986; Timmer, 1994).

Among these studies, only Nuhu et al. (2009) was undertaken in the north-eastern Nigeria and employed the static linear regression model in drawing conclusion about how markets were cointegrated and none attempted forecasting price of agricultural produce. This study has adopted a vector Autoregressive Model (VAR) and an Error Correction Model (ECM) in addressing the spatial market integration. Also, previous studies (Simister & Chanda, 2009) claimed an alarming increase and instability in staple food prices in the northern Nigeria. The various components of price and the probability distribution of price were considered to estimate each component and forecast the prices of the three commodities (maize, rice and sorghum).

The extent of uncertainty caused by price inefficiency and instability in the agricultural sector has made the industry a risky one. Therefore, there is the need to examine the integration of rural and urban markets in relation to competitiveness, effectiveness of arbitrage and pricing efficiency in cereal grain (maize, rice and sorghum) marketing in the north- eastern Nigeria. The salient research questions for which answers were provided for in this study are:

(i) what is the magnitude of the various components of price?

(ii) what is the probability distribution of cereal price in the long-run?

(iii) does inter-market price dependencies exist and at what level?

(iv) is the price adjustment in the market delayed or instantaneous? aynd

(v) what is the nature of causality if any among rural and urban markets?

1.3 Objectives of the Study

The broad objective of this study is to analyze the price fluctuation and market integration of selected cereal grains in North-east Nigeria. Specifically the study:

i. estimated the extent of the various components of price;

ii. derived the probability distribution of cereal price in the long-run;

iii. determined the existence and level of inter-market price dependencies;

iv. examined the speed of price adjustment to long-run equilibrium; and

v. examined the Granger-Causality among urban and rural markets.

1.4 Research Hypotheses

The following null hypotheses were tested to guide the study:

(i) farmers will not receive better prices in the long-run.

(ii) cereal grain markets are spatially independent and inefficient

(iii) there is price collusion with instantaneous price adjustment,

(iv) there is price matching with delayed price adjustment, and

1.5 Justification of the Study

Agricultural prices are important economic variables in a market economy. Price relationships have a significant influence on decisions relating to the type and volume of agricultural production activity. They provide a measure for reaching judgment on policy formulation and administrative and executive action.

In the short-run, an individual farmer needs output prices to determine the price and volume of his sales so as to optimize the return from his farm production. In the long run, knowledge of price trends helps a farmer to formulate the investment plan on his farm and to take decision on the structure and nature of his enterprise. An understanding of the normal differences in the prices of his products and production requisites during the year helps a farmer to react logically to the marketing situations in order to optimize the planning of the sale of his product and the purchase of his supplies. His production plan is governed by the price expectations of the various commodities he can produce.

Business organizations use agricultural price data in a number of ways; such as planning the size of their agricultural business enterprise, determining the time and place for purchasing agricultural production requisites, deciding on inventory expansion or contraction and hedging, selecting the market and time of sale of their produce so as to reap the best advantage and formulating credit policies. These organizations also use price information to decide on the nature and volume of storage accommodation needed for stocking goods and to determine the quantum of flow required from time to time to keep prices from fluctuating sharply.

Accurate and reliable agricultural price information for different crops in different areas at different times is necessary for any rational policy on prices of agricultural products. To this end, this work is hoped to be a valuable source of information to policy makers, producers and consumers. It would also be relevant in the academics for teaching and research purposes as well as a body of knowledge that would promote greater awareness on market price survey. It would also add to the volume of literature on price analysis.

1.6 Limitations of the Study

The following were the limitations of the study:

i. the study of spatial market integration requires information on prices, trade flows and transfer costs, however, the study was limited to wholesale prices, since that was the only information available. Transfer cost and other information on cost that are needed in the determination of factors responsible for cointegration are always difficult to come by especially in Africa. Therefore, the study only performed the cointegration of rural and urban markets;

ii. the study did not cover the entire North-eastern states due to the intense security challenges posed by insurgent Boko Haram in the geopolitical zone, hence only the two states of Adamawa and Taraba were purposively selected for the study since these were the less vulnerable states as at the time of study; and

iii. analysis such as that of Markov Chain and decomposition of time series data, were done manually as a result of non-availability of statistical packages to handle them, hence cumbersome. Because all the analysis of Markov chain and decomposition technique were done manually and as result took a lot of time in bringing the result out.

CHAPTER TWO

LITERATURE REVIEW

In this chapter, a review of literature on price fluctuation and market integration were provided. Some concepts on spatial competition were discussed. Theoretical framework was presented in section 2.2. In sections 2.3, 2.4 and 2.5 time series, unit roots and spatial market integration were discussed, respectively. Finally, empirical studies related to the research were also presented.

2.1 Spatial Competition

The most natural criterion for the separation of consumers and an individual consumer market is a spatial one. Households, farms, and business exist, purchase and consume in a spatial environment. Products are manufactured at one location and then distributed to various and numerous markets, when factors such as a transportation costs and general frictions of distance, such as loss of information and inconveniences, markets are more clearly understood in a spatial environment.

Hotelling (1929) first focused on the location of the firm, suggesting that consumers do not always buy from the least expensive supplier because firms are differentiated by their locations or product characteristics. He described the disutility of travel to make a purchase as different from simply a disparity of transportation cost. Thus, consumers at different locations pay different prices for the same good. Capozza and Van Order (1978) stated two essential distinguishing features of spatial competition: transportation costs and downwards sloping average costs curves over some range of quantity sold. In the modern world, transportation costs include shipping costs for remote purchases and must vary across possible purchase sites to make location matter. Average cost curves are assumed to be negatively sloped within some quantity range (due to economics of scale or fixed costs) since otherwise there would no advantage to concentrating production.

Often discussed in the literature are two basic, yet opposing forces that influence a firmôs location decision to either cluster with competing firms or to disperse from them. The first force leads firms to locate near competitors in an attempt to capture, or steal, more customers. Pinske and Slade (1998) termed this effect the *market share effect*. Working against the *market share effect* is the *market power effect*. The *market power effect* relies on the theory that reduced spatial competition leads to overall decreased competition and increased sales. Basically, firms locate further away from competition in order to capture consumers within a specific area. Thus the theory of *market power effect* is for firms to locate further from rivals. Pinske and Slade (1998) in a review of empirical literature, found that the *market share effect* dominates over *market power effect*. That is, firms tend to cluster. The three main conjectural variations considered in the analysis of spatial economic theory (Greenhut, Norman & Hung, 1987) are Loschain competition, Hotelling-Smithies competition, and Greenhut-Ohta competition. The Hotelling-Smithies assumption is equivalent to the Betrand assumption in the traditional, non-spatial analysis of an oligopoly; that is rivals will not alter price regardless of action made by the firm. Hotelling-Smithies competition can result in market prices that are higher or lower than in perfect competition.

According to Greenhut and Ohta (1975) firms treat their market and price as highly available. The Greenhut-Ohta model assumes each firm selects a pricing policy to maximize profits subject to a given price constraints at the edge of its market. Greenhut-Ohta competiton theory leads to lower prices and is very similar to Hotelling-Smithies competition in its predicted pricing behaviour. The Hotelling-Smithies and Greenhut-Ohta assumptions about firmsô conjectural variations lead to the following theoretical predictions.

- as transport cost and/or fixed cost approach zero, non-spatial perfect competition results, and the firmsô price approaches marginal costs.
- increases in fixed costs, marginal costs, and transport cost all lead to the classical theory result of an increase in price.
- as more firms enter the industry or market, the increased competition lowers price.
- price fall the long run as population increases.

Loshain competition occurs when firms believe that rivals will pursue price strategies to maintain a fixed market area, implying price changes will be matched exactly. Loschain competition leads to a contradiction of the expected outcome of non-spatial competitive theory. Loschain behaviour leads to high shot-run profits which are diluted by entry in the long run (Fik, 1988). The theoretical predictions for Loschian competition are as follows:

- as transport cot and/or fixed cost approaches zero, price will approach the non-spatial monopoly price.
- as fixed cost and transport costs rise, price fall, whereas an increase in marginal cost leads to ambiguous results.
- as firms enter and thus competition increases, prices increases.
- price increases as population density, or consumers, increases.

Very few studies have been done on spatial competition in the agribusiness sector. Fik (1988) studied spatial competition in food markets or supermarkets. He theorized that price competition in the retail food markets is highly dependent on the location and /or the distance to rival firms. His result concluded a solid link between price and the intensity of price reaction as a decreasing function of distance. Durham, Sexton & Song (1996), examined the role of spatial pricing in the allocation of tomatoes from farms to processing facilities across the state of

California. The aim of the study was to determine if the tomato farmers were shipping the product to the most profitable processing facilities. The result indicated that farmers were hauling the tomatoes an extra 10 miles per trip to the processing plant. This misallocation was estimated to cost an extra $7.41 million dollars in transportation cost. However, this represented only a 1.9% loss from potential industry wide profit.

2.1.1 Estimating spatial price relationship

Various approaches have been used to study spatial price relationships. The estimation of static bivariate correlation coefficient is a traditional method of measuring the spatial price relationship. From a modeling perspective, the approaches to spatial price analysis and market integration can be grouped into two categories. In the first group is the Law of One Price (LOP), and Ravallion model. These approaches are based on co-movement of prices. The second approach is the co-integration test. This allows prices to be determined simultaneously and permits seasonal variation in transfer costs.

One of the approaches to test the LOP is regressing the price of one market on the price of another market and test whether the slope coefficient is 1. Considering the two markets: market 1 as local market and market 0 as central market, the basic model for it is as follows:

$$P_{1t} = b_0 + b_1 P_{0t} + u_t$$

P_1 and P_0 are the prices in two markets expressed in logarithmic form. Assuming that products are homogenous and there is an absence of transportation cost, the LOP holds if $b_1 = 1$ and $b_0 = 0$. However, the existence of transfer cost cannot be ignored. Transfer cost may vary with the lapse of time so the ignorance of it may affect the LOP test. Moreover, Ravallion (1986) states that such models represent only a simple radial configuration of market linking one market directly with another market. Such a model also does not take into account the intermediate markets via which a local market trade with the central market. He further argues that this model provides limited information about the market integration. Ravallion extended the bivariate method to a dynamic model which captured both short-run and long-run dynamic adjustment processes. It is based on the behavioral assumption that, it requires a time to adjust before the price shocks in the central market are transmitted to the local market. The model involves regressing the price of one market at time t to the lagged price and the price of another market at time t.

$$P^1_t = \text{Ŭ}P^1_{t-1} + \text{ɓ}P^0 + e_t$$

The hypothesis for short run market integration is given by ɓ = 1. It indicates that the price shocks in the central market are immediately transmitted to the local market price. While for long run market integration in which the market prices are constant over time and is not disturbed by the shocks in the central market- it requires that Ŭ + ɓ = 1

With the advancement in time series modeling, the co-integration approach has been widely used, using time series data on prices that exhibit random walk. Generally, if two markets are integrated the prices of the two markets are considered to be co-integrated. However, McNew (1996) argues that the variables that maintain economic equilibrium do not necessarily satisfy a co-integrating relationship because of transfer costs. Recognizing the importance of transaction cost, researchers have applied switching models that endogenize the transfer cost in the model and account for multiple regimes. Bausch (1997) used the parity bounds models (PBM), which takes into account the transfer costs. In this model, the transfer costs determine the parity bounds within which the commodity in two markets may vary independently. This model distinguishes three possible trade regimes:

(a) at the parity bounds-the spatial price differential is equal to the transfer cost;

(b) inside parity bounds-in which prices deferential are less than the transfer costs; and

(c) outside parity bounds-in which price differential is greater than the transfer costs.

The higher the incidence of outside parity bounds the lower the market integration. Another approach is switching regression systems which are estimated using the maximum likelihood estimation technique (Spiller & Huang, 1986). In this case the prices are not treated as the predetermined variables. The transfer costs are determined within the system, and the probability that markets are integrated is allowed to vary continuously. Sexton et al, (1991) applied the same method with an extension to study the effect of legged price, which allows for determining the probability of efficient arbitrage, glut and shortage for a given market. Both Spiller and Huang (1986) and Sexton et al, (1991) have assumed a continuous trade and the direction of trade flow as constant. The discontinuous trade and time varying non-stationary transaction costs are the major problems that affect the spatial price analysis (Barrett & Li, 2002).

Though the importance of transfer costs in spatial price analysis is well recognized, the lack of suitable data on transfer cost constraint the modeling process. Getting a reliable data on transfer cost over the selected period of time is a problem. Moreover, most of these models are based on specific assumption and have ignored the seasonality in model specification. Agricultural commodities being seasonal in production, the prices of commodities and price spread are expected to vary seasonally.

2.2 Theoretical Framework

The principle of market integration is hinged on the ñLaw of One Priceò (LOP), which is the hallmark of the model or theory of perfect competition. A central prediction of the theory of perfect competition is that the price of all transactions will tend to uniformity, allowing for differences in transportation costs between different spatial markets. The Marshallian repositions on the economic market state that two regions are in the same economic markets for a homogenous goods if the price for that goods differs by exactly the inter-regional transportation cost. The most common expression of LOP is given by:

$$Y_{1t} = K + Y_{2t}$$

Where Y_{1t} and Y_{2t} are equal prices of commodity in two spatially differentiated markets, rural and urban respectively. If K = 0, then the two prices are equal. This is the strict version of the LOP. If on the other hand, K is not equal to 0, then the prices have a proportional relationship, but their levels would differ owing to factors such as transportation cost, interest rates, market fees, quality differences, etc. This is the weak version of the LOP (Asche, Bremnes & Wessells, 1999).

The static price correlation or regression approach has traditionally been the basic approach for testing the presence and level of integration in pairs of spatially dispersed markets. A typical regression model to test for market integration between two markets under the traditional static method is specified as follows:

$$Y_{2t} = K + BY_{1t} + et$$

Where;

Y_{1t} = price for a central (urban) market in time T

Y_{2t} = price series for a peripheral (rural) market in time t

K = the intercept term

B = a parameter of the slope

et = error term

The test for convergence to LOP is carried out by testing the null hypothesis: HO: B = 1. The static model fails to determine the structure of the error term, nor does it produce an unbiased estimate. Also, the possibility of the presence of unit roots in the price series cannot be ruled out. Hence, normal inferences are not valid on the parameters in Equation 2. The LOP can therefore not be tested for by running this regression (Asche et al., 1999). The next plausible step is to test the series for non-stationarity. It is expected that two price series of the same group of commodities might have a long-term equilibrium relationship between the series. Stationarity tests were proposed by Dickey and Fuller (1979).

2.3 Time Series

Pearson (1925) explicitly described the different components of a time series. These components were;

i. a long-term or secular trend often termed as the growth element;
ii. a wave-like or cyclical element in which rise and fall correspond to prosperity and depression of a business cycle;
iii. a seasonal movement or short-term fluctuations; and
iv. a random or irregular variation.

Decomposing an observation in a series into the above four components constitute the analysis of a time series. An observation is generally considered to be the end result as a sum of these components or as a product of these components; the time series model accordingly termed as an additive or a multiplicative model.

2.3.1 Stationary and nonstationary time series

Most economic time series are strongly trended and hence nonstationary. Yet, many economist and econometricians specify relationship between economic time series variables as if they were stationary. Correct and appropriate specification and estimation of time series models require that we determine whether the time series are stationary or nonstationary. For example, difficulties arise when running regression equations with time series that are clearly nonstationary. This leads to the so-called ñnonsenseò correlations, or ñspuriousò regression (Granger & Newbold, 1974). It should be emphasized that a meaningful equilibrium or long-run relationship can only be properly specified between (or among) stationary economic time series variables.

2.3.2 Stationarity

One important class of stochastic processes is that of stationary stochastic processes. The concept of stationary time series arises from the existence of nonstationary stochastic processes. We may define a stationary process as one whoôs joint and conditional distributions are invariants with respect to displacement in time. From this definition, it is obvious that if the underlying stochastic process which generates a given time series is stationary (that is invariant overtime), then one can model the process by means of an equation with fixed coefficients that can be estimated from past data. It should be noted that since the time series are stationary, the structural relationship described by the equation is also stationary, that is, invariance with respect to time. However, if the characterization of the stochastic process changes over time, that is, the process is nonstationary, then it is clearly difficult to represent the time series over the past and future periods by a simple equation or model. This is why a regression of a relationship specified between nonstationary time series will exhibit unstable parameter estimates (Iyoha & Ekanem, 2004).

According to Dittoh (1985), a stationarity possesses the following properties:

(i) Its joint and conditional distributions are invariant with respect to displacement in time. Ts, if the series Yt is stationary, then P (Yt, é ..Yt + k) = P(Yt + m,é .Yt + k + m) and P(Yt) = P(Yt + m) for any t, k, and m.

(ii) The mean of the series, defined as εy = E (Yt) must, also, be stationary, so that E(Yt) = E(Yt + m) for any t and m.

(iii) The variance of the series ǔ^{2}y = E(Yt - εy)^2 must be stationary so that E[(Yt ï εy)^2)] = E[(Yt + m ï εy)^2].

(iv) For any lag k, the covariance of the series Yk = cov(Yt, Yt + k) = E [(Yt ï εy)(Yt + k ï εy)] must be stationary so that cov (Yt, Yt + k) = cov (Yt + m, Yt + m + k).

Therefore, if the stochastic process is stationary, the probability distribution, P (Yt) is the same for all time t and its shape can be inferred by examining a histogram of the observation Yt, é .., Y_T of the time series. An estimate of the mean εy of the process can be obtained from the sample mean of the series.

$$\overline{Y} = \frac{1}{T}\left[\sum_{t=1}^{T}(Yt)\right]$$

While an estimate of the variance ǔ^{2}y can be obtained from the sample variance.

$$S^2 y = \frac{1}{T}\left[\sum_{t=1}^{T}\left(Yt - \overline{Y}\right)^2\right]$$

2.3.3 Nonstationarity

Since most time series encountered in applications are nonstationary, there is need to analyze nonstationary time series. Although simple nonstationary time series models can be directly analyzed, the usual procedure is to transform a nonstationary time series to a stationary one before modeling and estimation. Fortunately, it has been found by statisticians and econometricians that even though most economic time series are nonstationary, they have the desirable property that if they are differenced just once (or sometimes trice), the resulting time series will be stationary. This type of nonstationary time series is called homogenous while the number of times which the time series must be differenced in order for it to attain stationarity is known as the order of integration or homogeneity.

Thus, consider the nonstationary time series denoted by Y(t) is first-order homogenous nonstationary, then φY(t) = Y (t) ï Y(t-1) is stationary. Similarly, if Y(t) is second-order homogenous nonstationary, then $φ^2$Y(t) ï φY(t-1) is stationary.

2.4 Unit Roots

Testing for the existence of unit roots is a key pre-occupation in the study of time series models and cointegration. A stochastic process Y(t) is known as a unit root if its first difference, Y(t) é Y(t-1) is stationary. Thus stochastic process with a unit root is itself nonstationary. Another way of looking at it, is the testing for the presence of unit roots which is equivalent to testing whether a stochastic processes is a stationary or nonstationary process. In sum, the presence of a unit root implies that the time series under scrutiny is non-stationary while the absence of a unit root means that the stochastic process is stationary. Maddala and Kim (1998) has offered an interesting perspective and interpretation on the testing for unit roots. According to him, test for unit roots is a formalization of the Box-Jenkins method of differencing the time series after a visual inspection of the corellelogram. No wonder then that testing for unit roots plays a central role in the theory and technique of cointegration.

Currently, the most commonly accepted method of testing for unit roots is by use of the Augmented Dickey Fuller (ADF) test (Dickey & Fuller, 1979; Obayelu & Salau, 2010). The Augmented Dickey-Fuller (ADF) test is considered superior to the Dickey-Fuller (DF) test because it adjusts appropriately for the occurrence of serial correlation. The Microfit 4.1 for Windows PC software, Persaran and Persaran (1997) provides facilities for performing DF and ADF tests.

2.5 Conceptual Framework

Spatial market integration refers to co-movements of prices, and more generally, to the smooth transmission of price signals and information across spatially separated markets. There are several reasons for studying market integration. Such study makes it possible to identify groups of integrated markets, so as to avoid duplication of government intervention. If locations A, B and C are well integrated, then the government may think of withdrawing from, or at least reduce its effort to influence the price process in those locations. A scarcity in A is quickly transmitted to B and C, making it redundant to duplicate the same programme (for example, an open market sale operation or a procurement activity) in all three locations. Moreover, by giving a more detailed picture of the process of transmission of incentives across the marketing chain, knowledge of market integration is relevant to the success of policies such as market liberalization or price stabilization. Market integration ensures a regional balance among food-deficit and food-surplus region, and regions producing non-food cash crops (Delgado, 1986). If price transmission does not occur, the localized scarcities and abundance may result in excessive strain on the population (Ravallion, 1986).

The study of market integration has usually tried to characterize the degree of co-movement of prices across spatially separated markets. Since prices are the most readily available and often the most reliable information in developing countries marketing systems; market integration studies have almost exclusively referred to events resulting in price changes. Most specifically, market integration is restricted to the interdependences of price changes across spatially separated locations in the market.

2.5.1 Measures of integration

The intuitive idea behind the measurement of market integration is to understand the interaction among prices in spatially separated markets. In the extreme case of two markets A and B completely separated from each other, the prices of the same commodity should not be related. If the areas where market A is located experiences a bad harvest, prices will suddenly increase. In market B, there is no reason to assume that a bad harvest has also occurred. In the absence of communication flows between the two markets, prices in B would not show any movement. On the other hand, if A and B were integrated, the price in B would also increase. This is because some food would flow from B to A decreasing the available supply in B. At the same time the price in A would be lower than B in the absence of market integration.

Therefore, the co-movement of prices gives an indication of the degree of market integration. However, it is conceivable that two pairs of market (A, B) and ($A^{\sim}$, $B^{\sim}$) exhibit the same price co-movement and yet show a different process of price adjustment. That suggests that the dynamics of price adjustment may also give important information about the integration of the two markets. If for example, price shocks from A to B take longer to be transmitted, than from $A^{\sim}$ to $B^{\sim}$, even though the index of price co-movement between A and B is the same as between $A^{\sim}$ and $B^{\sim}$, then we may think of the second pair more integrated than the first one.

The analysis of and testing for unit roots naturally lead to the theory of cointegration. This is because, basically, cointegration deals with the methodology of modeling nonstationary times series variables. In one way, cointegration can be looked upon as an attempt to improve on the Box-Jenkins methodology. Cointegration retains the focus and emphasis on the dynamic structure of the time series while bringing in explanatory variables as suggested by traditional economic theory of an econometric modeling. According to Maddala (1992), ñthe theory of cointegration explains how to study the interrelationship between the long term trends in the variables, trends that are differenced away in the Box-Jenkins methods. Another way to conceptualizing cointegration and error-correction modeling is that it is an extension and generalization of the traditional approach to modeling short-run disequilibrium by use of the partial adjustment (Also called stock adjustment) model. It will be seen later that the error-correction model (ECM) which incorporates the previous periodôs disequilibrium, in the final equation, can be conceptualized as a straight forward generalization of the partial adjustment model. However, use of the methodology of cointegration and ECM adds more richness, flexibility and versatility to the econometric modeling of dynamical systems and the integration of short-run with long-run equilibrium.

The tight linkage between cointegration and ECM stems from the Granger representation theorem. According to this theorem, two more integrated time series that are cointegrated have an error correction representation, and two or more time series that are error correcting are cointegrated (Eagle & Granger, 1987). In short, the two concepts are isomorphic, as each implies the other. The concept of cointegration and ECM are introduced to avoid spurious regression. While the theory of cointegration was developed by Granger (1983) and Granger and Weiss (1983), ECM was introduced by Phillip (1964). It have been observed that since the application of ECM, it has been playing an important role in the dynamics of both short-run (change) and long-run (levels) adjustment processes. The cointegration and ECM takes account of the dynamics adjustment to steady state targets by including in the short-term dynamics as a measure of how far from equilibrium the variables were at the start of the period.

The VECM which employs cointegration is used in the analysis of the model specified for this study. A prerequisite for the VECM estimation is the determination of the characteristics of the time series variables in the model as to whether they are stationary or non-stationary. The VECM is restricted vector autoregressive (VAR) designed for use with non-stationary variables that are known to be cointegrated. VECM specification restricts the long run behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. Vector error-correction models (VECMs) are widely used to model economic variables that are non-stationary individually but linked by long-run relationships. A ñstandardò VECM assumes that these variables follow a linear adjustment process towards their long-run equilibrium. Eagle and Granger (1987) showed that if the variables, say Xt and Yt is found to be cointegrated, there will be an error representatives which is linked to the said equation, which gives the implication that changes in dependent variable is a function of the imbalance in cointegration relation (represented by error correction term) and by other explanatory variables.

According to Hendry and Juselius (2000), the VECM is facilitated when variables are first differenced stationary and cointegrated. Determination of stationarity is important in that it ascertains the order of integration and if not present, the number of times a variable has to be differenced to make it stationary. Cointegration is a restriction on a dynamic model, it is inherently multivariate, since a single time series cannot be cointegrated and it is testable. A method of classification for non-explosive processes are denoted by I(0), those that become stationary processes by taking first, second differences are designated as I(1), I(2) respectively.

Each of the economic variables is I(0) or I(1) are: the Dickey-Fuller (DF) and the Augmented Dickey Fuller (ADF) tests. The DF and ADF procedures are based on the standard t-test. Fuller, (1976) can be carried out by applying a regression such as: $x_t = ax_{t-1} + c_t \ d \ u_{t.}$ on the variable and comparing the t- value with Fuller (1976) t-distribution table, if the t-value is significantly negative, the variable regarded as I(0) instead of I(1). The ADF test allows for more dynamics than the DF and the number of lags can be varied. But on situation where the ADF test proves inconclusive, the graphical representation of the data in levels and first differenced may be relied upon (Koekemoer, 1999).

Cointegration vectors are of considerable interest when they exist, since they determine I(0) relations that hold between variables which are individually non-stationary. Such relations are often called ólong-run equilibriaô, since it can be proved that they act as óattractorsô towards which convergence occurs whenever there are departures (Banerjee et al., 1993; Granger, 1986). Hendry and Juselius (2000) states that when data are non-stationary purely due to unit roots integrated once, denoted I(1), they can be brought back to stationarity by the linear transformation of differencing, as in $x_t - x_{t+1} = \varphi x_{t-1}$

To find out which variables adjust, and which one do not adjust, to the long-run cointegration relations, an analysis of the full system of equations is required. According to Hendry and Juselius (2000), the constant terms, ´$_t$, can both describe an intercept in the cointegration relations and linear trends in the variables and empirical analysis can be used to estimate both effects. However, a rank (r) determination for cointegrating vectors can be based on the maximum likelihood approach proposed by Johansen (1988). In this, the first, and most crucial step is to discriminate empirically between zero and non-zero eigenvalues when allowing for sample variation, and then to impose an appropriate cointegration rank restriction r and π matrix.

2.6 Markov Chain

Andrei Adreevich Markov (1856-1922) was the first to develop the modern theory of stochastic processes. In mathematics, a (discrete-time) Markov chain, named after A.A. Markov, is a discrete-time stochastic process with the Markov property (Breiman, 1992). In such a process, the past is irrelevant for predicting the future given the knowledge of the past.

There are also continuous-time Markov chains. A Markov chain is a sequence X_1, X_2, X_3é X_n of random variables. The range of these variables, i.e., the set of their possible values, is called the state space, the value of X_n being the process at time n. Of the conditional probability distribution of X_n + 1 on past states is a function of X_n alone, then:

$$P\ (X_n + 1 = X|X_0, X_1, X_2\text{é}\ \ X_n) = P\ (X_n + 1 = |X_n).$$

Where X is some ñStateò of the process.

The identity above identifies the Markov property. Markov produced the first result in 1906 for these processes. Markov chains are related to Brownian motion and the Ergodic hypothesis, two topics in Physics which were important in the early years of the twentieth century, but Markov appears to have pursued this out of a mathematical motivation namely, the extension of the low of large numbers to dependent events. Markov chains are used to model various processes in queuing theory and statistics, and can also be used as a signal model in entropy coding techniques such as arithmetic coding. Markov chain also has many biological applications, particularly population processes, which are useful in modeling process that is (at least) analogous to biological population. Hidden Markov models have been used in bioinformatics as well, e.g. for coding region/gene prediction (Markov, 1971).

2.6.1 Markov processes and random walk hypothesis

The term ñrandom-walkò arose in a bizarre way in the correspondent column of the journal ñNatureò in 1905, in which there was a discussion about how best to set about finding a drunken man who had for some reason, previously been left in an empty field. The drunken man (assuming of course that his faculties have not been totally paralyzed) will walk, or stagger, at random, without any particular purpose or plan. Therefore, the best place to start looking for him is where he was left, as this is the least biased estimate of his actual location (Feear, 1988).

Earlier, Bachelier (1990) had published a study of commodity prices which exhibited random-walk characteristics, although he did not use the term. He stated that commodity price speculation in France then was a ófairô game because neither buyers nor sellers could expect to make profits since the difference between the actual and expected price each day would, if added together for a long enough periods, sum to zero, that is, would cancel out. Also, in 1953, the Royal Statistical Society met in London to discuss a rather unusual paper. Its author, Kendall (1983) was a distinguished statistician, and the subject was the behavior of stock and commodity prices. Kendal had been looking for regular price cycles, but to his surprise he could not find them. Each series in his study appeared to be ña wandering oneò almost as if once a week the demon of chance drew a random number and added it to the current priceò. In other words, the prices seemed to follow a random walk.

Nothing much happened for well over half a century apart from studies which were not specifically aimed at investment strategies. However, in 1959, two studies were published in the USA by Roberts (1959) and Osborne (1959), both of which suggested that stock markets prices were the result of random process. Indeed, Osborne, a physicist, likened their behavior to that of molecules suspended in solution. In Britain, Little (1962) observed a similar randomness in the movements of earnings and growth rates in over 500 listed companies which he published under the title óHiggledy Piggldey growthô, his findings were doubted by Rayner, but he subsequently was converted to the same view and they jointly published a book under the title ñHiggledy Piggledy Growth Againò (Rayner & Little, 1966).

Fama (1965) studied the proportionate daily price change of the thirty shares comprising the Dow Jones industrial average between 1957 and 1962. He found out that there was no significant serial correlation (relationship overtime) among the price changes, not even if a ólaggedô relationship were used. To ensure that the low levels of correlation found were not biased by a small number of extreme observations, Fama looked at the signs of the price changes (plus or minus) rather than their size, to see if runs of one sign tended to persist. If they did, then this would imply a trend, and the randomness of the data would be in doubt. Overall, the departure from randomness was very small, and thus a further piece of evidence was added in support of the random-walk hypothesis.

Markov process (a new test) is specifically applicable to systems that exhibit probabilistic movement from one state (or condition) to overtime. For example, Markov analysis can be used to test the random walk hypothesis and other aspects of the efficient market hypothesis under a different set of assumptions that are traditionally needed. The Markov test does not require annual returns to be normally distributed, although they do require the Markov chain to be stationary. Markov chain stationary is defined as constant transition probabilities overtime. However, one cost of modeling returns with Markov chains is information that is lost when no continuous values returns are divided into discrete states (McQueen & Thorley, 1991).

2.7 Analytical Framework

Time series may be affected by some factors, which are recurring or non-recurring and periodic or random. Hence all these four components; trend, circular, seasonal and irregular/random, jointly or severally, are found in a time series (Kelechi, 2004). The decomposition of time series prices is to isolate trend, cyclical movement, seasonal, and irregular component in order to explain the dynamics of price variability. We may assume a multiplicative or additive relationship among these components. In the first case, the observed value (yt) at any time is assumed to be the resultant product of the play of the four forces:

$$Yt = T^* C^* S^* R$$

That is to say thus, the four components are related to one another. Also, St, Ct, Rt are expressed as percentages. Practically, all the series in the economic and business domains consists of seasonality and cycle, which are proportional to the trend (Kelechi, 2004). Hence, the multiplicative model will be appropriate for this study. In the second case, it is the resultant sum of the four forces;

$$Yt = T + C + S + R$$

The multiplicative hypothesis amount to a long-additive relation.

Since $Yt = T^* C^* S^* R$

Therefore, $\ln Yt = \ln T + \ln C + \text{Ln} S + \text{Ln} R$

2.7.1 Studies on market integration around the world

Cointegration is a technique that is used to assess the market integration. Market integration is a relationship between two markets with regard to prices of a certain commodity. Markets are said to be integral if price variation in one market associated with the price prevailing in other market and vice versa. This is refluxed by correlation between prices of two markets with same period.

Farooq (1970) studied on market performance of rice marketing system in East Pakistan. In order to know the relationship, he computed correlation between secondary markets between terminal and secondary markets and between terminal markets and found them to be 0.90, 0.86 and 0.80, respectively. Thus, it indicated that the lesser the distance the higher was the correlation and greater the degree of market integration.

Byln (1973) estimated the market integration by computing the correlation coefficients for the de-trended and de-seasoned data for eight markets in Punjab. The author pointed out that the average ŕrô was equal to ŕrô between Delhi and other markets indicating the dependence of Delhi prices on the prices all over other collecting markets. The study also showed the lower ŕrô prices were lower and vice- versa.

Thakur (1974) studied food grain marketing efficiency in Gujarat to estimate market integration. He computed the correlation coefficients between wholesale prices to ten markets. He found that only three markets showed higher correlations between wholesale prices for paddy compared to Bajra and Jowar. The correlation coefficients of price series between different markets were high, which pointed out to a high degree of pricing efficiency.

Krinshnaswamy (1975) studied the behavior of market arrivals of (food) groundnut prices of Rajasthan. He observed that six out of eight cases studied showed that market arrivals were positively related to prices.

Singh and Arora (1975) examined the extent of market integration of groundnut prices in some important market of Punjab for the year 1962 to 1967-68 and 1972-72 by calculating correlation coefficients. The authors found higher variation in groundnut prices during earlier period (1962-63 and 1967-68) than during the later period (1972-73). Their analysis yielded higher órô between Khanna and Malerkotta (0.872) and lower órô between Khanna and Sangrus Ludhiana and Mathura markets (0.67). The study further reported that during later period, that is, 1972-73, the value of órô was higher than the earlier two in all markets.

Bhat (1980) studied movement of paddy and groundnut prices in the selected market of Karnataka. He employed zero order correlation coefficient analysis for analyzing market integration. Further, the findings suggested a strong integration of markets in price formation indicating the influence of price in one market over the prices in other markets. The órô values were higher in the cases of bigger markets compared to smaller markets indicating the influence of tradersô participation in determining the degree of market integration.

Bhide, Chuwathury, Heady and Muralidharan (1981) studied the structural changes in the arecanut market and Mangalore, using data on the size distribution of firms and coefficients in inequality (Gini coefficients) for the period from 1965-66 to 1972-73. Further, they projected the distribution of firms in different size categories by using regression analysis. The analysis suggested an increasing degree of competitiveness in the market structure, characterized by a more equal distribution of shares in the market transactions

Krugman (1986) analyzed the market integration in terms of storage cost of cowpea in Nigeria and showed that on an average the stock had to be held for about eight months to secure maximum gains. Significantly, there was high degree of variability from year to year in both prices and arrivals, suggesting that a farmer or a trader could not be assured of profit from storage every year.

Singhal (1986) studied five primary and one terminal markets in Uttar Pradesh to analyzed spatially and temporally, the rape-seed mustard price structure using correlation coefficients technique for spatial analysis. He found that almost every year there were periods of attack 6 to 8 weeks at a strength when the terminal market (Kanpur) price was considerably in excel of the primary market price (after taking transport costs into account). It was concluded that, the primary and terminal markets were spatially disintegrated.

Ali (1988) made an attempt to study three regulated market in Sharanpur district (UP) and concluded that these markets were competitive based on the non-significant correlation between weighted average rice and number of buyers and sellers, no restriction of entry and traders and awareness of price by all functionaries.

Bhatta and Bhat (1988) analyzed the extent of price relationship for arecanut between selected markets of Sirsi and Mangalore using the correlation method. The results revealed that Mangalore market was more efficient than Sirsi market. The commercial nature of the crop and its varied market behaviour was clear from the fact that there was a direct relationship between supply and price.

Indira (1988) estimate the extent of price relationship for coffee between three pool sale centers-Bangalore, Coimbatore and Vijayawada. The results revealed that Bangalore prices have shown positive relationship with both Coimbatore and Vijayawada prices. The prices have also shown positive relationship with each other. However, there was relatively lower influence of Bangalore prices on Coimbatore prices than on Vijayawada prices.

Prabhakar (1988) studied the market integration of silk cocoon markets of Ramanagaram and Vijayapura in Karnataka. The association between the two markets was studied using the bivariate correlation analysis. The correlation coefficient was found to be 0.947 and was highly significance at one per cent level of significance, indicating that the two markets were highly correlated.

Dinakar (1990) assessed the extent of price integration between the markets by using coefficient of variation technique. He noticed a poor integration between the markets and secondary markets was demonstrated by significant difference in the coefficient of variation of prices.

Arya (1991) analyzed the spatial integration of four markets in Gujarat using Zero order price series correlation analysis. The study revealed significant and high correlations in the price movements between the markets and concluded that the markets under consideration were integrated in terms of price movements.

Gemtessa (1991) analyzed the integration of Ethiopian coffee prices with world prices using the correlation coefficient. The correlation coefficient of the monthly average prices secured at domestic and word markets for 12 months lag were calculated. The bivariate correlation coefficient between the two market prices of coffee revealed that they moved together in the same direction. The lagged cross-correlations of domestic prices and world prices of coffee also revealed that they moved together in the same direction. The lagged cross-correlations of domestic prices and the world prices of coffee for the period of 1979-80 to 1987-88 indicated that the world prices of coffee had a stronger influence on the domestic prices, than that of domestic price influence on world prices of coffee.

An early study of grain markets in Ghana used both the Ravallion model and cointegration methods to examine the relationships between maize, sorghum, and millet prices in three markets. The study uses monthly wholesale prices over the period 1970-1990 in two markets: Techiman, a maize zone in the center, and Bolgatanga, a sorghum-millet zone in the north. The author finds that maize markets are relatively well integrated and that there are links between the markets for maize, sorghum, and millet. On the other hand, the speed of transmission was rather slow, with full adjustment taking three months.

Lutz, Tilburg and van Kamp (1994) examined the impact of agricultural market liberalization on maize price behavior in seven markets in Benin. The data consist of maize prices from the seven markets at 4 and 7 day intervals over the periods 1987ï 9 and 1998ï 2001. The seven markets include three urban centers (Cotonou, Parakou, and Bohicon) and four rural centers (Ketou, Glazoué, and Azové). The Johansen rank test was used to identify the number of common trends found among the seven markets. In the first period, all seven markets were cointegrated with each other, indicating that they followed a common trend. In the second period, only six of the seven markets followed a common trend, the prices in Ketou not having a long-run relationship with prices in the other markets. In addition, the study compared the speed of adjustment to the long-run equilibrium in the two periods. It found that, there was no consistent pattern: the adjustment seems to be more rapid in the second period for some of the markets, but prices in Cotonou, Parakou, and Azové adjusted more slowly in the second period. Overall, the authors concluded that most of the markets in Benin were integrated in the sense that they followed a common trend, but there is no evidence of improvement in the degree of integration or the speed of adjustment to shocks.

Mamatha (1995) used the co-integration analysis for examining the market integration of selected species of India and New York prices. The results indicated that the coefficients were found to be negative and significantly different from zero in case of Indian and New York prices of pepper, chillies, turmeric and ginger confirming the stationary of the series. It also indicated that, both the Indian and New York series for selected spices had the same order of integration.

Badiane and Shively (1998) examined the degree of integration and the speed of adjustment in Ghanaian maize prices. The study used monthly wholesale maize price data over the period 1980-1993 for three markets: Techiman, a surplus zone in the center, Accra, a deficit market in the south, and Bolangtanga, a maize-deficit market in the extreme north of the country. The analysis was carried out with an autoregressive model in price levels, as well as a model of price variability. The authors found that maize prices in both deficit markets are relatively well integrated with maize prices in Techiman, the surplus market. However, the relationship is closer between Techiman and Accra than between Techiman and Bolangtanga, presumably due to the shorter distance between them. Furthermore, they find that the economic reforms introduced in 1983, including agricultural market liberalization, reduced the level and volatility in maize prices in wholesale markets, though the degree of seasonality is still high.

Sharma, Kiber and Ram (1998) studied the annual prices of milk, butter and ghee in six markets (Delhi, Kanpur, Bombay, Patna, Colcutta and Madras). The price correlation coefficient between the markets ranged from 0.9529 to 0.9991 for ghee indicating that prices of milk, ghee and butter in different markets are highly correlated. This implies that there is a high degree of inter market integration for milk and milk products and that prices of milk products cannot be determined in isolation in a single market as they are influenced by price variation in other markets. This is true in the case of products such as butter and ghee that have a long shelf and are easily transportable.

Thorsen (1998) studied the spatial integration in Nordic timber market. The degree of spatial integration was tested through a co-integration analysis and a complete identification of the statistical models for long-run. When the results were interpreted in terms of factor price equalization and efficient commodity arbitrages, the Nordic timber markets were found to be strongly integrated.

Bassolet and Lutz (1999) analyzed the integration of cereal markets in Burkina Faso which were liberalized in 1992. At the same time a market information service (MIS) was created to collect and disseminate weekly cereal prices of regional markets by radio. A comparison of results of the whole period under study (1990-1995) with the results of the period after MIS (1992-1995) showed that the impact of the diffusion of prices on market integration was moderate.

Samarajeeva and Gunatilake (1999) studied the demand function for coconut using co-integration analysis. The study made use of 20 years Sri Lankan time series data (1978-1997) to estimate the demand function for coconut oil incorporating own price, three substitute prices and income. The results of Dickey-Fuller and Augmented Dickey-Fuller tests revealed that the quantity consumed and processed of palm oil are integrated to the order zero, while prices of coconut oil and soya and income were integrated of order one.

Zanias (1999) analyzed the seasonality and spatial integration in agricultural market especially the soft wheat market of five European Union member states (France, Italy, Belgium, Germany and UK). Co-integration analysis was made use of by incorporating the seasonal components of the agricultural price series in the testing procedure. The results showed that some of the markets turn out to be integrated while in some cases, a unified market cannot be assumed. These results differ in some cases from those obtained by co-integration tests which ignored seasonal unit roots.

Abdulai (2000) adopted a threshold cointegration model to examine the relationships among maize prices in the same three markets in Ghana. The analysis used monthly wholesale maize data over 1980-1997 for Accra, Techiman, and Bolgatanga. The study found that, prices in Accra responded more quickly to changes in Techiman than do prices in Bolgatanga, reflecting the fact that Accra is closer and a more active market. Half of the full adjustment in prices back to the long-run relationship occurs in 4-7 weeks. In addition, the results indicate that an increase in the maize price in Techiman is more quickly transmitted to the two deficit markets than a decrease; in other words, the marketing margin is more quickly corrected when it is compressed than when it expands. This could occur as a result of collusion among traders, changes in inventory, and search costs. Overall, the study finds that maize prices in different markets are relatively well integrated.

Jayesh (2001) studied market integration for spices using correlation coefficient. The zero order correlation matrix of prices showed a strong integration among the selected markets of Kerala, Karnataka and Tamil Nadu for both pepper and cardamom.

Balappa shivaraya (2002) has made an attempt to examine the extent of price integration of onion and potato in the selected markets of North Karnataka, comprising Belgaum, Bijapur, Dharwad, Gulbarga, Raichur and Hubli. Zero-order correlation matrix between average wholesale prices of onion clearly indicated the integration among the selected markets, except Bijapur with other markets. However, the magnitude of integration was found to be higher between Belgaum and Raichur (0.9447) between Hubli and Raichur (0.9439), between Belgaum and Hubli (0.9253), Raichur and Gulbarga (0.8669) and Belgaum and Gulbarga (0.8393).

Kuiper, Lutz and Tilburg (2003) focused on the issue of price leadership between retail and wholesale prices in Benin in order to test the common assumption that retail prices follow the wholesale prices in the same market. They used retail and wholesale price data from periodic markets operating every four day in five markets Cotonou, Bohicon, Azové, Dassa, and Kétou.

The tests for cointegration indicated that, retail and wholesale prices were strongly co-integrated. The coefficient on the long-run relationship implies that retail prices are 2-18% above the wholesale price in the same city. The study then examined whether wholesalers or retailers were ñprice leadersò using the Granger causality test. It found that in three of the four markets, the wholesale price in each period is significantly affected by the retail price in the previous period, but not the other way around. These markets include the two large urban areas: Cotonou and Bohicon. In only two markets do wholesalers play a price leader role. The authors interpreted this to mean that wholesalers can only influence prices when they carry out inter-city trade and thus have alternatives to selling to retailers.

Arya (1991) examined market integration in Mozambique using monthly retail prices of maize over 1994-2001 and estimates of transfer costs. They used the parity bounds method (PBM) which distinguished among three regimes: competitive trade (when the price difference is equal to the transfer cost), non-trading markets (when the price differences is smaller than the transfer cost), and disequilibrium (when the price difference exceeds transfer cost). A measure of the level of the integration of a market pair is the proportion of the time they were in the first two regimes. The results suggested that markets within southern Mozambique were efficient by 55%, while those in central Mozambique were efficient by 84%. Southern and central Mozambique was relatively integrated, but the transfer costs between northern Mozambique and the rest of the country were too high to justify maize trade. These findings were supported by data that indicated maize trade flows within southern and central Mozambique, but little trade between northern Mozambique and the rest of the country. A vector-autoregression (VAR) analysis confirmed that prices in each of the six main markets were linked to prices in one or two of the other markets.

Farooq (1970) reexamined the Ethiopian price data using an extended version of the parity bounds method (PBM). It is extended to allow the probability of each type of regime to gradual change in response to changes in policy. The model was tested on monthly data on wheat and maize prices in Ethiopia during a period when the Ethiopian Grain Trading Enterprise was relieved of its responsibility to stabilize prices and made to operate as a commercial enterprise. The policy change causes a statistically significant shift in the PBM parameters in only a few of the market pairs tested. Maize markets were characterized by price differences below marketing costs even though flows were observed, suggesting trading losses. In contrast, wheat price differences often exceeded transfer costs, implying excess profits.

Mutambatsere, Mabaya and Christy (2007) used the extended Parity Bounds Model to examine maize market integration among five southern African Countries: Botswana (Gaborone), South Africa (Gauteng), Malawi (Blantyre), northern Mozambique (Mocuba) and southern Mozambique (Maputo). The PBM was extended by using outside estimates of transfer costs and trade flows among the five markets. The model distinguishes among six regimes: each of the three PBM regimes with or without trade.

Van Campenhout (2007) analyzed the relationship between maize prices in seven markets in Tanzania using weekly price data over the period 1989-2000. He used a threshold auto-regressive (TAR) model which allows pairs of prices to be linked only when the difference between them exceeds a threshold. The study found that, the implied marketing cost was 2-11% of the mean of the two prices, depending on the market pair being analyzed. Generally, the markets that were close to each other, such as Iringa and Mbeya, had a small threshold, while those that were farther, such as Iringa and Dar es- Salaam, had a larger threshold. The study measured the half-life of the adjustment process, that is, the number of weeks it takes for half of the full adjustment to take place. Across the six pairs of markets analyzed, the half-life of adjustment was between 4 and 12 weeks. The analysis also showed that the speed of adjustment had decreased over the 11-year period, the decline being statistically significant in four of the six market pairs. In addition, the threshold decreased 8-55%, implying a reduction in marketing costs between markets and a closer link between maize prices in different cities.

Meyers (2008) provided a more recent study of maize markets in Malawi. The analysis uses weekly maize prices from ten markets over the period 2001-2008, focusing on the difference in price within nine pairs of markets. The price spreads were quite volatile and often turn negative, suggesting that the trade flows were not steady and that there may even be trade reversals. The study found strong evidence of a long-run relationship in six of the ten market pairs tested. Half of the full adjustment back to the long-run equilibrium occurs within 1-2 weeks for all market pairs. This adjustment is more rapid than estimated by earlier studies of Malawi maize markets by Goletti and Babu (1994), suggesting an improvement in market efficiency over time. It is also comparable to the speed of adjustment of maize and soybean markets in the United States, estimated to range between 0.2 and 3 weeks (Goodwin & Piggot, 2001). The estimated threshold above which price transmission occured ranged from 0.5 Malawi kwacha/kg to 6.4 MK/kg across the nine market pairs studied, equivalent to US$ 5 to 61 per ton at December 2004 exchange rates. For most of the pairs, the threshold estimates appeared to correspond with estimates of the marketing cost, but for two pairs, the threshold seemed too large, given the short distance between the markets.

Moser, Barrett, and Minten (2009) examined rice markets in Madagascar using four quarters of data on prices and transportation cost for almost 1400 communes. They applied the Parity Bounds Model (PBM) which distinguishes among the three trading regimes, as described above. At the sub-regional level, 69% of the communes appeared to be in competitive trading markets, 21% are in non-trading (or segmented) markets, and 10% are in disequilibrium. At the regional and national level, however, markets were more likely to be either segmented (due to high transportation costs) or in disequilibrium, possibly indicating imperfect competition.

2.7.2 Empirical evidence from market integration in Nigeria

There has been quite a bit of research over the years on the integration of various combinations of Nigerian foodstuffs markets. The principal studies in this area include those of Anthonio (1968, 1988), Jones (1969), Thodey (1969), Hays and McCoy (1977), Delgado (1986), Adekanye (1988), Ejiga (1988), Dittoh (1994), Okoh (1999), Okoh and Akintola (1999), Nuhu et al. (2009), Obayelu and Salau (2010), and Ugwamba and Okoh (2010). These studies covered market integration, price efficiency and pricing conduct of various foodstuffs (gari, rice, cowpea, cassava roots, vegetables, sorghum, and maize) in different regions of Nigeria. The price series used for the various studies were collected weekly or fortnightly by the researchers except for Okoh (1999), and Okoh and Akintola (1999) which used monthly series collected by staff of Agricultural development projects (ADPs). With the exception of Dittoh (1994), Okoh (1999), Okoh and Akintola (1999) and Obayelu and Salau (2010), these studies used correlation coefficients and simple static regression equation of the form ($P_1 = A + bP_1$) for each conclusions about the integration and efficiency of the markets for various foodstuffs.

Markets were adjudged to be integrated or efficient if the correlation coefficient (r) or regression coefficient (b) attained values greater than zero but not greater than one. If $R>0.9$, market were said to be highly integrated; if $R>0.8$, then markets were said to be moderately integrated. But if $R<0.5$, then there is no integration and the series move independently of each other (Adekanye, 1988). In the extreme case, perfect market integration ($R=0.10$) occurs when prices are stabilized at the same level all over the country. This is rarely the case, but it is indicative of the fact that integration as measured by price co-movements and price transmission is heavily affected by government intervention. The general conclusion from these studies is that apart from gari, cowpea and rice, the markets were poorly integrated. The findings of these studies are doubtful. This is because the bivariate correlation coefficient and static regression methods are beclouded by problems of overwhelming seasonal and secular trends, as well as the possibility of autocorrelation from a static model calibrated to non-stationary time series, leading to spurious correlations and inferential errors (Blyn, 1973; Delgado, 1986; Granger and Newbold, 1974; Harris, 1979; Iyoha and Ekanem, 2004; Palaskas and Harris-White, 1993; Ravalion, 1986; Timmer, 1994;). Delgado (1986) adopted the variance decomposition approach, which decomposed the variance of food-grain price into components. With Delgadoỗs approach, market integration is defined as the existence of stable price spreads among markets in a given season, despite considerable variations in prices. The study concluded that the markets are not well integrated. The method is dependent on correlation of non-stationary time series with its flaws of possible spurious correlation and inferential errors.

Dittoh (1994) applied the Ravallion model to the study of market efficiency in vegetable markets in Northern Nigeria. The Ravallion approach used an autoregressive distributed lag (ADL) model for testing ñShort-runò integration involving the correlation of price series of reference (urban) markets as well as non-price determinants of demand and supply. It is a one-way approach to market integration. Its basic flaws are the problems of simultaneity of failure to measure the level of integration where the flow between rural and urban areas reverse with the season, and colinearity among explanatory variables, as well as the problem associated with non-stationary time series data. Okoh (1999), Okoh and Akintola (1999), Okoh and Egbon (2005), and Obayelu and Salau (2010), adopted the Mendoza and Rosegrant (1995) methodology, which applied a bivariate autoregressive model fashioned after the Ravallion approach but avoiding the problems associated with it by ascertaining the stationarity of data and differencing where necessary to obtain differenced stationary series. Theoretically, the model is based on background of agricultural marketing system of developing countries which is characterized by a highly atomistic production size and numerous farmers growing crops on small farms all over the country side, and by an oligopolistic market. The study showed the presence of some form of price leadership in the market system. However, it is not known that the models bases on differenced series alone eliminate all long run information in the series, and hence ignore any possible long run relationship between the series (Farret & Page, 1998).

The various studies on the integration of Nigeria markets suggest that the major sources of poor integration and inefficiency includes the poor price formation transmission channels, too many intermediaries and the high cost of transportation, as well as the sources and validity of price data. An important observation is that while markets have characteristics of perfect competition, the price correlation results shows that they are not integrated. This conclusion could be a result of faulty methodology. The notion of cointegration, which accommodates both the short and long run responses, has not yet been applied to the study of integration of North-eastern Nigeria foodstuffs markets. The current study therefore will adopt Johansenős procedure for cointegration analysis with its applied error correction model.

2.8 Analysis of Time Series

Time series may be affected by some factors, which are recurring or nonrecurring and periodic or random. Hence, all these four components; trend, circular, seasonal and irregular/random, jointly or severally, are found in time series. The decomposition of time series prices is to isolate trend, cyclical, seasonal and irregular/random components in order to explain the dynamics of price variability. A multiplicative or additive relationship among these components may be assumed. In the first case, the observed value (yt) at any time is assumed to be the resultant product of the play of four forces:

$Yt = T \times C \times S \times R$ that is to say, the four components are related to one another. Also St, Ct and Rt are expressed in percentages. Practically, all series in the economic and business domain consist of seasonality and cycle, which are proportional to the trend (Kelechi, 2004). Hence the multiplicative model is to be adopted for this study because the model permits the estimation of each of the four components (Gangadharappa, 2005).

Generally, a mathematical function is fitted over the whole course of the time series by the square principle for estimation of the trend. Anderson (1950) determined the presence of seasonal components through the technique of analysis of variance. Anderson has further pointed out that the statistical inference would be facilitated when least square approach of seasonal adjustment was employed.

Jogenson (1964) developed the general linear statistical model for time series estimates of trend, cycle and seasonal components and derived within the framework of this model, estimators which are unique, unbiased estimators and having minimum variance.

Tobin and Arthur (1964) used a low face fitted (simple moving average) of length six months for broiler chick prices and of length twelve months following hatchery supply floods and the resulting filtered series revealed cycles of approximately 30 months for both series. A time difference of 12 to 18 months was found to exist between the peaks of the two series for 30 months cycles.

Lovelle (1968) viewed the problem as seasonal adjustment axiomatically and examined the logical implication of certain simple consistency requirement that might be applied in apprising alternative procedure for seasonal adjustment. Lovelle considered five such criteria viz., sum-preserving, product-preserving, idempotency, orthogenality and lemmetry to be ratified by a good seasonal adjustment procedure.

Waugh and Miller (1970) employed a harmonic analysis to measure the length and amplitude of handling the prices of fish. A twelve month moving average was employed.

Weiss (1970) used spectral analysis empirically to identify the cyclical pattern in world cocoa prices. He hypothesized the existence of three cycles of 12-24 years, 13-24 months and the seasonal cycles. The results suggested that in addition to seasonal fluctuations there existed a periodic fluctuation in cocoa prices due to lags in production response and consumption response with length of 14 years and 22 months respectively.

Parikh (1971) with the help of spectral techniques analyzed short term fluctuations in coffee prices. The occurrence of 24 months cycles was confirmed. The study revealed that various price series were coincident. He observed that though the broad features of the coffee cycles could be interpreted fairly as full understanding would require a simultaneous equation of economic model considering the response of production, consumption and stock to price changes. He used the original series; trend eliminated series and filtered series for coffee prices recorded in New York market, for various grade of coffee. The maximum lag used was n/5.

Gurumallappa (1972) observed a continuous rising trend in the price of groundnut in Raichur district. The lowest and the highest seasonal indices were observed during the months of October and June respectively.

Kupper (1972) made an investigation concerning the use of partial sum of fourier series and spherical harmonics as regression models in important practical situation, where the usage of polynomial was subjected to criticism.

Kendall (1973) prescribed criteria through regression for choosing between additive and multiplicative models. But, the criteria turned to be inconclusive in many cases. Multiplicative model is found to be more appropriate than additive model as seasonal, cyclical and random components, tends to remain more nearly constant in magnitude relative to trend than in absolute terms; which in turn would help in computing both constant seasonal index and moving seasonal index as the case may be and to compare percentage fluctuations of the cyclical movements. It was to be approximated by a continuous function of time.

In a study by Ejiga (1988), it was indicated that indigenous distribution system operates in a competitive manner particularly with regard to pricing constraints. Reduced distribution /marketing efficiency arise from poor transport, lack of storage and processing facilities, poor facilities, and poor information system, lack of standardized weight and measures and inadequate credit facilities. His study was on the indigenous food distribution system in Nigeria with particular reference to cowpea marketing. His report also agreed with the later findings of Abdissa and Dereje (2001) on maize marketing in Ethiopia.

Purandara Rao (1974) studied the problems of arecanut in Karnataka in 1965-1973. The seasonal indices were constructed from 12 months centered moving average for Mangalore, Shimoga and Sirsi markets. The study indicated that the arrivals were high during harvesting seasons. Arrivals were peak between January and April in Mangalore and December and May in almost all the markets. However, the prices were at peak during August in Shimoga, September in Mangalore and Sirsi. No analysis was carried out to remove secular trend from the data.

Okwoli (1984) in a study on marketing channels in Borno State discussed instability in prices of cattle. He stressed that the nomads and small-scale cattle producers hardly sell their best animals; they rather sell the skinny ones, mainly in period of food shortage. The middlemen that buy the animals usually keep and feed them until they attain desirable sizes before selling them out in the market. The prices they charge will be such that it covers their cost of feeding the animals, transportation cost if any and their anticipated profit in addition to the prices at which the animals were bought. He further stated that the unstable supply of cattle by producers in Borno State is due to weather influence on forage availability, disease and non-profit aims of the nomads (who are major cattle producers in the state) brings about price instability. Price is usually higher during rainy season than the dry season, reason being that the nomads and the small-scale farmers become reluctant to sell their cattle as forage become abundant in the rainy season, but in the dry season they sell an appreciable number to avoid loss due to starvation from lack of forage. Therefore, the low supply of cattle in rainy season increase price and income of producers while higher supply in dry season lower price and income. Hence instability in price of cattle results into unstable income to farmers.

In a study by Chengappa (1980), data on the coffee industry pertaining to the period 1954-1978 was subjected to spectral and cross spectral analysis. Chengappa observed a 24 months cycle in the domestic price of coffee at various levels. However, export showed a 36 months cycle which was attributed to world coffee price fluctuation. The study revealed a high value of coherence both in the long frequency components and in short frequencies between retail and wholesale prices. However, this was not true of the forms and export prices. His analysis further revealed that quantities released do not respond readily to short-run price changes.

Salami (1981) conducted a study on meat storage resulting in price fluctuation. Salami revealed that preserved meat under storage in most cases is more costly than those sold in the market without preservation. This is due to the added cost incurred by the storage process. These costs included cost of storage facility, the store itself, the cooling system and maintenance that enhance good preservation to keep meat free from spoilage and other deteriorating effects. The retailers also anticipate certain level of profit which when added to the cost of the product give rise to the price of the product. Prices are then set according to the mark ups hence the rise and fall of meat prices.

Eshwaraprasad (1989) examined the seasonal indices of arrivals and price of turmeric in Guntar market for the year 1970-1971 to 1985-1986 by using the ratio of moving average movement. The results of the study indicated that the indices of arrivals were higher in the months of March, April, May and June in both bulbs and fingures and during these months, the price indices were lower in both commodities. Higher price was observed during the months of September to February.

Ashok Kumar (1989) studied the price and arrivals of arecanut from 1961-62 to 1986-87 in the major markets of Karnataka viz., Bangalore, Shimoga and Sirsi. A 12 months centered moving averages were computed to study the trend behavior of price and arrivals, polynomial regression equation was fitted to estimate the trend components (after removing the cycle). A harmonic analysis was done for the purpose of explaining intra-year fluctuations in the market. For testing significant difference in seasonal patterns over years, Friedmansô two ways ANOVA was used.

Agarwal and Sharma (1990) analyzed the seasonal indices of pulse crops in Rajasthan during the period 1972-1987. The results of the study indicated that price indices were at the peak arrival (April to May for gram and October to November for moog and ward pulse crops) and the highest during sowing period of the crops (October to November for gram and June to July for moth and moong). Arhas depicted minimum prices during January to February and maximum in the month of October.

Naik, Kunnal, and Katageri (1990) studied the short-term and long-term variation in the prices and arrivals of groundnut in Gadag and Ranebennur regulated markets in Karnataka. The results indicated the arrivals were highest in September-October and April-May in Ranebennur markets and during October-January in Gadag market. They concluded that farmers sold bulk of their produce immediately after harvest. The analysis of seasonal pattern in price showed the presence of seasonality over months and years in both markets.

Singh, Singh and Yadav (1995) concluded a study on seasonal variation in arrivals and their effect on price of wheat in Bihar. The study was based on a secondary data obtained from four APMC of Bihar. The selected markets were Sasasam and Mohania which are primary markets and Dhanbad and Boker which are secondary markets. The study indicates that the seasonal variations in arrivals of wheat are more apparent in primary markets than in secondary markets. However, wheat arrivals were more sensitive to their ruling price in secondary markets than that of primary markets.

Parmindar Singh, Suyah and Raju (2000) adopted a linear equation and moving average to examine the trend as well as seasonal variation of arrivals and price of rape-seed and mustard in Haryana. The findings of the study of trend and seasonality in arrivals and price of rape-seed and mustard revealed that price of raped-seed and mustard from 1985-86 to 1995-96 showed general tendency of rising while the arrivals indicated great fluctuations from year to year in all markets.

Aminu (2010) considered only seasonal component on a study conducted on the analysis of seasonality and returns to storage of tomatoes in Jigawa State, in Nigeria. It was found that tomato marketing was affected by seasons and that August to December were months that had the lowest supply while February to April were months of highest supply.

Reuben and Mshelia (2011) conducted a study on price variation and decomposition in yam markets of southern Taraba state used a centered moving average method. Variability of prices overtime was exhibited by plotting average price per kg (an average yam tuber) over months. Results indicated that April-June were months with the highest price while October-December were month with the lowest price.

2.9 Markov Processes

The occurrence of a future state in a Markov process depends on the immediately preceding state and only on it.

If $t_0 < t_1 <$ é .tn (n=0,1,2,é ..) represents points in time the family of random variables $\{ɜ_{tn}\}$ is a Markov process if it possesses the following Markovian property.

P $\{ ɜ_{tn} = X_n | ɜ_{tn-1} = X_{n-1}$,é é $ɜt_0 = X_0\}$

P $\{ ɜ_{tn} = X_n | ɜ_{tn-1} = X_{n-1}\}$

For all possible values $ɜt_0$, $ɜ_{t1}$, é . $ɜ_{tn}$.

The probability $P_{xn ï 1}$, X_n=P $\{ɜ_{tn} = X_n | ɜ_{tn-1} = X_{n-1}\}$ is called the transition probability. It represents the conditional probability of the system being in X_n at t_n, given it was in X_{n-1} at t_{n-1} (with X representing the states and t the time). This probability is also referred to as the one-step transition because it describes the system between t_{n-1} and t_n. An m-step transition probability is this defined by

P_{xn}, X_{n+m} = P{tn-m = $X_{n+m} | ɜ_{tn} = X_n$} (Idolor, 2010; Ozar et al., 2010).

2.9.1 Markov Chains

Markov chain is a special class of mathematical technique which is often applicable to decision problems named after a Russian Mathematician who developed the method. It is a useful tool for examining and forecasting the frequency with which customers remain loyal to one brand or switch to others. For it is generally assumed that customers do not shift from one brand to another at random, but instead will choose to buy brands in future that reflect their choices in the past. Other applications of Markov chain analysis include models in manpower planning, models for assessing the behavior of stock prices, models for estimating bad debts or models for credit management, models for predicting agricultural production and prices (Agbadudu,1996).

In decision making processes one is often faced with making decision based upon phenomena that have uncertainty associated with them. This uncertainty is caused by inherent variations that elude control or due to the inconsistency of national phenomena. Rather than treat variations qualitatively, we can incorporate it into a mathematical model and thus handle it quantitatively. This treatment generally, can be accomplished if the natural phenomena exhibit some degree of regularity, so that a probability model can describe tits variation.

Markov chain has the special property that probability involving how the process will evolve in the future depends only on the present state of the process and so are independent of events in the past (Hillier & Lieberman,1995). Markov chain is a mathematical technique which combines the idea of probability with those of matrix algebra to predict future states of events such as voting trends, sales planning etc (Madawaki, Biradawa & Adeleke, 2002). Its outline is as follows: A Markov chain is a series of states of a system that has the Markov property. At each time the system may have changed from one state it was in the moment before, or it may have stayed in the same state. This change of state is called transition. If a sequence of states has the Markov property, it means that every future state is conditionally independent of very prior state given the current state (Mshelia, 1991, Obodos, 2005).

Markov chain is a sequence of events or experiments which the probability of occurrence for an event depends upon the immediately preceding event. It is also referred to as first-order Markov chain process, first-order-Markov process or Markov chain. For a finite Markov chain, we assume that the sequence of experiments (or events) has the following properties:

(i) The outcome of each experiment is one of a finite number of possible outcomes a_1, a_2é .a_n.

(ii) The probability of outcome aj on any given experiment is not necessarily independent of the outcomes of previous experiments but depends at most upon the outcome, ai of the immediately preceding experiment.

(iii)There are given number P_{ij} which represent the probability of outcome aj on any given experiment, given that outcome ai occurred on the preceding experiment. That is, probability of moving from position *i* to position *j* in one step, or in one movement, or in one experiment is P_{ij}. The outcomes a_1, a_2,...a_n are called states and the numbers P_{ij} are called transition probabilities. The number of experiments or number of movements is sometimes referred to as steps. At times the probability distribution of the initial state is given, but this may not be necessary when determining steady state equilibrium (Agbadudu, 1996). The number P_{ij} which represent the probability of moving from state a_i to a_j in one step can be put in the form of a matrix called the transition matrix. This matrix for a general finite Markov chain process with states a_i, a_2... a_n is given by:

$$P = P_{ij} = \begin{matrix} P_{11} & P_{12} & \cdots\cdots & P_{1n} \\ P_{21} & P_{22} & \cdots\cdots & P_{2n} \\ P_{n1} & P_{n2} & \cdots\cdots & P_{nn} \end{matrix}$$

Here the sum of the elements of each row of the matrix P is 1. This is because the elements in each row represent the probability for all possible transitions (or movements) when the process is in a given state. Therefore for state a_i, I = 1, 2,é n the transition probabilities is given as follows:

$$\sum_{j=1}^{n} P_{ij} = 1$$

If we let E_1, E_2é E_j (j=0,1,2, é ..) represent the exhaustive and mutually exclusive outcome (states) of a system at any time, Initially, at time t_0, the system may be in any of these states. Let $aj^{(o)}$ (j = 0,1,2,é) be the absolute probability that the system is in state E_j at t_0. Assume further that the system is Markovian. The transition probability is defined as:

$$P_{ij} = P\{\varepsilon t_n = j | \varepsilon t_{n-1} = i\}$$

This basically is the one step probability of going from state *i* at t_{n-1} to state j at t_n, assuming that these probabilities are stationary over time. The transition probabilities from state E_i to state E_j can be more conventionally arranged in a matrix form as follows:

$$\left\{\begin{matrix} P_{00} & P_{01} & P_{02} & P_{03} \\ P_{10} & P_{11} & P_{12} & P_{13} \\ P_{20} & P_{21} & P_{22} & P_{23} \\ P_{30} & P_{31} & P_{32} & P_{33} \\ \vdots & \vdots & \vdots & \vdots \end{matrix}\right\}$$

The matrix P is called a homogenous transition or stochastic matrix because all the transition probabilities P_{ij} are fixed and independent of time. The probabilities P_{ij} must satisfy the conditions:

$$\sum P_{ij} = 1 \text{ for all } i$$

P_{ij} Ó0 for all i and j

Indicating that all row probabilities must add up to one while any single entry in the row or column could have a probability of Ó0. The Markov chain is now defined. A transition matrix P together with the initial probabilities $\{a_{j(o)}\}$ associated with the state E_j completely defines a Markov chain (Okpachu, 2006; Taru & Mshelia, 2007). It is also common to think of a Markov chain as describing the transitional behaviour of a system over equal intervals. Situation exists where the length of the interval depends on the characteristics of the system and hence may not be equal. This is referred to as imbedded Markov chains.

2.10 Price Forecasting Models

A considerable numbers of empirical studies in the field of agriculture have been carried out using different forecasting models. A brief survey of some of these studies is presented thus:

Chatfield and Protharo (1973) highlighted that the Box-Jenkins procedures was not suitable for sale forecasts with a multiplicative seasonal component in this analysis, monthly data on sales of a company was used. The adequacy of the model was tested using Box-Pierce test.

Delgado (1986) used Box-Jenkins model to analyses whole price indices of rice, wheat, jowar and grain. The short-term forecasts were found to give good results while the same was not true of long-term forecasts. Janus quotients of the forecasts showed that the model gave good results. Newbold and Granger (1974) compared the forecast performed of the Box-Jenkins, Holt-winters and step-wise regression models. The study indicated that each method had its own advantage over the others. It was opined that the Box-Jenkins gave better forecasts in the short-run, but the method required time and skill to compute the results. The result indicated that for time series with less than 30 observations step-wise regression was better, for data between 30 to 50 observations. A combination of Holt-winters and step-wise regression was found suitable for series of 50 and above the Box-Jenkins performed well for data with strong seasonal and long fluctuations the Holt-winters model was suggested.

Protharo and Wallis (1976) examines the extent to which variations in a series could be explained first by a dynamic econometric model and then by an ARIMA model. Econometric model clearly indicated that they provided a closer estimate and behavior of the series during the sample periods.

Chatfield (1977) observed that the Box-Jenkins approach being a valuable addition in the forecast tool bag, which have deeper understanding of time series behavior. Even though, it was found to be more expensive yet the accuracy justified the cost.

Makridakis and Hibbon (1979) observed that accuracy of forecasts are negatively associated with the error term. Several tests to arrive at the accuracy of forecasts like Mean Square Error (MSE). Theilôs ôUô coefficient and Mean Absolute Percentage Error (MAPE) were suggested.

Chengagappa (1980) applied the Box-Jenkins model to forecast pool sale and export auction prices of coffee. Monthly data were used to the distinct seasonal variation in prices; the ARIMA seasonal model was applied. The pool sale price forecasts were found to be accurate when compared to forecasts of export prices. This was attributed to possible lack of stationarity to the data. Hence, the adoption of differencing procedure or a transformation to make the data stationary was found necessary for a better estimate of export prices.

Achoth (1985a) analysed the supply, price and trade of Indian tea by fitting ARIMA models to data on prices and production. The moving average models were found to be most suitable. Among the prices series, particular month was related both to production of the previous month as well as to the production of the same month in previous years. The forecasts yielded reasonably good results as judged from the tests of their efficiency. The forecasts of prices were superior when compared to the forecast of quantities, which was attributed to the highly structured pattern of price behavior.

Acthoth (1985b) fitted the seasonal ARIMA model to price data of tea at Calcutta and Cochin auctions to production data of Northern and Southern regions of the country and quantity of tea exports and their prices. He identified that the moving average model was most suitable. The forecasts from these models yielded reasonably good ex-post and ex-ante forecasts judging from the test of their efficiency. The forecast of the prices were superior to the forecasts of the quantities which may be due to the predictable pattern of price behavior. Further, some of models fitted to the quantity series did revealed a certain degree of inadequacy which was not considered serious probably because certain cyclic pattern may not have been captured by the model.

Devaiah, Venikatagiriyappa and Achott (1988) attempted forecasting the prices of cocoons at Ramanagaram market by using ARIMA models. The forecasts were made for 13 months from April 1987 to April 1988. The forecasted values were observed to be close to the actual prices.

Lanciotti (1990) presented a paper that analyses time series data of monthly prices for a group of dairy products with the aim of obtaining reliable forecasts. The method of analysis employed was ARIMA as put forward by Box-Jenkins. The time series data covered both wholesale and retail prices for butter.

Yin and Min (1999), used univariate Box-Jekins modeling strategy using quarterly price series from Time Mart South, results showed that most of the selected pipe pulpwood and saw timber markets in six southern US could be evaluated using ARIMA models, and that short-term forecasts, were fairly accurate. It is suggested that forecasting future prices could aid timber producers and consumers alike in timing harvests reducing uncertainty and enhancing efficiency.

Mastry (2001) used ARIMA models, also called Box-Jenkins models after their developers, a group of models allowing the analysis of time series with various features. The article demonstrates the possible usage of the Box-Jenkins methodology for the analysis of time series for agricultural commodities. The paper contains a basic mathematical explanation of ARIMA models together with a practical illustration of a price development forecast for a selected agricultural commodity.

Markov chain was used to study the sizes of hog producing firms by Jude and Swanson (1961), structural changes in fresh citrus packing industry in Florida by Farris and Padberg (1964), in Betenit market in India by Blide et al*.,* (1981), in cereal production in Britain by Mellor (1982; 1984) and in maize production by Okunmadewa (1999) as cited by Onu (2000). Okpachu (2006) employed Markov chain techniques in the study of the efficiency measurement in soybean marketing in Benue State, he obtained the transitional probability matrix P for the quantities of soybean sold by the soybean traders and estimated the proportions of soybean traders expected to be in the different size categories at equilibrium. He classified the quantities sales into three size categories (physical states) as S, for the two successive years, 2003 and 2004. These size categories were S_1, 1-1000 bags, S_2 1001- 2000 bags, S_3 greater than 2000 bags. The result indicated that in the long-run, 42% of the respondents will sale from 1-1000 bags, 47 % at 1001- 2000 bags while 11% will sale above 2000 bags. The study unfolded that in the long run or at equilibrium, the market power will be concentrated in the hands of 89 % of the respondents who sold 1-2000 bags.

Onu (2000) on the analysis of the structure and performance of cotton marketing in Northern Nigeria first categorized the buyers on the basis of the quantity of cotton that was purchased by each buyer, the categories were S_1 (0-20 tonnes), S_2 (21-80 tonnes), S_3 (81-10) and S_4 (above 171 tonnes), result indicated that 2% of the firm would purchase less than 20 tonnes, 12.49% would purchase between 21-80 tonnes, 43.53% would buy more than 170 tonnes. This measure of structural development shows that the cotton market in Northern Nigeria during the 1996 -1998 marketing period tended towards high concentration.

2.11 Estimation of Transition and Initial Probability Matrix

Any Markov process can be completely described by means of its transition probability matrix (TPM) from which one may read off the conditional probability M_{ij} of the j^{th} state occurring next period given that the process is currently in the i^{th} state (Ryan, 1973).

A study can assume three state of nature, Markov chain model aptly described as rise (r), drop (d) and stable (s); can be used to show the three basic possible price movements. With this, we can derive the probability of the cereal price, rising, dropping or remaining stable; and the future direction of price, with sum of the probabilities equaling one. This three state system is set as the initial probability vector (U_o) which gives the probability of the system being in a particular state.

Furthermore, given the previous sate (price) of cereal in a rise (r), drop (d) or stable (s); transition to a new state or rise, drop or stable is also possible. This we can have as a rise in price leading to another rise (rr), or drop (rd) or stable (rs). We can also have a drop leading to a rise (dr) or drop (dd) or stable prices (ds). Finally, we can have a stable price situation leading to a rise in prices (sr), drop (sd) or stable prices (ss). Markov chains are often described by a directed graph where the edges are labeled by the probabilities of moving from one state to the other. The directional graph for our model of cereal price, transition is thus shown in Figure 2.2.

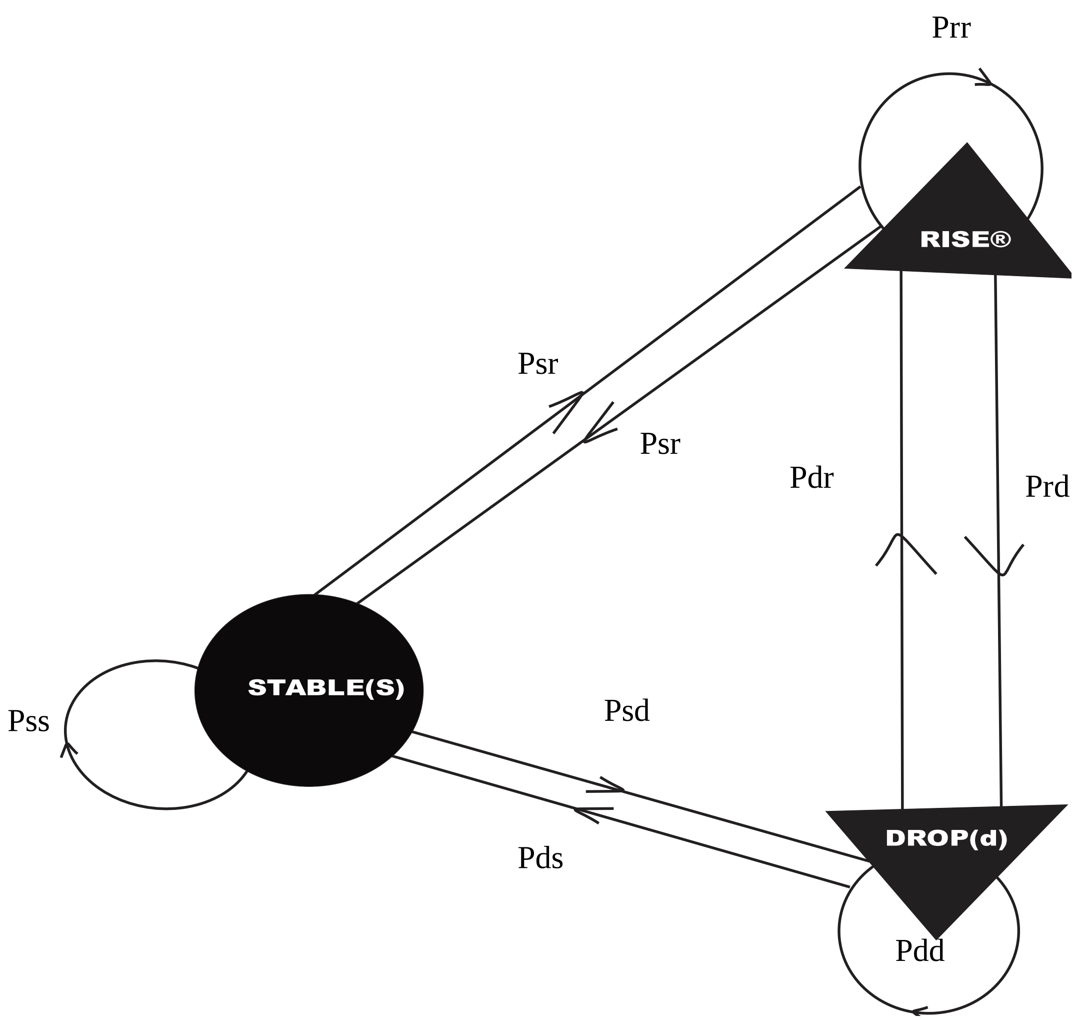

Figure 2.1: Transition Matrix

From the three state systems shown in Figure 2.1, transition could occur from state x to y or z depicted as (stable), (rise) and (drop). Therefore, for any transition, the probability of moving to the next state is given as P_i and the sum of probabilities must equal 1 depicted as follows:

$$\sum_{i=j}^{n} P_i = 1$$

If we assume that the system was previously in a particular state X transition from the previous state X to new state is possible provided the previous state is in a non-absorbing state. A state *ij* is called absorbing if it is impossible to leave that state. The state *ij* is thus absorbing if and only if $P_{ij} = 1$ and $P_{ij} = 0$ for $i \neq j$. Therefore, given an initial probability vector U_o, we can compute the probability of it being in the next state once we have derived the transition matrix. Therefore,

$$U_1 = U_o . P$$

$$U_2 = U_1 . P$$

$$U_3 = U_2 . P$$

$$U_n = U_{n-1} . P$$

The various probabilities for this occurrence can be put in a matrix P, which is called the transition matrix and shows the probability of the system a moving from state to state. It gives the probability of transiting from rise to rise, rise to drop, rise to stable and so on. Here, a short term three state of nature (rise, drop and stable) Markov chain model with transition and initial probability matrix is given below:

$$U_o = [U_r \ U_d \ U_s] = [P_r \ P_d \ P_s]$$

Also:

$$P = \begin{bmatrix} P_{rr} & P_{rd} & P_{rs} \\ P_{dr} & P_{dd} & P_{ds} \\ P_{sr} & P_{sd} & P_{ss} \end{bmatrix}$$

Where:

U_o = initial probability vector

P = transition probability matrix

$U_r = P_r$ = probability of cereal price rising

$U_d = P_d$ = probability of the cereal price dropping

$U_d = P_d$ = Probability of the cereal price remaining stable

P_{rr} = probability of price rising after a previous rise

P_{rd} = probability of price rising dropping after a previous rise

P_{rs} = probability of price rising remaining stable after a previous rise

P_{dr} = probability of price rising after a previous drop

P_{dd} = probability of price dropping after a previous drop

P_{ds} = probability of price remaining stable after a previous drop

P_{sr} = probability of price rising after a previous stable state

P_{sd} = probability price dropping after previous stable

P_{ss} = probability of price remaining stable after a previous stable state

CHAPTER THREE

METHODOLOGY

3.1 The Study Area

The study area is Northeastern Nigeria. It comprises six states, namely; Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe. The area lies between latitudes 7^o 30˜ and 14^o North of the equator and longitudes 9^o and 15^o East of the Greenwich meridian. It shares boundaries with Cameroon and Chad Republics to the east, Benue and Plateau States to the South, Jigawa and Kano States to the West and Niger Republic to the North. The number of inhabitants of the area is put at 18,971,965 million based on the 2006 census (FRN, 2007). The mean annual rainfall in the area ranges from 250 mm around Nguru (Borno State) to about 1310 mm around Sugu (Adamawa State), while mean annual temperature ranges from 200^oC to 400^oC (NAERLS/PCU, 2004). The region falls within three vegetation zones made up of Sahel, Sudan and Guinea Savanna. Growing season in the study area lasts between two months in the northern part to about five and half months in the southern part of the area. Major crops grown in the area include rice, maize, millet, sorghum, cowpea, cotton, groundnut, yam, potato, cassava and water melon (Ojanuga, 2006). Among these crops, maize and sorghum are the main staple while rice is an alternative staple food. There is no government presence or intervention on the pricing of commodities but rather market forces completely determine the pricing of all agricultural commodities. The major occupations of the inhabitants of the area include farming, fishing, trading, weaning, dyeing and gathering. Infrastructure such as markets, road network, electricity, schools and institutions, hospitals and banks are found in the area.

3.2 Sampling Procedure

Purposive sampling technique was adopted for the study. This was done in the selection of Adamawa and Taraba States from the 6 states that made up the North-east geopolitical zone. This was adopted to avert the risk of travelling to the violence prone states, as a result of the activities of insurgent Boko Haram. Privilege information suggests that the data on rural and urban prices of agricultural commodities could only be obtained from the various states Agricultural Development Programmes offices. Because, all other organizations, such as the Central Bank of Nigeria and National Bureau of Statistics, record data on agricultural commodities prices only at the urban levels. Also, the latest publication on agricultural commodity prices by the National Bureau of Statistics, as at the time of sourcing data for this research was for the period 1997-2006, hence, not up-to-date.

3.3 Data Collection

Only secondary data were used in the study. Secondary data on monthly basis for the prices of 100kg of three cereal grains, maize, rice and sorghum in both rural and urban markets in the study area were obtained from Adamawa and Taraba States Agricultural Development Program (ADPs) offices for a period of 10 years (2001-2010). The reliability of the price series from the ADP was assumed to be high coupled with the fact that it is the only information available, so the study was constrained to adopt the price series despite problems that may be inherent in the series

3.4 Data Analysis

The study adopted both descriptive and inferential statistics. Objective i was achieved using time series analysis such as the isolation of the prices in components using a decomposition technique as well as graphs, in this case, the prices of rural and urban markets were averaged to make each year with twelve observations (100kg/month) to have one hundred and twenty observations in all, then observations in each year were made into four quarters. Objectives ii was achieved using inferential statistics such as Markov Chain model processes, since the knowledge of today and yesterday are only required to predict tomorrow (Markov Chain) only data on the prices of 100kg of the three commodities for the year 2009 and 2010 were used to achieve the objective. Objectives iii, iv and v were achieved using inferential statistics such as bivariate autoregressive model combined with its error correction model (ECM), in this case, monthly prices of 100kg of rural and urban markets for the period 2001-2010, for maize, rice and sorghum each were considered.

3.4.1 Model Specification

3.4.2 Components of time series

It is assumed that each component is independent of the others and can be analyzed separately, and that each component is generated by a particular underlying process or model (Adekanye, 1988; Grega, 2002; Ojile, 2002). These components are; secular trend (Tt), cyclical variations (Ct), seasonal variations (St) and irregular (random) variations (Ir).

The graph of such a time series data gives a rough idea about the nature of fluctuations in the value of the variable with time. The fluctuations have the combined effect of various causes such as the ones mentioned above which sometimes induce sharp rise and fall. Segregating these various types of fluctuations in the time series is known as analysis of time series. The important basic components of time series are i) secular trend (Tt) ii) seasonal variation/periodic movements (St) iii) cyclical movements (Ct) and iv) irregular variations (It).

Secular trend (Tt): Over a long period of time, time series is very likely to show a tendency to increase or decrease over time. The factors responsible for such changes in time series are the growth of population change in the taste of people, technological advances in the field *etc.*

There are different types of trends, some of them are linear and some are non-linear in their form. For shorter period of time, in most of the situations the straight line provides the best description of trend and for longer period of time, the non-linear form generally provides a good description of the trend. Often, it may be possible to describe such movements a structured mathematical model. In the absence of such a definite format, approximately a polynomial or a free hand could describe the movements.

Periodic movement (seasonal variation) (St): The variation within a year is called as seasonal variation. The main causes of seasonal variations are customs, climates *etc.* Such seasonal components can be analysed through harmonic analysis.

Cyclical movements (Ct): Cyclical movements are fluctuations which differ from periodic movements (cyclical movements) have longer duration than a year and have periodically of several years as in business cycles.

Irregular variations (It): Here the effects could be completely unpredictable, changing in a random manner. A given observation is affected by episodic and accidental factors. These are also known as causal series and are affected by the unknown causes. These unknown causes act in an unpredictable manner.

3.4.3 Isolation of time series components

For analysis of time series data, a model is essential. Generally two broad approaches are resorted to. One is a multiplicative model and the other is an additive model. There could be other approaches too resulting in a hybrid model of these two. In this present study, multiplicative model has been employed, since many agricultural data admit such a model as a more appropriate one.

Let the original observation at the time point to be denoted by Yt and the four components *viz.,* Trend, seasonal, cyclical and irregular variations by Tt, St, Ct and It, respectively, for a time period t (where, t = 1, 2, 3é). Then the multiplicative model can be expressed as; Yt = Tt x St x Ct x It, t = 0, 1, 2é $t_{n.}$ In obtaining the trend component, a four point moving average for the price (Y) was computed by adding the first four values and dividing the result by four and placed against second value of price (Y), next, the second, third, fourth and fifth values were added and divided by four and the value was placed against the third price (Y) value on the next row (trend). This went continuously until the last trend value was obtained, by doing that the first and last two values on the trend row were missed. This was applied for the computation of trend values on Table 4.1, 4.2 and 4.3.

3.4.4 Transition Probability

The technique of Markov chain was developed during the twentieth century and was used primarily in physics and chemistry. Its use in economics is rather recent. Markov chain processes are now of special interest in problems relating to planning in agriculture. This has been demonstrated by (Atobatele, 1986; Dittoh, 1985; Mshelia, 1991; Okpachu, 2006; Onu, 2000).

In the simplest language, the theory of Markov chain assumes the existence of a physical system S which has a number of possible system S_1,S_2, é , S_n and at each instance of time can be in one of these states. Then the time after successive trails can be denoted by t_0, t_1, t_2é t_n with t_o representing the starting point in t, t_1, the time of conclusion of the first trial etc. For Markov chains, the probability of passing to some state, $S_{1,}$ at a time depends only on the sate that the system was at the preceding time and does not change, if its state was at earlier times is known.

With a given set of states (S_1, S_2,é S_n), it is assumed possible to estimate the probability, P_{ij}, of moving from state S_i to state S_j. Let the starting or initial probability be denoted by

$$P_i (0) = prob (S_i \text{ at } t_o)$$

The set of the starting probabilities can be arranged as row vector as:

[P (0) = P_1(0) , P_2 (o),é P_n(0)

P(0) is probability vector that gives the probability of the system being in state S_1, S_2, é .., S_n respectively,t the start. As stated earlier, P_{ij} denote the transition from state, *i* to state *j*. Then, by arranging the transition probabilities in a rectangular array, a matrix P is obtained by:

$$P = \begin{Bmatrix} P_{11} & P_{12} & P_{13}\ldots\ldots & P_{1n} \\ P_{21} & P_{22} & P_{23}\ldots\ldots & P_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ P_{n1} & P_{n2} & P_{n3} & P_{nn} \end{Bmatrix}$$

This matrix, P, is called the transition matrix. Since the P_{ij}ôs are probabilities, it follows that the probabilities in each row sum to unity. This of course is not true for columns. It should be noted, that,

$$\Sigma P_{ij}[0] = 1$$

However, if the elements of P do not depend on time, the transition probabilities are stationary. Further, P is a stochastic matrix because:

i. P is square
ii. the elements of P are non-negative; and
iii. each row of P adds up to unity

Various types of projections can be obtained from the transition matrix and the vector of initial probabilities. Projection techniques based upon Markov processes depend solely on the assumption that the elements of individual matrix have stationary transition probabilities.

An appreciation of how much projection can be achieved is possibly by a considering a basic element in questions such as ñif the system starts at a state S_1 at a time and the pattern of behavior (Markov process) of individual units as given by matrix transitional P is expected to continueò what would be the state of affairs in t_1, t_2, t_3,é é t_k years? If one lets $P_j(k)$ be the probability of the system being in state j after k steps, P_j (o) would mean that initially the system is state j. Thus: [P (o) = P_1(o),P_2(o),é é .,P_j(o)] and is a probability vector that gives the probability of the system being in state S_1, S_2,é é é S_j

$$\Sigma P_j \; K = 1$$

The probability of the system being in state *j* after *i* step is given by

$P_j(1) = [P(o)] P_j$ for any *j* .

3.4.5 Using Markov Chain

This is hinged on some two major assumptions:

i. that the matrix of transition probability remain constant from period to period
ii. that the farmers (respondents) population remains essentially the same for the period for which the forecast was made as in the period which forms the basis for deriving the transition matrix.

Major advantage of using Markov chain is in forecasting, predicting or projecting what future trends will be in some agricultural variables, in this case first order of Markov chain was used.

3.4.6 Limitation of Markov Chain Model

Markov chain analysis assumes the inter-temporal constancy of the transition probability matrix and therefore do not incorporate any structural changes over time or over the years

Secondly, there is the difficulty in obtaining the standard errors associated with estimates

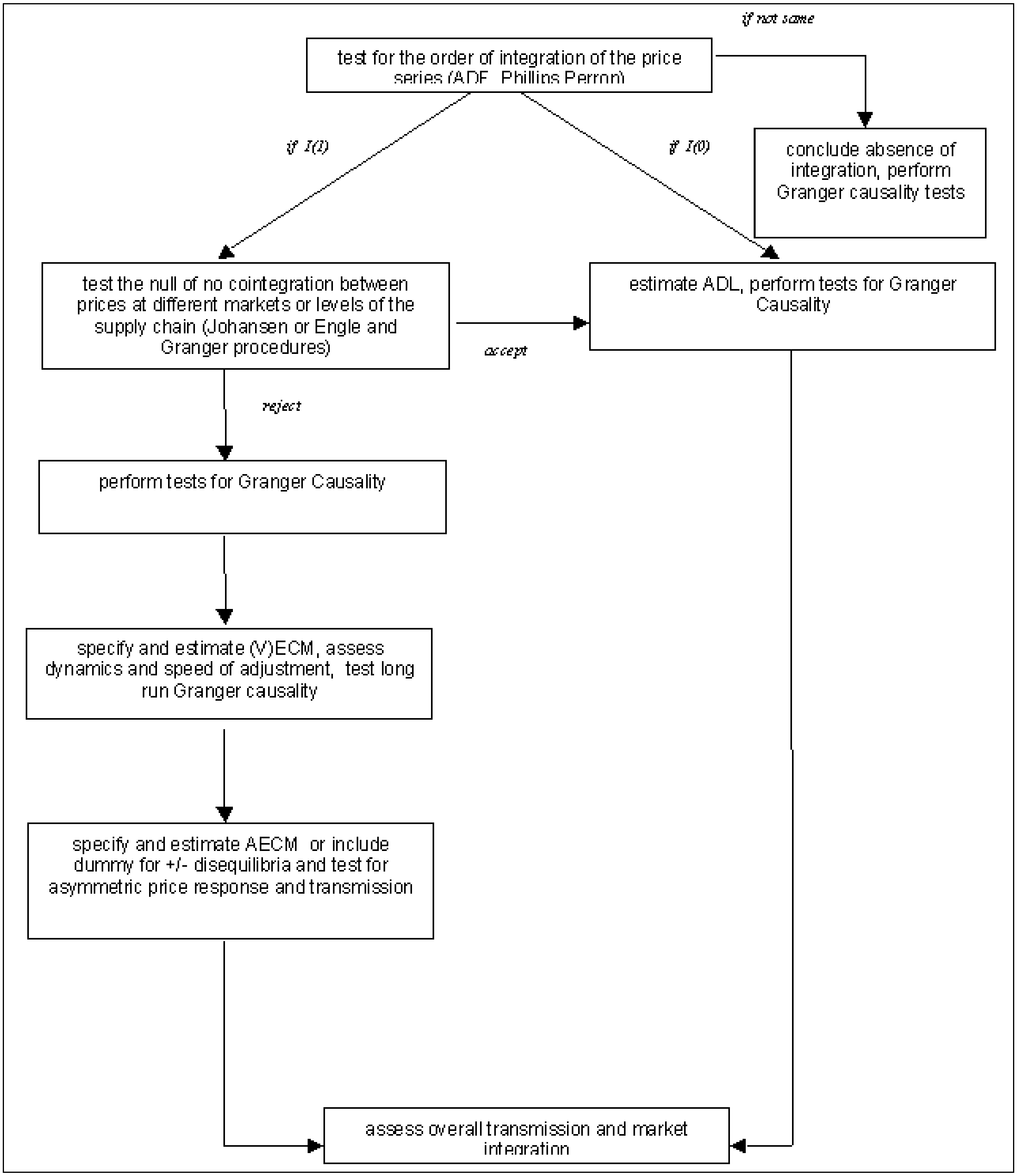

Figure 3.1: Estimation of market integration: Johansen co-integration test procedure

Source: Adapted from Rapsomanikis, Hallam and Comforti, (2000) In view of the above diagram on the empirical tools that can be used to assess the notional components of market integration and price transmission, we proceed to apply the proposed time series techniques on selected commodity markets in a sequence depicted in Diagram 1. The way in which the tests for the components of transmission have been ordered is to some extent *ad hoc*. The sequence of the tests is as follows:

(i) For each pair of prices, we start by testing for the order of integration for each price utilizing the Augmented Dickey-Fuller (Dickey and Fuller, 1979). In the event that the series have a different order of integration 1(0), we conclude that the markets are not integrated. We test for Granger Causality within a Vector Autoregression (VAR) framework to assess price transmission between the markets or along the supply chain.

(ii) In the event that the tests indicate that the series are integrated of the same order (say 1(1)), we proceed by testing the null of non-cointegration against the alternative hypothesis of one cointegrating vector using the Johansen procedure (Johansen 1988), or we test for the null of non-cointegration following Engle and Granger (1987). Evidence against the null of no cointegration is taken to indicate that prices co-move and that markets are integrated. We do not impose and test for any restrictions on the cointegrating parameter estimate. Inference on the extent of price transmission based on the size of the parameter may be misleading. In the event that the null of non cointegration is not rejected, we conclude that the markets are not integrated.

(iii) In the event that tests indicate the price series are cointegrated, we proceed by focusing on the error correction representation, in the form of a (V)ECM and on examining the short run dynamics, the speed of adjustment and the direction of Granger causality in the short or the long run following Granger (1981).

(iv) At the next stage, based on our results on the direction of causality, we discuss the results and comment on the nature of price transmission and market integration. It is important to note that the above testing framework does not identify the factors that affect market integration and price transmission.

Consider a Vector Autoregression (VAR) of two variables p_{1t} and p_{2t}. A VAR expresses a vector of variables as a linear sum of a set of lags of itself. A simple case of a VAR between two variables is:

$$\begin{pmatrix} p_{1t} \\ p_{2t} \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} + \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \begin{pmatrix} p_{1t-1} \\ p_{2t-1} \end{pmatrix} + \begin{pmatrix} v_{1t} \\ v_{2t} \end{pmatrix}$$

The issue of cointegration can once again be addressed by looking at the VAR, but extending it to contain a second lag. An example of a VAR(2) would be

$$\begin{pmatrix} p_{1t} \\ p_{2t} \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} + A_1 \begin{pmatrix} p_{1t-1} \\ p_{2t-1} \end{pmatrix} + A_2 \begin{pmatrix} p_{1t-2} \\ p_{2t-2} \end{pmatrix} + \begin{pmatrix} v_{1t} \\ v_{2t} \end{pmatrix}$$

This has the Vector Error Correction (VECM) representation:

$$\begin{pmatrix} \Delta p_{1t} \\ \Delta p_{2t} \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} + (A_1 + A_2 - I) \begin{pmatrix} p_{1t-1} \\ p_{2t-1} \end{pmatrix} + \begin{pmatrix} v_{1t} \\ v_{2t} \end{pmatrix}$$

The rank of the matrix ($A_1 + A_2 - I$) is equal to the number of cointegrating vectors. If the rank of ($A_1 + A_2 - I$) is equal to two, then both variables can be shown to be stationary. If the rank of (A_1

$+A_2$ -I) is zero then the series are not cointegrated, whilst if the rank of ($A_1 + A_2$ - I) is one then the variables are cointegrated.

Therefore, in the case of two variables, cointegration can be tested by testing the significance of the characteristic roots or eigenvalues of ($A_1 + A_2 - I$). If the variables are not cointegrated the characteristic roots λ_1, λ_2 are equal to zero. Similarly if the rank of ($A_1 + A_2 - I$) is equal to one, $0 < \lambda_1 < 1$ and λ_2 is equal to zero. Johansen (1988, 1991) derived the distribution of two test statistics for the null of no cointegration referred to as the Trace and the Maximum Eigenvalue test.:

$$\lambda_{trace} = -T \sum_{i=1}^{2} \ln(1 - \hat{\lambda}_i)$$

$$\lambda_{max} = -T \ln(1 - \hat{\lambda}_2)$$

The first statistic tests the null hypothesis that the number of independent cointegrating parameters is less than or equal to two, whilst the second statistic tests the null hypothesis that the number of cointegrating parameters is one against an alternative of two cointegrating parameters.

3.4.1.5 Error correction representation of cointegrated equation or systems

Johansen derived an Error Correction Representation of a cointegrating system. He defined two (n×r) matrices *a* and *b*, where n is the number of variables (in the case of price transmission exercise n equals 2) and r the rank of $(A_1 + A_2 - I)$. The properties of these matrices are:

$(A_1 + A_2 - I) = ab'$ (a.7)

The matrix b is the matrix of cointegrating parameters, whilst the matrix a represents the adjustment of the variables towards the long run equilibrium, if it exists. In the case of two variables such as p_{1t} and p_{2t}, the error correction representation or Vector Error Correction Model (VECM) is as follows:

$$\begin{pmatrix} \Delta p_{1t} \\ \Delta p_{2t} \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} + \begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} (p_{1t-1} - \beta p_{t-2}) - A_2 \begin{pmatrix} \Delta p_{1t-1} \\ \Delta p_{2t-1} \end{pmatrix} + \begin{pmatrix} v_{1t} \\ v_{2t} \end{pmatrix}$$

b represents the long run multipliers where a rank restriction has been imposed:

$$\frac{a_{12}}{1 - a_{11}} = \frac{a_{21}}{1 - a_{22}} = \beta$$

In this case the lack of a cointegrating relationship would also imply no Granger causality between the series, but only if $A_2 = 0$. More generally, Granger causality does not require cointegration. However, cointegration does imply causality in at least one direction.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Components of Price

Tables 4.1, 4.2 and 4.3 show the isolation of the price series into its various components; trend, seasonal, cyclical and random/irregular variations, decomposed from the price of maize, sorghum and rice respectively. Maize and Sorghum are normally harvested between November and December, after this period, in January/February, the supply reaches its peak and prices drop to their lowest level. After the month of March and possibly April when the farmers are left with marketable surplus (differences between total agricultural output and the subsistence needs), the supply start to decline and the prices start to increase. In general and in a normal year, prices start to decline immediately before December in anticipation of the new harvest and rise as supply dwindles after May and keep on rising to August.

As shown in the tables, the magnitude of all the components was negligible except for the seasonal component which fluctuated over time. Cyclical and random components did not exhibit any form of fluctuation. This was much likely due to short period of time undertaken by the study as it confirmed report by Reddy, Ram, Sastry and Devi (2009) that a minimum period of 30-40 years was required to analyze a cyclical component. Random variation had also exhibited a stationary and negligible value indicating that variables attributed to this component such as war, extreme flood and drought were not experienced during this period under study. The study is in agreement with that of Abdissa and Dereje (2001) that this component is as a result of unforeseen circumstances that if absent the component may not be seen.

Figures 4.1 and 4.2, 4.3 and 4.4, and 4.5 and 4.6 depict the graphical presentation of Tables 4.1, 4.2 and 4.3 respectively. In the figures, especially 4.1 and 4.2, and 4.3 and 4.4, they looked more alike when compared to Figures 4.5 and 4.6 indicating that maize and sorghum were close substitutes and there was higher seasonal effect on sorghum than maize. Figures 4.5 and 4.6 are graphs of local dehusked rice. This kind of locally processed rice is mostly consumed by low income group who cannot either afford or access the so called ñforeignò rice. In all the commodities, there was only price hike in 2008. While previous study (Simister & Chanda, 2009) claimed an alarming increase and instability in staple food prices in the northern Nigeria, evidence from data in this study has shown that the increasing price of these staples was a function of time. (Simister & Chanda, 2009) emphasized that, through 2002 to mid-2008, agricultural commodities including cereals have experienced unprecedented fluctuations and continuous increase prices, this is unfounded. In 2007-2008, developing country markets including Nigeria, experienced unprecedented shifts in the prices of staple foodstuffs. Very sharp rises were experienced in the prices of many products-notably; rice, wheat, corn, meat, coffee and milk-and the world faced its worst food crisis in generation. This is shown on Tables 4.2 and 4.3 being rice and sorghum, respectively. Most worrisome, is that, whenever reports are being made about increasing prices of staple food, few or no report is made on the increasing cost of production inputs such as fertilizer, herbicides and other cost of agronomic activities.

Fluctuations quite existed, but not at an alarming rate as claimed by Fafchamps (2000), Nuhu et al. (2009), Akpan and Aya (2009) and Okunneye (2010), because, variations of commodity price between locations and over time is a natural market phenomenon (Rashid & Minot, 2004). In fact, price variation is necessary for the existence of a market as it create the incentives that attract market actors to engage in trade. Excessive variability and, in some cases, no variability of staple food prices should rather be a point of concern.

Figures 4.1 and 4.2 were extrapolated from Table 4.1 as shown on the table, the cyclical and random components, two of the four components were marginal and so insignificant to report. Trend component showed an upward dwindles and the seasonal variation was component was also visible though not persistent.

Figures 4.3 and 4.4 were also extrapolated from Table 4.2 (sorghum), the cyclical and random components were marginal indicating that such variables responsible for those components such as war, flood and drought did not occur under the time studied, hence could not appear on the graph. The seasonal effect in sorghum seems to be greater compared to that of maize. This can be concluded that the fluctuation observed in sorghum during the time under study indicated seasonal effects to have been responsible. Figures 4.5 and 4.6 were also extrapolated from Table 4.3 (rice). All the figures follow almost similar trend been that cyclical and random components were also not seen (marginal values). The figures also indicated that seasonal factors were mainly responsible for the instability observed in the series.

Table 4.1: Trend, Seasonal, Cyclical and Random Variations for Maize

Year	Quarters	Y (Price)	SMA (Trend)	CMA SMA1+2/2	Seasonal Variations Y/CMA*100	Deseasonalized Yt/St	Cyclical Varaitions CMA/T	Random Variations Yt/T.S.C.
2001	1	3737.83						
	2	3504.66	2622.99					
	3	3249.5	3041.03	2831.01	114.78	28.31	0.99	0.01
	4	1997.16	3125.62	3038.33	64.77	30.83	0.99	0.01
2002	1	3412.83	3201.89	3163.76	107.87	31.64	0.99	0.01
	2	3843	3399.57	3300.73	116.43	33	0.97	0.01
	3	3554.16	3164.37	3281.97	108.29	32.82	1.04	0.01
	4	2788.33	3135.21	3149.79	88.52	31.49	1.05	0.01
2003	1	2472	3341.82	3238.52	76.33	33.39	0.97	0.01
	2	3726.33	3657.28	3499.55	106.48	34.99	0.96	0.01
	3	4380.66	4092.1	3874.69	113.06	38.75	0.95	0.01
	4	4050.16	4334.33	4213.22	96.13	42.13	0.97	0.01
2004	1	4214.83	4318.54	4326.44	97.42	43.26	1.00	0.01
	2	4691.66	3976.75	4147.52	113.12	35.2	1.04	0.01
	3	4317.5	3777.25	3877	111.36	38.77	1.03	0.01
	4	2683	3537.29	3657.27	73.36	36.45	1.03	0.01
2005	1	3416.83	2721.08	3129.19	109.19	31.29	1.15	0.01
	2	3731.83	4005.37	3363.23	110.95	33.63	0.84	0.01
	3	4469.16	3885.4	3943.88	113.31	39.44	1.02	0.01
	4	4403.66	7345.56	5615.48	78.42	56.15	0.76	0.01
2006	1	2937	3818.83	5582.19	52.61	55.82	1.46	0.01
	2	3354.83	3326.71	3572.77	93.89	35.73	1.07	0.01
	3	4579.83	3706.37	3516.54	130.24	35.16	0.95	0.01
	4	2435.16	4613.49	4159.93	58.54	41.59	0.90	0.01
2007	1	4455.66	5506.95	5060.22	88.05	50.6	0.92	0.01
	2	6983.33	6872.07	6189.51	112.83	61.89	0.9	0.01
	3	8153.66	7319.62	7095.85	114.91	70.96	0.91	0.01
	4	7895.66	7319.62	7095.71	111.28	70.95	0.97	0.01
2008	1	6245.83	5700.33	6509.98	95.94	65.09	1.14	0.01
	2	3977.66	3726.41	4713.37	84.39	47.13	1.26	0.01
	3	4682.16	5059.41	4392.76	106.59	43.93	0.87	0.01
	4	7361.16	5285.25	5172.33	142.32	51.72	0.98	0.01
2009	1	4216.66	6073.95	5679.6	74.24	56.79	0.94	0.01
	2	4881	5508.08	5791.02	84.29	57.9	1.05	0.01
	3	7837	6767.54	6137.81	127.68	61.29	0.91	0.01
	4	5097.66	2775.03	4771.29	106.84	47.71	1.72	0.01
2010	1	9254.5	6565.54	4670.54	198.15	46.71	0.71	0.01
	2	5521.83	7100.58	6833.06	80.81	68.33	0.96	0.01

3	6388.16
4	7237.83

Source: Field Data, 2001-2010

Table 4.2: Trend, Seasonal, Cyclical and Random Variations for Sorghum

Year	Quarters	Y (Price)	SMA (Trend)	CMA SMA1+2/2	Seasonal Variations Y/CMA*100	Deseasonalized Yt/St	Cyclical Variations CMA/T	Random Variations Yt/T.S.C
2001	1	2726.33						
	2	3499.33	3043.87					
	3	3718.66	3349.91	3196.89	116.32	31.97	0.95	0.01
	4	2231.16	3385.33	3367.62	66.25	36.68	0.99	0.01
2002	1	3950.5	3358.79	3372.06	117.15	33.72	1.00	0.01
	2	3641	2745.96	3052.38	119.28	30.52	1.11	0.01
	3	3612.5	3512.54	3129.25	115.44	31.29	0.89	0.01
	4	3430.33	3860.83	3686.69	93.05	36.87	0.95	0.01
2003	1	3366.33	3444.29	3652.56	92.16	36.53	1.06	0.01
	2	5034.16	4107.33	3775.81	133.33	37.76	0.92	0.01
	3	5276.66	4058.95	4083.14	129.23	41.12	1.01	0.01
	4	2752.16	3669.58	3864.27	71.22	38.64	1.05	0.01
2004	1	3172.83	3338.74	3508.16	90.44	35.08	1.05	0.01
	2	3476.66	3272.16	3305.45	105.18	33.05	0.01	0.01
	3	3953.33	3953.33	3612.72	109.43	36.13	0.91	0.01
	4	2485.83	3413.46	3683.39	67.49	36.83	1.08	0.01
2005	1	2963	3724.5	3568.98	83.02	35.69	0.96	0.01
	2	4251.66	4499.29	4111.89	103.39	41.12	0.91	0.01
	3	5197.5	4259.04	4379.17	118.69	43.79	1.03	0.01
	4	5585	8774.5	6516.77	85.7	65.32	0.74	0.01
2006	1	12002	9425.13	9099.82	131.89	91.00	0.97	0.01
	2	12313.5	9177.88	9301.51	132.38	93.02	1.01	0.01
	3	7800	9728.13	9453.01	82.51	94.53	0.97	0.01
	4	12396	7799.88	8764.01	141.44	89.64	1.12	0.01
2007	1	6486	5175.83	6487.86	99.97	64.88	1.25	0.01
	2	4517.5	5773.43	5474.63	82.52	54.74	0.95	0.01
	3	5171.83	7114.33	6443.88	80.26	64.43	0.91	0.01
	4	6918.33	9649.41	8381.87	82.54	83.82	0.87	0.01
2008	1	11849.66	11652.75	10651.08	111.25	106.51	0.91	0.01
	2	14657.83	12870.49	12261.62	111.25	122.61	0.95	0.01
	3	13185.16	13455.41	7371.45	111.25	73.00	0.55	0.01
	4	11789.33	12186.54	12820.98	111.25	128.21	1.05	0.01
2009	1	14144	11231.08	11708.81	111.25	117.09	1.04	0.01
	2	9627.66	11409.5	11320.29	111.25	113.2	0.99	0.01

	3	9363.33	10233.08	10821.29	111.25	108.22	1.06	0.01
	4	12503	9356.42	9794.75	111.25	97.98	1.05	0.01
2010	1	9438.33	8917.83	9137.13	111.25			
	2	6121	8045.89	8481.86	111.25	84.81	1.05	0.01
	3	7609						
	4	9015.23						

Source: Field Data, 2001-2010

Table 4.3: Trend, Seasonal, Cyclical and Random Variations for Rice

Year	Quarters	Y (Price)	SMA (Trend)	CMA SMA1+2/2	Seasonal Variations Y/CMA*100	Deseasonalized Yt/St	Cyclical Variations CMA/T	Random Variations Yt/T.S.C
2001	1	6855.33						
	2	7219.16	7145.96					
	3	4703.5	7031.08	7088.52	66.35	70.89	1.01	0.01
	4	9805.83	6744.12	6865.62	142.83	60.65	1.02	0.01
2002	1	6395.83	4580.41	6722.14	95.15	67.21	0.10	0.01
	2	5896.16	5470.29	5662.27	104.13	56.62	1.23	0.01
	3	4878.66	5470.12	5025.35	97	50.3	0.92	0.01
	4	6047.16	6154.71	5470.21	110.55	54.7	1.00	0.01
2003	1	5059.16	6260.49	5812.42	87.04	58.12	0.94	0.01
	2	5895.5	6577.25	6207.6	94.97	62.08	0.99	0.01
	3	7617	7166.58	6418.87	118.67	64.19	0.98	0.01
	4	6470.33	7099.25	6871.92	94.16	68.72	0.96	0.01
2004	1	6326.16	7731.66	7132.92	88.67	71.33	1.00	0.01
	2	8252.83	7858.58	7415.46	111.29	74.18	0.96	0.01
	3	7347.66	7706.21	7795.12	94.26	77.95	0.99	0.01
	4	9000	7972.33	7782.4	115.65	77.82	1.01	0.01
2005	1	6833.33	8219.79	7839.29	87.17	77.92	0.98	0.01
	2	7643.83	8050.62	8096.06	94.41	80.96	0.98	0.01
	3	8412.16	7607.45	8135.21	103.4	81.36	1.01	0.01
	4	9989.83	7386.37	7829.03	127.1	78.59	1.03	0.01
2006	1	6156.66	6485.04	7496.91	82.12	74.97	1.01	0.01
	2	5871.16	7446.03	6935.71	84.65	69.36	1.07	0.01
	3	7527.83	8332.4	6965.54	104.07	69.66	0.94	0.01
	4	6384.5	8929.61	7889.22	80.93	78.89	0.95	0.01
2007	1	10000.61	9543.94	8631.01	115.87	86.31	0.97	0.01
	2	9416.66	9110.45	9236.78	101.95	92.37	0.97	0.01
	3	9916.66	9060.2	9327.1	106.32	93.27	1.02	0.01
	4	8841.83	10271.2	9085.33	97.32	90.85	1.02	0.01

2008	1	8266.66	11474.25	9665.7	85.53	96.65	0.94	0.01
	2	9215.66	13158.87	10872.73	84.76	108.73	0.94	0.01
	3	14760.66	14615.83	12316.56	119.84	123.17	0.95	0.01
	4	13654	15642.79	13887.35	98.32	138.87	0.94	0.01
2009	1	15005.16	16223.33	15129.31	99.18	151.13	0.95	0.01
	2	15043.5	14317.42	15933.06	94.42	159.33	0.97	0.01
	3	18868.5	12931.17	15270.38	123.56	152.71	0.98	0.01
	4	15976.16	10927.46	13624.3	117.26	136.25	0.01	0.01
2010	1	7381.5	10927.46	11929.32	61.88	119.29	1.05	0.01
	2	9510.5	9203.08	10065.27	94.49	100.65	1.09	0.01
	3	10841.66						
	4	9078.66						

Source: Field Data, 2001-2010

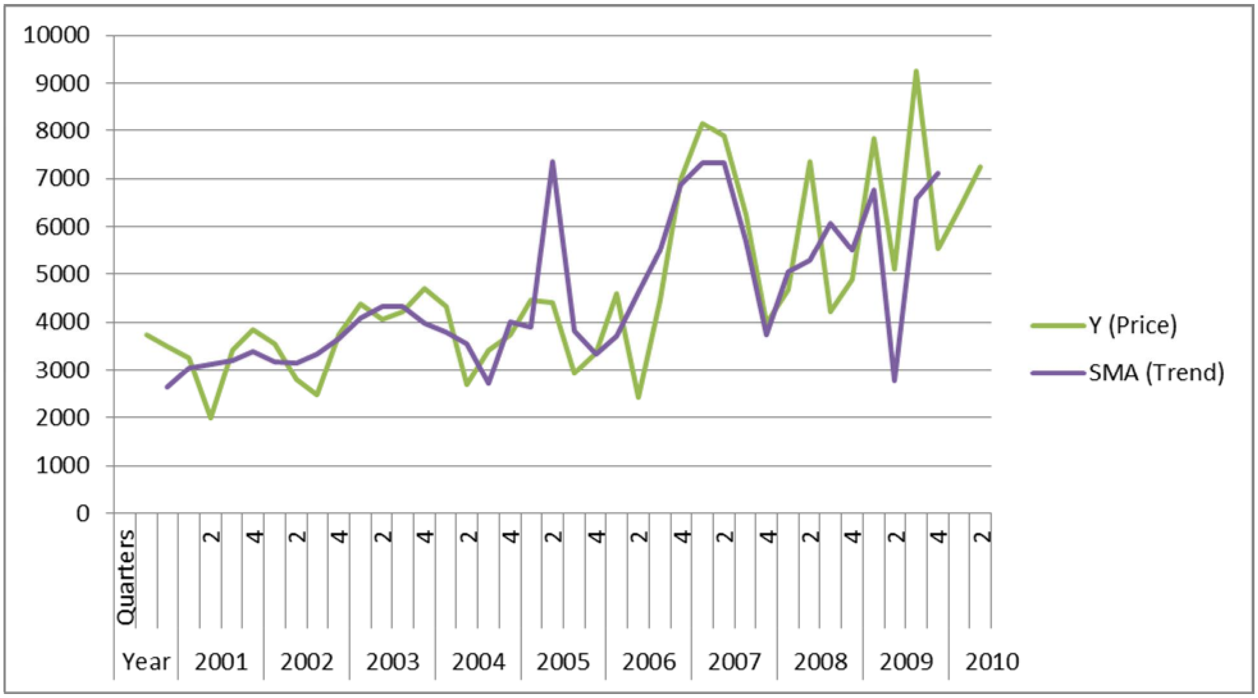

Figure 4.1: Isolation of Actual Price and Trend Components of Maize
Source: Field Data, 2001-2010

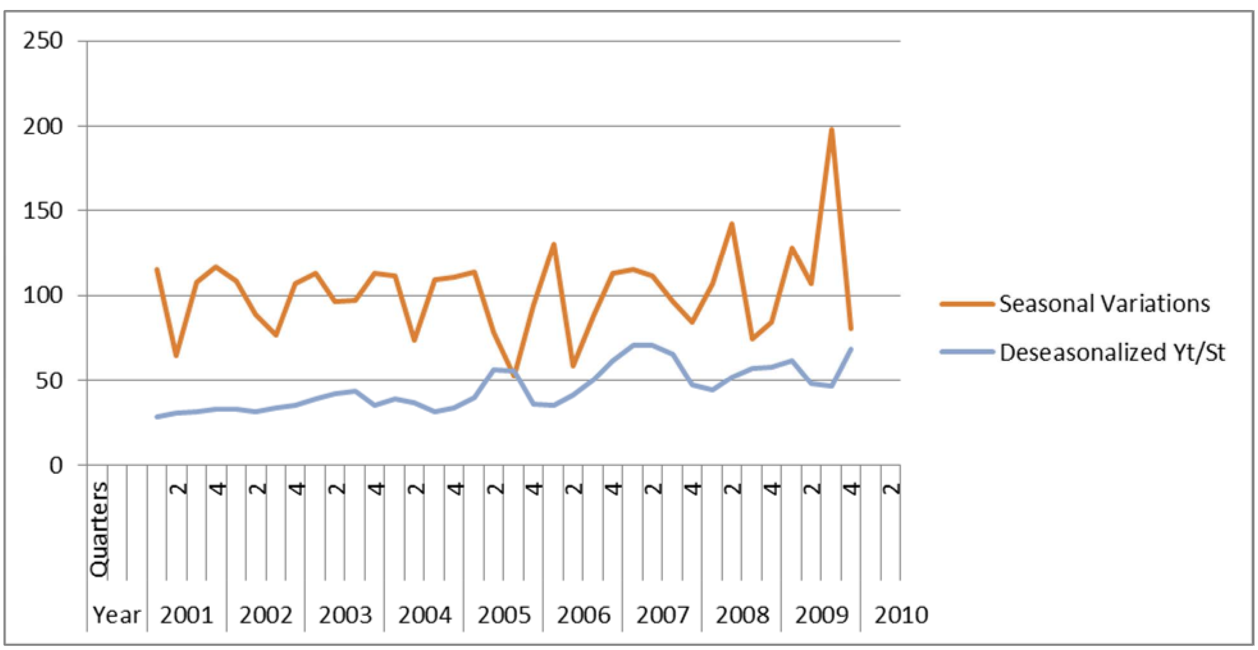

Figure 4.2: Isolation of Seasonal Component and Deseasonalized data (Seasonal Adjustment) for maize
Source: Field Data, 2001-2010

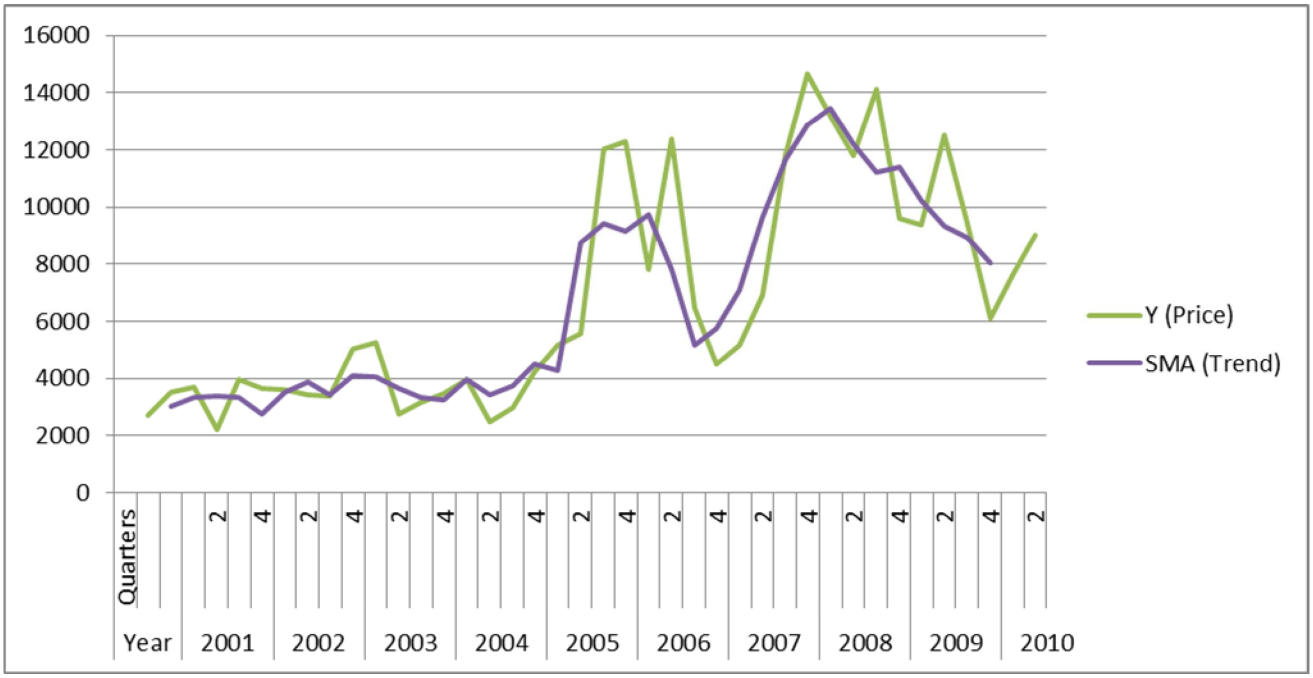

Figure 4.3: Isolation of Actual Price and Trend Components of Sorghum
Source: Field Data, 2001-2010

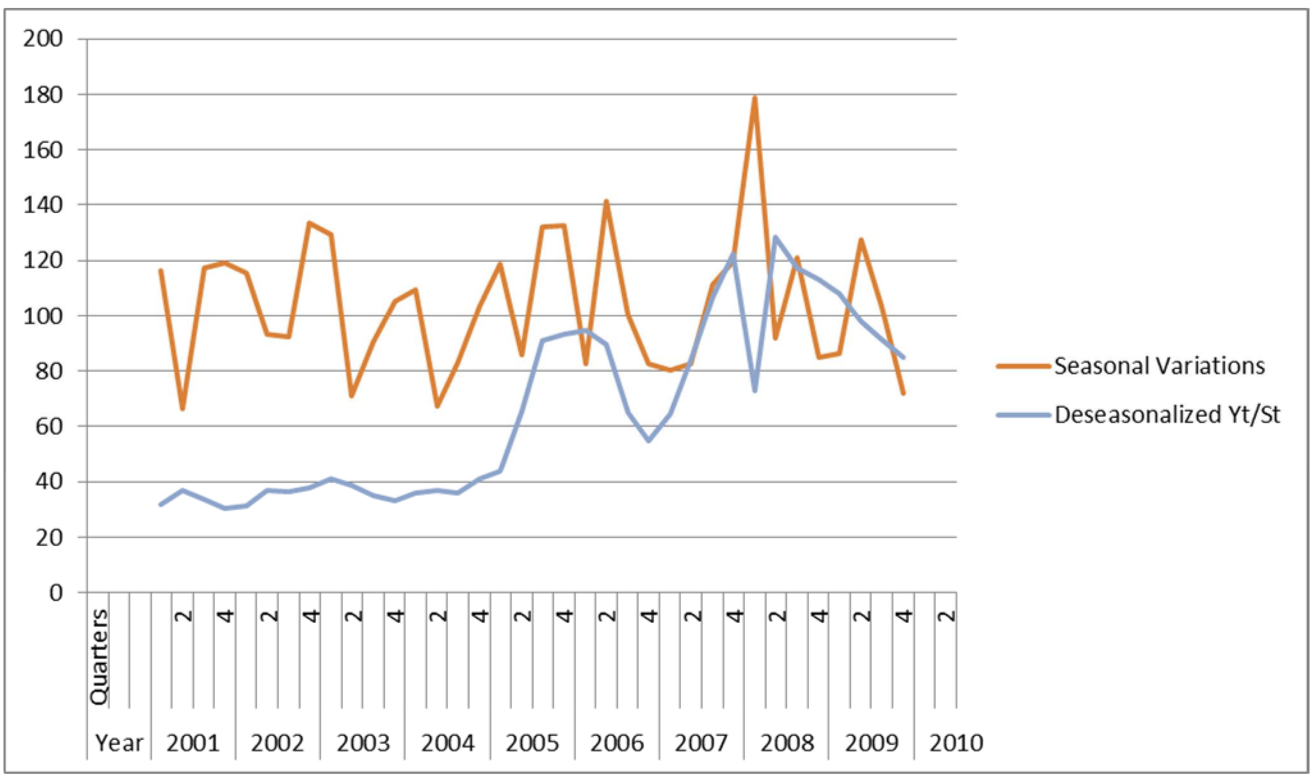

Figure 4.4: Isolation of Seasonal Component and Deseasonalized Data (Seasonal Adjustment) for Sorghum
Source: Field Data, 2001-2010

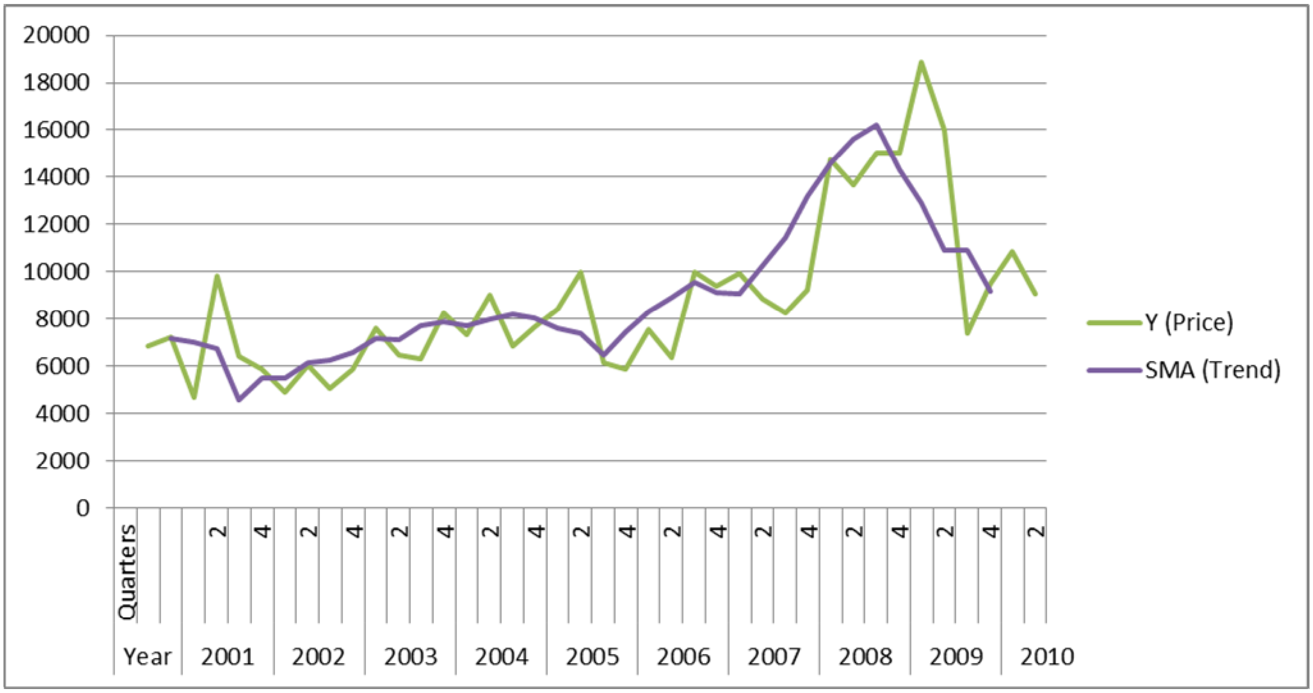

Figure 4.5: Isolation of Actual Price and Trend Components of Rice
Source: Field Data, 2001-2010

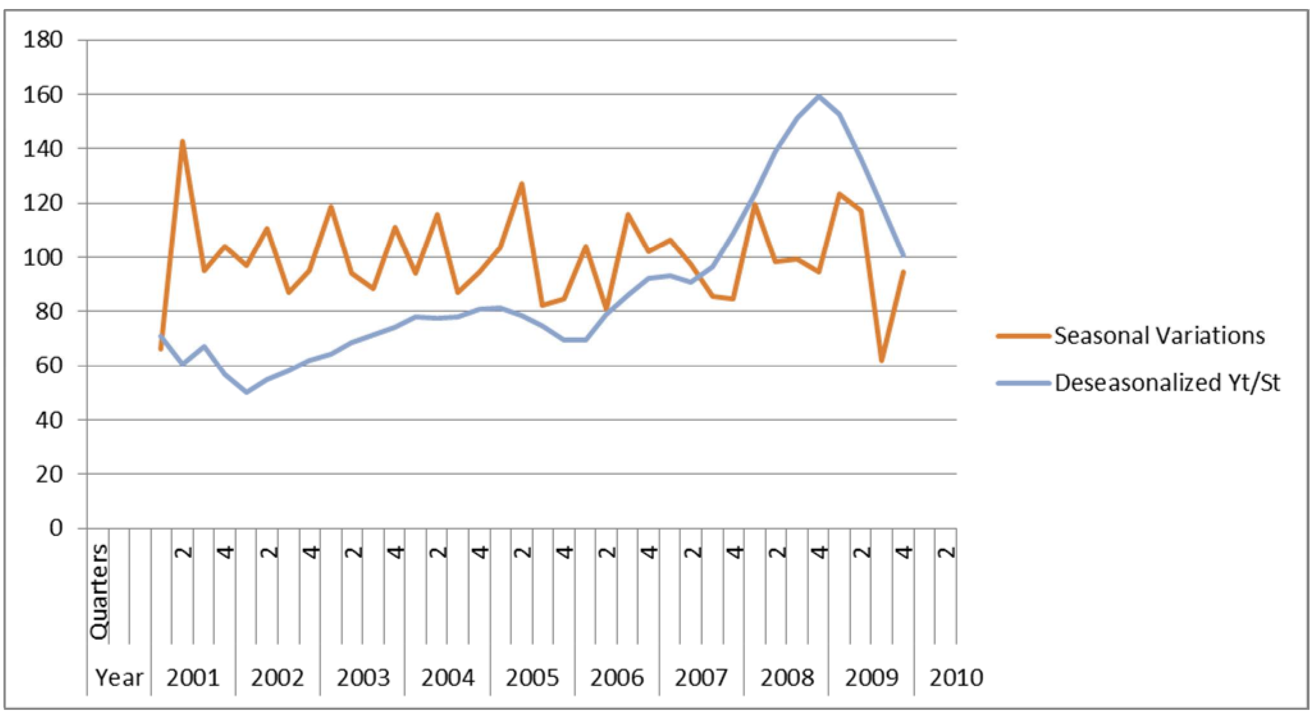

Figure 4.6: Isolation of Component and Deseasonalized Data (Seasonal Adjustment) for Rice
Source: Field Data, 2001-2010

4.2 Probability Distribution of Cereal Grain Price in the Long-run

4.2.1 Maize

In order to estimate the transition matrix and probability vector for the price of maize in 2009 and 2010, the first step has been the classification of price into three categories obtained from the monthly price of maize in 100kg in 2009 and 2010 from the offices of Agricultural Development Programmes in Adamawa and Taraba States. Each of the three categories was designated in a price state ñSò. These states were:

S_1, Ò₦7, 000,

S_2, = ₦7, 000 ï ₦8, 000, and

S_3, Ó₦8, 000.

Recalled the matrix P thus:

$$P = \begin{bmatrix} p_{11} & p_{12} & p_{13} \\ p_{21} & p_{22} & p_{23} \\ p_{31} & p_{32} & p_{33} \end{bmatrix} = e_1, e_2, e_3$$

In the first category, (S_1 Ò₦7, 000), P_{11} was price at S_1 in 2009 and in the same state in 2010. P_{12} was the price in S_1 in 2009 and transited to S_2 in 2010 while P_{13} was price at S_1 in 2009 but transited to S3 in the year 2010. P_{21} was price in S_2 in 2009 but transited back to S_1 in 2010, P_{22} was price in S_1 in 2009 and remain in the same state in 2010 while P_{23} was price in S_2 in 2009 but transited to S_3 in 2010. P_{31} was price at S_3 in 2009 but transited back to S_1 in 2010, P_{32} was price at S_3 in 2009 and was in S_2 in 2010, P_{33} was price at S_3 in 2009 and remain in the same category in 2010.

Table 4.4: Flow chart for Transition Matrix of Maize in 2009 and 2010 Seasons

Class		Year t + 1 2010			
		S_1, Ò7000	S_2, = 7000 ï 8000	S_3, Ó8000	Total Year t -1
Year t ï 1 2009	S_1, Ò 7000	1	1	1	3
	S_2, = 7000 ï 8000	1	2	2	5
	S_3, Ó 8000	3	1	0	4
	Total Year t +1	4	4	3	12

Source: Field Data, 2001-2010

Result: S_1, = 0.18, S_2, = 0.48, S_3, = 0.34 (equilibrium state)

This can be interpreted into percentage as 18%, 48% and 34%, respectively.

Confirmation 0.18 + 0.48 + 0.34 = 1

4.2.1.1 Interpretation of maize transition matrix

From the result of the initial probability, in the long-run, this indicated that 18 % of the price that would be received on maize would fall in óStateô S_1, 48 % in S_2, and 34 % in S_3. This showed that, maize farmers would experience an unfavorable price; this is strange, because one would expect that as a result of few hands that are into farming and consequence increase in population coupled with activities of insurgent Boko Haram, there would be pressure on food items leading to increase food prices. Unfortunately, this did not hold, because the youths do not longer see this commodity as stable food. This study has revealed a possible price decline in the grain sub-sector. This could lead to a misleading allocation of inputs in agricultural sector, which could seriously damage production ability and international competiveness of the industry. In the opinion of Grega (2002), if agricultural products prices were too low, the situation in the sector could be deteriorating by the consequent outflow of qualified labor force to other sectors of the economy and lead to migration of rural population to the urban areas and so, cause the depopulation of the rural areas. While trading losses is also possible from the tradersô point of view. Therefore, the null hypothesis of farmers to receive high price for maize is rejected against the alternative hypothesis that farmers would receive low price

4.2.2 Rice

In order to estimate the transition matrix and probability vector for the price of rice in 2009 and 2010, the first step was the classification of the prices into three categories obtained from the monthly price of rice in 100kg/₦ in 2009 and 2010. Each of the three categories was designated in a price state ñSò. These states were:

S_1, = less than ₦10, 000,
S_2, = ₦10, 000 ï ₦12, 000, and
S_3, = above ₦12, 000

Recalled the matrix P thus:

$$P = \begin{bmatrix} p_{11} & p_{12} & p_{13} \\ p_{21} & p_{22} & p_{23} \\ p_{31} & p_{32} & p_{33} \end{bmatrix} = e_1, e_2, e_3$$

In the first category, (S_1 Ò₦10, 000), P_{11} was price received at less than ₦10, 000 in year 2010. P_{12} was price received at less than ₦10, 000 in year 2009 but received at price between ₦10, 000 ï ₦12, 000 in 2010. P_{13} was price received at less than ₦4, 000 in year 2009 but transited to the last category of price (> ₦12, 000) in the year 2010. P_{21} indicates the price received between ₦10, 000 ï ₦12, 000 in year 2009 but received a price less than ₦10, 000 in 2010, P_{23} was the price received at ₦10000 ï ₦12000 but received more than ₦12, 000 in 2010. P_{31} was the price received at more than ₦12000 in 2009 but received price at less than ₦10, 000 in 2010. P_{32} was price received at more than ₦12, 000 in 2009 but received ₦10, 000 - ₦12, 000 in 2010 while P_{33} was price received at more than ₦12, 000 in 2009, but still received the same amount in 2010.

Table 4.5: Flow chart for the Transition Matrix of Rice Price in 2009 and 2010 Seasons

Class		Year t + 1 2010			
		S_1, Ò4000	S_2, = 10000 ï 12000	S_3, Ó12000	Total Year t -1
Year t ï 1 2009	S_1, Ò 4000	2	1	0	3
	S_2, = 10000 ï 12000	1	1	2	4
	S_3, Ó 12000	1	0	4	5
	Total Year t +1	4	2	6	12

Source: Field Data, 2001-2010

Result: S_1, = 0.27, S_2, = 0.68, S_3, 0.05 (equilibrium state)

This can be interpreted into percentages as 27%, 68% and 5%, respectively.

Confirmation: 0.27 + 0.68 + 0.050 = 1

4.2.2.1 Interpretation of the transition matrix for rice

From the result of the initial probability, in the long run, it shows that 27% of such prices <₦10, 000 will be received, 68% (₦10, 000 ï ₦12, 000) of the price will be received in the long run, while only 5% of the price (> ₦12, 000) will be received. This concludes that, in the long-run, more of the farmers will receive a relatively better price for rice, price state ñS_2ò. This may be an indication that rice is a cash crop, unlike maize and sorghum that would earn unfavorable price in the future. Here, the null hypothesis that farmers will receive high prices for rice in the long run is accepted.

4.2.3 Sorghum

In order to estimate the transition matrix and probability vector for the price of sorghum in 2009 and 2010, the first step was the classification of prices into three categories obtained from the monthly price received on the commodity in 100kg/₦ in 2009 and 2010. Each of the three categories was designated in a price state ñSò. These ñstatesò were:

S_1, Ò₦7, 000,

S_2, = ₦7, 001 ï ₦9, 999, and

S_3, Ó₦10, 000.

Recalled the matrix P thus:

$$P = \begin{bmatrix} p_{11} & p_{12} & p_{13} \\ p_{21} & p_{22} & p_{23} \\ p_{31} & p_{32} & p_{33} \end{bmatrix} = e_1 e_2 e_3$$

In the first category, (S_1 Ò₦7, 000), P_{11} was price received at equal or less than ₦7, 000 in year 2009 and also received the same amount in year 2010. P_{12} was price received at equal or less than ₦7, 000 in 2009 but transited to a ₦7, 001 ï ₦12, 000 in the year 2010 and P_{13} was price received at equal or less than ₦7, 000 in 2009 but transited to the last category. P_{21} indicated the price received on the commodity in 2009 (₦10, 000 - ₦12, 000) but transited to S_1 (Ò₦7, 000) in 2010, P_{22} price in state S_2 (₦10, 000 - ₦12, 000) in 2009 and remained in the same state into S_3 in 2010. P_{31}wasrice at S_3 (Ó₦10, 000) in 2009 and transited to S_1 (Ò₦7, 000) in 2010, P_{32} was price at S_3 in 2009 but was at S_2 in 2010 while P_{33} was price at S_3 in 2009 but still in S_3 in 2010.

Table 4.6: Flow chart for the Transition Matrix of Sorghum in 2009 and 2010 Seasons

Class		Year t + 1 2010			
		S_1, Ò7000	S_2, = 7001 ï 9999	S_3, Ó10000	Total
Year t ï 1 2009	S_1, Ò 7000	1	2	2	5
	S_2, = 7001 ï 9999	2	1	1	4
	S_3, Ó 10000	1	2	0	3
	Total Year t +1	4	5	3	12

Source: Field Data, 2001-2010

Result: S_1, = 0.48, S_2, = 0.25, S_3, = 0.27 (equilibrium state)

This can be interpreted into percentages as 48%, 25% and 27%, respectively.

Confirmation: 0.48 + 0.25 +0.27 = 1

4.2.3.1 Interpretation of the transition matrix for sorghum in 2009 and 2010 seasons

From the result of the initial probability, in the long run, it showed that 48 % of the price would be at state óS_1ô, Ò₦7, 000 and 25 % at óS_2ô (₦7, 001- ₦9, 999), while 27 % would be at óS_3ô, Ó₦10,000. This indicates that in the long-run, price of sorghum would be relatively lower; this is strange, because one would expect that as a result of few hands that are into farming and consequence increase in population coupled with activities of insurgent Boko Haram, there would be pressure on food items leading to increase food prices. Unfortunately, this did not hold, because the youths which form larger part of the society do not longer see sorghum as staple food either as a result of longer time it takes to prepare the food from sorghum or it has gone out of fashion. The null hypothesis that farmers will not receive better prices in the long-run is accepted for sorghum since the highest steady state fell at the lowest state. And considering the fact that sorghum being a major staple after maize, it may be a disincentive effect to farmers since chances exist both for marketable and marketed surplus. The assertion is that farmers worldwide should receive a fair price for commodities they produce, not only sufficient to make a living (and the financial rewards are always low for the hours worked) but also an adequate profit to invest in their farm. The null hypothesis that farmers will not receive better prices in the long-run is accepted for sorghum since the highest steady state fell at the lowest state.

4.3 Existence and Level of Inter-market Price Dependency

4.3.1 Unit root tests

The result presented in Table 4.7 examined the time series properties of prices of maize, rice and sorghum in both rural and urban markets. The variables were examined for non stationarity using the Augmented Dickey-Fuller unit root test (Dickey & Fuller, 1979). The result of the ADF unit root test indicates that price of rice in the rural and urban locations were non stationary at their levels, but became stationary at the first order difference. Prices of maize in both locations were stationary at their levels. However, according to Obayelu and Salau (2010) at first differencing, a time series that has one unit root and another that has a double unit root can still be cointegrated, where the resulting linear combination is *I*(1). That is to say, two or more integrated time series of any order can be cointegrated if there exist a linear combination of the two that is of a lower order of integration, e.g, *I*(1) Ÿ *I*(0) or *I*(2) Ÿ *I*(1) if this is true, the OLS estimator of the regression in the levels is consistent.

From the unit root test results, urban and rural prices of maize are stationary at levels (has no unit root). As reported by Rapsomanikis, Hallam and Comforti (2004), that in the event the series have a different order of integration such as *I*(0), the series can be concluded to be stable at levels. This implies they can be estimated directly at their levels using the vector autoregressive (VAR) model and subsequent examination of whether Granger causality exists and in which direction. Urban and rural prices of rice were stationary after their first difference, thus, were integrated at order one *I*(1) which necessitated the estimation of the vector error correction model (VECM). However, urban and rural prices of sorghum were *I*(1) and *I*(1), respectively in their natural form, which warranted their transformation to a log form (Obayelu & Salau, 2009). After this, they became stationary after first difference (integrated at order one), this implied that the variables were *I*(1) and any attempt to specify the dynamic function of the variable in the level of the series will be inappropriate and may lead to problems of spurious regression in line with Rashid (2004).

Table 4.7: Augmented Dickey-Fuller Unit Root Test

Variable	Constant	Trend	Lag	ADF	95% critical value	ADF	95% critical value	Order
				Level		First difference		
(PM)urban	with	With	0	-5.5993	-3.4480	-	-	*I*(0)
(PM)rural	with	With	0	-6.1002	-3.4480	-	-	*I*(0)
(PR)urban	with	without	1	-2.7401	-2.8861	-9.5855	-2.8863	*I*(1)
(PR)rural	with	without	1	-2.1952	-2.8861	-8.5720	-2.8863	*I*(1)
Log(PS)urban	with	without	0	-2.5263	-2.8858	-9.6189	-2.8861	*I*(1)
Log(PS)rural	with	without	2	-2.1750	-2.8863	-8.6847	-2.8868	*I*(1)

Source: Field Data, 2001-2010

4.3.2 Impulse response function (IRF) for rural and urban price of maize

Short-run dynamics interrelationship between markets can be better observed by computing the impulse response function, which shows the persistent effect or asymmetric effect of shocks between related market prices (Goodwin & Harpper, 2000). The estimated coefficients of the VAR and contemporaneous model indicate the direct effects on the price of maize in urban and rural markets. Yet, we are also interested in the total effects (direct and indirect effects) that the price of maize in rural market will have on the urban price. Thus, in Figure 4.7 we present the results from the impulse response for the level of urban price of maize. The actual impulse response function was based on the above estimated model of the vector autoregressive (VAR) estimate using the actual data (Table 4.7).

An IRF traced the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. A shock to one variable, has not only directly affected another variable but is also transmitted to all of the other endogenous variables through the dynamic (lag) structure of the VAR. Our innovations were assumed to be contemporaneously uncorrelated after a transformation, and the numbers in parentheses are the response standard errors. The IRF results in Figures 4.7 and Table 4.8, traced out the response or described how the urban market price reacted over time to exogenous impulses (shocks) in the rural market price. The result on the table shows that urban market price of maize was affected contemporaneously by the shock to itself (first column) and also affected contemporaneously by the shocks from the rural counterpart (second columns). The response was also portrayed graphically, with horizon (period) on the horizontal axis and response on the vertical axis. From the table, the first column is the response of urban market price of maize to itself; the second column is the response of urban market price of maize to the rural price.

The urban price of maize responded to its own structural innovation and seemed to appear greater than the response of rural price. A market shock to urban market price of maize was stronger on itself at all horizons (from the first to the tenth months) and was less than the shock to rural price in all the periods. Also, urban price innovations played a larger role in explaining its response in short-run, than it did in the long-run. Indeed, for the ten period horizons, urban price of maizeôs shocks explained a greater proportion of the response of itself than the shocks from the rural price.

Overall, it appeared that, innovations in urban price of maize was an important contributor to variability of rural price either in the short or long-run, while as economic shocks to rural price of maize also contributed to the variability of urban price in the long run.

From the graph, let us consider the ñResponse of PMU to PMR.ò If we increase rural price for one time period, at time period 0, then the urban price will start to increase, and urban price will grow more quickly than other wise for about two months and then start to fade. In general, there was strong market integration between the urban and rural prices of maize.

Table 4.8: Vector Auto regression Estimates for Urban/Rural Prices of Maize

Regressors	PMU	PMR
PMU(-1)	0.526228	0.227754
	(6.35562)	(3.38986)
PMR(-1)	0.432536	0.437497
	(3.69446)	(4.60509)
Constant	703.3857	1224.900
F-statistics	89.05751	55.92043

Source: Field Data, 2001-2010

4.3.3 Johansen cointegration test

Cointegration tests were conducted by using the recorded rank procedure developed by Johansen (1988). This method should produce asymptotically optimal estimates since it incorporates a parametric correction for serial correlation. The nature of the estimator means that the estimates are robust to simultaneity bias, and it is robust to departure from normality (Johansen, 1988). Johansen method detects a number of cointegrating vectors in non-stationary time series.

Johansen procedure was used to determine the rank r and to identify a long-run rural-urban markets price relationship of three different cereal grains. The number of lags used in this VAR is based on the evidence provided by the Akaike Information Criteria (AIC). However, cointegration between the prices means that the prices follow the same long-run trends, which they cancel in the price differentials. The existence of cointegration by itself does not imply which price equilibrium adjusts and which do not, nor does it entails whether any adjustment is

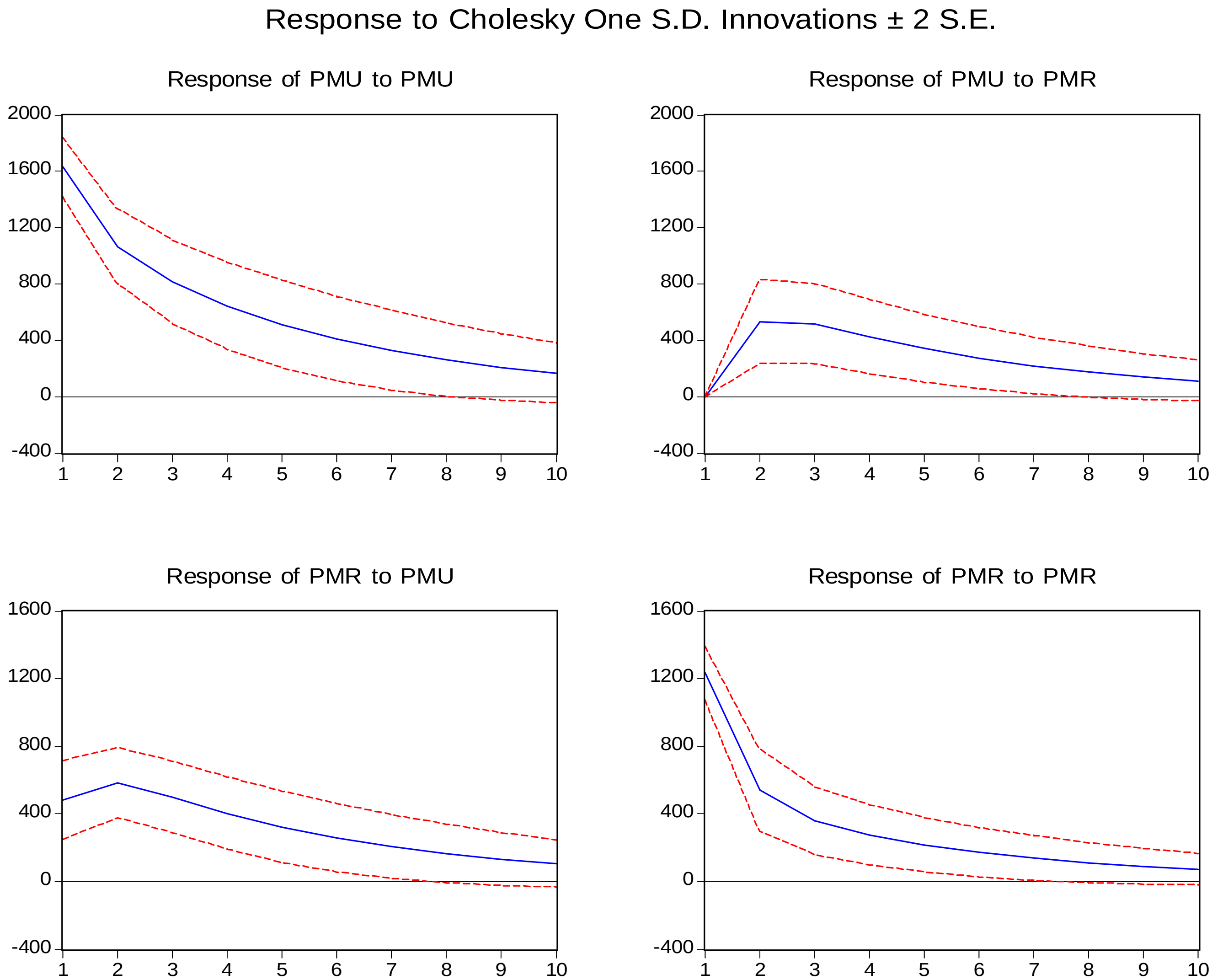

Figure 4.7: Graphs of the Impulse Response Function

Source: Field Data, 200-2010

fast or slow. Cointegration between the rice prices could arise, if the price differentials between two locations were stationary. However, cointegration at such does not say anything about the direction of causality.

Unlike the Engleï Granger procedure that is based on Ordinary Least Square (OLS) estimate, Johansen vector auto regression relies on two maximum likelihood estimates, these are the trace statistic and max-eigenvalue, though the trace statistic is considered more reliable than the max-eigenvalue statistic (Tables 4.9, 4.10 and Tables 4.11, 4.12). The trace statistic indicated no cointegration at ɟ ’ 0.05.

Table 4.9: Eigen Values and Trace Statistic Test for Rice

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Per cent Critical Value	1 Per cent Critical Value
None *	0.101350	18.77239	15.41	20.04
At most 1 *	0.050886	6.162705	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Trace test indicates 2 cointegrating equation(s) at the 5% level
Trace test indicates no cointegration at the 1% level
Source: Field Data, 2001-2010

Table 4.10: Eigen values and Max-Eigen Statistic for Rice

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Per cent Critical Value	1 Per cent Critical Value
None	0.101350	12.60968	14.07	18.63
At most 1 *	0.050886	6.162705	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Max-eigenvalue test indicates no cointegration at both 5% and 1% levels
Source: Field Data, 2001-2010

Table 4.11: Eigen Values and Trace Statistic Test for Sorghum

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Per cent Critical Value	1 Per cent Critical Value
None **	0.155275	25.01746	15.41	20.04
At most 1 *	0.044079	5.274405	3.76	6.65

*(**) denotes rejection of the hypothesis at 5%(1%) level
Trace test indicates 2 cointegrating equation(s) at 5% level
Trace test indicates 1 cointegrating equation(s) at 1% level
Source: Field Data, 2001-2010

Table 4.12: Eigen value and Max-Eigen Statistic for Sorghum

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.155275	19.74305	14.07	18.63
At most 1 *	0.044079	5.274405	3.76	6.65

*(**) denotes rejection of the hypothesis at 5%(1%) level
Max-eigenvalue test indicates 2 cointegrating equation(s) at 5% level
Max-eigenvalue test indicates 1 cointegrating equation(s) at 1% level
Source: Field Data, 2001-2010

4.4 Speed of Price Adjustment to Long-run Equilibrium

4.4.1 Rice

The cointegration equation is presented on Table 4.13, the cointegrating equation is given the equation for the change in urban price (first column) and change in rural (second column). The adjustment coefficient on CointEq1 (Table 4.13) for the urban price is negative (*a apriori*), insignificant and very small at 17.1% a month, the adjustment coefficient on rural price is positive, as it should be, but fairly large 59.2% a month, and significant. All the adjustment was being done by rural price of rice. Lagged of urban price of rice was significant in its own equation and not significant in the rural priceӳ equation, but lagged of rural price were insignificant.

Table 4.13: Vector Error Correction for Long-run estimates for Rice

Regressors	Long-run estimates	Standard error	t-value
PRU	1.000		
PRR	-1.276030	0.26636	-4.791057
Constant	1252.744		

Source: Field Data, 2001-2010

Table 4.14: Vector Error Correction for Short-run estimates for Rice

Error Correction	D(PRU)	D(PRR)
CointEq1	-0.170725	0.592237
	(-1.86382)	(2.61099)
D(PRU(-1))	-0.27910	-0.319457
	(-2.74929)	(-1.26802)
D(PRR(-1))	-0.178996	-0.234610
	(-1.56664)	(-0.82923)
Constant	191.6992	193.7115
R^2	0.167541	0.488167
R^{-2}	0.145634	0.474698
F	7.647886	36.24297

D = difference operator, Figures in parentheses are t-values, PRU = Urban Price of Rice, PRR = Rural Price of Rice
Source: Field Data, 2001-2010

4.4.1.1 Vector error correction model result and interpretation for rice

The results of the vector error correction estimate are presented on Table 4.13 and Table 4.14 for long and short-run estimates, respectively. The result of the short-run test indicated that, rural price of rice had a value of -0.178996 and long-run value of -1.276030. The result implied that, a 1% increase in urban price of rice in the short-run had increased the rural price by 18%, while in the long-run, rural price would increase by 127.6 %.

The Error Correction coefficient, the speed with which the system adjusted to shocks and restored equilibrium between the short and long-run, measured by the ECM was -0.170725 for the urban price and 0.592237 for the rural price. The model came out with the expected negative sign and also indicated that the speed of restoring equilibrium back into the system in response to exogenous shock was slow.

Further interpretation of the absence of cointegration between the two market prices implies that the two prices do not follow the same long-run trend. As a result, the market price in the urban market either drifted above or below the rural market price in the long-run, implying that urban market price either costs too much or rural market price cost less. This is not surprising, as Rashid and Minot (2010) highlighted that market locations lack integration due to inadequate public goods (such as infrastructure), inefficient flow of information, imperfect competition, and incomplete or missing institutions for risk management like credit and insurance- all of which qualify as sources of market failures. Taru and Lawal (2011) have detected some of these indexes of market failures coincidently in the area covered by this study, and are likely to be responsible for the absence of integration in these markets. Nuhu et al. (2009) reported that the transportation system in Nigeria and indeed the North eastern part is not adequate. Most roads particularly those leading to the rural villages where farming activities are carried out are seasonal roads and are not motorable during the rainy season. Adeoye, Dontsop Nguezet, Badmus and Amao (2011), in a study of the integration of banana and plantain in rural and urban market in Oyo State found bad roads as the major factor responsible for market segmentation among market. According to Olukosi and Isitor (1990), inaccessibility of producing rural areas to fast means of transportation results in location surpluses at the producing areas and shortages at the urban consuming areas making the rural and the urban markets segmented. This gives the ground of rejecting the null hypothesis of price matching with delayed price adjustment.

4.4.2 Sorghum

The cointegration equation for this model is presented on Table 4.15, and following the cointegrating equation is given the equation for the change in urban price (first column) and change in rural (second column). The adjustment coefficient on Cointegration equation 1 for the urban price was negative as it should be, generally, low coefficient indicates slow adjustment and high coefficient indicates rapid adjustment, hence the coefficient was very small (29.5%) a month and significant, the adjustment coefficient on rural price was positive, as it should be, but fairly small 38.0% a month, and significant. The adjustment is being done by both the rural price and urban price of sorghum. However, the rural price of sorghum adjusted faster, than the urban price.

In general, traders are perceived to be better informed than Farmers, and assertions that opportunities for the knowledgeable to ñexploitò the less knowledgeable have been made by numerous researchers (Manuel & Maunahan 1982; Olgado, Abunvawan & Domingo, 1977). These studies argued that asymmetric information, coupled with farmers' heavy reliance on traders for information, provide traders with market power and enable unscrupulous traders to manipulate prices to the disadvantage of the farmers. In the opinion of Mendoza and Rosegrant (1995), this impairs poor market integration. On the other hand, the absent of market integration implied imperfections in the market and a departure from competitive conditions. This according to economic theory provides a potential opportunity for middle men to realize excessive profits. Hay and McCoy (1977) noted however, that market segmentation may not only result from exploitative practices of traders but are likely to be as a result of the nature of production and defects in the marketing system.

Table 4.15: Vector Error Correction of Long-run estimates for Sorghum

Regressors	Long-run estimates	Standard error	T-value
LOG(PSU)	1.000		
LOG(PSR)	-1.002185	0.09050	-11.0743
Constant	-0.175882		

Source: Field Data, 2001-2010

Table 4.16: Vector Error Correction of Short-run estimates for Sorghum

Error Correction	D(PSU)	D(PSR)
CointEq1	-0.29517	0.38034
	(-2.12564)	(2.65164)
DLOG(PSU(-1))	0.086645	0.070313
	(0.55397)	(0.43097)
DLOG(PSU(-2))	0.200324	-0.117872
	(1.44483)	(-0.81501)
DLOG(PSR(-1))	-0.181272	-0.285472
	(1.38375)	(-2.08910)
DLOG(PSR(-2))	-0.196370	-0.188395
	(-1.84776)	(-1.69945)
Constant	-0.008405	0.015556
R^2	0.057755	0.264635
R^{-2}	0.015312	0.231510
F	1.360753	7.989075

D = difference operator, CoinEq1 = cointegration equation, PSU = Urban price of sorghum, PSR = Rural price of sorghum, LOG = Logarithm.
Source: Field Data, 2001-2010

4.4.2.1 Vector error correction model result and interpretation for sorghum

The results of the vector error Correction estimate are presented in Table 4.15 and Table 4.16 for long and short-run estimates respectively. The result of the short-run test indicated that, the rural price of sorghum had a short-run value of -0.181273 and long-run value of -1.002185. The result of the rural price indicated that a 1% increase in urban price of sorghum in the short-run had increased rural price by 18%, while in the long-run, rural price would increase by 100.2%.

The Error Correction coefficient, the speed with which the system adjusted to shocks and restored equilibrium between the short and long-run, measured by the ECM was -0.29517 for the urban price and 0.38034 for the rural price. The model came out with the expected negative sign for the urban market. The negative value of the adjustment parameter implies that positive deviations from the long-run equilibrium are corrected by decreases in prices in a particular market. It indicated that the speed of restoring equilibrium back into the system in response to exogenous shock was slow.

Further interpretation of the absence of cointegration between the two market prices implies that the two prices do not follow the same long-run trend. As a result, the market price in the urban market might have drifted above or below the rural market price in the long-run, implying that urban market price of sorghum either costs too much or rural market price costs less.

4.5 Granger-Causality among Rural and Urban Markets

4.5.1 Maize

Table 4.17 indicates the direction of causality between urban price of maize and rural price of maize. The variables used in these tests were stationary at their levels. The Granger test was conducted with a lag length of ɟ ʼ 0.005 and ɟ ʼ 0.05. The result indicated that there existed an interdependent and bi-directional causality between urban price of maize and rural price of maize. An increase in rural price of maize led to an increased urban price of maize and vice versa.

It is important to note that although cointegration between two price series implies Granger causality in at least one direction, the opposite is not necessarily true. In this case, lack of cointegration between the two trending price series may indicate that market integration is absent, as other factors such as transaction costs, some price signals are passing through from one market to another. On the other hand, lack of Granger causality may not imply an absence of transmission, as price signals may be transmitted instantaneously under special circumstances.

From the results of the Augmented Dickey-Fuller unit root test, impulse response function, the speed of adjustment and Granger-Causality, inferences can be drawn that urban and rural market prices of maize obeys the Law of One Price (LOP), indicating that urban and rural markets of maize were efficient, non-collusive with an indication of perfect price matching.

Table 4.17: Pairwise Granger Causality Tests for Maize

	Observation	F-Statistics	Probability
RUMPM-URMPM	119	11.49117**	0.0007
URMPM-RUMPM	119	13.64907**	0.0002

**indicating a significance level of ɟ ’ 0.05

Source: Field Data, 2001-2010

4.5.2 Rice

Table 4.18 presents the direction of causality between urban price of rice and rural price of rice. The variables used in these tests were assumed to be stationary and well integrating. The Granger test was conducted with a lag length of 2 and 5% level of significance. The result indicated that, there existed no interdependent and any form of causality between urban price of rice and rural price of rice. An increased rural price of rice did not lead about an increase in the urban price of rice and vice versa. We conclude that the urban and rural prices of rice were inefficient, with an indication of collusive behavior.

Table 4.18: Pairwise Granger Causality Test for Rice

	Observation	F-Statistics	Probability
RUMPR-URMPR	118	2.454352	0.1172
URMPR-RUMPR	118	1.607884	0.2048

Source: Field Data, 2001-2010

4.5.3 Sorghum

Table 4.19 indicates the direction of causality between urban and rural price of sorghum. The variables used in these tests were assumed to be stationary. The Granger test was conducted with a lag length of 2 and 5% level of significance. The result indicated that there existed no interdependent and bi-directional causality between urban price of sorghum and rural price of sorghum. An increased rural price of sorghum did not lead to an increase in the urban price of sorghum and vice versa. This conforms to the cointegration test, where the cointegration test found no cointegration equation, implying that they did not follow each other in the long-run trend.

Table 4.19: Pairwise Granger Causality Test for Sorghum

	Observation	F-Statistics	Probability
RUMPS-URMPS	117	1.267137	0.5307
URMPS-RUMPS	117	3.544102	0.1700

Source: Field Data, 2001-2010

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The study was on price fluctuation and market integration of selected grains in North-eastern Nigeria. Specific objectives of the study were to: (i) estimate the various components of price; (ii) drive the probability distribution of cereal grains price in the long-run; (iii) examine the Granger Causality among rural and urban markets; (iv) determine the existence and level of inter-market price dependencies; and (v) examine the speed of adjustment to long-run equilibrium. A purposive sampling technique was employed to select two states (Adamawa and Taraba) out of the six states that made up the north-east geopolitical zone, this was adopted to avert the risk of travelling to the violence prone states, because privileged information have it that, the data needed by the study were best obtained from the various statesô Agricultural Development Progamme offices. The study only used a secondary data obtained from the two states (Adamawa and Taraba) from their respective ADP offices on the prices of three cereal grains; maize, rice and sorghum for ten years (2001-2010). Both descriptive statistics such as price decomposition technique and inferential statistics such as Markov Chain and vector autoregressive combined with its error correction models were used for the analyses.

Results obtained indicated that, only trend and seasonal variations were visible, cyclical component was reported to be absent as longer period of time is needed in other to identify this component, while random component was stationary and negligible indicating that there were no any variables that attribute to it during the time under study. The study also revealed that, prices of the three cereal grains would not be favorable to the farmers in the long-run, this was glaring, because the prices of maize and sorghum fall under the lowest category of the price ñStateò only the price of rice was under the second ñStateò. Further, the result of the market integration for urban and rural market prices of maize were *I*(0) interpreted as integrated of order zero, meaning that there was no unit root or they were stationary at levels. Also, there was an indication of a bi-directional movement of price signals, that is, price signals were seen coming from rural to urban market as well as going back from urban to rural markets, indicating that an increase in the price of maize in rural market will increase the price in urban market and vice versa.

Prices in the rural and urban markets of rice and sorghum were integrated of *I*(1) interpreted as ñintegrated of order 1ò suggesting that other analysis such vector autoregressive VAR and error correction model ECM could be applied to test the level of adjustment to long-run equilibrium and then finally test the direction of flow of price signals among the markets. Both prices of rice and sorghum at rural and urban markets have shown no evidence of cointegration, the prices drift apart accepting the null hypothesis that the cereal grain markets are spatially independent and inefficient. There were also no price signals in either of the market for all the commodities except maize.

5.2 Conclusion

It was found that prices of cereal grains in the long-run will not be favorable to farmers. This is a breaking ground, as farmers and the stakeholders in agricultural sector should take precaution. The study also revealed that rural and urban prices of cereal grains were not cointegrated, this has led to the acceptance of the null hypothesis that cereal grains market are spatially independent and inefficient. This establishes the non-existence of Law of One Price (LOP) as against claims by previous studies that cointegration exist between rural and urban prices of agricultural commodities, though such conclusions were drawn based on the classical static linear regression and correlation analyses, and as such the findings were spurious. This is a vacuum which this study has fielded. Among the three commodities, none had shown any cointegration between its price in rural and urban markets. Granger causality (unidirectional) existed between rural and urban prices of maize, while there was no Granger causality between rice and sorghum markets. The market price for cereal grains in the north-eastern Nigeria has not experienced an erratic fluctuation as has been reported globally, but the 2007-2008 price panic where prices of most agricultural produce experienced hike was seen in the prices of sorghum and rice. The Farmers are also vulnerable to poor prices of commodities in the long-run which may be a disincentive effect to the farmers. Also, the marketing and price information transmission mechanism for cereal grains marketing can be concluded inefficient.

5.3 Recommendations

Findings of the study showed imperfect market integration for North-eastern Nigeria cereal grain markets, this indicate that there may be substantial benefits in developing better infrastructure facilities to effectively link production centers to market centers and in improving market knowledge by providing more relevant, accurate, and timely public market information. Marketing costs could be significantly reduced if' better roads and marketing facilities were built. Improvements in the methods of' collecting and disseminating public market information could result in more transparent prices to all market agents. Better market information services would also enable market agents to read price signals more accurately and promptly, and therefore to make more reliable price forecasts that would aid them in making correct marketing decisions. This analysis does not, however, permit analysis of the relative returns to alternative investments in market infrastructure and services neither does it on the factors responsible for market integration. Extensions of the time-series analysis to test the effect of' structural variables such as density and quality of roads and bridges and penetration of extension and market services would help to identify the most productive investments.

5.4 Major Contributions of the Study to Knowledge

The research has contributed to knowledge in several ways. Specifically, the study has:

i made a pioneering attempt at establishing the non-existence of Law of One Price (LOP) between rural and urban prices of cereal grain prices in north-east Nigeria;

ii established the major source of variability in the price series from 2001-2010;

iii given an insight into how likely the future of cereal grain prices would be;

iv established theoretical and empirical framework for linking market cointegration and market efficiency; and

v also made a pioneering study on the technique of price decomposition in the Department of Agricultural Economics, University of Nigeria, Nsukka.

5.5 Suggestions for further study

This study and in fact most other studies on market integration adopted the use of secondary data in making conclusion on the cointegration of rural and urban markets. Similar study should be undertaken using primary data and on specific markets in both rural urban. Also, other models, such as Parity Bound Model (PBM) should be employed concurrently with Vector Autoregressive Model to testing the integration of market prices and the result compared.

REFERENCES

Abdissa, G., & Dereje, B. (2001). Maize marketing in Ethiopia. A Review, 117-124.

Abdulai, A. (2000). ñSpatial price transmission and asymmetry in the Ghanaian maize market.ò *Journal of Development Economics,* 63, 327ï 349.

Achoth, L. (1985). Supply Price and trend of Indian Tea: An Econometric analysis. (Unpublished doctoral dissertation) University of Agricultural Science, Bangalore.

Achanya, S. S. (2004). State of the Indian farmer-a millennium study agricultural marketing Department of Agric. Cooperation Ministry of Agriculture, Government of India.

Adegeye, A. J., & Dittoh, J. S. (1985). *Essentials of agricultural economics.* Impacts publishers, Ibadan.

Adekanye, T. O. (Ed) (1988). The Markets for foodstuff in Western Nigeria. *Readings in Agricultural Marketing.* Lagos, Longman.

Adeoye, B., Dontsop Nguezet, P. M., Badmus, M. A., & Amao, I. O. (2011). Price transmission and integration of Banana and Plantain in Oyo State, Nigeria. *APPN Journal of Agricultural and Biological Sciences,* 6(5), 1-7.

Agarwal, N. L., & Sharma, K. C. (1990) Price behavior of pulse crops in Ragasthan. *Indian Journal of Agricultural Marketing,* 4(2), 128-139.

Agbadudu, A. B. (1996). *Elementary operations research.* Benin City, A.B. Mudiaga limited.

Akande, T. (2001). An overview of the Nigerian rice economy, A pilot project report, The Nigerian rice economy in a competitive world: constraints, opportunities and strategic choices, WARDA, 11 p.

Akpan, S. B., & Udoh, E. J. (2009). Estimating grain relative price variability and inflation rate movement in different agricultural regimes in Nigeria. *Humanity and Social Sciences Journal,* 4(2), 107-113.

Akpan, S. B., & Aya, E. A. (2009). Variance in consumers prices of selected food items among markets in Cross River State. *Global Journal of Social Sciences,* 8(2), 49-52.

Ali, S. A. (1988). A study of the market structure, conduct and performance and infrastructural facilities of agricultural regulated markets in western Uttar Pradesh. *Indian Journal of Agricultural Marketing,* 2(1), 71.

Aminu, A. (2010). Analysis of seasonality and gross real returns to storage of tomato in selected rural and urban markets in Nigeria. *Savannah Journal of Agriculture,* 5, 1-9.

Anderson, R. L. (1950). Tests of significance in time series analysis. In T. C. Kommun (ed). New York, John Wily and sons.

Anthonio, Q. B. O. (1968). The Marketing of staple foodstuffs in Nigeria: a study in pricing efficiency, (Unpublished doctoral dissertation) University of London.

Anthonio, Q. B. O. (1988). Agricultural and food marketing: its theoretical relevance for development. In: T.O. Adekanye, (Ed), *Readings in Agricultural Marketing*, Lagos, Longman Nigeria pp. 193-199.

Ariyo, J. A., Voh, J. P., & Ahmed, B. (2001). Long term change in food provision and marketing in Kano regions, 1960 ï 2000 dry-land research working paper, 34, 30.

Arya, A. (1991). Spatial integration of regulated markets in Kheda district of Gujarat. *Indian Journal of Agricultural Marketing,* 5(2), 207-209.

Asche, F., Brennes, H., & Wessels, C. R. (1999). ñProduct aggregation, market integration and relationship between prices: an application to world Salmon marketsò *American Journal of Agricultural Econnomics* 81(August, 1999), 568-88.

Atobelele, J. T. (1986). The Size, structure and changing income pattern under new technology in Oyo state. (Unpublished doctoral dissertation) University of Ibadan, Nigeria.

Ashok Kumar, K. S. (1989). Price and arrivals of aceranut in selected major markets of Karnataka. (Unpublished masterôs thesis) University of Agricultural Sciences Bangalore.

Bachelier, L. (1990). Theorie da lg speculation. Gauthier-Villars, Parris, translated in P. A. Contner (ed), *The Random Character of Stock Prices*. Cambridge, MIT Press.

Balarabe, A. S. (2003). Analysis of urban household consumption of cereals in Kaduna metropolis of Kaduna State. (Unpublished Masters thesis Ahmadu Bello University Zaria).

Balappa, S. (2002). Infrastructure for price stabilization of potato in Karnataka. (Unpublished doctoral dissertation University of Agricultural Sciences Dhawad).

Balarabe, A. S., Ahmed, B., & Chikwendu, D. O. (2006). Analyses of price and income elasticities for cereals food crops in an urban town of Kaduna, Nigeria. *Agrosearch,* 8(1), 59-65.

Balcombe, K.V. & Morrison, J. (2002). Commodity price transmission: a critical review of techniques and application to selected export commodities. report to the Food and Agriculture Organization of the United Nations.

Banajee, A., Delgado, J. J., Galbraith, J. W., & Hendry, D. F. (1993). *Cointegration, error correction and the econometric analysis of non-stationary Data*. New York, Oxford University press.

Barrett , C. B. (2005). *Spatial Market Integration*, Cornell University.

Bassolet, B., & Lutz, C. (1999). Information services and integration of cereal market in Burkina Faso. *Journal of African Economics,* 8(1), 31-51.

Bausch, B. (1997). Transfer costs, spatial arbitrage and testing for food markets integration, *American Journal of Agricultural Economics*, 79, 477-487.

Bhat, V. S. (1980). Temporal and spatial variations in arrivals and prices of paddy and groundnut in selected markets of Karnataka: an economic analysis. (Unpublished masters thesis) University of Agriculture Sciences, Bangalore.

Bhatta, R., & Bhat, A. R. S. (1998). An economic analysis of price and supply of arecanut in Karnataka. A case study of Sirsi and Mangalare Markets. *Journal of Institute of Economic Research,* 23(1), 46-48.

Bhide, S. A., Chowathury, E. O., Heady, E. O., & Muralidharan, M. A. (1981). Structural changes in an agricultural assembling marketing. A case study of arecanut (Betenut) market in Mangalore, Karnakata State. *Indian Journal of Agricultural Economics,* 34(2), 81-87.

Blyn, G. (1973). Price series correlation as measure of market in Peninsula Malaysia. *Indian Journal of Agricultural Economics,* 28, 56-59.

Brahmaprakask, B., & Srivastava, S. (1994). Pattern of marketing arrivals and prices of gram in Uttar Pradesh. *Indian Journal of Agricultural Marketing,* 8(1), 13-16.

Breiman, L. (1992). Stochastic Process: In Fafchamps, S., Farmers and price fluctuation in poor Countries. *Quarterly Journal of Economics*, 15(6), 1-27.

Cappoza, D. R. & van Order, R. (1978). A generalized model of spatial competition, *The American Economic Review*, 68(5), 896-908.

Chatfield, C., & Prothero, D. L. (1973). Box and Jenkins seasonal forecasting problems in a case study. *Journal of Royal Statistical Society of Am*erica, 140(4), 492-510.

Chatfield, C., (1977). Recent development in time series analysis. *Journal of Royal Statistical Society of America,* 140(4), 482-491.

Chengappa, P. G. (1980). An analysis of Indian coffee Price: a spectral approach (Unpublished doctoral dissertation) IARI New Delhi.

Delgado, C. I. (1986). A variance component approach to food chain market integration in Northern Nigeria. *American Journal of Agricultural Economics,* 68, 970-979.

Devaiah, M., Venikatagiriyappa, C., & Achott, L. (1988). Spatial integration and price relationship of Ramanagaram over mino silk cocoon markets of Karnataka. Proceedings of the International Congress on Tropical Sericulture, Central Silk Board, pp. 77-84.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root, *Journal of the American Statistical Association,* 74, 427-431.

Dinakar, B. C. (1990). Commodity system of edible oil seeds: A case study of groundnut in Karnataka, Yellow thesis National Institute of Bank Management, Pune, 19-34.

Dittoh, J. S. (1994). Market Integration: the case of dry season vegetables in Nigeria. *Issues in African Rural Development,* 2, 89-101.

Dittoh, J. S. (1985). Production responses in peasant agriculture ï a time series and cross-sectional analysis of cotton in North Eastern Ghana, (Unpublished M.Phil dissertation) University of Ibadan Nigeria.

Doll, J. P., & Orazem, F. (1984). *Production Economics: Theory with application* (ed). New York John Wiley.

Durham, C. A., Sexton, R. J. & Ho Song, J. (1996). Spatial competition, uniform pricing and transportation efficiency in California processing tomato industry, *American Journal of Agricultural Economics*, 78 (1), 115-125.

Ejiga, N. O. O. (1988). Price Efficiency for cowpea in northern Nigeria. Reading. In T.O. Adekanye (Ed) *Agricultural Marketing,* Nigeria Longman, 157-167.

Engle, R. F., & Granger, C. W. J. (1987). Cointegration and error correction: Representation, estimation, and testing. *Econometrica.* 55, 251-256.

Eshwaraprasal, Y., Sreeram Murthy, C., & Sathaynarayana, G. (1989). An analysis of arrivals and Price of turmeric in Guntur market. *Indian journal of Agricultural Marketing,* 3(1), 34-37.

Fafchamps, M. (2000). Farmers and price fluctuations in poor countries. *Quarterly Journal of Economics,* 15(6), 1-27.

Fama, E. F. (1965). The Behaviour of stock prices, *Journal of Business,* 38, 34-105.

Faminow, M. D., & Benson, B. L. (1990). Integration of spatial markets, *American Journal of Agricultural Economics,* 72(1), 49-62.

Farooq, M. C. (1970). Structural and performance of rice marketing system in East Pakistan, Department of Agricultural Economics Cornelio University Ithaca, New York, 80-85.

Farris, P. L., & Padberg, D. I. (1964). Measures of market structure changes in Florida fresh citrus packaging industry, *Agricultural Economics Research,* 16, 4.

Federal Republic of Nigeria, FRN (2007). Official gazette. 24(94), Lagos Federal Government Printer.

Ferret, A., & Page, M. J. (1998). Cointegration of South African Index Future contracts and their underlying Spot market indices. *Journal of Studies in Econometrics,* 22(1), 69-90.

Feear, J. (1988). *The Management of business finance.* Longman-Pitman Publishing.

Fik, T. J. (1988). Spatial competition and price reporting in retail food markets, *Economic Geography*, 64(1), 29-44.

Food and Agriculture Organization (FAO), (1996). The world sorghum and millet economies: fact trends and outlook. FAO Document repository W1808/E.

Food and Agriculture Organization (FAO), (2008). The state of food insecurity in the world, high food prices and food security threats and opportunities.

Fuller, W. A. (1976). *Introduction to statistical time series.* New York, Wily and Sons.

Gangadharappa, H. (2005). A statistical study of variation in arrivals and prices of potato in the selected markets of Karnakata. (Unpublished Masters thesis) University of Agricultural Sciences Dharwad.

Gemtessa, K. (1991). An analysis of the Ethiopian coffee exports. (Unpublished masterôs thesis), University of Agricultural Sciences Bangalore.

Gilbert, E. H. (1969). Marketing staple foods in northern Nigeria: a case study of staple food marketing system serving Kano city. (Unpublished doctoral dissertation) Stanford University California.

Global Information and Early Warning System on Food and Agriculture (GIEWS), (2008). Special report (Benin, Niger and Nigeria). http://www.fao.org/docrep1010/ai464e00.htm accessed 8th May, 2010.

Goletti, F., Ahmed, R., & Farid, N. (1995). Structural determinants of markets integration: the case of rice markets in Bangladesh. *The Developing Economics,* 33(2), 185-202.

Gonzalez-Revera, G., & Helfand, S. M. (2001). The Extent, pattern, and degree of market integration: a multivariate approach for the Brazilian rice market. *American Journal of Agricultural Economics,* 88(3), 576-92.

Goodwin, B. K., & Schroeder, T. C. (1991). Cointegration tests and spatial price linkages in regional cattle markets. *American Journal of Agricultural Economics,* 72(2), 452-62.

Goodwin, B. K., & Harpper, D. C. (2000). Price transmission threshold behavior and asymmetric adjustment in the US pork sector. *Journal of Agricultural and Applied Economics,* 32(3), 543-553.

Granger, C. W. J. (1969). Investigating causal relationship by econometric models and cross spectral method, *Econometrica*, 37, 424-438

Granger, C. W. J. (1981). ñInvestigating causal relationship by econometric models and cross-spectral methodsò *econometrica,* 37, 424-438.

Granger, C. W. J. (1983). Forecasting white noise, In A. Zeller (Ed), Applied time analysis of economic data, Washington DC, Bareau of the Census, 308-314.

Granger, C. W. J., & Weiss, A. A. (1983). Time series analysis of error-correcting model. *In studies in econometrics, time series, and multivariate statistics*. New York academic press.

Granger, C. W. J. (1986). ñSome properties of time series data and their use in econometric model specification.ò *Journal of Econometric,* 16, 121-130.

Granger, C.W. J. (1988). Some recent developments in the concept of causality, *Journal of Econometrics, 39, 199-211*

Granger, C. W. J., & Newbold, P. (1974). Spurious regression in econometrics. *Journal of Econometrics,* 2, 111-120.

Greenhut, M. L. & Ohta, H. (1975). Monopoly output under alternative spatial pricing techniques, *American Economic Review*, 62, 705-713.

Greenhut, M. L., Norman, G. & Hung, C. (1987). *The economics of imperfect competition: A spatial approach*, New York, Cambridge University Press.

Grega, C. (2002). Price stabilization as factor of competitiveness of agriculture. *Journal of Agricultural Economics,* 48(7), 281-284.

Gurumalappa, T. M. (1972). An economic analysis of marketing of groundnut in Raichur District. (Unpublished Masters thesis) University of Agriculture Sciences, Bangalore.

Harris, B. (1979). There is method in my madness: or is it vice versa? Measuring agricultural market performance. *Food Research Institute Studies,* 17, 197-218.

Hays, H. M., & McCoy, J. H. (1977). Food grain marketing in northern Nigeria: spatial and temporal performance. *Journal of Development Studies,* 14, 182-192.

Hendry, D. F., & Juselius, K. (2000). Explaining cointegration analysis: Part 1. *Energy Journal,* 21, 1-42.

Hillier, F. S., & Lieberman, G. J. (1995). *Introduction to Operations Research* (6th ed) New York McGraw-Hill.

Hotelling, H. (1929). Stability in competition, *Economics Journal*, 39, 41-57.

Idolor, E. J. (2010). Security prices as Markov processes. *International Research Journal of Finance and Economics,* 59, 62-76.

Indira, M. (1988). An economic analysis of coffee marketing in India. (Unpublished doctoral dissertation) Institute of social and economic change, Bangalore.

Ismaila, U., Gana, A. S., Twanya, N. M., & Dogara, D. (2010). Cereals production in Nigeria: problems, constraints and opportunities for betterment. *African Journal of Agricultural Research,* 5(12), 1341-1350.

Iyoha, M. A., & Ekanem, D. T. (2004). *Introduction to econometrics*. Benin March publishers.

Jayesh, T. (2001). Production and export performance of selected prices in south India: an economic analysis, (Unpublished Masterǿs thesis) University of agricultural sciences Dharwad.

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control, 12,* 231-254.

Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models, *Econometrica,* 59, 551-1580

Jones, W. O. (1969). Structure of staple food marketing in Nigeria as revealed by price analysis? food research institute studies, *Stanford California,* 8(2), 95-123.

Jorgenson, D. L. (1964). Minimum variance linear unbiased seasonal adjustment of economic time series. *Journal of American Statistical Association*, 59, 667-724.

Kelechi, O. F. (2004). Time series analysis of monthly sales in silicon oil and gas limited port harcourt, River state. (Unpublished B. Tech project) Federal University of Technology, Yola-Nigeria.

Kendall, M. G. (1973). Time series analysis, Charles Gibben and Company, London.

Koekemoer, R. (1999). Private consumption expenditure in South Africa: the rate of price expectations and learning. (Unpublished doctoral dissertation) University of Pretoria.

Krishnaswamy, L. (1975). Behavior of market arrivals of food grains in Warangal District of Andhra Pradesh. *Indian journal of Agricultural marketing,* 129(1&2), 6.

Krugman, P. (1986). Pricing to market when exchange rate changes, NBER working paperNo 1926

Kuiper, W., Lutz, C., & Van Tilburg, A. (2003). ñVertical price leadership on local maize markets in Benin.ò *Journal of Development Economics,* 71, 417ï 433.

Kupper, L. (1972). Fouries series and spherical harmonic regression. *Journal of applied statistics,* 21, 121-128.

Lanciotti, C. (1990). Forecast of monthly prices for a group of dairy products: an application of the Box-Jenkins techniques. *Rivista-di-Economia-Agraria,* 45(3), 465-492.

Little, I. M. D. (1962). Higgledy Piggledy Growth. *Bulletin of the Oxford Institute of Statistics,* 24(2), 387-412.

Livingstone, L., & Ord, H. W. (1984). *Agricultural economics for tropical Africa*. Ibadan Heinemann.

Lovelle, M. C. (1968). Alternative axiomatic statistics of seasonal adjustment. *Journal of America Statistical Association,* 61, 800-802.

Lutz, C., Van Tilburg, A., & van der Kamp, B. (1994). ñThe process of short- and long-term price integration in the Benin maize market.ò European Review of Agricultural Economics, 22, 191ï 211.

Maddala, G. S. & Kim, I. (1998). Unit roots, cointegration and structural change, Cambridge University Press

Madawaki, M. D., Biradawa, K., & Adeleye, A. (2002). *Quantitative business techniques*. Maiduguri, Compaq Publishers.

Mamatha, B. G. (1995). Export trade of selected spices in India: an economic analysis. (Unpublished Masters thesis) University of Agricultural Sciences Bangalore.

Manuel, P., & Maunahan, M. V. (1982). Coconut/copra marketing system: Its structure, conduct, performance. Philippine Council for Agricultural Resource and Research Development, Los Bafios, Laguna, Philippines. Mimeo.

Markidakis, S., & Hibbon, M. (1979). Accuracy of forecasting: an empirical investigation. *Journal of Royal Statistical Society of Australia,* 142(120), 97-145.

Markov, A. A. (1971). Extension of the theorems of probability theory to a sum of variables connected in a chain. In R. Howard, *Dynamics probabilities systems*, New York, John Wiley.

Mastry, V. (2001). The use of Box-Jenkins methodology to predict the price development of agricultural commodities. *Acta Universities Agriculturae et silviculture. Mendelianae-Brunensis,* 49(2), 165-172.

Maziya-Dixon, B. I., Akinyele, O., Oguntona, E. B., Nokoe, S., Sanusi, R. A., & Harris, E. (2004). Nigeria food consumption and nutrition survey 2001-2003 summary. IITA, Ibadan.

McNew, K. (1996). Spatial market integration: definition, theory and evidence, *Agricultural and Resource Economics Review*, 25, 1-11.

Meyers, R. 2008. ñEvaluating the efficiency of inter-regional trade and storage in Malawi maize markets.ò Report for the World Bank. Michigan State University, East Lansing, MI.

McQueen, G., & Thorle, S. (1991). Are stocks returns predictable? a test using Markov Chains. *The Journal of Finance,* 56 (1), 27-35.

Mellor, C. J. (1982). Dynamics statistical models of agricultural supply with an application. (Unpublished doctoral dissertation) University of Nottingham.

Mellor, C. J. (1984). An application and extension of the Markov Chain model to cereal productions. *Journal of Agricultural Economics,* 5(5), 203-207.

Mendoza, M. S., & Rosegrant, M. V. (1995). Pricing conduct of spatially differentiated markets. In G. J. Scott (Ed), price*, products and people analysis agricultural and developing countries*, Briston, Lynne Reiner Publishers Inc, USA pp. 30-35.

Mills, T. (1990). *Time series techniques for economists*. New York, Cambridge University Press.

Mizrahi, A., & Sullivan, M. (1979). *Finite mathematics in business and social* sciences (3rd ed). New York, John Wiley.

Moser, C., Barrett, C., & Minten, B. (2009). ñSpatial integration at multiple scales: rice markets in Madagascar.ò *Agricultural Economics,* 40, 281ï294.

Mshelia, S. I. (1991). Economics of cotton production in Nigeria. A case study of outgrowers under AFCOTT Yola, (Unpublished Masters thesis) University of Ibadan, Nigeria).

Mutambatsere, E., Mabaya, E., & Christy, R. (2007). ñIntegration and equilibrium in the maize markets in Southern Africa.ò selected paper prepared for presentation at the American Agricultural Economics Association annual meeting, Portland, July 29 ï August 1, 2007.

Naik, R. S., Kunnal, L. B., & Katageri, I. S. (1990). Analysis of price and arrivals of groundnut in Gadag and Ranebennur markets of Karnataka. *Indian Journal of Agricultural Marketing,* 14(2), 178-183.

Newbold, P., & Granger, C. W. J. (1974). Experience with forecasting univariate time series and the combination of forecasts. *Journal of Royal Statistical Society of Australia,* 137, 131-165.

Nuhu, H. S., Ani, A. O., & Bawa, D. B. (2009). Food grain marketing in northeast Nigeria: a case study of spatial and temporal price efficiency. *American Eurasian Journal of Sustainable Agriculture,* 3(3), 473-480.

Nzomoi, J. N. (2008). Agricultural commodity price fluctuation, poverty and food, In: security in Kenya assessed. Http://cerdi.org/colloque.IMSA2008.

Obayelu, A. E., & Salau, A. S. (2010). Agricultural response to prices and exchange rate in Nigeria: application of co-integration and vector error correction model (ECM). *J Agric. & Sci.,* 1(2), 73-81.

Obodos, E. (2005). Predicting stock market prices in Nigeria: a preliminary investigation. (Unpublished Masters thesis) University of Benin Nigeria.

Oguntunde, A. O. (1989). Traditional convention food from major Nigerian cereal. *Nigeria Food Journal,* 7, 59-61.

Ojanuga, A. G. (2006). Agro-ecological zones of Nigeria Manual. In F. Berding and V. O. Chude, (Eds) Publication of National special programme for food security, Abuja, Nigeria.

Ojile, G. O. F. (2002). Price analysis of foodstuffs in three markets areas of Adamawa State. (Unpublished B. Tech project) Federal University of Technology, Yola-Nigeria.

Okoh, R. N., & Akintola, J. O. (1999). Price conduct of spatially differentiated markets. The case of cassava roots in Nigeria. *African Journal of Root and Tuber Crops,* 4(2), 7-81.

Okoh, R. N. (1999). An analysis of oligopolistic pricing and market integration of cassava roots and products in Delta and Edo States. (Unpublished doctoral dissertation) University of Ibadan, Nigeria.

Okoh, R. N., & Akintola, J. O. (2005). Oligopolistic pricing and market integration of cassava roots and products in Delta and Edo States, *Nigeria Journal of Economics and Rural Development,* 14(2), 21-54.

Okoh, R. N., & Egbon, P. C. (2005). The integration of Nigeriaȍs rural and urban foodstuffs markets. African Economic Research Consortium, Nairobi Research Paper 151, November 2005, 1-34.

Okpachu, A. S. (2006). Efficiency measurement of soyabean marketing in Benue State, Nigeria. (Unpublished Master thesis) Federal University of Technology Yola.

Okunmadewa, F. (1999). Poverty and income in Nigeria-measurements and strategies for reform. paper presented at the Vision 2010 Workshop April, 1997 Abuja. In Okunneye, P.A. (1995) Nigeria Agriculture on the run refuses to move. University of Agriculture, Abeokuta inaugural lecture series 2, 36.

Okunneye, P. A. (2003). Rising cost of food prices and food insecurity in Nigeria and its implication for poverty reduction. CBN Economic and Financial Review, 39(4), 23-38.

Okwoli, O. B. B. (1984). Marketing channels of cattle in Borno State. (Unpublished BSc. project) University of Maiduguri, Nigeria.

Olgado, **S.,** Abunvawan, J., and Domingo, B. (1977). Yellow corn marketing. Part Il1, Ilocos region. Special Studies Division office of the Secretary, Department of Agriculture. Quezon City.

Olukosi, J. O., & Isitor, S. U. (1990). *Introduction to agricultural marketing and prices: principles and application*. Zaria, GU Publication.

Onu, J. I. (2000). An analysis of the structure and performance of cotton marketing in Northern Nigeria. (Unpublished doctoral dissertation) University of Ibadan, Nigeria.

Osborne, M. (1959). Brownian motion in the stock market. *Operations Research,* 7(2), 145-173.

Ozah, A. P., Adesina, F. A., & Dami, A. (2010). A Deterministic cellular automata model for simulating rural land use dynamics; a case study of Lake Chad Basin. ISPRS archive xxxviii, part L1-8-2W9, core spatial databases-updating, maintenance and services from theory to practice. Haifa, Israel, 2010 accessed http://www.isprs.org/proceedings/xxxviii/482wa/papers/final-105/isprs. pdf retrieved 15 June 2011.

Palaskas, T. B., & B. Harris-White, B. (1993). Testing market integration: new approaches with case material from the West Bengal Food Economy. *The Journal of Development Studies,* 30(1), 1-57.

Parikh, A. (1971). Study on coffee price: a spectral approach. *Congress Journal of Agricultural Economics,* 19(3), 15-22.

Pasaran, M. H., & Pasaran, B. (1997). *Working with microfit 4.0 interactive econometric analysis*. Oxford, Oxford University Press.

Paulino, L. A., & Sarma, J. S. (1988). Analysis of trends and projections of food production and consumption in Brazil and Nigeria. International food policy research institute, Washington D.C. USA.

Perminder Singh, K. S., Suyah, L., & Raju, J. (2000). Analysis of prices and arrivals of represented and mastered in Haryana. *Indian Journal of Agricultural marketing,* 14(2), 59-65.

Phillips, A. W. H. (1964). Stabilization policy in a closed economy. *Economics Journal*, 64, 290-33.

Pinske, J, & Slade, M. S. (1998). Contracting in space, *Journal of Econometrics*, 85(1), 125-154.

Prabhakar, Y. S. (1998). An economic analysis of silk cocoon marketing in Karnataka. (Unpublished Masters thesis) University of agriculture Bangalore.

Prakash, A. (1998). The transmission of signals in a decentralized commodity marketing system: the use of the UK pork market. (unpublished doctoral dissertation) University of London.

Prothero, D. L., & Wallis, F. (1976). Modelling micro economic time series. *Journal of Royal Statistical Society of Australia,* 139, 468-500.

Purandara Rao, R. (1974). Analysis of marketing problems of arecanut in Karnataka. (Unpublished Masters thesis) University of Agricultural Sciences Bangalore.

Rashid, S. (2004). Spatial integration of maize markets in post-liberalized Uganda. *Journal of African Economies*, 13(1), 103-133.

Ravallion, M. (1986). Testing market integration: *American Journal of Agricultural Economics,* 68, 102-109.

Rayner, A.L., & Little, M. D. (1966). *Higgledy Piggledy Growth Again.* Oxford, Basil Blackwell.

Reuben J., & Mshelia, S. I. (2011). Analysis of price variation and decomposition in Yam markets of southern Taraba State, of Nigeria. *Journal of Agriculture and Social Sciences,* 2(1), 39-44.

Roberts, H. V. (1959). Stock market ópatternô and financial analysis: methodological suggestions. *Journal of Finance,* 14(1), 1-10.

Ryan, T. M. (1973). Security prices as Markov processes. *Journal of Financial and Quantitative Analysis,* 8(1), 12-36.

Salami, O. (1981). Marketing of dried meat in Borno State. (Unpublished B.Sc project) University of Maiduguri, Nigeria.

Samarajeeva, S., & Gunatilake, H. M. (1999). Estimation of demand function for coconut oil; a cointegration analysis. *Tropical Agriculture Research,* 11, 324-334.

Sharma, A. K., Kiber, R., & Ram, K. (1998). A study of inter-market integration in milk and milk product in India. *Indian Journal of Diary Sciences,* 51(3), 168-171.

Sexton, R. J., Kling, C. L., & Carman, H. F. (1991). Market Integration, efficiency of arbitrage, and imperfect competition: methodology and application to U.S. Celery. *American Journal of Agricultural Economics,* 73(3), 568-80.

Simister, J., & Chanda, R. (2006). Using food prices to predict harmful effect of drought: northern Nigeria as a case study. development ideas and practices working paper Dip 06-01 accessed http://www.developemnt-ideas-ano-practices.org.

Singhal, A. L. (1986). Rape seed mustard price structure in Uttar Pradesh. *Indian Journal of Agricultural Economics,* 2(4), 23-26.

Singh, H. B., & Arora, B. S. (1975). Anlytical study on spatial price diffrencials in groundnut in Punjab markets. *Agricultural Marketing*, 36(3), 34-42.

Singh, B. B. Singh, R. K., & Yadav, R. V. (1995). Seasonal variation in arrival and effect on price of wheat in. *Indian Journal of Agricultural Marketing*, 9(1), 1-3.

Spiller, P. T. & Huang, C. J. (1986). On the extent of the market: wholesale gasoline in the Northeastern United States, *The Journal of Industrial Economics*, 35, 131-145.

Taru, V. B., & Mshelia, S. I. (2007).Predicting market prices of maize and guinea corn using Markov Chain processes. *J. Agric & Soc. Sci.,* 3(4), 137-139.

Taru, V. B., Mshelia, S. I., Jonathan, R., & Tumba, D. (2009). Estimation of seasonal price variation and price decomposition of maize and guinea corn in Michika Local Government Area of Adamawa State Nigeria. *J. Agric. Soc. Sci.,* 5(1-2), 1-6.

Taru, V. B. & Lawal, H. (2011). Concentration in the North-eastern Nigeria yam Market: A Gini Coefficient Analysis. *Journal of Tropical Agriculture, Food, Environment and Extension,* 10(2), 49-57.

Thakur, D. S. (1974). Food grains marketing efficiency. A case study of Gujarat *Indian Journal of Agricultural Economics,* 29(4), 61-74.

Thodey, A. R. (1969). Analysis of stable food price behavior western Nigeria. (Unpublished doctoral dissertation) University of Illinois, Urbane.

Thorsen, B. J. (1998). A spatial integration in Nordic Timber Market: long-run equilibria and short-run dynamics. *Scandinavian Journal of Forest Research,* 13(4), 488-498.

Timmer, P. C. (1994). A Model of rice marketing margins in Indonesia. *Food Research Institute Studies*, 13(2), 74.

Ugwumba, C. O. A., & Okoh, R. N. (2010). Price spread and the determinant of catfish marketing income in Anambra State, Nigeria. *J. Agric & Soc. Sci.,* 6, 73-78.

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

Volltrath, T. L. (2003). North American Agricultural market integration and its impact on the food and fiber system. Agricultural information bulletin No. 784 market and trade economic division Economic and Research Services USDA, USA.

Waugh, F. E., & Miller, M. M. (1970). Fish cycles: a harmonic analysis. *American Journal of Agricultural Economics*, 52, 422-430.

Weiss, J. G. (1970). A spectral analysis of world Cocoa prices. *American Journal of Agricultural Economics,* 52, 122-125.

Williams, T. O. (2009). Fluctuating food prices: causes, challenges and opportunities. The commonwealth yearbook. Accessed http://scitech-soc.org/assest/stso1/soc/food/cyb_09-food pdf retrieved 28/07/2010.

World Bank (2000). Global economics prospects and the developing countries, pp. 103-127.

World Food Programme (WFP) (2011). Annual report, retrieved: www wfp.org/policy-resource

Wudiri, B. B. (1992). Recent development in cereal production in Nigeria. IITA, Ibadan. pp. 13-15.

Yin, R., & Min, R. S. (1999). Forecasting short-term timber prices with univariate ARIMA model. *Journal of America Statistical Association,* 25(1), 154-158.

Zanias, G. P. (1999). Seasonality and spatial integration in agricultural product markets. *Agricultural Economics,* 20(3), 253-262.

Zulauf, C., & Roberts, M. (2008). Price instability: corn, soyabeans, wheat, 1989 ï 2007. Ohio State university AED economics. Accessed from http://aede.osu.edu/resoruces/docs.dsiplay.php?cat= 21/09/2011.

Appendix

Probability Distribution of Cereal Grain Price in the Long-run

Maize

Dividing each row by the row total to obtain P given by

$$P = \begin{pmatrix} {}^{1}/_{3} & {}^{1}/_{3} & {}^{1}/_{3} \\ {}^{1}/_{5} & {}^{2}/_{5} & {}^{2}/_{5} \\ ¾ & ¼ & {}^{0}/_{4} \end{pmatrix} = Ȧ_1, Ȧ_2, Ȧ_3$$

$$P = \begin{pmatrix} 0.33 & 0.33 & 0.33 \\ 0.2 & 0.4 & 0.4 \\ 0.75 & 0.25 & 0 \end{pmatrix}$$

P is called the transition matrix. Since the P_{ijs} are probabilities, it follows that the probabilities in each row sum to unity. This is of course not true for columns. To determine the equilibrium vector equation eP =e, was used.

$$Ȧ_1, Ȧ_2, Ȧ_3 = \begin{pmatrix} 0.33 & 0.33 & 0.33 \\ 0.2 & 0.4 & 0.4 \\ 0.75 & 0.25 & 0 \end{pmatrix} = Ȧ_1, Ȧ_2, Ȧ_3$$

To find the co-factors;

C_{11} - $\begin{bmatrix} 0.45 & 0.4 \\ 0.25 & 0.0 \end{bmatrix}$ C_{12} + $\begin{bmatrix} 0.2 & 0.4 \\ 0.75 & 0 \end{bmatrix}$ C_{13} - $\begin{bmatrix} 0.2 & 0.4 \\ 0.75 & 0.25 \end{bmatrix}$

+ 0.1   -0.3   + 0.25

C_{21} - $\begin{bmatrix} 0.33 & 0.33 \\ 0.25 & 0 \end{bmatrix}$ C_{22} + $\begin{bmatrix} 0.33 & 0.33 \\ 0.75 & 0.00 \end{bmatrix}$ C_{23} - $\begin{bmatrix} 0.33 & 0.33 \\ 0.75 & 0.25 \end{bmatrix}$

+ 0.0825   -0.2475   + 0.165

C_{31} - $\begin{bmatrix} 0.33 & 0.33 \\ 0.25 & 0 \end{bmatrix}$ C_{32} + $\begin{bmatrix} 0.33 & 0.33 \\ 0.75 & 0 \end{bmatrix}$ C_{33} - $\begin{bmatrix} 0.33 & 0.33 \\ 0.75 & 0.25 \end{bmatrix}$

+ 0   0.066   - 0.066

The determinant is obtained thus:

$|A| = 0.1C_{11} + (-0.3)\ C_{12} + 0.25\ C_{13}$

0.33 (01) + 0.33 (-0.3) + 0.33 (0.25)

0.033 + 0.03 + 0.0825

= 0.1455 = 0.15

Transposing the element of the matrix and solving thus:

$$\begin{bmatrix} 0.1 & -0.3 & 0.25 \\ 0.0825 & -0.2475 & 0.165 \\ 0 & 0.066 & -0.066 \end{bmatrix}^{T^1}$$

$$1/_{0.15} \begin{bmatrix} 0.1 & -0.0825 & 0 \\ -0.3 & -0.2475 & 0.066 \\ 0.25 & 0.165 & -0.066 \end{bmatrix}^{T^1}$$

Solution: 1.22, 3.21 and 2.32

Summation of all the elements gave:

1.22 + 3.21 +2.32 = 6.75

Divide each element by the summation of the element thus:

Answer: S1, = 0.18, S2, = 0.48, S3, = 0.34

Probability Distribution of Cereal Grain Price in the Long-run

Rice

Dividing each row by the row total to obtain P given by;

$$P = \begin{pmatrix} {}^{2}/_{3} & {}^{1}/_{3} & {}^{0}/_{3} \\ {}^{1}/_{4} & {}^{1}/_{4} & {}^{2}/_{4} \\ {}^{1}/_{5} & {}^{0}/_{5} & {}^{4}/_{5} \end{pmatrix} = \dot{A}_1, \dot{A}_2, \dot{A}_3$$

$$P = \begin{pmatrix} 0.67 & 0.33 & 0 \\ 0.25 & 0.25 & 0.5 \\ 0.2 & 0 & 0.8 \end{pmatrix}$$

P is called the transition matrix. Since the P_{ijs} are probabilities, it follows that, the probabilities in each row sum to unity. This of course is not true for columns. To determine the equilibrium vector, the equation eP=e, was used.

$$\dot{A}_1, \dot{A}_2, \dot{A}_3 = \begin{pmatrix} 0.67 & 0.33 & 0 \\ 0.25 & 0.25 & 0.5 \\ 0.2 & 0 & 0.8 \end{pmatrix} = \dot{A}_1, \dot{A}_2, \dot{A}_3$$

To find the co-factors;

$$C_{11} \; - \begin{bmatrix} 0.25 & 0.5 \\ 0 & 0.8 \end{bmatrix} \qquad C_{12} \; + \begin{bmatrix} 0.67 & 0 \\ 0.2 & 0.8 \end{bmatrix} \qquad C_{13} \; - \begin{bmatrix} 0.25 & 0.25 \\ 0.2 & 0 \end{bmatrix}$$

+ 0.2-0   0.536-0   0-0.05
= -0.2   + 0.536   +0.05

$$C_{21} \; - \begin{bmatrix} 0.33 & 0 \\ 0 & 0.8 \end{bmatrix} \qquad C_{22} \; + \begin{bmatrix} 0.67 & 0 \\ 0.2 & 0.8 \end{bmatrix} \qquad C_{23} \; - \begin{bmatrix} 0.67 & 0.33 \\ 0.25 & 0.25 \end{bmatrix}$$

0.264-0   0.536-0   0.1675 ï 0.0825
-0.026   +0.536   -0.085

$$C_{31} \; - \begin{bmatrix} 0.33 & 0 \\ 0.25 & 0.5 \end{bmatrix} \qquad C_{32} \; + \begin{bmatrix} 0.67 & 0 \\ 0.2 & 0.8 \end{bmatrix} \qquad C_{33} \; - \begin{bmatrix} 0.67 & 0.33 \\ 0.25 & 0.25 \end{bmatrix}$$

0.165-0   0.536-0   0.1675 ï 0.0825
- 0.165   + 0.536   - 0.085

The determinant is obtained thus:

$$|A| = 0.67C_{11} + 0.33\, C_{12} + 0C_{13}$$

$$0.67\,(-0.2) + 0.33\,(0.536) + 0\,(0.05)$$

$$= 0.65$$

$$|A| = 0.65$$

The elements of the matrix are transposed and solved thus:

$$\begin{bmatrix} -0.2 & 0.536 & 0.05 \\ 0.264 & 0.536 & -0.085 \\ -0.165 & 0.536 & -0.085 \end{bmatrix}^{T^1}$$

$$1/|A| \begin{bmatrix} -0.2 & -0.264 & -0.165 \\ -0.536 & 0.536 & 0.536 \\ 0.05 & -0.085 & -0.085 \end{bmatrix}$$

$$\begin{pmatrix} -0.2 & -0.264 & -0.165 \\ 0.536 & 0.536 & 0.536 \\ 0.05 & -0.085 & -0.085 \end{pmatrix}$$

= 0.967 + 2.47+ 0.1846 = 3.6216

Each element is divided by sum of elements.

Answer; S_1, = 0.267, S_2, = 0.68, S_3, = 0.050

Probability Distribution of Cereal Grain Price in the Long-run

Sorghum

Dividing each row by the row total to obtain P given by:

$$P = \begin{pmatrix} {}^{1}/_{5} & {}^{2}/_{5} & {}^{2}/_{5} \\ {}^{2}/_{4} & {}^{1}/_{4} & {}^{1}/_{4} \\ {}^{1}/_{3} & {}^{2}/_{3} & {}^{0}/3 \end{pmatrix} = \dot{A}_1, \dot{A}_2, \dot{A}_3$$

$$P = \begin{pmatrix} 0.2 & 0.4 & 0.4 \\ 0.5 & 0.25 & 0.25 \\ 0.33 & 0.67 & 0 \end{pmatrix}$$

P is called the transition matrix. Since the P_{ijs} are probabilities, it follows that, the probabilities in each row sum to unity. This is course is not true for columns. To determine the equilibrium vector, the equation eP =e, was used.

$$\dot{A}_1, \dot{A}_2, \dot{A}_3 = \begin{pmatrix} 0.2 & 0.4 & 0.4 \\ 0.5 & 0.25 & 0.25 \\ 0.33 & 0.67 & 0 \end{pmatrix} = \dot{A}_1, \dot{A}_2, \dot{A}_3$$

Finding the co-factors:

C_{11} $-\begin{pmatrix} 0.25 & 0.25 \\ 0.67 & 0 \end{pmatrix}$ C_{12} $\begin{pmatrix} 0.5 & 0.25 \\ 0.33 & 0 \end{pmatrix}$ C_{13} $-\begin{pmatrix} 0.5 & 0.25 \\ 0.33 & 0.67 \end{pmatrix}$

0- 0.16765   0 - 0.0825   0.335 - 0.0825

+0.1675   - 0.0825   -0.2525

C_{21} $-\begin{pmatrix} 0.4 & 0.4 \\ 0.67 & 0 \end{pmatrix}$ C_{22} $\begin{pmatrix} 0.2 & 0.4 \\ 0.33 & 0 \end{pmatrix}$ C_{23} $-\begin{pmatrix} 0.2 & 0.4 \\ 0.33 & 0.67 \end{pmatrix}$

0- 0.268   0. - 0.132   -0.002

+0.068   -0.32

C_{31} $-\begin{pmatrix} 0.4 & 0.4 \\ 0.67 & 0 \end{pmatrix}$ C_{32} $+\begin{pmatrix} 0.2 & 0.4 \\ 0.5 & 0.25 \end{pmatrix}$ C_{33} $-\begin{pmatrix} 0.2 & 0.4 \\ 0.5 & 0.25 \end{pmatrix}$

+0.268   -0.15   ï 0.15

The determinant is obtained thus:

$|A| = 0.1C_{11} + -0.4C_{12} + 0.4C_{13}$

0.2 + 0.1675 + 0.4 (-0.0825) + 0.4+ 0.2525

0.3675 + 0.3175 + 0.6515 = ||1.34||

$|A| = 1.34$

The elements of the matrix are transposed and solved thus:

$$\begin{pmatrix} 0.1675 & -0.0825 & 0.2525 \\ 0.\ 268 & -0.132 & -0.002 \\ 0.268 & -0.15 & -0.15 \end{pmatrix} T^1$$

$$1|A| \begin{pmatrix} 0.1675 & -0.268 & 0.268 \\ -0.0825 & -0.132 & -0.15 \\ 0.2525 & -0.002 & 0.15 \end{pmatrix}$$

$= 0.525, 0.27, 0.29$

Summing the results given by

$0.525+ 0.27 + 0.29 = 1.085$

Divide each element by total.

Answer; S_1, = 0.48, S_2, = 0.25, S_3, 027