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IMPACTS OF PRODUCTIVITY SHOCKS ON FOOD PRICE IN NIGERIA

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ABSTRACT
Production shocks are key determinants of food prices as they affect agricultural output and determine the quantity of food supplied in an economy. Production shocks are a major source of economic fluctuations and as such their importance cannot be over emphasized. This study therefore analyzes the effects of production shocks on the monthly food price index in Nigeria. Data sourced from the National Bureau of Statistics (NBS) were analyzed using descriptive statistics and Johansen Cointegration Test. The exogenous shock variables included are quantity of fertilizer, amount of labor, temperature and rainfall and their effects were compared with the effects of interest rates on food prices. The results obtained from the analysis revealed that all the shocks including the interest rate had an inverse relationship with the monthly food price index. It is therefore recommended that in controlling fluctuations in food price, policies which reduce the effects of shocks and increase agricultural outputs such as an improved fertilizer subsidy system and the development of new agricultural technologies should be combined with the tightening of monetary policies to facilitate the prompt regulation of food prices.

KEY WORDS: Shocks, food price index, fluctuation, climate *etc*.

INTRODUCTION

Shocks are unexpected or unpredictable events that affect an economy positively or negatively and are usually accompanied by the response of economic variables like output and employment. Production shocks are exogenous and may be a temporary negative shock such as floods or drought or a permanent positive shock such as changes in technology or a permanent (positive or negative) change in climatic conditions (Warr, 2011). Production shocks in agriculture ranges from risky agricultural production environment, existence of ex post adjustments in off farm labor supply, pests, diseases to the adoption of crop genetic diversity and choice of mechanism for coping with changes in weather. Such shocks may combine with other factors such as lack of access to fertilizer, rising production costs such as irrigation pumps and machinery, high transportation costs as a result of higher prices of petroleum and fertilizer to lead to slow growth of crop yield (Warr, 2011). The most important pathway through which most households are affected by shocks in the domestic economy and international markets is through changes in domestic prices as they have real income effects. In agriculture, they determine the extent of food (agricultural) growth and affect domestic supply conditions thereby contributing to fluctuations in food prices. Low income households often suffer the most as they tend to devote larger shares of their incomes to food than higher income households do. Agricultural production shocks also have direct effects on farm incomes and thereby farm household's access to food as households which normally produce enough food may face shortage before the next harvest. Improving agricultural productivity and resilience to agricultural production shocks (Cavatassi *et al*, 2006) as well as understanding the behavior of food markets particularly the price transmission between international and domestic markets (FAO, 2012) are critical components of reducing poverty and improving food security within the country. The food price index (FPI) shows the change in food prices faced by households over time. They provide important signals to farmers, processors, wholesalers, consumers and policy makers about the changing structure of food and agricultural economies. According to Totten (2010), the three primary factors which affect food price are factors which affect the cost of food transportation and food processing, natural causes which affect food supply and human causes which interrupt or otherwise disrupt food supply. Production shocks can also be categorized under these factors as the agricultural sector is constantly being affected by changes such as introduction of new technology (for processing or production), climate change (natural) and changes in government policies (human) amongst others.

Climate change affects food production directly through changes in agro ecological conditions and indirectly by affecting growth and distributions of incomes and thus demand for agricultural produce (FAO, 1999). Nigerian agriculture is particularly vulnerable to climate change as it is predominantly rain fed. Even livestock production which involves the herding of cattle, goats and sheep raised principally in the northern states is also heavily dependent on rainfall and equally vulnerable (Mendelsohn, et al 2000). Shortages in farmers output as a result of climate change has led to an abrupt increase in food price. Pest and crop diseases migrate in response to climate changes and variations, for example in Nigeria, the tse tse fly has extended its range northward and will potentially pose a threat to livestock in the drier northern areas. It is estimated that by 2100, Nigeria and other West African countries are likely to have agricultural losses of up to 4 percent of GDP due to climate change (Mendelsohn,*et al* 2000). Parts of the country that experiences soil erosion and operate rain fed agriculture could have a decline in agricultural yield of up to 50 percent between 2000 – 2012 due to increasing impact of climate change (Agoumi, 2003; IPCC, 2007) Natural resource constraints, especially climate change and the limited availability of productive land and water pose substantial challenges to producing food at affordable prices.

Productivity shocks contribute to the variations in the requirements of labor in agricultural production. Variations in labor supply may also be as a result of several factors which include migration, health conditions (e.g HIV, malaria and injury), wage rate, risky production environments and availability of child labor among others (Larochelle *et al*, 2006). Labor productivity is procyclical and is also dependent on the type of labor. Hired labor, women and children are considered to have less productivity when compared to men in farming households (Larochelle *et al*, 2006). Most rural farming households respond ex – ante to risky production environments and ex – post to unexpected climatic shocks by households combining off farm work with farming. Off farm work is used by farm households to respond to farm production shocks through supply of labor to the off farm labor market (Rose, 2001, Lamb 2003). However, the type and level of involvement of farming households is unequally distributed (Mathenge *et al*, 2010). The determinants of the supply of labor to the off farm market can be generalized from both the push and pull perspectives. In the presence of shocks or risky environments, labor is pushed to do off farm work while as a pull phenomenon households will engage in off farm work so as to reduce risks on their current portfolio of activities as a result of poor land quality, external shocks to agriculture, high input prices and low output prices.Technology shocks have long term effects as they cause permanent changes in the production function. Improvements in agricultural technologies improve labor productivity and create surplus agricultural labor that can provide for the growing urban areas (Huffman *et al*, 2007). Fertilizer can be organic or inorganic (Ogunlade *et al*, 2009) and its use has played a major role in the transition of traditional agriculture to a modern one. The advent of inorganic fertilizer has enabled farmers to achieve the high yields that drive modern agriculture. The use of nitrogen fertilizer use would continue to increase substantially as global population and food requirements grow. Fertilizer use in Nigeria is considered low (around 6kg per hectare) and this coupled with poor execution of government policies has been identified as a major hindrance to the utilization of this technology (Obasi *et al*, 2005). Increases in agricultural output have been largely due to area expansion rather than increased productivity and fertilizer subsidies have been one of the major policy instruments used to increase agricultural productivity. However, the fertilizer procurement, distribution and subsidy policies in Nigeria have been inconsistent over time resulting in wide variations in the supply of subsidized fertilizer (Obasi *et al*, 2005; Nagy and Edun, 2002). The availability of subsidized fertilizer increases the amount of fertilizer available to farmers as 1kg of subsidized fertilizer reduces demand for commercial fertilizer by between 0.19 and 0.35kg (IFPRI, 2009). Factors such as leakages in the subsidy system, adulteration of fertilizer, late delivery among others have prevented farmers from reaping its benefits. Productivity shocks even if they do not account for all or even most fluctuations play a major role in playing them. This study aims to investigate the effects of some production shocks on the monthly food price index in Nigeria over the period of 1996 – 2008 using the error correction model. Shocks considered in this study are climate change (rainfall and temperature), quantity of labor available for agriculture and quantity of fertilizer available to farmers in Nigeria over the period of study. The study was carried out under the following sub-sections: Abstract, Introduction, methodology, results and discussions and Conclusion.

METHODOLOGY

Data and Analysis

Data used for this study include the monthly food price index, interest rate, rainfall, temperature, quantity of labor available for agriculture and quantity of fertilizer imported into Nigeria sourced from the National Bureau of Statistics (NBS) covering the period 1996 - 2008. Data were analyzed using the unit root test, Johansen Cointegration Test and the Error Correction model (ECM).

Analytical Framework

The Unit Root Test:

Determining the most appropriate form of trend in data is an important econometric task as if data is trending, some form trend removal is required. The unit root test can be used to determine if trending data should first differenced or regressed on deterministic functions of time to render the data stationary.

Consider the stylized trend – cycle decomposition of a time series y_t

$$y_t = \beta_0 + \beta_{1y_{t-1}} + \mu_t$$

Autoregressive unit root tests are based on testing the null hypothesis that $\beta_1 = 1$ (difference stationary) against alternative hypothesis that $\beta < 1$ (trend stationary). The time series y_t has a unit root if $\beta_1 = 1.0$ (exactly) and the unit root implies that y is 1(1) i.e. integrated to the order of 1. First differencing is appropriate for 1(1) time series and time trend regression is appropriate for 1(0) time series.

Cointegration Test

Economic and finance theories often suggest the existence of long run equilibrium relationships exist among non stationary time series variables. If these variables are 1(1), then cointegration techniques can be used to model long run relations.

Consider two time series y_t *and* x_t that are both 1(1), both can be said to be cointegrated if there exists a parameter a such that $u_t = y_t - ax_t$ is a stationary process.

Economic variables tend to move together, but in order to obtain a linear combination of the series that is stationary, more variables may need to be included. Therefore, y_t is said to be cointegrated if there exist such a vector β_1 such that $\beta_1^1 y_t$ is trend stationary. If there exist r of such linearly independent vectors of β_1 such that i = 1,……..r then y_t is said to be co integrating with the rank r.

The matrix $\beta = (\beta_1 \dots\dots \beta_r)$ is called the co integrating matrix.

Cointegration and the Error Correction Model:

By regressing x_t on y_t , the co integrating vector z_t can be obtained i.e.

$$x_t = \beta_1 y_t + Z_t$$

The linkage between cointegration and the ECM stems from the theory proposed by Granger (Keele, 2004). The theory states that two or more integrating time series that are cointegrated have an error correction component. Z represents the portion of x_t not attributable to y. Z will capture any shock to either x and y and the error correction relationship by capturing the degree to which x and y are out equilibrium. If x and y are co integrated then the relationship between the two would adjust accordingly.

The Cointegration Model

Where there is cointegration among the variables, the Error Correction Model (ECM) was used to correct for diequilibrium and reconcile the long run behavior. The model is stated as follows:

$$\Delta y_t = a_0 + a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + a_6X_6 + a_7ECM + e_t$$

Where y_t = Food Price Index

X_1 $to X_6$ = Vector of lagged food price index, interest rates and exogenous shock variables

i.e. fertilizer, labor, rainfall, temperature

Δ = difference operator

ECM (-1) = Error Correction Factor

e_t = stochastic error term assumed to be normally distributed with zero mean and constant variance

RESULTS & DISCUSSION

Description of the Exogenous Shock Variables, Interest rates and the Food Price Index

Figures 1 to 5 shows some descriptive statistics of the co movement between the variables included for the analysis. The movement relationship between temperature and food price index within the period investigated was shown in figure 1 with an existence of co-movement between temperature and food price index. A rise in temperature therefore brings about a corresponding increase in food price index and vice versa. Figure 2 shows that there were variations between the movement of rainfall and food price index, with rainfall and food price index being at their peaks in 2006 and 2008 respectively. Both rainfall and the food price index rose in 2007 and 2008 with no co-movement between them. Figure 3 shows the movement relationship between fertilizer and food price index. The quantity of fertilizer appears relatively constant with very little differences in the quantities available monthly. In addition, there was a sharp growth in the food price index between 2002 and 2003 while the quantity of fertilizer was lowest in 2003. There appears to be no co movement between the two variables, but both variables had an upward trend in 2008. Figure 4 shows variations in the movement of the amount of labor available for agriculture and the food price index. The food price index rose between 2002 and 2003 while the amount of labor was relatively constant over this period. There was a sharp drop in the amount of labor available between 2005 and 2006 while the food price index was relatively constant over the same period. The amount of labor available was however lowest in 2006. The movement relationship between interest rate and food price index is shown in figure 5. The figure shows that there were co-movements between the food price index and interest rate most especially between 1996 and 2008. Both variables were at their minimum and peak levels in 1998 and 2008 respectively.

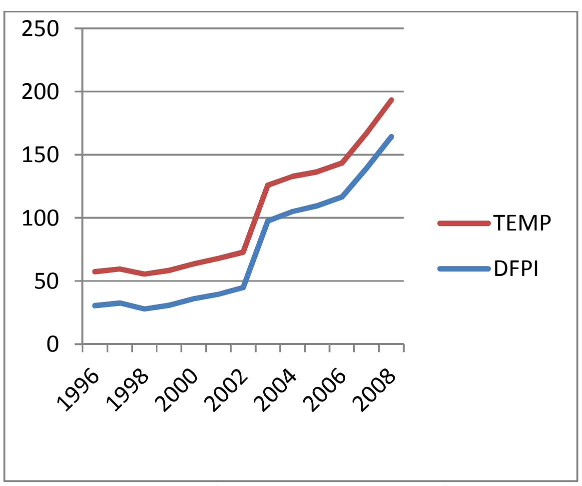

FIGURE 1: Trend of Temperature and the food price index

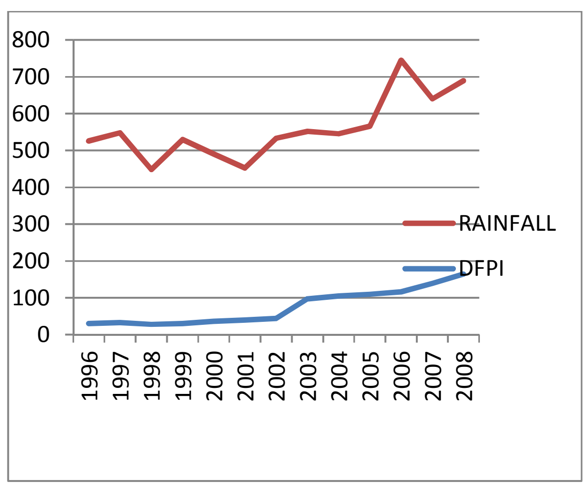

FIGURE 2: Trend of the food price index and rainfall

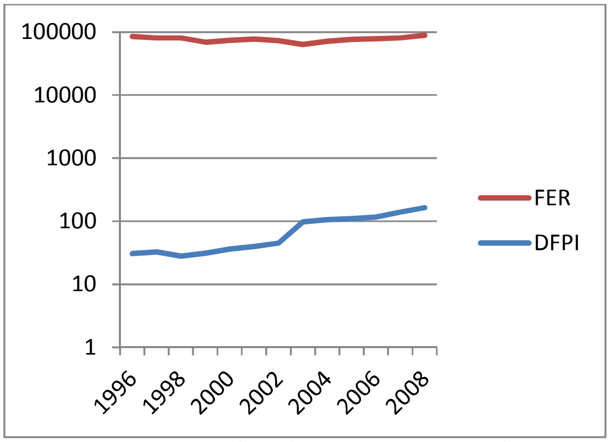

FIGURE 3: Trend of the food price index and fertilizer

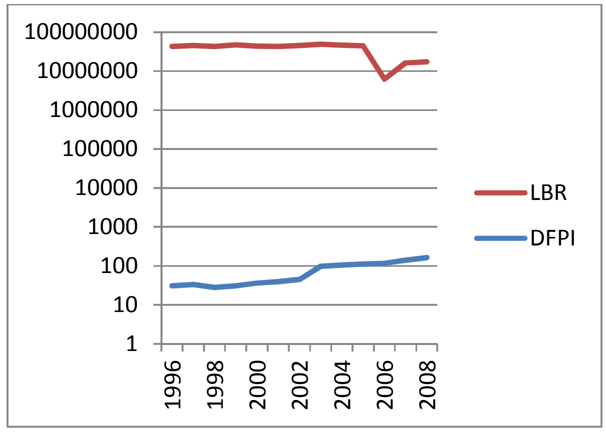

FIGURE 4: Trend of the food price index and labor

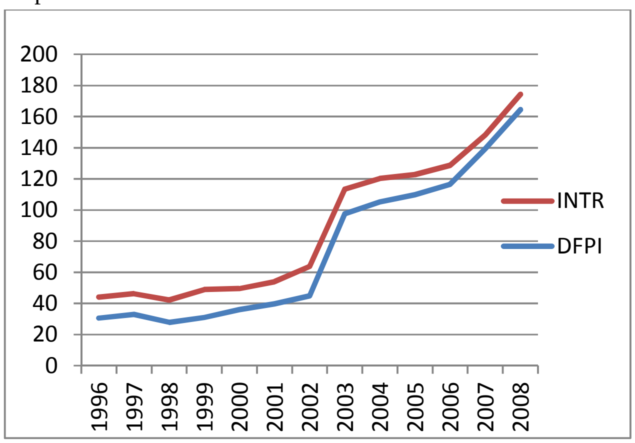

FIGURE 5: Trend of the food price index and interest rates

The Relationship between Exogenous Shock Variables and Interest rates and the Food Price Index

In order to determine the relationship between the exogenous shock variables and the food price index, an Error Correction Model was used. The first step was to determine whether the set of variables at the present level were stationary or not using the unit root test. Table 1 shows the result of the unit root test. By comparing the absolute values of the computed statistics with the critical values at 5 percent, all the variables were found to be stationary at first difference.

TABLE 1: Result of stationarity test

Variable	Level	1st difference	Unit root
FPI	-0.2325	-5.5205	1(1)
Fertilizer	-0.7093	-5.1070	1(1)
Interest rate	-1.1229	-5.11072	1(1)
Labor	-1.7471	-6.1931	1(1)
Rainfall	-1.7601	-5.8197	1(1)
Temperature	0.3185	-3.8054	1(1)

TABLE 2: Result of Cointegration test

Hpothesize no of CE	Eigen value	Trace statistics	0.05 critical value
None**	0.3829	242.7239	156.00
At most 1**	0.3491	168.3815	124.24
At most 2*	0.2132	102.2422	94.15
At most 3	0.1748	65.3151	68.52
At most 4	0.0973	35.7253	47.21
At most 5	0.0673	19.9511	29.68

*(**) denotes rejection of the hypothesis at 5%(1%) significance level

L.R. test indicates 3 cointegrating equation(s) at 5% significance level

In the next step, it was established whether cointegration exists among the variables or not. The Johansen cointegration test was used and the results are shown in table 2. The test rejected the null hypothesis of no cointegration at 5 percent level until the null hypothesis of r = 3 where the trace statistic 65.311 is greater than the critical value 68.52. This implies there are at least 3 cointegrating equations in the model. The existence of more than one cointegrating vector implies that the sytem under examination is stationary in more than one direction. The Johansen test suggests that there could be a long run steady state relationship among the food price index and interest rate and the exogenous shock variables. Table 3 shows the regression result of the Error correction Model for the food price index and the shock variables and interest rate. The regression result is given as follows:

$FPI = 0.005290 + 0.140661FPI_{(-1)} – 2.208469F – 0.483606I – 0.059665L – 0.010929R – 0.029068T$

Where FPI(-1) is the lagged monthly food price index, F is the quantity of fertilizer available to farmers, I is the monthly interest rate, L is the monthly amount of labor available for agriculture, R is the monthly mean rainfall and T is the mean monthly temperature. The result shows that the included variables explained about 71 percent of the variations in the food price index. The computed F-statistic is 39.3 and it is statistically significant at 1 percent Results of the analysis shows that all the production shocks considered including the interest rate had inverse effects on the monthly food price index even though the climatic shock variables were not significant. Raising the monthly interest rate by 0.48 units and increasing the quantity of fertilizer and the amount of labor by 2.01 and 0.06 units respectively would lead to a unit decrease in the monthly food price index. The price index of the previous month also had a positive effect of 0.14 units on the current month’s price index. The negative coefficient of the rainfall variable is in line with apriori expectation. Ayinde (2010) shows that rainfall has a positive impact on agricultural output, that is, increase or decrease in rainfall causes an increase or decrease in agricultural output. Short term fluctuations linked to variations in national yields are influenced by climate among other factors (Thomas and Metz, 1998). Felix *et al*, (2012) reveals that rainfall volatility has a negative impact on agriculture as it reduces output and household income. The non significance of the climatic variables can be attributed to the monthly data used as rainfall is seasonal in Nigeria. The non significance of the temperature variable goes in line with Ayinde (2010) which showed that there was no linkage between temperature and agricultural output. The food price index of the previous month had a positive relationship with the current month’s food price index. This reveals that high food prices in the previous month would also contribute significantly to high food prices in the present month. Changes in the food price index show the extent of food inflation in an economy. High food prices signify high inflation rates which causes consumers to cut back on their spending power or reduce their purchase capacity (Oner, 2012) Government policies such raising the monetary policy rates are used to reduce such high inflations directly.

The interest rate variable had a significant negative relationship with food price index. This reveals that high interest rates reduce or lead to lower food prices. This explains why governments make policies to raise their interest rates when food prices are high. Real interest rates are an important influence on real food prices (Frankel, 2006). When interest rates are high money flows out of the economy and vice versa. High interest rates raise the cost of holding inventories, lower demand for inventories and contribute to total lower demand of commodities (Frankel and Rose, 2009), thus forcing high (food) prices to drop. The quantity of labor available for agriculture also had an inverse relationship with the food price index which was statistically significant. This indicates that the higher the quantity of labor available for agriculture the lower the price of food. External shocks to agriculture such as crop failure and other weather related shocks are major factors which determine the supply of labor to agriculture (Mathenge and Tshirley, 2010). Mock et al, 2003 reveals that variations in labor supply and their productivity have led to variations in food production, loss of family income and decline in food consumption among rural household. The quantity of fertilizer available to agriculture had significant negative relationship with the food price index. This reveals that the higher the quantity of fertilizer available to farmers the lower the food price index. Improvements in agricultural technology save labor, increase agricultural productivity, reduce price and promote industrialization (Huffman *et al*, 2007). Controlling for exogenous weather risks, fertilizers are effective in driving crop yield improvements which support the continuously growing population. Almost half of the people on earth are currently fed as a result of synthetic nitrogen fertilizer use (Erisman *et al*., 2008). The statisitical significance of the error correction term implies that the variables in the food price index model have strong tendencies to adjust to their disequilibrium by moving toward the trend values of their counterparts.

TABLE 3: Regression result of the Error Correction Model

Variable	Coefficient	Std. error	T.stat	Prob.
C	0.005290***	0.001814	2.916551	0.0041
FPI(-1)	0.140661***	0.047533	2.959224	0.0036
Fertilizer	-2.208469***	0.164860	-13.39600	0.0000
Interest	-0.483606***	0.079804	-6.059934	0.0000
Labor	-0.059665***	0.014942	-3.992993	0.0001
Rainfall	-0.010929	0.108506	-0.100719	0.9199
Temperature	-0.029068	0.645081	-0.045060	0.9641
ECM	-0.032580**	0.014267	-2.283665	0.0239

R^2 = 0.71,** = significant at 5%, *** = significant at 1%

CONCLUSION & RECOMMENDATIONS

The food price index in Nigeria appears to be inversely affected by exogenous production shocks and interest rate. The rainfall and temperature variables though not significant also had inverse effects. In regulating food price and controlling inflation, governments often make policies to tighten their monetary policies and raise their interest rates. However, according to FAO (2011), food price volatility may increase because of stronger links between agriculture and energy markets as well as increased frequency of weather shocks. Higher frequencies of extreme weather events would lead higher frequencies of production shocks which will tend to increase fluctuations in food prices. Productivity enhancing investments in agriculture have strong poverty reducing effects (Warr, 2011). For policy implementation, this paper therefore recommends that monetary policies should be complemented with policies that reduce the effects of shocks on agriculture and increase output to reduce price fluctuations.Increasing the quantity of fertilizer available to farmers would lead to higher productivity and lower food prices. The Nigerian government should intensify efforts to improve the fertilizer subsidy program to prevent leakages and encourage farmers to utilize the benefits. The development and acquisition of other new technologies in agriculture should also be encouraged. In adverse weather conditions the frequency of negative shocks like pests and diseases, droughts and floods increase destroying crops. Farmers tend to leave farm work to engage in off farm work to reduce effects of such negative risks on their portfolio thereby reducing the amount of labor available for agriculture thus reducing productivity. There should therefore be increased awareness on the effects of climate change and new adaptation methods should be developed and disseminated to help farmers mitigate the effects of climate change and other potential shocks associated with it. Weather forecasts should also be made to help farmers prepare before hand for adverse weather conditions.

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