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Analysis of Foodstuff Price Volatility in Ghana: Implications for Food Security

John K. M. Kuwornu (Corresponding author)
Department of Agricultural Economics and Agribusiness,
P.O. Box LG 68
University of Ghana, Legon – Accra
Email: jkuwornu@ug.edu.gh / jkuwornu@gmail.com

Akwasi Mensah-Bonsu
Department of Agricultural Economics and Agribusiness,
P.O. Box LG 68
University of Ghana, Legon – Accra
Email: ambonsu@ug.edu.gh

Hassan Ibrahim
Department of Agricultural Economics and Agribusiness,
P.O. Box LG 68
University of Ghana, Legon – Accra

Abstract

In recent years, price volatility is becoming increasingly relevant to producers and consumers in the saturated food markets amidst stiff completion and globalisation. The analysis of price volatility is necessary to develop bidding strategies or negotiation skills in order to maximize profit. The generalised autoregressive conditional heteroscedasticity (GARCH) regression model is used to forecast foodstuff prices in Ghana over the period 1970 to 2006. The data used are monthly wholesale prices for maize, millet, and rice obtained from the Ghana Ministry of Food and Agriculture. The empirical results reveal that foodstuff prices exhibit high volatility with continual increasing prices over the study period. The results of the out-sample forecast reveal that maize, millet and rice prices would increase by 23%, 11% and 10% respectively in the next month. The study recommends the provision of adequate storage facilities, and farmers' market centres in the districts to stabilize food prices. The increases in food prices have implications for food and nutrition situation of the poor in Ghana.

Key words: Price Volatility, Foodstuff, Food Security, Generalised Autoregressive Conditional Heteroscedasticity (GARCH) Regression, Ghana

1.0 Introduction

In Ghana, food prices for rice, maize and other cereals increased by 20 to 30 percent between the last few months of 2007 and beginning of 2008 (Wodon *et al.*, 2008). This raised concerns about future food prices and their effect on food security in Ghana. Since food prices affect future production, consumption and marketing, it is important to examine the nature of food prices in Ghana as well as determine future food prices to enable government, producers and the consumer make informed decisions. The study therefore seeks to address the following question: What are the forecast prices of selected foodstuff? Therefore, the objective of this study is to forecast foodstuff (cereal: maize, rice and millet) prices. The effect of cereal prices on food security is the focus of this study, since cereals are the most widely consumed food crops in Ghana.

In a market-oriented economy with perfect information a key variable in the food system is the price of the commodity (Gortz and Weber, 1986). According to Gortz and Weber (1986), prices lead to revenues which provide incentives to participants through rewards (profits) and penalties (losses). Prices therefore, serve as an efficient means for seeking out production possibilities and potential, as well as allocating scarce resources within an economy. In view of this, price forecasting is becoming increasingly relevant to producers and consumers in the new competitive food markets. For both spot markets and long-term contracts, price forecast are necessary to develop bidding strategies or negotiation skills in order to maximize profits. White and Dawson (2005) indicated that, planting decisions are taken on the basis of expected prices at harvest; hence forecasting food price will give farmers the opportunity to take informed decisions regarding planting in the future. This study seeks to provide an approach to predict next-period food prices based on the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) methodology. Price forecasting systems are also of considerable importance to food security management by governments and non-governmental organizations. It permits cost reduction in food security operations by hitting a critical price level.

The relevance of food security is undisputable. Food security emerged as a concept in the mid 1970s, when rapidly increasing prices caused global food crises (World Bank, 2008). Attention focused first on food availability but then quickly moved to food access and food use and most recently, to human right to adequate food (World Bank, 2008). Food security is defined, as when all people at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 1996). In other words, it is the availability of food, access to food, and utilization of food. Gregory *et al.*, (2005) explained that, food availability refers to the existence of food stocks for consumption. Household food access is the ability to acquire sufficient food in terms of quality and quantity to meet all household members' nutritional requirements. Access to food is determined by physical and financial resources, as well as by social and political factors. Utilization of food depends on how food is used, whether food has sufficient nutrients, and a balanced diet can be maintained. It is these facets of the food system that need to be met in order for food security to be realized. Food systems encompass food availability (production, distribution and exchange), food access (affordability, allocation and preference) and food utilization (nutritional and societal values and safety).

In low income countries where food dominates budgets and economic activity, poor households use a variety of mechanisms to cope with income and consumption risk, including diversification of cropping patterns, using risk-reducing inputs (e.g. irrigation), obtaining off farm employment, storing food, and/or buying livestock and other assets as a store of wealth for hard times (Myers, 2006). The world has more than enough food to feed everyone, yet world-wide around 852 million people are chronically hungry due to extreme poverty while up to 2 billion people lack food security intermittently due to varying degrees of poverty (World Bank, 2008). The highest incidence of food insecurity or undernourishment is in Sub-Saharan Africa (SSA) where one in every three suffers from chronic hunger (World Bank, 2008). Despite the fact that Ghana made considerable progress in terms of poverty reduction over the past fifteen years, about 1.2 million people, representing 5% of the population are food insecure and 2 million people are vulnerable to become food insecure following any natural or man-made shock (World Food Programme, 2009). In the same vein, although food availability for direct human consumption grew by 19 percent between 1960 and 1994-96, to 2720 kcal/day (against an estimated minimum daily energy requirement of 2200kcal/day), availability is still very uneven (FAO, 2003). In Sub-Saharan Africa (SSA) calorific intake is still only 2150 kcal/day compared to 2050kcal/day thirty years earlier. In contrast, the average calorie consumption in South Asia rose from 2000 kcal/day to 2350 kcal/day in the same period (FAO, 2003).

The rest of the study is structured as follows: Section two presents a review of existing literature related to food prices and forecasting. Section three explains the method of analysis and source of data for forecasting foodstuff prices. In section four, the empirical results of forecasted foodstuff prices are presented and discussed. The conclusions are presented in section five.

2. 0 Literature review

Despite the global effort and control measures taken over the years, there has been a steady upward trend in world food prices at a modest rate. While many developing countries experienced persistent inflation during and prior to 1972, reasonable monetary stability existed in most industrial economies. Hence the industrialized countries are least affected by the increases in prices while the developing countries are hard hit by such increases (Harold, 1986). Harold (1986) noted that since 1972 world commodity prices have risen at rates incomparable to over a quarter of the 20th century. A major contributor has been the nearly threefold increase in crude oil price since October 1973 (Harold 1986).

According to ISSER (2008), a barrel of crude oil that sold for $54 at the beginning of 2007 shot up to $86 by the end of the year. It continued climbing rapidly and was generally expected to reach $200 by the end of 2008. Oil price increases exert both direct and indirect upward pressures on aggregate prices. Research on the linkages between food price change and food security has focused mainly on low-income (poor) countries, looking mainly at national food security or household food security. It particularly looks at the impact of prices on nutrition and labour supply, the cost of food price instability to households caused by increased risk and uncertainty, and how food demand and real income are affected by changes in food prices (Lovendal *et al.,* 2007).

According to Shively (1996), increased price variability can have detrimental impacts on both consumers and producers of agricultural commodities. He continued that since stocks are a large proportion of a farm household's portfolio in developing countries, and since the level of market risks and ability to bear risks may be correlated with income, low-income farmers are likely to be sensitive to price risks. Jones and Sanyang (2008) observed that, higher food prices have affected price increases in downstream and upstream products and services. Consequently, these result in people eating less frequently and in lesser quantities, as well as cheaper and less nutritious food.

Jones and Sanyang (2008) realized that, the impacts of these are increased levels of malnutrition and disease, increased poverty, and threat to peace, stability and social cohesion. Alderman (1992) categorized food security into household and market-level food security. Both of these categories have transitory as well as chronic dimensions. He noted that, most households utilize markets for a portion of their consumption. However, for developing countries, the market for most farm products is so fragmented as a result of governmental regulations trade restriction measures across national boundaries, such as tariffs and import duties and other charges. This often influences the behaviors of a particular price series, such as prices received by farmers for grain, over time in different countries. Alderman (1992), indicates that households with different income sources are affected diversely in the face of weather or pest induced shocks, price increases, or in light of changes in policies and market conditions. Therefore, increases in food prices as reported by ISSER, (2008), raise concerns about the food and nutrition situation of poor people in developing countries, about inflation and, in some countries, about civil unrest.

ISSER, (2008), further argued that, high food prices have radically different effects across countries and population groups. At country level, countries that are net food exporters will benefit from improved terms of trade, although some of them are missing out on this opportunity by banning exports to protect consumers. Net food importers, however, will struggle to meet domestic food demand. Given that almost all countries in Africa are net importers of cereals, they will be hard hit by rising prices. Higher food prices lead poor people to limit their food consumption and shift to even less-balanced diets, with harmful effects on health in the short and long run. Given that the market is the main arbiter of how the available food is distributed both within and between countries, Sinha (1976) stated that, lack of sufficient purchasing power will remain the chief obstacle in the way to feed the poor adequately. Those who have no jobs with no purchasing power and those who have jobs with low purchasing power to back their demand, will be unable to buy food even if there is an abundance of it. Parry *et al.,* (2005) reported that, the livelihoods of subsistence farmers and pastoral people, who are already weakly linked to markets, are negatively affected by increases in food prices. The increase in food prices exacerbates the stress of regional shortfalls in production leading to an increase in the risk of hunger.

The extent to which changes in food prices affect food consumption at the household level depends on the commodity type and can be analyzed by looking at demand elasticities for food in relation to changes in income and prices (Lovendal *et al.,* 2007). Own price elasticities for basic food items, such as cereals, are quit low because they cannot be substituted by other food items. On the other hand, the price elasticities for other food items, such as meat, are usually high; hence households make substantial shifts between expensive and cheaper food items when prices increase. They concluded that, price increases for inelastic food items can lead to real income falls for poor households, because price increases for inelastic food items will lead to higher relative spending on these items. They noted that, this in some circumstances results in a drop in calorie intake for households spending a large share of their income on food and with limited ability to smoothen consumption. Consequently, households face a significant risk of food consumption falling below a critical level in regards to health and survival.

Alderman (1992), used wage indices as an indicator of trend in earning power in Ghana and the number of kilos of grain obtained for each day of employment as an indicator of purchasing power. In this study, he found out that, even though the minimum wage was revised in eight of the ten years covered in the study, nevertheless it could neither adapt to June seasonal price rise, nor always keep pace with inflation. He concluded that, it was an insufficient basis for subsistence for an individual during shortage and given that, a kilogram of maize provides roughly 1.5 times the calorie requirement of an adult, in many years in the decade the wage rate was insufficient for an individual to adequately support dependents. This clearly demonstrates that, salary earners in Ghana are not left out on the adverse effect of food price increases. Price increases erode salary earners ability to manage the negative effects, leading to situations of limited access to food, consequently causing food insecurity. Price increases have various repercussions on agricultural output and incomes.

Bantista and Valdes (1993) reported that, when agricultural products are underpriced, domestic output suffers not only because the static efficiency of resource use declines, but also, and more importantly, there are adverse effects on agricultural labour supply, capital accumulation and technological change over the long term. Increased food price instability/risk can lead agricultural producers to adopt risk-reducing strategies such as shifting towards more stable and lower value crops, reducing investments in new technologies or reduce use of purchased inputs (Lovendal *et al.,* 2007). Lovendal *et al.,* (2007) concludes that, such strategies can lead to inefficient levels of investments and/or resource allocation and can also reduce competitiveness of the agricultural sector. They also argued that, food price fluctuations can lead to macroeconomic fluctuations, which can dampen investments and reduce economic growth.

Bantista and Valdes (1993) also stated that, the magnitude of the output loss attributable to lower static efficiency depends on not only on the short run supply elasticity, but also on how depressed agricultural prices are in relation to border prices; which differ widely from country to country.

Commodity price can be seen to fluctuate irregularly to a greater or lesser degree, depending on whether they are compared with price fluctuations in manufactured-goods markets or speculative markets. When compared to the price fluctuations of manufactured goods, foodstuff prices fluctuate more frequently and more widely (Lapp *et al.,* 1970). The price fluctuation in foodstuff is explained by the fact that, the agricultural industry remains peasant-bound, with flexibilities of market fragmentation, inadequate storage, irrigation and transportation (Frimpong-Ansah, 1996). International price instability has generally been attributed to supply fluctuations due to output variations. Natural phenomena, the breakdown of buffer stocks arrangements or fluctuations in demand over the course of business cycles among others, are factors that cause variation in output. Price instability has also been attributed to cobweb-like phenomena. Sources of commodity price fluctuation can be ascribed to so-called “unpredictable” events such as devaluation of currency, changes in the prospects of war or changes in government policy.

Shively (1996) noted that, a prominent component of structural adjustment in Ghana in 1983 was devaluation and a switch from fixed exchange rate regime to managed float. The results indicated that the immediate effect was higher and more volatile prices, followed by lower and less volatile prices. Beginning with the demand-supply explanation for price irregularity, Ferris (1998) stated that, market prices will be stable so long as demand and supply remain in equilibrium; once this equilibrium condition changes, prices will accordingly vary. Lovendal *et al.,* (2007) confirms, that demand for commodities remain relatively constant over the short period. This is particularly true in the developed economies, where consumers' habit change slowly and food consumption is not likely to be reduced with rising prices. Industrial demand in developed countries also tends to remain constant, with manufacturers responding only slowly to price variations. It is changes in supply, therefore, that must be responsible for price irregularity. Starting with agricultural commodities, one finds that weather or changes in technique often produce unexpected changes in supply; for extracted commodities, unusual geological conditions or unexpected labor problems are likely to change supply. In developing countries, where crop disease and political turmoil are common, these circumstances are likely to be even severe. Since demand remains relatively inelastic and supply changes frequently, market equilibrium becomes unstable and prices subsequently behave irregularly. High dependence on food imports suggest that food prices will be influenced by fluctuations in imported food prices (Lovendal *et al.,* 2007); since Ghana is a net food importer there is an effective price transmission.

According to Lovendal *et al.,* (2007), the extent to which changes in international prices are transmitted into domestic markets would be affected by the overall economic environment. In addition, the transmission of international food prices is also influenced by market structure. In their classification of the market structure, they said fresh produce from domestic sources can have several marketing channels for transfer of produce from importers or produces to consumers. These markets are more competitive and subject to prices determined by the forces of supply and demand. Meanwhile, one emerging factor behind rising food prices in Ghana is the high price of energy (ISSER, 2008). Energy and agricultural prices have become increasingly linked. With oil prices at all-time high and the US government subsidizing farmers to grow crops for energy, US farmers have massively shifted their cultivation towards biofuel feed stocks, especially maize, often at the expense of soybean and wheat cultivation. High energy prices have also made agricultural production more expensive by raising the cost of mechanical cultivation, and of inputs such as fertilizers and pesticides, as well as of transportation of inputs and outputs (ISSER, 2008). Another source of price increases is the growing world population's demand for more and different kinds of food. Rapid economic growth in many developing countries has pushed up consumer purchasing power, generated rising demand for food, and shifted food demand away from traditional staples and towards high-value foods such as meat and milk. This dietary shift is leading to increased demand for grains used to feed livestock. In addition, poor weather conditions have also played a role in the rise of food prices, for example, the northern part of the country experienced severe flood in 2007 resulting in loss of most farm produce (ISSER, 2008).

2.1 Food Production in Ghana

The most important part of agricultural production is food production. Although in certain countries the production of non-food agricultural crops, for example, rubber, cocoa, and fibers, may be of considerable importance for exports and foreign exchange. On worldwide basis food production is the most significant part of agriculture in terms of area of production and value of the resulting product (Tarrant, 1980). The more advanced the economy of a country is, the less its agricultural production is used directly for food. Food is increasingly processed and packaged so that the value added by the processing and packaging may exceed the value of the original agricultural product (Tarrant, 1980).

Ghana produces 51% of its cereal needs, 60% of fish requirements, 50% of meat and less than 30% of the raw materials needed for agro-based industries (FASDEP II, 2007). Production of roots, tubers and vegetables such as tomatoes and onions, the most widely used food crops, is rather erratic and fluctuates between scarcity, sufficiency and glut, depending on the vagaries of the weather (FASDEP II, 2007). In view of this, there is high dependence on imported foodstuff to fill the gap, which invariably exposes the economy to the variations in the developed countries, as in crude oil prices, taxes and other trade restrictions. The vast majority of crop farming in Ghana is smallholders who are constrained by the lack of mechanization and consequently low productivity.

The problem of low productivity is multifaceted. This includes over-reliance on rainfall and the planting of relatively low-yielding varieties of seeds. According to MoFA (2007), the principal crop products in Ghana are industrial crops including, cocoa, oil palm, coconut, coffee, cotton, tobacco, kola; starchy staples including cassava, cocoyam, yam, maize, rice, millet, sorghum, plantain; and fruits and vegetables which includes, pineapple, citrus, banana, cashew, pawpaw, mangoes, tomatoes, pepper, okro, garden eggs, onions among others.

However, the effect of cereal prices on food security is the focus of this study, since cereals are the most widely consumed food crops in Ghana. Over the years, maize and millet production in Ghana has grown from 996,000 metric tonnes and 144,000 metric tonnes in 1997 to 1,013,000 metric tonnes and 169,000 metric tonnes respectively in 2000. Production fell to 938000 metric tonnes and 134,000 metric tonnes respectively in 2001 and maintained a steady production within the range of 1,158,000 metric tonnes to 1,400,000 metric tonnes and 144,000 metric tonnes to 185,000 metric tonnes respectively, from 2001 to 2006. This indicates a 20% and 28% increase in production for maize and millet respectively. Rice production was very unstable over the period 1997 to 2002. Production fluctuated between 95,000 metric tonnes to 136,000 metric tonnes and maintained a relatively stable production level between 115,000 metric tonnes to 121,000 metric tonnes within the period 2003 to 2006. Meanwhile, yam, plantain and cassava have maintained a steady production level over the period 1997 to 2006; which reveals a growth rate of about 3% to 9% per annum, whilst cocoyam has a constant production level.

3.0 Methodology

This section presents the theoretical framework, the method of analysis and source of data.

3.1 Theoretical Framework

3.1.1 Forecasting Prices

Many agricultural commodities trace out a fairly definable and consistent seasonal pattern largely due to the seasonal nature of agricultural production. This study is focused on cereals prices, particularly maize, rice, and millet. The rational is that these are the cereals for which the average consumption is high and they also contain the highest caloric content.

The prices of maize, rice, and millet are recorded in nominal terms and therefore are deflated using equation (1). This is done to bring all values to a common denominator.

$$\frac{Price}{Index\,(Base\,Year\;1977=100)}\times 100 = Deflated\;\; Price\;\;(1977=100) \tag{1}$$

In estimating prices, there are three steps involved. The first one is testing for unit roots using the augmented Dickey-Fuller test. The second step is choosing the appropriate model that fits the data; the autoregressive model and its lag length is considered. The final step is to forecast, using the chosen model and make comparison with actual values.

In estimating the forecasting models, it is assumed that the future is like the past. This therefore requires stationarity in the values. Unit root test is conducted to test for stationarity. The study uses the GARCH model to forecast foodstuff prices. The motivation for GARCH modeling is that price series exhibit the phenomena of volatility clustering, where the prices are subject to swings in value of an extended time period followed by periods of relative calm (Romilly, 2005).

3.1.2 Test for Unit Roots

Longo *et al.,* (2007) recommends that, priori to estimation of model, the presence of unit roots in the variables must be examined using Dickey-Fuller tests to test for stationarity. To do this, the study first establishes the stationarity of the data sets in order to avoid spurious regressions and their associated problems. It is assumed that the data belong to a white noise time series process in which each element in the sequence has; $E(\varepsilon_t)=0,\ E(\varepsilon_t^2)=\sigma^2, and\ Cov(\varepsilon_t,\varepsilon_s)=0\ for\ all\ t\neq s.$ This implies that each element in the series is drawn from the population with zero mean, constant variance and is independently and identically distributed (Greene, 2003). With this stochastic process, the study then proceeds to test for unit roots as described by Gujarati (2004) and Greene (2003).

3.1.3 ARCH and GARCH Estimation

Autoregressive Conditional Heteroskedasticity (ARCH) models are specifically designed to model and forecast conditional variance of the dependent variable. The variance of the dependant variable is modeled as a function of past values of the dependant variable and independent or exogenous variables (Green, 1997). The ARCH and GARCH model is generally used for the following purpose; first, to analyze the risk of holding an asset or the value of an option. Second, forecast confidence intervals by modeling the variance of the errors and third, to obtain efficient estimators by proper handling of heteroskedasticity in the errors. An ordinary ARCH model is a special case of a Generalized autoregressive Conditional Heteroskedasticity (GARCH) specification in which there are no lagged forecast variances of the conditional variance equation. In developing the GARCH model, three specifications are considered :
(a) The conditional mean equation (b) the conditional variance and (c) the conditional error distribution.

GARCH (1 1) Model

Equation (2) represents the conditional mean, which is a function of exogenouse variables with an error term. The conditional variance (σ_t^2) is a one period ahead forecast variance based on past information:

$$P_t=\alpha+\rho P_{t-1}+u_t$$

$$\sigma_t^2=w+\lambda u_{t-1}^2+\beta\sigma_{t-1}^2 \qquad (3)$$

The conditional variance equation in (3) is a function of three terms :

(i) A constant term : w

(ii) News about volatility from previous period, measured as the lag of the squared residual from the mean equation (2) : u_{t-1}^2 represents the ARCH term

(iii) Last periods forecast variance : σ_{t-1}^2 represent the GARCH term

The (1 1) in GARCH (1 1) refers to the presence of a first-order GARCH term (the first term in parentheses) and a first-order ARCH term (the second term in parentheses).

GARCH (1, 1) forecasting model has two options: Dynamic forecast and Static forecast. Dynamic forecast is a multi-step forecasts starting from the first period in the forecast sample. The previously forecasted values for P_{t-1} are used in forming a forecast of the subsequent value of P_t . Whilst, the Static forecast calculates a sequence of one-step-ahead forecast, using actual, rather than forecasted values for lagged dependent variables.

3.1.4 Method of Analysis

Forecasting Food Prices Using GARCH (1, 1)

The deflated prices of maize, rice, and millet are forecasted using GARCH (1, 1). The prices are denoted as follows: p_m = Price of maize; p_r = Price of rice, p_{mi} = Price of millet. The current price is estimated on the assumption that, past prices influence current prices. The regression equation was run for lagged prices of selected foodstuffs for one to the fourth period.

$$P_t = \alpha_0 + \alpha_1 P_{t-1} + u_t \quad (4)$$

$$P_t = \alpha_0 + \alpha_1 P_{t-1} + \alpha_2 P_{t-2} + u_t \quad (5)$$

$$P_t = \alpha_0 + \alpha_1 P_{t-1} + \alpha_2 P_{t-2} + \alpha_3 P_{t-3} + u_t \quad (6)$$

$$P_t = \alpha_0 + \alpha_1 P_{t-1} + \alpha_2 P_{t-2} + \alpha_3 P_{t-3} + \alpha_4 P_{t-4} + u_t \quad (7)$$

Equations (4), (5), (6) and (7) are estimated for monthly prices of maize, rice, and millet in Ghana, from 1970:01 to 2004:01 and the forecasting model was chosen based on the following measures: Mean absolute error (MAE), Mean absolute percentage error (MAPE), and Theil inequality. LM test is used to determine the coefficient of estimation of Equations (4, 5, 6 and 7) using Eviews and the lag of the squared residuals $\left(u_{t-1}^2\right)$ obtained in equation (4, 5, 6 and 7) is regressed on a constant term and the lag of last periods forecast variance to obtain equation the conditional variance, equation (8).

$$\sigma_t^2 = w + \lambda u_{t-1}^2 + \beta \sigma_{t-1}^2 \quad (8)$$

The ARCH and GARCH effects in equations, 4, 5, 6 and 7 were used to determine the forecasting equation for the monthly food prices. Using estimated equations 4, 5, 6 and 7, the next period prices for the selected foodstuffs were estimated by substituting current price P_t with past price P_{t-1} as follows:

$$P_{t+1} = \hat{\alpha}_0 + \hat{\alpha}_1 \hat{P}_t \quad (9)$$

For this study the forecasting of each selected foodstuff price was evaluated using static forecast. Following Leuthold *et al.*, (1970), the Theil Inequality Coefficient was used to determine the predictive performance of the GARCH forecast model. Equation (4) proved effective and is therefore considered the forecast model for the study.

Residual Test/ ARCH LM Test

This is a Lagrange multiplier (LM) tests for autoregressive conditional hetroskedasticity (ARCH) in the residuals. The test statistic is computed by an auxiliary regression as follows.

$$P_t = \alpha_1 P_{t-1} + u_t \quad \Rightarrow u_t = P_t - \alpha_1 P_{t-1} \quad (10)$$

To test the null hypothesis that there is no ARCH up to order q in the residuals, the following regression is run.

$$u_t^2 = \lambda_0 + \left(\sum_{s=1}^{q} \lambda_s u_{t-s}^2 \right) + v_t \tag{11}$$

Where u_t is the residual. This is a regression of the squared residuals on a constant and lagged squared residuals up to order q. The null hypothesis is that, $\lambda_s = 0$ in the absence of ARCH components. .

In a sample of T residuals under the null hypothesis of no ARCH errors, the LM test statistic equals number of observations*R-square (TR^2). The test statistic TR^2 follows Chi (X^2)-distribution with q (lag length) degrees of freedom. If TR^2 calculated is greater than the chi-square table value (TR^2 critical), we would reject the null hypothesis in favour of the alternate hypothesis. Hence there is ARCH effect in the GARCH model. It is expected that, there is an ARCH effect in the GARCH (1, 1) model, since the model is conditional on past prices.

3.1.5 Sources of Data

The data used are monthly wholesale prices for maize, millet, and rice as reported by the Ghana Ministry of Food and Agriculture (MoFA) foodstuff price compilation (1970-2006). Domestic maize, rice, and millet production were all taken from MoFA compilation. The prices are expressed in Cedis per 100 Kilogram and are deflated by the consumer price index (CPI).

4.0 Empirical Application and Results

This section presents forecast of selected foodstuff prices (i.e., maize, millet, and rice).

4.1 Forecasting Foodstuff Prices

4.1. 1 Unit Root Test

Before estimating equation (4), (5), (6) and (7) a test on unit root, was conducted for each price set using Augmented Dickey-Fuller test. Under the null hypothesis that the true process is a random walk with or without drift. The results of the Augmented Dickey-Fuller test of maize, rice, and millet prices are individually signifiant at 10% level (see tables 1, 2, and 3). The results rejects the null hypothesis of a unit root in favour of the alternative hypothesis of stationary time series.

Table 1: ADF for Maize Price

Null Hypothesis: PM has a unit root

Exogenous: constant and linear trend

Lag Length: 2(Automatic based on AIC, MAXLAG=2)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.80735	**0.0805**
Test critical values:	1% level	-3.9854	
	5% level	-3.4230	
	10% level	-3.1341	

*MacKinnon (1996) one-sided p-values.

Table 2: ADF for Rice Price

Null Hypothesis: PR has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 2 (Automatic based on AIC, MAXLAG=2)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.90965	**0.0517**
Test critical values:	1% level	-3.9830	
	5% level	-3.4219	
	10% level	-3.1334	

*MacKinnon (1996) one-sided p-values.

Table 3: ADF for Millet Price

Null Hypothesis: P has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 2 (Automatic based on AIC, MAXLAG=2)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.45996	**0.0604**
Test critical values:	1% level	-3.9830	
	5% level	-3.4219	
	10% level	-3.1334	

*MacKinnon (1996) one-sided p-values.

GARCH (1, 1) Estimation of Selected Foodstuff Prices

4.1.2 Estimation of Maize Price

Table 4 presents the results of GARCH (1, 1) estimation of maize prices in Ghana. The period 1970:01 – 2004:12 was used to estimate the model, while 1970:01 – 2006:12 represents the in-sample forecast. The regression was run for lagged values of the dependent variable from one to four as specified in equations (4), (5), (6) and (7). The maximum-likelihood estimation is used under the assumption of a Gaussian distribution of conditional errors and equation (3) chosen on the presence of ARCH and GARCH. The in-sample forecast conducted is reported in Table 5. The constant term in the equation is significant at 10% level and the mean value significant at 1% level. This shows that, maize price is dependent on immediate past prices and a constant term. Hence, the past behavior of maize prices and a constant term influences maize price today and the future. The sum of the ARCH and GARCH effects (1.002) indicates that, maize prices are very volatile. This could be attributed to the seasonality in production. The Coefficient of Determination (R^2) is not meaningful, since there are no regressors in the mean equation. The estimated equation is the given forecast equation below.

Table 4: GARCH (1, 1) Estimation of Maize Price

Dependent Variable: Pm

Method: ML - ARCH (Marquardt) - Normal distribution

Date: 20/09/10 Time: 22:25

Sample (adjusted): 1970M02 2004M12

Included observations: 443 after adjustments

Convergence achieved after 25 iterations

Variance backcast: ON

GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

	Coefficient	Std. Error	z-Statistic	Prob.
C	**0.280692**	23.39624	0.011997	0.0190
Pm(-1)	**1.232746**	0.037450	26.36723	0.0000
		Variance Equation		

C	**7.859984**	1.545179	5.086779	0.0000
RESID(-1)^2	**0.005668**	0.000867	6.537110	0.0000
GARCH(-1)	**0.997014**	0.001481	673.1357	0.0000

In –Sample –Forecast

Table 5: In-sample Forecast of maize price

Forecast: PmF

Actual: Pm

Forecast sample: 1970M01 2006M12

Adjusted sample: 1970M02 2006M12

Included observations: 443

Root Mean Squared Error	49.14154
Mean Absolute Error	14.41543
Mean Absolute Percentage Error	45.11501
Theil Inequality Coefficient	**0.084618**
Bias Proportion	**0.002932**
Variance Proportion	**0.004238**
Covariance Proportion	**0.992830**

The static forecast was used to forecast maize prices, primarily due to that fact that, maize production is seasonal and the Theil inequality coefficient for static forecast is better than the dynamic forecast. As the Theil draws closer to zero, it indicates good performance of the model in forecasting. The first two statistics (Root Mean Square Error and Mean Absolute Error) depends on the scale of the dependant variable, the smaller the error them, the better the forecasting ability of the model. The bias proportion indicates that, the mean of the forecast is 0.0029 from the actual values of maize prices. The forecast variance is 0.0042 from the variance of the actual maize prices. From the forecast model, the bias and variance proportions are small, and most of the bias is concentrated on the covariance, hence the forecast is good. The static forecast is used for a one-step-ahead forecast and the forecast are based on actual past values. Hence, this model can only predict the next month price of maize. Unfortunately, if the static forecast is used for months beyond the next month, it would not reflect the seasonality in maize production, consequently resulting in improbable forecast. In this respect we perform the Out –Sample –Forecast.

Out –Sample –Forecast of maize price

The out of sample forecast was conducted for 2007:01 to 2007:03

Table 6: Out of sample forecast of maize price

	$\hat{p}_{200701} = 0.28 + 1.233\,\hat{p}_{200612}$
Month	**Price**
January, 2007	**571.39**
February, 2007	**704.80**
March, 2007	**869.29**

The results indicate 23% increase in price for the next month.

Estimation of Millet Price

Table 7: GARCH (1, 1) Estimation of millet Price

PMI = 2.836584319 + 1.109889*PMI(-1)

Dependent Variable: PMI

Method: ML - ARCH (Marquardt) - Normal distribution

Date: 20/09/10 Time: 20:56

Sample (adjusted): 1970M02 2006M12

Included observations: 443 after adjustments

Convergence achieved after 245 iterations

Variance backcast: ON

GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

	Coefficient	Std. Error	z-Statistic	Prob.
C	2.836584	9.304617	0.304858	0.7605
PMI(-1)	**1.109889**	0.011150	88.69333	**0.0000**
		Variance Equation		
C	1571.111	103.1866	15.22592	0.0000
RESID(-1)^2	**0.943311**	0.255736	4.470675	**0.0000**
GARCH(-1)	**0.013474**	0.009977	-1.350557	**0.0768**
R-squared	0.983969	Mean dependent var		193.7412
Adjusted R-squared	0.983823	S.D. dependent var		350.7534

S.E. of regression	44.61215	Akaike info criterion	10.35622
Sum squared resid	871726.8	Schwarz criterion	10.40242
Log likelihood	-2288.903	F-statistic	6721.116
Durbin-Watson stat	1.952026	Prob(F-statistic)	0.000000

Estimated equation (8) was selected over the other equation based on the ARCH and GARCH effect. Table 7 presents result of the GHARC (1, 1) estimation of millet price. The mean equation represents the first part of the table, with the dependent variable being deflated millet price and the second part represents the variance equation with conditional variance as the dependent variable. The maximum-likelihood estimation is used under the assumption of a Gaussian distribution of conditional errors. The coefficient on the conditional variance is positive and individually significant at 1%. This indicates the presence of ARCH and GARCH effect. The constant term is not significant. The coefficient of the first lagged value of millet price was significant at 1%. Hence millet price today is determined by the immediate past millet price.
The sum of the ARCH and GARCH effect (0.9567) indicates that, millet prices are highly volatile.

For the millet price, the static forecast model was chosen over the dynamic model for the same reason stated above. The bias proportion indicates that, the mean of the forecast is 0.00077 from the actual values of millet prices. The variance of the forecast is 0.0137 from the variance of the actual maize prices. The bias is concentrated at the covariance with a value of 0.985, hence the forecast is good (see table 8). Unlike maize price, only the first lag of millet price influence current and next period price.

In-Sample-Forecast

Table 8: In- sample forecast for millet of millet price

Forecast: PMIF

Actual: PMI

Forecast sample: 1970M01 2006M12

Adjusted sample: 1970M02 2006M12

Included observations: 443

Root Mean Squared Error	44.35967
Mean Absolute Error	14.22702
Mean Absolute Percentage Error	850.8496
Theil Inequality Coefficient	**0.055758**
Bias Proportion	**0.000776**
Variance Proportion	**0.013722**
Covariance Proportion	**0.985502**

Table 9: Out-Sample Forecast of millet price

$\hat{p}_{200701} = 1.109\,\hat{p}_{200612}$	
Month	**Price**
January, 2007	**961.42**
February, 2007	**1066.21**
March, 2007	**1182.42**

This represents about 11% increase in price for the next month.

4.1.3. Estimation of Rice Price

The basic estimation procedure is repeated for monthly rice price. Table 10 presents result of the GHARC (1, 1) estimation of rice price. The coefficients of the conditional variance for both ARCH and GARCH are positive and significant at 5%. The coefficient of the first lagged variable of rice price is significant at 1%. Hence rice price today is determined by rice price in the immediate past period.

Table 10: GARCH (1, 1) Estimation of Rice Price

Dependent Variable: P

Method: ML - ARCH (Marquardt) - Normal distribution

Date: 10/16/02 Time: 20:59

Sample (adjusted): 1970M02 2006M12

Included observations: 443 after adjustments

Convergence achieved after 400 iterations

Variance backcast: ON

GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

	Coefficient	Std. Error	z-Statistic	Prob.
C	3.030839	39.20972	0.077298	0.9384
P(-1)	**1.100494**	0.035152	28.46225	**0.0000**
		Variance Equation		
C	1750.516	575.7654	3.040329	0.0024
RESID(-1)^2	**0.709440**	0.308841	2.297108	**0.0216**

GARCH(-1)	**0.288265**	0.155905	2.362117	**0.0182**

R-squared	0.980291	Mean dependent var	270.6941
Adjusted R-squared	0.980111	S.D. dependent var	482.8336
S.E. of regression	68.09385	Akaike info criterion	11.02861
Sum squared resid	2030906.	Schwarz criterion	11.07481
Log likelihood	-2437.836	F-statistic	5446.236
Durbin-Watson stat	2.415302	Prob(F-statistic)	0.000000

The coefficient on the conditional variance is positive and individually significant at 5%. This indicates the presence of ARCH and GARCH effect. The constant term is not significant. The coefficient of the first lagged value of rice price was significant at 5%. Hence rice price today is determined by the immediate past rice price. The sum of the ARCH and GARCH effect (0.997) indicates that, rice prices are highly volatile.

Again, the static forecast was used to estimate forecast price of rice. The mean of the forecast is 0.00002 from the actual values of maize prices; the variance of the forecast is 0.00079 from the variance of the actual maize prices. From the forecast model, the bias and variance proportion is small, and most of the bias is concentrated on the covariance (0.999) hence the forecast is good (See Table 11).

Table 11: In-Sample Forecast for Rice Price

Forecast: PRF

Actual: PR

Forecast sample: 1970M01 2006M12

Adjusted sample: 1970M02 2006M12

Included observations: 443

Root Mean Squared Error	67.70848
Mean Absolute Error	18.90713
Mean Absolute Percentage Error	580.5628
Theil Inequality Coefficient	**0.061296**
Bias Proportion	**0.000022**
Variance Proportion	**0.000791**
Covariance Proportion	**0.999188**

Table 12: Out-of-Sample Forecast

$\hat{P}_{2007.01} = 1.1004\hat{P}_{2006.12}$	
Month	**Price**
January, 2007	**1388.50**
February, 2007	**1527.90**
March, 2007	**1681.30**

This also indicates a 10% increase in rice price for the next month.

5.0 Conclusions

This analyzes volatility in foodstuff prices implications for food security in Ghana. Monthly foodstuff prices from 1970 to 2004 were used to estimate the forecasting equation whilst 1970 to 2006 was used to estimate the in-sample forecast. The generalised autoregressive conditional heteroscedasticity (GARCH) regression model is used to forecast foodstuff prices in Ghana over the period 1970 to 2006. For all the foodstuff prices, the current price is related to its value in the previous period plus a white noise error term. The positive GARCH effect in the models for maize, millet and rice suggest that, volatility in current period is related to volatility in the past period. The results of the Out-sample forecasts reveal that maize, millet and rice are forecasted to increase by 23%, 11% and 10% in prices respectively for the next month. Following the findings of Alderman (1992), and Jones and Sanyang (2008), the increases in food prices (maize, rice and millet) have implications for food and nutrition situation of the poor in Ghana. Thus, higher food prices lead the poor to limit their food consumption and shift to even less-balanced diets, with harmful effects on health in the short and long run. The forecasting performance of the GARCH (1, 1) model was evaluated using Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), and Theil inequality coefficient. The GARCH (1, 1), models for maize, millet and rice demonstrate high price volatility in foodstuff prices. However, the forecasting model yields unsatisfactory forecast. Hence, it can hardly be employed for true–out – of sample forecasting, primarily due to the fact that, past prices alone are insufficient to capture the food prices dynamics in the forecasting sample. The fluctuations of the monthly prices shows market failure arising from lack of proper storage facilities and infrastructure, especially with the abolition of the Food Distribution Corporation in Ghana, a government agency under the liberal economic reforms pursued by the People National Defense Council in the 1980s. Without adequate storage facilities food prices are more volatile hurting both producers and consumers. Further the lack of farmer's market centers in the districts exacerbates the problem. There is the need for District Assemblies to establish more farmer markets in the key towns to address this problem. Districts were empowered by the 1945 act which established the first All-African Cabinet in Ghana to establish district and town markets. This objective was vigorously pursued in the First Republic. However these efforts were largely abandoned after 1966 military coup which overthrew the government 46 years ago. The provision of market infrastructure will enhance access to better functioning markets in the Districts. Hence opening up of agricultural markets will address the rising food prices situation and to a large extent food security.

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