# A DISEQUILIBRIUM MODEL OF THE DEMAND FOR AND SUPPLY OF RICE PADDY IN NIGERIA

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*ABSTRACT*

*In the face of recent economic upheavals, the need to feed an ailing and hungry society cannot be overemphasized. This was clearly seen in the economic tremors felt in the Nigerian economy when the government put a sledge on the importation of major food products. One of the products highly affected was rice paddy, which had a spiral pattern of consumption. With the recent rush in the demand of rice paddy and inadequacy in its supply, it became imperative to model the disequilibrium in the demand for and supply of rice paddy in Nigeria. In order to achieve this, a simultaneous equations model was adopted. Applying 3-stage least squares (3SLS) technique to time series data spanning 1980-2015, the study found that demand for and supply of rice were price inelastic. It suggested, therefore, that there should be policy that would stimulate sustained increase in domestic rice production capacity while maintaining the fragile and volatile market of the commodity.*

**JEL classification:** D58, 013, Q15

## 1. Introduction

THE Nigerian economy was mainly dominated by the agricultural sector before the discovery of oil in the 1950s. The agricultural sector is the largest and most significant source of food, employment and income for the populace. Thus, the productivity, growth and efficiency of the sector are central to the general interests of economic development planning of any country. One product of the agricultural sector which has dominated the sector is rice, which has fast become a staple food in Nigeria due to changing consumer preferences, rising incomes, and growing urban population (Nwanze, Mohapatra, Kormawa, Keya and Bruce-Oliver, 2006). The consumption of rice, according to Ibitoye, Idoko and Shaibu (2014) has no

cultural, religious, ethnic or geographical boundary. As a result, its demand and consumption have continued to witness momentous changes with increasing population across all socioeconomic classes (Ogunsumi, Ajayi, Amire and Williams, 2013). Over 90 percent of the populace consumes rice at various stages of preparation (Kuku-Shittu and Pradesha, 2013). Consequently, the rate of rice importation is growing faster than both production and population.

The demand for rice in Nigeria has been increasing at a much faster rate than in any other African country since the mid-1970s (Daramola, 2005). FAOSTAT (2013) confirms that the per capita consumption of rice in the country increased from as low as 3.4kg/year in 1976 to 20.9kg/year in 2009. A number of factors are responsible for this observed trend and they include acceleration in the population growth rate, increase in per capita income, changes in family occupational structures and rapid urbanization which ushered in changes in lifestyles that encourage food that require minimal preparation time putting rice at the centre of this requirement (Akpokodje, Loncon and Erenstein, 2001; Akande, 2002; Kuku-Shittu and Pradesha, 2013; UNEP, 2005)

In spite of the growing demand for rice by consumers, Umeh and Atarboh (2007) asserted that producing rice to meet up with the local demand has eluded Nigeria for a long time despite efforts by the government through the years; hence, the gap created by insufficient supply response has been bridged by increasing imports. This growing dependency on rice imports has been threatening to deplete Nigeria's scarce foreign currency reserves, increasing its vulnerability to global price shocks, and raising overall concerns about food insecurity. The wide gap between domestic production and demand has various economic implications. According to Abubakar (2013), over N1 billion is spent daily by the country on rice importation, thus making Nigeria a net importer of rice, despite that rice is cultivated in some parts of the country (Ayanwale, Akinyosoye, Yusuf and Oni, 2011). The demand for rice keeps growing, and has not been matched with the available supply. This trend portends danger particularly to the welfare of the citizenry and the economy in general if left unchecked. This is because, according to Hassan and Johnson (1976), demand for food is inelastic. This implies that demand parameters are important for the development of national price stabilization, as well as economic policies; hence, it is a variable for effective design of fiscal policies (Nzuma et al., 2010).

Consequently, Nigeria has been motivated to introduce initiatives designed to promote domestic rice production in order to displace rice imports and achieve self-sufficiency as in the past (Akinbile, 2007). The nation has done this either through

import restrictions as well as through investments to improve rice output and quality. This can be seen in the adoption of various agricultural programmes. These include the Presidential Initiative on Rice, introduced in 1999; the National Programme for Food Security (NPFS) launched in 2001, and the Agricultural Transformation Agenda (ATA) (Adesina, 2012; Akaeze, 2010). These programmes were introduced due to the economic danger posed by large volumes of milled rice being imported into the country every year since the 1990s. In each of these programmes and other agricultural policies adopted in the past, the introduction of import barriers has always been adopted as a policy choice. Unfortunately, the effects of the demand responses have not led to any significant supply response. Thus, as with any other commodity, one of the fundamental questions economists would want to ask and answer is: How do we model the rice market? In particular, what determines the supply for rice, what determines the demand for rice, and by what equilibrium process are rice prices and quantities determined? These constitute the thrust of this research.

## 2. Literature Review

Jayne (1993) studied the sources and effects of instability in the world rice market, assessing the causal link between domestic agricultural policies and world price instability in the rice market for seven major rice trading countries over the period 1960-1987. A comparison of the estimated transmission and absorption effects with those implied under free trade, by incorporating several behavioural restrictions drawn from standard trade theory was carried out as well as using sensitivity analysis to determine the robustness of the results to changes in domestic and international price elasticities. The major structural and behavioural factors that account for the great degree of price variability in world rice markets relative to other major grain markets, and an examination of the dynamic effects of these factors on the organization and performance of international rice market was also highlighted by the study. The findings showed that stabilization policies in some countries have aggravated world price instability and otherwise for some other countries. Thus, the link between domestic price stability and world price instability appears, in the case of the rice market, to be exaggerated. If domestic agricultural policies had been overemphasized as sources of instability in the global rice market, an explanation is required for the high degree of volatility in the market. Among the factors identified by the study are: a persistently thin and disjointed market where price information is difficult to get, and where the development of harmonization mechanisms to reduce trade uncertainties are

thwarted by major traders who sporadically float in and out of the market; very low consumption responsiveness to domestic prices in the countries examined; and the absence of a major actor or institution that stabilizes world rice prices through stock and trade policies, as it is with other grain markets.

Kuku-Shittu and Pradesha (2013) used data from the living standards measurement study–integrated surveys on agriculture (LSMS–ISA), a national survey on household welfare conducted by the Nigerian Bureau of Statistics (NBS) in partnership with the World Bank to econometrically analyse rice demand in Nigeria. the results revealed that overall, the income elasticity of demand for rice in Nigeria is quite high, suggesting that demand for rice would grow fast as income level increases for both local and imported rice, with rural households showing higher demand for rice compared to urban households when their incomes increase. There was also a tendency to switch consumption at some critical income levels from local rice to imported rice.

Ayinde, Bessler and Oni (2014) studied model supply responses in Nigerian rice production, including standard arguments and price risks for the period 1970 – 2011 and using descriptive equilibrium output supply function, cointegration and vector autoregressive distributed lag models. The results showed that producers are more responsive to price and non-price factors, as well as price risks and exchange rate. The study suggested, therefore, that price risk should be reduced, so as to increase the responses of producers to supply and bridge the gap in production. Also, Umar, Amin, Shamsudin and Mohamed (2014) estimated the demand equation for the Malaysian rice sector using time series data for the period 1980-2012. The autoregressive distributed lag (ARDL) model was employed in the analysis. The results indicated that rice was a normal good in the short run and an inferior good in the long run; and the demand for rice was largely inelastic.

## 3. The Model

In this section, a model of rice supply and demand in Nigeria is presented, along with an explanation of the problem that arises in its estimation.

### 3.1 Demand analysis

According to elementary economics, demand is the ability and willingness of consumers to buy a certain amount of a commodity at a certain price during a given period of time (Hyman, 1997). The quantity of a commodity that an individual is willing to buy over a certain time period depends on the price of that commodity, the prices of other commodities, income and individual preference. There exists an

inverse relationship between the price and the quantity demanded of a commodity. In other words, if the price of a commodity decreases, the quantity demanded of that commodity will increase, other factors being constant (Ekanam and Oyefusi, 2000).

### 3.2 Supply analysis

Supply is the quantity of commodity available for sale at a certain price during a given period of time. The supply for a commodity depends on the price of that commodity, the prices of the other commodities, and income. Therefore, there exists a direct relationship between the price and quantity supplied of a commodity. That is, if the price of a commodity decreases, the quantity supplied of that commodity will decrease, considering that other factors are constant.

### 3.3 The general framework

Supposing there are *N*-rice markets isolated in time and indexed by $t = 1, 2. . . N$, for each market $t$, let $p_t$ denote the price of rice, $q_t$ denote the quantity of rice transacted, and $x_t$ denote a vector of covariates characterizing the market. For each market $t$, the market demand function $q^d{}_t$ gives the quantity of rice that price-taking consumers would purchase, while the market supply function $q^s{}_t$ gives the quantity of rice that price-taking firms would offer, both as function of price. Markets are assumed to clear, which means that the transaction $(p_t, q_t)$ is assumed to be an equilibrium outcome. In other words, for all markets $t$, the price $p$ tends to equate supply and demand:

$$q_t^d(p_t; x_t) = q_t^s(p_t; x_t) \qquad (1)$$

Markets vary in their values of $(q^d{}_t, q^s{}_t, p_t, q_t, x_t)$. For each market $t$, we can only observe the equilibrium price $p_t$, the equilibrium quantity $q_t$, and the covariates $x_t$, but cannot observe either the demand function $q^d{}_t$ or supply function $q^s{}_t$.

### 3.4 A linear market model

The study assumed that both demand and supply functions are linear with fixed coefficients and additive residuals. The structural form of this model is given as:

$$demand: q_t^d(p_t; x_t) = \delta_t^d p_t + x_t' \delta_x^d + \mu_t^d \qquad (2)$$

$$supply: q_t^s(p_t; x_t) = \delta_t^s p_t + x_t' \delta_x^s + \mu_t^s \qquad (3)$$

$$market\ clearing: q_t^d(p_t; x_t) = q_t^s(p_t; x_t) = q_t \qquad (4)$$

The demand equation 2 and supply equation 3 are the structural equations of this linear rice market model. Since economic theory predicts that demand curves should be downward-sloping, while supply curves should be upward-sloping, it is expected that $\delta_p^{\ d} \leq 0$ and $\delta_p^{\ s} \geq 0$. Solving the structural equations 2 and 3 for price and quantity as functions of the covariates, the following reduced forms of equations for the linear rice market model are obtained:

$$price: p_t = x_t' \pi_x^p + \varepsilon_t^p \quad (5)$$

$$quantity: q_t = x_t' \pi_x^q + \varepsilon_t^q \quad (6)$$

Econometric analysis seeks to estimate the structural parameters ($\delta^d_p$, $\delta^d_x$, $\delta^s_p$, $\delta^s_x$). However, estimating the demand equation 2 and supply equation 3 separately by ordinary least square (OLS) will not yield efficient or consistent estimates of these structural parameters for two reasons. The first problem with equation-by-equation ordinary least squares is a lack of identification. According to Goldberger (1991), prices are endogenously determined in the supply-and-demand system; hence, the coefficient on price is not identified unless one uses instruments for price. Otherwise, these estimates will not be consistent. The second problem with equation-by-equation ordinary least squares is a lack of efficiency. If there are restrictions on the parameters in the model, the joint estimation of demand and supply equations will be more efficient than the equation-by-equation ordinary least squares (Goldberger, 1991; Ruud, 2000). Since equation-by-equation ordinary least square suffers from identification and efficiency problems, it is imperative to specify the demand and supply equations.

### 3.5 Demand equation

The demand for agricultural production is a function of its current price as well as prices in the past. This is expressed as:

$$q_t^d = f(p_t, p_{t-1}, p_{t-2}, p_{t-3}, \dots) \quad (7)$$

Equation 7 can be numerically rendered as:

$$q_t^d = \alpha_0 + \alpha_1 p_t + \alpha_2 p_{t-1} + \alpha_3 p_{t-2} + \dots \quad (8)$$

Equation 8 is an infinite distributed lagged model. In order to operationalize equation 8, the study applied the Koyck transformation (Koyck, 1956). Under the Koyck scheme, it is assumed that $\alpha_0 = \alpha_0 \lambda k$, where $k$ = 0, 1, 2, 3… and λ is the

coefficient of decay, with $0 < \lambda < 1$. Imposing the Koyck scheme into equation 8, the following was obtained:

$$q_t^d = \alpha_0 + \alpha_0\lambda p_t + \alpha_0\lambda^2 p_{t-1} + \alpha_0\lambda^3 p_{t-2} + \ldots \quad (9)$$

Lag equation 9 one period to obtain:

$$q_t^d = \alpha_0 + \alpha_0\lambda p_{t-1} + \alpha_0\lambda^2 p_{t-2} + \alpha_0\lambda^3 p_{t-3} + \ldots \quad (10)$$

Multiply equation 10 by λ to obtain the expression:

$$\lambda q_t^d = \lambda\alpha_0 + \alpha_0\lambda^2 p_{t-1} + \alpha_0\lambda^3 p_{t-2} + \alpha_0\lambda^4 p_{t-3} + \ldots \quad (11)$$

Subtract equation 11 from equation 9 to obtain:

$$q_t^d = \alpha_0(1-\lambda) + \alpha_0\lambda p + \lambda q_{t-1}^d \quad (12)$$

For simplification, it is assumed that $A_0 = \alpha_0(1-\lambda)$, $\alpha_1 = \alpha_0\lambda$ *and* $\alpha_2 = \lambda$. Therefore, equation 12 can be rewritten as follows:

$$q_t^d = A_0 + \alpha_1 p + \alpha_2 q_{t-1}^d + \varepsilon_1 \quad (13)$$

### 3.6 The supply equation

It was also assumed that supply of agricultural product is a function of current and lagged prices. Thus the following expression was obtained:

$$q_t^s = f(p_t, p_{t-1}, p_{t-2}, p_{t-3}, \ldots) \quad (14)$$

The function of equation 14 can be written as:

$$q_t^s = \beta_0 + \beta_1 p_t + \beta_2 p_{t-1} + \beta_3 p_{t-2} + \ldots \quad (15)$$

As explicitly applied in the case of the demand equation, the Koyck scheme will render equation 15 as:

$$q_t^s = \mathrm{B}_0 + \beta_1 p + \beta_2 q_{t-1}^s + \varepsilon_2 \quad (16)$$

### 3.7 The price equation

In the price equation, it was assumed that the current price of agricultural production depends on past price, ceteris paribus. Thus, the price equation can be expressed as follows:

$$p = f(p_t, p_{t-1}, p_{t-2}, p_{t-3}, \dots) \quad (17)$$

The function of equation 17 can be expressed as:

$$p = \sigma_0 + \sigma_1 p_{t-1} + \sigma_2 p_{t-2} + \sigma_3 p_{t-3} \quad (18)$$

As it is in the case of previous equations, the Koyck transformation was also applied to give the expression:

$$p = \sigma_0 + \sigma_1 p_{t-1} + \sigma_2 (q_t^d - q_t^s) + \varepsilon_3 \quad (19)$$

### 3.8 The system

Equations 13, 16 and 19 made up a complete system, as can be seen in the following:

$$q_t^d = \mathrm{A}_0 + \alpha_1 p + \alpha_2 q_{t-1}^d + \varepsilon_1 \quad (13)$$

$$q_t^s = \mathrm{B}_0 + \beta_1 p + \beta_2 q_{t-1}^s + \varepsilon_2 \quad (16)$$

$$p = \sigma_0 + \sigma_1 p_{t-1} + \sigma_2 (q_t^d - q_t^s) + \varepsilon_3 \quad (19)$$

Where: $\alpha_1, \alpha_2 < 0$; $\beta_1, \beta_2 > 0$; $\sigma_1 > 0$; $\sigma_2 > < 0$

The model presented by this system of equations contains three endogenous variables ($q^d{}_t$, $q^s{}_t$ and $p$). It also holds constant all other exogenous variables that might influence demand, supply and price of rice. In order to address both the identification and efficiency issues, the system equations can be estimated using the three-stage least squares (3SLS). In order to obtain equilibrium, equate equations 13 and 16:

$$\mathrm{A}_0 + \alpha_1 p + \alpha_2 q_{t-1}^d + \varepsilon_1 = \mathrm{B}_0 + \beta_1 p + \beta_2 q_{t-1}^s + \varepsilon_2 \quad (20)$$

Equilibrium quantity is obtained thus:

$$\mathrm{A}_0 + \alpha_1 p + \alpha_2 q_{t-1}^d + \varepsilon_1 = \mathrm{B}_0 + \beta_1 p + \beta_2 q_{t-1}^s + \varepsilon_2 \quad (20)$$

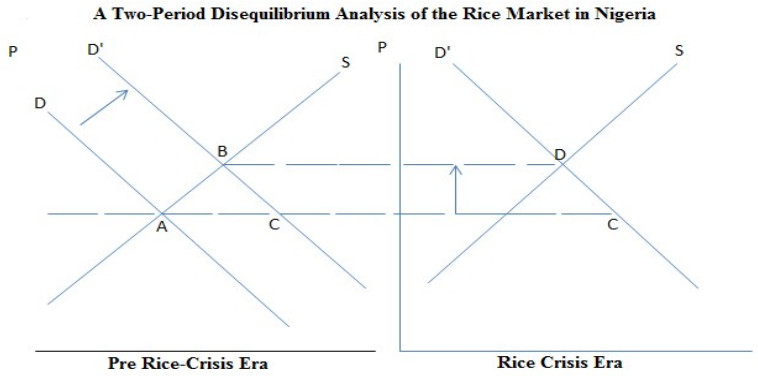
$$\alpha_2 q_{t-1}^d = (\mathrm{B}_0 - \mathrm{A}_0) + (\beta_1 p - \alpha_1 p) + \beta_2 q_{t-1}^s + (\varepsilon_2 - \varepsilon_1)$$

$$q_{t-1}^d = -\frac{(\mathrm{A}_0 + \mathrm{B}_0)}{\alpha_2} - \frac{p(\alpha_1 + \beta_1)}{\alpha_2} + \frac{\beta_2 q_{t-1}^s}{\alpha_2} - \frac{(\varepsilon_1 + \varepsilon_2)}{\alpha_2} \quad (21)$$

Or:

$$q_{t-1}^{s} = -\frac{(A_0+B_0)}{\beta_2} - \frac{p(\alpha_1+\beta_1)}{\beta_2} + \frac{\beta_2 q_{t-1}^{d}}{\beta_2} - \frac{(\varepsilon_1+\varepsilon_2)}{\beta_2} \quad (22)$$

This scenario can be illustrated graphically. Figure 1 shows that a rise in the demand of rice from D to D shifted the equilibrium from A to B, creating a gap in supply. In order to fill that gap, the Nigerian government in the past has resorted to importation of rice. As noted previously, this has resulted in fiscal disequilibrium, which has further worsened the trade balance and exacerbated economic crisis in the country.




**Source: Authors' Formulation (2017)**

**Figure 1: Two-period disequilibrium analysis of the rice market in Nigeria**

## 4. Methodology

This study employed time series data on demand, supply and price of rice to estimate the simultaneous equation (equations 13, 16 and 19). The demand of rice is given by rice consumption in metric tonnes, while supply is given by milled rice production in metric tonnes in Nigeria spanning 1980 to 2015. The data were elicited from the database of United States Department for Agriculture (USDA). The nominal producer price of rice gathered from the agricultural production database of FAO was deflated into real price using 2005-based consumer price index (CPI) series for Nigeria from the statistics of International Rice Research Institute (IRRI, 2015). All the variables are expressed in the log form. Estimating the model with such a data enables us to interpret the coefficients as short-run elasticities.

## 5. Results

The result of the estimation of the specified model is presented in table 1.

**Table 1: 3-stage least squares result**

| *Variables* | *Equations* | | |
|---|---|---|---|
| | *Demand* | *Supply* | *Price* |
| C | -1.5352 | 1.3821 | 0.1599 |
| | (-2.736)*** | (2.664)*** | (1.939)* |
| P | -0.4894 | 0.0752 | - |
| | (-1.774)* | (3.407)*** | |
| D(-1) | 0.4113 | - | - |
| | (2.4235)** | | |
| S(-1) | - | 0.8504 | - |
| | | (14.7342)*** | |
| (D-S) | - | - | 0.1856 |
| | | | (4.923)*** |
| P(-1) | - | - | 0.6319 |
| | | | (1.8348)* |
| $R^2$ | 0.627 | 0.651 | 0.718 |
| F-Stat. | 42.05 | 51.72 | 47.33 |
| Durbin h Stat. | -2.725 | 2.082 | -0.942 |

*Source*: e-Views output

*Note*: t-values in parenthesis. The notations *, **, ***, denote significance at the 10%, 5% and 1% level respectively.

### Demand equation

The summary statistics of the demand equation are satisfactory. Over 62 per cent of the systematic variations in the demand for rice paddy can be attributed to the explanatory variables in the demand model. As can also be seen, the significant F-value shows that the overall equation is statistically significant. The computed Durbin H statistic showed that there was a mild negative serial correlation in the error term of the specification. A close look at the demand equation result shows that the price of rice negatively (significantly) affect Nigeria's demand for rice paddy, while the previous year demand of rice positively influences the current year demand. This is true, as can be seen in the recent rush in the demand of rice in the Nigerian market. The result shows that rice demand is price inelastic. This result agrees with Mohanty, Wailes and Chavez (2010) and Umar et al. (2014).

### Supply equation

The summary statistics of the supply equation are also satisfactory. Over 65 per cent of the systematic variations in the supply of rice paddy can be attributed to the explanatory variables in the supply model. The significant F-value shows that the

overall equation is statistically significant. The result of the supply equation shows that the price of rice positively and significantly influences the supply of rice paddy in Nigeria. The previous year supply of rice also has a positive influence on the current year supply. This can be attributed to the fact that businessmen and importers of rice paddy will be spurred into increasing supply due to huge profits in the previous year. The result also shows that rice supply is price inelastic. In other words, a change in the price of rice leads to a not-so-significant supply response, creating a consistently significant market for the product and confirming the dominance of rice on the Nigerian menu list. Therefore, increasing the domestic production capacity is of high importance in order to bridge the importation gap created by a shortfall in local production capacity.

**Price equation**

In the price equation, it was observed that the previous year's price of rice (lagged price) influenced the current price positively, which implies that the price of rice is usually expected to increase in succeeding years. Possible reasons for this include, among other, increase in the volume of imported rice and the low domestic productive capacity of rice. The Walrasian coefficient was positively signed, indicating that the rice market was characterized by excess demand for rice paddy. This variable is inelastic with respect to excess demand variable of rice paddy.

**Conclusion and Recommendations**

The study takes a cursory look of the demand for and supply of rice paddy in Nigeria. Using a disequilibrium model, the demand for rice paddy is negatively influenced by the price level of the commodity. On the other hand, the supply of rice is positively influenced by its price. In terms of price of rice paddy, the previous year's price will positively affect the current price, with an attendant implication of an expected continuous increase in price occasioned by shortage in the supply of the commodity. Consequently, it is imperative to offer these policy recommendations in the face of an impending food crisis in Nigeria:

1. The government should formulate and implement a domestic price policy that guarantees and stimulates local rice farmers in their rice production. In order to achieve this, the government should launch agricultural programmes to boost local rice production, meet the demand and discourage over-reliance on rice importation.
2. There should also be a comprehensive food policy, coupled with social engineering programmes to boost rice production. This will lead to a

decrease in the volume of rice import and increase domestic production capacity of rice.

3. Rice prices should be reviewed periodically to reflect current inflation rates.
4. There should be a policy also to eradicate rice importation through the use of policies on tariffs and quotas.

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