# Supply Response of Domestic Rice and Price Risk in Northern Ghana

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**Abstract**

*The research aims at assessing the supply response of domestic rice and the price risk as well as the factors influencing the supply by estimating autoregressive distributed lag (ADL), error correction models and double logarithmic model of the linear zed Cobb Douglas model for major using a time series data that span about 45 years (19970 - 2015). The research obtains the short run and long run elasticity's as well as the elasticity's for the determining factor of domestic rice supply. The empirical result analysis suggests that producers are responsive not only to price but to price risk and exchange rate. It is observed that price risk need to be adequately reduced if meaningful improvement in rice production is expected from the price incentive.*

**Keywords:** Northern Ghana, Price, Price risk, supply response, Error Correction.

## *1. Background*

Rice is a significant staple crop in Ghana and its consumption has been rising unprecedented in many Ghanaian regions in recent time. The usage of rice keeps on increasing while the production of rice is relatively in shortage. The shortage in rice production led to the shift of developmental funds for infrastructure to the importation of rice (MoFA, 2011). In Ghana, the per capita consumption for rice annually on average increased from 17.5 kg during 1999-2001, to 22.6 kg during 2002-2004 and 26.1kg in 2012. Forecasting per capita consumption of rice indicates increase to 65.0 kg in 2017 if the trend remains the same (MOFA-NRDS, 2009). Ghana as at 2015 spends US$450 million in importing rice to make up for the shortfall in supply of the product. The country's self-sufficiency in rice production stood at about 30 per cent for the year ended 2015, leaving a deficit of 70 per cent (GNA, Monday, August 9, 2016). The focus of Ghana`s government is how to adopt appropriate strategies to increase rice production in the country and hence reduce food insecurity level of the people.

From the time span of 2000 to 2011, importation of rice rise from 187,256MT to 543,465MT representing about 190 percent. On the same past eleven-year period, the expenditure on rice importation increased from US$65.03 million to US$391.17 million (MOFA, 2011). As a result, the government has initiated a number of policies; increasing tariff on rice, (FASDEP I, II, METASIP, etc) and formed the Ghana Rice Inter-Professional Body (GRIB). The high per capita consumption level of imported rice, i.e 26 kg per annum (SRID-MOFA, 2012) has attracted the attention of many stakeholders and policy makers, as it may have effects on the marketing and production of domestic rice in Ghana.

Constraints faced by regions regarding rice production in Ghana varied based on many factors. The factors include; difference in working population, the preference attached to the commodity in the list of household schedule, natural endowment for expanded production and the productivity of the rice farms (Saka *et al*, 2005).

In Ghana, Northern Ghana comprising of Northern Region, Upper East and Upper West regions are considered to be the poorest regions, which majority of the people are engaged in agricultural activities, specifically the cultivation of rice for home consumption and commercial purpose (domestic sales). Though, Northern Ghana has been endowed naturally. The sector has not been able to produce enough rice for the domestic need of her numerous population and the gap between demand and domestic supply has further been widened by decades of growing importance of the commodity among households in every sector and region of the country. This has contributed to the enormous rice report in Ghana of which Ghana has emerged as a major importer of rice.

The three Northern regions popularly called Northern Ghana contribute less to the national production of rice based on the resource endowment (MoFA, 2015) and the most critical and prioritised issues in agricultural development economic is supply response of crops (Mushtaq and Dawson 2002). Agriculture contribution to the economy (Gross Domestic Product) where the sector is the largest employer of labour is greatly determining by the farmers` responsiveness to economic incentive. Policies and strategies in the agricultural sector play a critical role in increasing farm production (Rahji et al, 2008). Supply response is fundamental to an understanding of price mechanism (Nerlove and Bachman 1960). The response of famers to prices fluctuations for specific products has different reasons which entail resource application especially land and family labour, plant selection and techniques, opportunities outside labour, the price of the product and presence of income uncertainty as well as farmers' risk averse nature. According to Darmawi (2005) any profit oriented activity, especially in business linking to agriculture, the economic activity is always face with the condition of risk and uncertainty.

There are quite a number of studies that have attempted to estimate supply response of rice farmers in many countries in Africa including Ghana using both primary and secondary data. This include Ayindeet al., (2014), Alam (2013), Ojogho et al. (2013), Olubode-Awosola et al (2006),Ilorah (2000), Ajakaiye (1987), Idowu (1986),Berry (1976), Oni (1972),while Lopez and Ramos (1998) research in to other commodities. The studies can be criticized on the basis that, they gave insignificant attention to the analysis of the impact of price risks on supply response in Ghana`s agriculture and also most of the past studies can be criticized on the basis of the modelling technique adopted. This study used error correction model, autoregressive distributed lag model and supply function model to examine the supply response of rice production in Northern Ghana to price and price risk after and also ascertained the factors that affects the supply of rice in Northern Ghana after ensuring stationary and deflating the variables under consideration.

## 2. Methodology

### 2.1 Data set

The data used for this study is an average figure for the three regions (Upper East, Upper West and Northern region) which spans from 1970 to 2015. The data was obtained from various institutions in Ghana and online. Most of the data was obtained from Ghana Statistical Service, Ghana Ministry of Food and Agriculture Information Directorate, the Central Bank of Ghana data base, online data base managed by Food and Agricultural Organisation and the Ministry of Trade and Industry 2015 annual report. The data were indexed at the 1990 prices and converted to logarithm in order to arrive at coefficients of interest which are elasticity's.

### 2.2 Empirical Models

Hallam and Zanoli, 1993 dynamic unrestricted version of the error correction model was adopted to analyse the supply response of rice in Northern Ghana. The unrestricted model is stated as:

$$\Delta \ln PA_t = \beta_0 + \beta_1 \Delta \ln DPA_t + \beta_2 (\ln DPA_{t-1} - \ln PA_{t-1}) \quad (1)$$

Where $\ln PA_t$ is the dependent or explained variable representing the planted area at time t expressed in natural logarithms. Equation 1 model is consistent with a wide array of likely processes that explained the shifting of output towards the intended level. The desired planted area ($\ln DPA_t$ ) is assumed to be a linear function of a set of independent or explanatory variables including price risk as shown in equation 2 below.

$$\ln DPA_t = \beta_0 + \beta_1 \ln P_t + \beta_2 \ln RER_t + \beta_3 \ln PR_t + \beta_4 D_t + \beta_5 D_t \ln P_t + \beta_6 D_t \ln D_t + \varepsilon_t \quad (2)$$

Where $P_t$is the price of rice. It is calculated by dividing the nominal farm gate prices by the consumer price index (CPI). The derived price of rice is anticipated to have a positive sign and the coefficient is interpreted as the long run price elasticity's. $RER_t$ is the real exchange rate. It is obtained using Purchasing Power Parity (PPP) theory condition which state that:

$$RER_{it} = GHCR * \frac{MP_{it}}{DP_{it}} \quad (3)$$

Where *MP* is imported price or foreign price of rice using Tema harbour price for imported rice and *DP* is the domestic price measured in actual figures. The study expected that, a change of real exchange rate would capture the substitution effects both in production and consumption which indicate effects between traded and non-traded goods such as rice for sales and for domestic consumption and/or between rice imports and domestic production. The nominal exchange rate of Ghana cedi to US dollar was used in this study. Makin a priori assumption about the signs of the coefficient is difficult as the impact of changes in real exchange rate is a mixed phenomenon for domestically rice production sales and rice imported sales. $PR_t$ is the observation on price risk of domestic rice. The research adopts a very simple approach (Ghatak and Seale, 2001) which measures the observation on price risk as:

$$PR_{it} = \sqrt{(P_t - \overline{P})^2 / n_1} \quad (4)$$

$$\overline{P} = \sum P_t \Big/ n_2 \quad (5)$$

Where n is the number of observation.

The parameter weighted was assumed to be all equal and hence risk was specified in terms of total variability instead of the unexpected variability in prices. This paves way for direct estimation of equation 3 when risk is added. The risk variable parameter is expected to be negative. This study has the same challenge of uncertainty decisions with most empirical studies when there is the situation of either risk neutrality or risk aversion. For risk-neutral models, expected prices are proxies by ad hoc methods or by predictions from the of model of time-series. The proxies are fitted into supply-response models which are commonly estimated by methods on the assumption that, there are small errors of measurement in the estimation. Two-step practice is followed; though standard instrumental variables (IV) methods can be employ to remedy for linear measurement errors, leading to consistent estimates of both coefficients and standard errors (Pagan1984 and Murphy and Topel, 1985). Similarly, supply response models under risk aversion use proxies for risk by rejecting errors of measurement. Consequently, it generally leads to an underestimate of effects of risk on decisions (Pagan and Ullah,1988). There is no general procedure for obtaining consistent estimators in such models, so in appropriate analysis, standard two-step procedures are more fit in risk-averse models than in risk-neutral models. $D_t$ measures the impact of the regime change dummy variables which entail additive and interactions with relevant explanatory variables where the slope may change between before indexing year and after indexing period are introduced. D = 1 if t > year 1991 and 0 if t ≤ year1991

All the variables except $D_t$are expressed in natural logarithms. The general error correction model that measures supply response short run behaviour is given by:

$$\Delta \ln Q_t = \beta_0 + \sum_{i=1}^{m_1} \beta_{1i} \Delta \ln Q_{t-i} + \sum_{i=0}^{m_2} \beta_{2i} \Delta \ln P_{t-i} + \sum_{i=0}^{m_3} \beta_{3i} \Delta \ln RER_{t-i} + \sum_{i=0}^{m_4} \beta_{4i} \Delta \ln PR_{t-i} + \sum_{i=0}^{m_5} \beta_{5i} \Delta \ln D_t + \sum_{i=0}^{m_6} \beta_{6i} \Delta \ln T_{t-i} + \lambda \varepsilon_t + \omega_t \quad (6)$$

Where $m_i$ (i = 1 to 6) measures the response of ln $Q_t$ to change in the repressors and λ is the error correction coefficient. If all the variables in equation (8) have unit roots and are co-integrated, then ECM will represent the short run behaviour of the supply response in (8). The parameter λ which is negative in general measures the speed of adjustment toward the establishment of long run equilibrium linkages between the variables. The test for the order of integration is usually the first step in any co-integration analysis.

Hence before the co-integrating equation is estimated, all the variables are tested to find out the presence of unit root using Augmented Dickey Fuller (ADF) test. The ADF test was performed on the time series of ln $Q_t$, ln $P_t$, ln $RER_t$, and ln $PR_t$, for the rice data. The ADF procedure involves estimation of the following regression.

$$\Delta Y_t = \alpha + \beta \Delta Y_{t-j} + \sum_{i=1}^{m} \gamma \Delta Y_{t-j} + \rho t + \varepsilon_t \quad (7)$$

Where $Y_t$is the variable concern, $t$ is a time trend. The null hypothesis that $Y_t$ has unit root implies that β = 0 in equation 7. So testing whether β = 0 means testing the null hypothesis that $Y_t$ has a unit root to the contrary research hypothesis that it is integrated of order zero. The optimum lag length m in equation 7 was chosen based on the Akaike final prediction error (FPE) criterion. The ADF test was performed on both the levels and first difference of the variables including constant and deterministic time trend ($\rho t$).In testing the series for stationary, Augmented Dickey Fuller (ADF) was employed together with Phillip Peron test (PP) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests and the results were arrived with the help of Stata 11.0 and JMulti. Next to the test for the order of integration is the analysis of the Autoregressive Distributed Lag Model (ADL). However, it is not possible therefore to examine co integration relationship when price risk is included in the supply response model. The modelling is therefore done using Autoregressive Distributed Lag Model (ADL) for regional average of rice commodity. The autoregressive distributed lag (ADL) model gives a general distributed lag frame work without explicitly specifying optimization changes. An ADL model can be written as:

$$P_{1t} = \alpha + \sum_{j=1}^{j} \beta_j P_{1t-j} + \sum_{k=0}^{k} \gamma_k P_{2t-k} + \varphi T + \varepsilon_t \quad (8)$$

Where $P_{1t}$, are series of variable P, a is an intercept, T is a time trend, and $\varepsilon_t$ is the error term. A key issue in estimating ADLs is identifying the right number of lags. Under parameterization can lead to wrong specification, however, over parameterization restricts the degree of freedom and increases forecast variance. Normally the relevant j and k are selected by means of information criteria such as the Akaike, Schwartz-Bayes, the Hannan Quinn and log likelihood. This is adopted to estimate equation 2 when price risk is included in the supply response equation. Initial running of the regression by imposing five lags gave unsatisfied results and the estimation proceeded by eliminating those variables with low t-values. Moving from the general to specific modelling of the ADL model improves the information criteria namely shwart criterion (SC), Hannan and Quiun (HQ) and the forecast prediction error (FPE). They decline as less significant variables and lags are eliminated on the basis of low t-values. At the same time, the equation standard errors increase; for price and price risk and their t-values are low, could not be eliminated, due to the fact that, they are interested variables particularly examined.

To analyse the determinants of rice supply in the study area, the supply function of Cobb-Douglas was adopted using output of rice as a dependent variable and planted area, producer price, quantity imported rice, weather variable (rainfall), price of rice and price of maize as independent variables.

The Cobb-Douglas function is stated as:

$$Y = b_0 . X_1^{b_1} . X_2^{b_2} . X_3^{b_3} . X_4^{b_4} . X_5^{b_5} . X_6^{b_6} . e^{\varepsilon} \quad (9)$$

The equation 9 can transform to a natural logarithmic of:

$$\ln Y = b_0 + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 X_4 + b_5 \ln X_5 + b_6 \ln X_6 + \varepsilon \quad (10)$$

Where:

Y = Supply of rice in kg
$b_0$ = Intercept
$b_1$ = Planted area in hectare
$b_2$ = producer price of rice in Ghana cedi
$b_3$ = quantity imported rice in kg
$b_4$ = rainfall in millimetres
$b_5$ = price of millet in Ghana cedi and
$b_6$ = price of maize in Ghana cedi

All variables are in natural logarithmic form after taking the average of the three regions under consideratio

## *3. Results and Discussion*

Table 1 shows descriptive statistics which mean, minimum and maximum for rice output and its related variables were analyzed for the data series. For the time period under study, rice has a maximum output of 9,245.04 and a minimum output 1,082.31 in kilograms with a mean of 1,143.35 kg. Planted area for rice on average has mean hectares of 43,670 which ranges from a minimum of 11, 564 to a maximum of 72,930. Producer price for rice in 50 kilograms has a mean value of GH¢32 with a minimum of GH¢9 and a maximum of GH¢73. The mean and minimum price of rice indicate higher value compared to the mean price of millet of GH¢27 and a minimum of GH¢8. However, the mean price of maize which is GH¢37 and a minimum of GH¢10 is greater than that of rice. Current price compares indicate that, rice in 50kg price which is GH¢73 is higher than both maize and millet prices of GH¢56 and GH¢45 respectively. The higher price in domestic rice price gives a sign of high demand for rice in Northern Ghana. This is confirmed by an increase in imported quantity from a minimum of 972.22 in 50kg to a maximum of 7,232.22 with an average of 2,456.23. The average rainfall as it affects rice production takes the mean value 776.96mm showing a steady supply of rainfall to the production of rice in Northern Ghana.

**Table 1: Summary Statistics of Variables**

| Variables | Observation | Mean | Minimum | Maximum | Standard Deviation |
|---|---|---|---|---|---|
| **Output of Rice** | 45 | 3,263.25 | 1,082.31 | 9,245.04 | 1,143.35 |
| **Planted Area** | 45 | 43,670 | 11,564 | 72,930 | 1,430 |
| **Price of Rice** | 45 | 32 | 9 | 73 | 28 |
| **Price of Maize** | 45 | 37 | 10 | 56 | 17 |
| **Price of Millet** | 45 | 27 | 8 | 45 | 26 |
| **Rainfall** | 45 | 776.96 | 289.97 | 1,890.11 | 564.43 |
| **Quantity of imported rice** | 45 | 2,456.23 | 972.22 | 7,232.22 | 1,023.22 |

**Authors `computation, 2015**

Based on the philosophy that test for constancy of economic series must precede their inclusion in regression model with the intention of avoiding estimating spurious regression, this study conducted the Augmented Dickey Fuller unit root tests which is confirmed by PP and KPSS tests on the levels and first difference of the economic series in the study. The result of the ADF, PP, and KPSS unit root tests is summarized in Table 2. Natural logarithm of the variables was taken to linearize the variable for easy attainment of stationary. The tests were used to test for stationary and non-stationary of the variable. On testing using ADF, PP and KPSS unit root tests, all of the variables were none-stationary at level while all were stationary at first difference. Both the ADF and PP test were carrying out to test the null hypothesis of non-stationary or there is unit root against the alternative of stationary or there is no unit root. However, the KPSS test is the opposite. It tests the null hypothesis of stationary against the alternative of non-stationary. We strongly reject the null hypothesis of no unit roots or stationary in the level of the series in all cases, but cannot reject the null hypothesis at the first difference of the series at the 1%. Therefore, the series under the study are first difference stationary processes i.e. they have unit root or are I (1).

**Table 2: Results of Unit root test of variables (ADF, PP and KPSS test)**

| Variables | Level | | | First difference | | |
|---|---|---|---|---|---|---|
| | **ADF Test** | **PP Test** | **KPSS Test** | **ADF Test** | **PP Test** | **KPSS Test** |
| **lnQ/lnY** | -2.345 | -1.382 | 3.535*** | -7.342*** | -5.464*** | 0.467 |
| **lnPA** | -1.453 | -1.439 | 2.469*** | -6.358*** | -5.433*** | 0.789 |
| **lnP** | -2.495 | -3.423 | 4.356*** | -6.993*** | -8.435*** | 0.286 |
| **lnRER** | -3.854 | -3.994 | 5.465*** | -10.245*** | -7.332*** | 0.632 |
| **lnR** | -2.003 | -3.456 | 3.454*** | -12.484*** | -9.436*** | 0.532 |
| **lnQMR** | -2.453 | -2.304 | 3.844*** | -9.354*** | -6.346*** | 0.376 |
| **lnMIP** | -1.483 | -1.939 | 2.335*** | -5.465*** | -5.537*** | 0.778 |
| **lnMAP** | -3.342 | -2.956 | 3.556*** | -6.466*** | -6.003*** | 0.628 |
| **lnPR** | -3.456 | -3.496 | 6.467*** | -8.564*** | -7.457*** | 0.396 |

Note: *, ** and *** represent significant level at 0.1, 0.05 and 0.01 in which ADF, PP and KPSS 1% critical values are -5.358, -5.358 and 0.846 respectively. lnR, lnQMR, lnMIP and lnMAP represent natural logarithm of rainfall, quantity of imported rice, millet price and maize price respectively.

Authors` computation, 2015

The results of the short run dynamics and ECM model (Table 3) shows that previous year planted area for rice is the most significant predictor of current cultivation. The elasticity is 0.22. Deviation from long run equilibrium as shown by the ECM is also negative and significant at 99 percent confidence level. The long run equation is stated as:

$$\ln PA_t = -0.0214 \ln P_t - 0.0115 \ln RER_t + 0.007 D_t - 001 D_t \ln P_t \quad (11)$$

Domestic rice producers respond to both own price and real exchange rate in the long run. The two elasticity's move in the same direction in that an increase in both price and exchange rate is not sufficient enough to stimulate increase in the planted area for rice, which is already declining due to lack of price incentive. The response is however lower than those obtained by previous research work on Nigerian cocoa supply response (Olusegun, *2009*).

**Table 3: Results of Error Correction and Autoregressive Distributed Lag Models**

| Variables | Error Correction Terms | | | | ADL | | | |
|---|---|---|---|---|---|---|---|---|
| | Δβ | Δβ(-1) | Δβ(-2) | Δβ(-3) | $\alpha$ | $\Delta\alpha(-1)$ | $\Delta\alpha(-2)$ | $\Delta\alpha(-3)$ |
| **PA** | | -0.22*** | 0.18 | | | -0.52 | 0.62 | 0.26** |
| | | (-3.42) | (1.24) | | | (-0.97) | (2.36) | (3.21) |
| **P** | | 0.31 | -0.27 | -0.19*** | | -2.31*** | 0.89** | -1.24 |
| | | (1.26) | (-0.74) | (-1.29) | | (-4.25) | (1.26) | (-4.26) |
| **RER** | | -0.11** | 0.13 | | | 0.42 | 0.53** | |
| | | (-2.01) | (0.85) | | | (0.89) | (1.02) | |
| **PR** | | | | | | -0.07** | | |
| | | | | | | (-1.19) | | |
| **D** | -0.06 | | | | 0.42* | | | |
| | (-0.37) | | | | (-1.37) | | | |
| **DP** | 0.04*** | | | | -0.66* | | | |
| | (0.28) | | | | (-1.21) | | | |
| **DPR** | | | | | -1.08*** | | | |
| | | | | | (-2.44) | | | |
| **R-square** | | | | | 0.63 | | | |
| **Adjusted $R^2$** | 0.895 | | | | | | | |
| **F** | 17.83 | | | | 5.42 | | | |
| **Error (-1)** | -2.45*** | | | | | | | |

*, ** and *** represent significant level at 0.1, 0.05 and 0.01 respectively. The figures in the bracket are the t-ratio.

**Authors` computation, 2015**

Table 3 again shows estimate of ADL modeling of rice planted area response. The results show that domestic rice producers are price risk responsive. Planted land area (lagged three years), real exchange rate (lagged two year) and duration dummies are major determinants of rice planted area response. The coefficients of both land area and exchange rate are significantly negative in their relation to planted area of rice. As it affects rice, there seems to be no more justification for further devaluation of the nations' currency. The results of the ADL modeling of rice planted area response indicate that previous year cultivated land area is a positive and significant predictor of current planted area of rice. The farmers are both price and price risk responsive. The coefficient of price risk is negative which conform to theoretical expectation.

Econometrics analysis to determine the factors that affect the supply of rice in Northern Ghana was ascertained using multiple regressions. The dependent variable was the supply of rice which output was used as proxy for rice supply and the independent variable were the planted area of rice, price of rice, rainfall, quantity of imported rice and prices of related substitute supply of maize and millet.

**Table 4: Results of factors affecting the supply of rice in Northern Ghana**

| Variables | Coefficient | t-Statistic | Probability | VIF |
|---|---|---|---|---|
| **Constant** | -2.686 | | | |
| **Planted area** | 4.289*** | 7.654 | 0.004 | 1.171 |
| **Price of rice** | 1.382*** | 2.332 | 0.008 | 1.097 |
| **Rainfall** | 0.754*** | 4.657 | 0.879 | 1.065 |
| **Quantity of imported rice** | -4.422* | -4.097 | 0.064 | 1.012 |
| **Millet price** | -5.754 | -3.187 | 0.213 | 1.003 |
| **Maize price** | -2.902** | -1.985 | 0.046 | 1.042 |
| **Adj-R2 = 0.726** | | | | |
| **n = 45** | | | | |
| **F Stat. = 43.861** | | | | |
| **Prob. (F Stat.) =0.000** | | | | |

*, ** and *** represent significant level at 0.1, 0.05 and 0.01 respectively.

Authors` computation, 2015

Table 4 showed, that the adjusted R2 value of 0.726, which meant that the independent variables were included in the model could explain variation in rice supply in Northern Ghana, which was 72.6 percent. The F value was significant at the 99% confidence level showed that the independent variable in the model jointly effect supply of rice in Northern Ghana.

Based on t test in Table 4 showed that planted area of rice has positive effect and significant on supply of rice in Northern Ghana at 99 percent confidence level and the response was elastic (4.289). That meant, the increase in the planted area of rice by 1 per cent would lead to an increase in supply of rice by 4.289 percent, assuming other factors are constant. This indicates that the supply of rice in the province of Northern Ghana responsive to changes in cultivated area. This research was relevant to the research of Tanko, et al. (2016). The study showed that increase in harvested area has positive impact on rice yield and concluded that, rice yield in Northern Region of Ghana increase as results of increase in planted area and not the adoption of new technology.

Prices of rice has a positive effect and significant on supply of rice in Northern Ghana at 95 percent confidence level, and the elastic response of 1.382 indicates that, the increase in rice prices by 1 percent would lead to an increase in supply of rice in Northern Ghanaby 1.382 percent. This indicates that the supply of rice in the Northern Ghana responsive to the price of rice. This research deals with the theory of "Change in quantity supply" which state that an increase or decrease in the price of a commodity would lead to an increase / decrease in the number of the commodity offered for sales. From the results of this research, it showed that producers respond positively to an increase in the price of rice and the reverse in the case when the price of the same commodity falls. This happened because of high expectation of increase in profit which is the driving force of every producer or seller. This research is in line with the research of Alam (2013), that affected the retail rice prices has positively significant affects the supply of rice in Central Sulawesi province at 95 percent confidence level and the response is elastic.

Quantity of imported rice in Northern Ghana has a negative relationship with supply of rice and is significant at 90 percent confidence level. The co-efficient of 4.422 implies, a 1 percentage increase in the quantity of imported rice in the study area would lead to 4.422 percent reduction in the supply of domestic rice. A prior expected sign was met as the results obeyed the law of substitution effects of supply which state that an increase in the quantity of commodity holding other factors constant will lead to a reduction of its price which will lead to an increase in the demand of the commodity and a reduction in the demand of its substitutes. Hence, an increase in the demand of imported rice as results of lower prices and quality of the product as asserted by Amikuzuno et al, (2013) will serve as a disincentive to domestic rice producers. This suggests the native relationship between supply of domestic rice and quantity of imported rice.

Maize price had negative effect and significantly to the supply of rice in Northern Ghana at 95 percent confidence level, but the response was elastic (-2.902). That meant, an increase in maize price by 1 percent would lead to a decrease in supply of rice by 2.902 percent. It became an indication that maize is a substitution in the supply of rice in Northern Ghana. If prices rise, the maize farmers would consume more rice so that the rice offers would be reduced, and vice versa.

The research of relief and with Site pure search (2002) which stated response of rice crop area was negatively related to the price of competitive plants. Supply of rice in Northern Ghana derived from rice production in the region itself and reserved early year rice. Government intervention in the economy in the supply of rice including rice in the country was fundamentally aimed at sustaining domestic rice production, protecting farmers, and ensuring rice sufficiency for the people so that they got easy access economically and physically sustainable (Saifullah, 2004). Millet price did not significantly affect the supply of rice in Northern Ghana. It became an indication that millet was not to be one of the substitutions of goods in the supply of rice in the Northern Ghana.

It is generally assert that in Ghana, many of the farmers depend on rain fed as the farms rely on rainfall for the production of crops. The results for rainfall indicate a positive relationship with the supply of rice in the study area. It indicates that a percentage increase in the quantum of rain water in mm will results an increase in the supply of rice by 0.753, though, is inelastic, it is statistically significant at 99 confidence level. This suggest that, rice production is below yield level due to insufficient rainfall and the adoption of irrigation is inadequate as the present of irrigation schemes could supplement the rain water to improve the production of rice. An increase in rice production assuming all things are the same will lead to an increase in the supply of rice in Northern Ghana.

## 4. Conclusion and Recommendation

This research intends at modeling the production and supply response of rice in Northern Ghana taking in to account the price risk of the commodity and also assessing the determining factors of domestic rice supply. The study derives both the short run and long run elasticity parameters. Generally, the results show that the model that include price risk in the argument forecasted better than the other without price risk does. The empirical result analysis suggests that producers are responsive not only to price but to price risk and exchange rate. Also, among the factor that influence supply of domestic rice, planted area, prices of domestic rice and rainfall, factors that positively enhance the supply of domestic rice significantly whilst quantity of imported and prices of maize are the factors that negatively affect supply of rice significantly. It is observed that price risk need to be adequately reduced if meaningful improvement in rice production is expected from the price incentive. In addition, policy makers should factor the construction of irrigation scheme to supplement the inadequate rain water when the desire production output of maize is expected. Ensuring greater and larger planted area through land distribution will be a right direction in the quest to increase rice production in Northern Ghana.

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