THE EFFECT OF EXCHANGE RATE VOLATILITY ON AGRICULTURAL EXPORTS IN NIGERIA: AN AUTOREGRESSIVE DISTRIBUTED LAG (ARDL) BOUNDS TEST APPROACH

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Abstract

There have been fluctuations in the exchange rate of Naira to other major world currencies especially the US Dollar over time. The implication of this on agricultural exports is unknown. This study determined the effect of exchange rate volatility on Nigeria’s agricultural export performance using annual data from 1980-2015. The Generalized Autoregressive Conditional Heteroscedasticity (GARCH-1,1) model was used to generate the exchange rate volatility series which was subsequently incorporated into the Autoregressive Distributed Lag (ARDL) Model for determining factors affecting agricultural exports (cocoa and rubber). The Bounds Test revealed long-run relationship among variables. The results indicated that exchange rate volatility did not significantly affect exports both in the short-run and the long-run. This may be partially attributed to the inelastic nature of agricultural commodities’ supply particularly in the short run. It was also revealed that there was a positive and significant relationship between exchange rate, inflation, GDP, domestic prices, world prices and agricultural export. The study recommended that fiscal and monetary policies such as lower interest rate and import restriction on certain agricultural products should be adopted by the relevant authorities alongside other measures which may improve local production to meet both international and local demands, thereby, improving agricultural export and raising foreign exchange earnings which may translate to sustainable economic growth and lead the country out of recession.

Keywords: Exchange rate, volatility, export, agriculture.

Introduction

Nigeria’s economy is the 21st in the world based on the nominal Gross Domestic Product (GDP) value of $405.1 Billion as at 2016 and the 20th largest based on purchasing power parity (Trading Economics, 2018). It is the most populous in Africa and seventh in the world with a projected population of about 188 million for 2017. According to Ake (1996), agriculture used to be the principal foreign exchange earner of Nigeria and the country was self-sufficient in food production in the 1960s and early 1970s and a major employer of the Nigerian working population. The proportion of the GDP attributed to agriculture as at the fourth quarter of 2016 was 24 percent (NBS, 2017). The sector recorded an annual growth rate of about 3.5 percent (Nigeria Data Fora, 2016) and now employs about 30 percent of the total labour force (World Bank, 2011).

GDP annual growth rate in Nigeria averaged 3.95 percent from 1982 until 2017, reaching an all-time high of 19.17 percent in the fourth quarter of 2004 and a record low of -7.81 percent in the fourth quarter of 1983 (Anonymous, 2017). The Nigerian economy shrank by 0.5 percent year-on-year in the first quarter of 2017, following an upwardly revised 1.7 percent contraction in the previous period. Over the years, Nigeria has pursued the objective of accelerating economic growth and development with a view to moving the economy to a more desirable state. In addition to the development of the
agricultural sector which has the potential to generate foreign exchange earnings and improve the
economy, the exchange rate is one of the most widely discussed issues.

Between 1970 and 1974, agricultural exports as a percentage of total exports fell from about 43 percent
to slightly over 7 percent. From the mid-1970s to the mid-1980s, the average annual growth rate of
agricultural export declined by 17 percent. The percentage of agricultural export relative to the total
export value is still low in the country not minding the plausible Heckscher-Ohlin theory of international
trade which identified resource endowment as a factor that encourage comparative cost advantage.
Abolagba et al., (2010) emphasized the fact that Nigeria has lost its role as one of the world’s leading
exporters of agricultural commodities. In addition, the country is currently suffering from a declining
as well as fluctuating income from its heavy dependence on oil exports and with the present situation
in the oil market, it has become necessary for the country to reconsider its agricultural export position.
According to FAOSTAT (2017), in 1961, Nigeria exported 197,000 tonnes of cocoa beans. This
increased to 304,000 tonnes in 1970 and declined steadily in the 1970s to 153,000 tonnes in 1980. The
figure however rose up to as much as 485,000 tonnes in 2006, but, subsequently declined to 248,000
tonnes in 2014. On the other hand, 58,000 tonnes of natural rubber was exported in 1961 and this
increased to 147,000 tonnes in 1990 and 151,000 tonnes in 2014.

Exchange rate is the price of one country’s currency expressed in terms of some other currencies.
According to Olisadebe (1995), the exchange rate is of great importance to a country such as Nigeria
which is a high import-dependent country aside its likely effect on exports and foreign exchange
earnings. Fluctuations in exchange rate may reduce the activities of potential investors in Nigeria
because it increases uncertainty over the returns of a given investment (Gerardo and Felipe, 2002).
Barkoulas et al., (2002) examined the impact of exchange rate fluctuations on the volume and variability
of trade flows and concluded that exchange rate volatility discourages expansion of the volume of trade
thereby reducing its benefits. Caballero and Corbo, (1989) proposed that if firm(s) hedge against
exchange rate rise, one could not expect to find a strong negative effect on trade. Hedging against risks
can be done via future or forward markets. Where forward market exists, the nature of uncertainty faced
by traders is transformed. A forward market represents a guaranteed forecast of exchange rate that will
prevail at the end of the contract period which a trader can take advantage of by the payment of small
margin in the forward market (Todani and Munyama, 2005).

In a study aimed at investigating the impact of exchange rate volatility on nonoil export flows in Nigeria,
Aliyu (2010) used quarterly data for period from 1986Q1 to 2006Q4 analyzed within the cointegration
and error correction framework. The results revealed that the naira exchange rate volatility decreased
nonoil exports. Adaramola (2016) examined the effect of real exchange rate volatility on export
volumes in Nigeria using quarterly data for the period of 1970Q1 to 2014Q4 and analyzed with Error
Correction Mechanism (ECM). The results showed that there was a long run relationship between real
exchange rate and its volatility and export volumes in the country. It was therefore concluded that real
exchange rate uncertainty had significant positive impact on the volume of trade of the Nigerian
economy during the study period.

commodities destabilizes future returns. In order to capture speculative activity the study employed a
speculation and a hedging ratio and the results showed that for most of the commodities, there were
positive influences of the speculation ratio on conditional volatility. Chi and Cheng (2016) examined
the short and long-run impacts of real income, bilateral exchange rate, and exchange rate volatility on
Australia’s maritime export volume to its major Asian trading partners using quarterly data for the
period of 2000Q1-2013Q2. It was found that exchange rate volatility had a significant long-run effect
in the majority of the cases examined, suggesting that exchange rate volatility was an important factor
affecting maritime export volume.
Numerous research works have shown that exchange rate has a direct impact on some macro-economic variables but few focused on the effect of its volatility on agricultural exports. This study therefore bridges this knowledge gap by assessing the effect of the exchange rate volatility on the agricultural export in Nigeria using cocoa and rubber as case studies. Specifically, the study established the trend in agricultural produce export, estimated the exchange volatility and determine its effect on agricultural export.

**Methodology**

**Data Source:** Annual data from 1980-2015 were sourced from the Central Bank of Nigeria Statistical Bulletin and FAOSTAT. Data were collected on cocoa and rubber exports quantities, agricultural domestic prices, world prices, inflation rate, real GDP and real exchange rate.

**Model Specification**

**Estimating Exchange Rate Volatility:** The exchange rate volatility series was estimated and incorporated into the ARDL equation as a variable in order to determine its significance or otherwise on cocoa and rubber export.

In order to measure volatility, the standard deviations were obtained as a measure of the degree to which exchange rate fluctuates in relation to its mean overtime. This have been used in some instances (Schnabl, 2007; Gadamecz and Mehrotra, 2013). This method assumes that exchange rate is normally distributed and does not reflect the distribution between an unpredictable component of the exchange rate process hence failing to capture the past information of the exchange rate. In the light of these, the Autoregressive Conditional Heteroskedasticity (ARCH) or GARCH has been widely applied to the studies on volatility. The exchange rate usually follows the GARCH process and captures past values of the exchange rate. Given that current exchange rate is given as:

\[
\ln RE_{t} = \alpha_{1} + \beta_{1} \ln RE_{t-1} + e_{t} \quad \ldots \ldots (1)
\]

Bollerslev (1986) extended Engle’s framework by developing a technique that allows the conditional variance to be an Autoregressive Moving Average (ARMA) process. Given that \( e_{t} = \sigma_{t} e_{t} \) and \( e_{t} \sim (0,1) \), the variance equation for the GARCH \((p,q)\) therefore, has the following form:

\[
\sigma_{t}^{2} = \omega + \sum_{j=1}^{q} \beta_{j} e_{t-j}^{2} + \sum_{i=1}^{p} \gamma_{i} \sigma_{t-i}^{2} \quad \ldots \ldots (2)
\]

Where \( p \geq 0, q > 0; \omega > 0, \beta_{j} \geq 0, \gamma_{i} \geq 0, j = 1, \ldots, q \) and \( i = 1, \ldots, p \) and \( \sum_{j=1}^{\max(p,q)} (\beta_{j} + \gamma_{j}) < 1 \)

Equation (2) is the GARCH \((p, q)\) model where \( p \) and \( q \) denote the lagged terms of the conditional variance and the squared error term, respectively. The ARCH effect is denoted by \( \sum_{j=1}^{q} \beta_{j} e_{t-j}^{2} \) and the GARCH effect \( \sum_{i=1}^{p} \gamma_{i} \sigma_{t-i}^{2} \).

**The ARDL model**

The model adopted for this study is stated as:

\[
AG = b_{0} + b_{1} RGDP_{t} + b_{2} REXR_{t} + b_{3} INFL_{t} + b_{4} AGP_{t} + b_{5} EXRV_{t} + b_{6} WP_{t} + e_{t} \quad \ldots \ldots (3)
\]

Due to the different order of integration of the series, the ARDL approach was adopted in analysing model as:
\[ \Delta \ln AG = \alpha + \mu \text{TREND} + \sum_{k=0}^{n_1} \theta_{n_1} \Delta \ln (\text{RGDP}_{t-n_1}) + \sum_{k=0}^{n_2} \theta_{n_2} \Delta \ln (\text{EXRV}_{t-n_2}) + \sum_{k=0}^{n_3} \theta_{n_3} \Delta \ln (\text{INFL}_{t-n_3}) + \sum_{k=0}^{n_4} \theta_{n_4} \Delta \ln (\text{AGDP}_{t-n_4}) + \sum_{k=0}^{n_5} \theta_{n_5} \Delta \ln (\text{EXR}_{t-n_5}) + \sum_{k=0}^{n_6} \theta_{n_6} \Delta \ln (\text{WP}_{t-n_6}) + \beta_1 \Delta \text{AG}_{t-1} + \beta_2 \Delta \text{RGDP}_{t-1} + \beta_3 \Delta \text{EXRV}_{t-1} + \beta_4 \Delta \text{INF}_{t-1} + \beta_5 \Delta \text{AGDP}_{t-1} + \beta_6 \Delta \text{EXR}_{t-1} + \beta_7 \Delta \text{WP}_{t-1} + \epsilon_t \]

Where:

AG - Agricultural export which are; cocoa bean and natural rubber quantity.
EXR= Real exchange rate, RGDP =Real gross domestic product, INFL= Inflation rate,
AGDP = Agricultural export domestic price, EXRV = Exchange rate volatility; WP = World market price
Where \( n_1, n_2, n_3, n_4, n_5, \) and \( n_6 \) represent optimal lag length.

**Results and Discussion**

**Descriptive Analysis:** Figures 1 and 2 showed the trend in the exchange rate volatility and agricultural exports (cocoa bean and natural rubber) between 1980 and 2015. From the graphs, it can be observed that the growth rate of agricultural exports has been fluctuating. It increased steadily between 1986 and 1989 and thereafter maintained a nearly constant pattern.

**Figure 1:** Trend of exchange rate volatility and cocoa export quantity: 1980-2015

**Figure 2:** Trend of exchange rate volatility and rubber export quantity: 1980-2015
Stationarity Test

Table 1 showed the result of the stationarity test using Augmented Dickey-Fuller (ADF) procedure. It was revealed that LCOQ (log of cocoa quantity exported), INFL (inflation rate) and ERV (Exchange Rate Volatility) were stationary at their level. On the other hand, EXCH (log of Exchange rate), LORQ (log of rubber exported), LOCP (log of cocoa price), LORP (log of rubber price), World Prices of Rubber and Cocoa (WP) and LRGDP (log of real GDP) were stationary at their first difference. Due to the fact that the series were integrated of different orders, the Engle-Granger single equation co-integration technique became inappropriate to detect the presence of long-run relationship among the variables as it is premised on stationary series or I(1) series alone rather than a mixture of both as in this case. ARDL Bound Test was therefore employed.

ARDL Co-integration Bounds Test Result:

The ARDL Bounds Test was conducted for the two equations estimated and the results are presented in Table 2. It was revealed that there were long-run relationships among the variables as the computed F-value was above the upper bounds.

Short-run Estimation Results

Model I (Cocoa Export):

The ARDL short-run model for the cocoa export function is presented in Table 3. The results showed that one year lag of cocoa export (LAG(-1)), the domestic price of cocoa, exchange rate, world price of cocoa (WPC) and real GDP were the significant factors affecting the quantity of cocoa exported over the years. Expectedly, all the significant variables except domestic price of cocoa (AGDP) came up with positive values implying that increases in these variables increase cocoa export ceteris paribus. The AGDP coefficient value of -0.12 implied that 1 percent increase in domestic price of cocoa led to a 0.12 percent reduction in cocoa export. Also, one percent increase in exchange rate caused 0.22 percent increase in cocoa export. The low coefficients may be due to the relatively inelastic nature of the export supply system in agriculture. Same interpretation applies for other coefficients. The negative sign of the domestic price may be interpreted to mean that the international market for the export of cocoa and the local market were competing for the produce. If the local market price is high, most dealers may be favourably disposed to selling their produce in the local market instead of exporting especially when the cost and the risks involved in the export is considered. Interestingly, the variable which was of most importance for the study i.e exchange rate volatility series did not significantly affect cocoa export. This may be partially due to the inelastic nature of most agricultural supply especially tree crop produce whose gestation period is longer relative to arable crops. The error correction variable (Coint Eq(-1)) showed that the system will adjust back to long-run equilibrium path due to any disequilibrium as a result of an external shock into the system at the rate of 97.6 percent per annum, that is 97.6 percent of the previous year disequilibrium is corrected in the current year.

Model II (Natural Rubber):

In the natural rubber equation (Model II), lagged quantity exported, domestic price and its one year lag, world price of rubber, inflation and real GDP significantly affected rubber export. Contrary to the cocoa export function, there was a direct relationship between domestic price and quantity of natural rubber exported. Surprisingly, inflation had positive effect on rubber export. The inflation coefficient value of 0.014 means that 1 percent increase in inflation rate led to a 0.014 percent increase in rubber export. The error correction coefficient value of -0.853 implied that 85.3 percent of the previous year disequilibrium in the system is corrected in the current years. The R-squared value of 0.89 implied that the variables were able to explain 89 percent of the total variations in rubber export.
The Long Run Model Estimation Results:

Model I (Cocoa Export): The long-run model results showed that the domestic price of cocoa, its world price, exchange rate and real GDP were positive and significantly affected cocoa export in the long run. The significance and the positive sign of GDP underscored the importance of economic growth in enhancing the performance of the agricultural sector. The trend coefficient of the cocoa model’s significant value of -2.815 implied that there was a nearly continuous autonomous decrease in the quantity of cocoa exported from the country over time *ceteris paribus*.

Model II (Rubber Export): The long run model showed that the domestic price of natural rubber, world price and exchange rate significantly affected rubber export. The positive value of the trend variable showed that there has been nearly a continuous increase in the quantity of exported natural rubber over the years, *ceteris paribus*.

Post-Estimation Diagnoses Results

The diagnosis results reported in Table 5 showed that the estimated models satisfied all the assumptions of the Classical Linear Regression Model, hence, the estimates obtained were reliable, consistent, efficient and suitable for forecasting and predictions. The result indicated that the error series of the two models estimated had constant variance, as the null hypothesis of homoscedasticity could not be rejected at 5% significance level. The error series generated from these estimated models also satisfied the normality assumption as confirmed by the Jarque-Berra test. Breusch-Godfrey LM test was adopted to determine if the error series auto-correlated. The test’s null hypothesis was that no autocorrelation existed, and, the null hypothesis could not be rejected at 5% level of significance for the two models estimated. In order to determine if the models were well specified, Ramsey Regression Specification Error Test (Ramsey RESET) also confirmed the linearity of the model at 5% level of significance.

Conclusion and Recommendations

From the results of the various analyses carried out in the study, it was revealed that domestic and world prices of the commodities (cocoa and rubber), exchange rate and real GDP were the significant factors affecting cocoa and rubber export. However, exchange rate volatility did not affect agricultural export neither in the short-run nor in the long-run. Furthermore, equilibrium in the export system is restored in less than two years in the event of any disequilibrium. It is recommended that domestic production should be encouraged through a guarantee minimum price scheme which will likely encourage proper planning and investment. Policies which are capable of enhancing economic growth should be implemented (as economic growth encourages export) while viable export policy is put in place.

References


Table 1: Unit root test

*Note: ***, ***, * denotes statistical significance at 1%, 5% and 10% level, respectively.*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Level</th>
<th>First difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With Intercept</td>
<td>With Trend&amp; Intercept</td>
</tr>
<tr>
<td>EXCH</td>
<td>-1.846</td>
<td>-0.945</td>
</tr>
<tr>
<td>LCOP</td>
<td>-0.984</td>
<td>-2.989</td>
</tr>
<tr>
<td>WPC</td>
<td>-1.527</td>
<td>-1.529</td>
</tr>
<tr>
<td>WPR</td>
<td>-0.919</td>
<td>-1.391</td>
</tr>
<tr>
<td>LCOQ</td>
<td>-3.797***</td>
<td>-5.422***</td>
</tr>
<tr>
<td>LORP</td>
<td>-0.934</td>
<td>-1.432</td>
</tr>
<tr>
<td>LRGDP</td>
<td>-1.846</td>
<td>-0.945</td>
</tr>
<tr>
<td>LORQ</td>
<td>-2,184</td>
<td>-2.287</td>
</tr>
<tr>
<td>ERV</td>
<td>-3.305**</td>
<td>-3.336*</td>
</tr>
</tbody>
</table>

Table 2: ARDL bound testing

Critical Value for model I (Cocoa export model): F statistic: 6.658
Critical Value for model II (Rubber export model): F statistic: 5.845

<table>
<thead>
<tr>
<th>Significance</th>
<th>I(0)bounds</th>
<th>I(1)bounds</th>
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</thead>
<tbody>
<tr>
<td>10%</td>
<td>3.03</td>
<td>4.06</td>
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<tr>
<td>5%</td>
<td>3.47</td>
<td>4.57</td>
</tr>
<tr>
<td>2.5%</td>
<td>3.89</td>
<td>5.07</td>
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<tr>
<td>1%</td>
<td>4.4</td>
<td>5.72</td>
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</table>
### Table 3: Short-run estimation results (The dynamic model)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model I (Cocoa Bean)</th>
<th>Coefficient</th>
<th>t-statistic</th>
<th>Model II (Natural Rubber)</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(LAG(-1))</td>
<td>0.8412**</td>
<td>2.251</td>
<td></td>
<td>0.2231**</td>
<td>2.511</td>
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<tr>
<td>D(LAG(-2))</td>
<td>0.0913</td>
<td>1.321</td>
<td></td>
<td>0.6192</td>
<td>1.2309</td>
<td></td>
</tr>
<tr>
<td>D(AGDP)</td>
<td>-0.1236*</td>
<td>-1.796</td>
<td></td>
<td>0.0933***</td>
<td>2.424</td>
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<td>D(AGDP(-1))</td>
<td>-0.0391***</td>
<td>-2.024</td>
<td></td>
<td>0.4512*</td>
<td>1.743</td>
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<tr>
<td>D(AGDP(-2))</td>
<td>0.0418</td>
<td>0.345</td>
<td></td>
<td>0.5729</td>
<td>1.087</td>
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<tr>
<td>D(WP)</td>
<td>0.023**</td>
<td>2.432</td>
<td></td>
<td>0.0191**</td>
<td>2.321</td>
<td></td>
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<tr>
<td>D(WP(-1))</td>
<td>0.349**</td>
<td>2.013</td>
<td></td>
<td>0.0287**</td>
<td>1.973</td>
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<tr>
<td>D(INFL)</td>
<td>0.0019</td>
<td>0.808</td>
<td></td>
<td>0.014***</td>
<td>-3.092</td>
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<td>D(INFL(-1))</td>
<td>0.0824</td>
<td>0.835</td>
<td></td>
<td>0.0912</td>
<td>1.439</td>
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<tr>
<td>D(EXCR)</td>
<td>0.2213**</td>
<td>2.132</td>
<td></td>
<td>-0.1664</td>
<td>-0.753</td>
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<tr>
<td>D(EXCR(-1))</td>
<td>0.0347*</td>
<td>1.0812</td>
<td></td>
<td>0.452</td>
<td>0.973</td>
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<tr>
<td>D(LRGDP)</td>
<td>1.4242***</td>
<td>2.970</td>
<td></td>
<td>1.0761**</td>
<td>2.429</td>
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<tr>
<td>D(ERV)</td>
<td>-0.7001</td>
<td>-0.319</td>
<td></td>
<td>-0.5288</td>
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<tr>
<td>@TREND</td>
<td>-0.1066**</td>
<td>-2.520</td>
<td></td>
<td>-1.3181**</td>
<td>2.379</td>
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<tr>
<td>CointEq(-1)</td>
<td>-0.9761***</td>
<td>-2.6419</td>
<td></td>
<td>-0.8530***</td>
<td>-3.387</td>
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<tr>
<td>R²</td>
<td>0.5874</td>
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<tr>
<td>Adj. R²</td>
<td>0.4764</td>
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<td>0.890</td>
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<tr>
<td>F-stats</td>
<td>5.289 ***</td>
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<td>31.61 ***</td>
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<tr>
<td>D.W</td>
<td>1.993</td>
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<td>2.410</td>
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*sig at 10%, **sig at 5%, ***indicates sig at 1%

### Table 4: Long-run model (The static model)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Cocoa Bean</th>
<th>Coefficient</th>
<th>t-statistic</th>
<th>Natural Rubber</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAGDP</td>
<td>0.0934**</td>
<td>1.974</td>
<td></td>
<td>0.2409**</td>
<td>1.830</td>
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<td>WP</td>
<td>0.0271**</td>
<td>2.102</td>
<td></td>
<td>0.0312**</td>
<td>2.302</td>
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<tr>
<td>INFL</td>
<td>0.0014</td>
<td>0.817</td>
<td></td>
<td>0.0113</td>
<td>-1.543</td>
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<tr>
<td>EXCR</td>
<td>0.1665**</td>
<td>2.166</td>
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<td>-0.1673**</td>
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<td>LRGDP</td>
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<td>-0.5288</td>
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<td>1.1074</td>
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<td>C</td>
<td>-21.3182**</td>
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<td>54.5419**</td>
<td>1.999</td>
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<td>@Trend</td>
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<td>-2.815</td>
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<td>0.1575</td>
<td>1.703</td>
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</tbody>
</table>

*sig at 10%, **sig at 5%, ***indicates sig at 1%

### Table 5: Diagnostic test

<table>
<thead>
<tr>
<th>Diagnostics tests</th>
<th>Cocoa bean F-stats.(Prob.)</th>
<th>Natural rubber F-stats.(Prob.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jarque-Bera</td>
<td>0.796 (0.9610)</td>
<td>0.500 (0.7786)</td>
</tr>
<tr>
<td>Breusch-Godfrey test</td>
<td>0.140 (0.8701)</td>
<td>2.035 (0.1546)</td>
</tr>
<tr>
<td>ARCH test</td>
<td>1.519 (0.2271)</td>
<td>0.007 (0.7990)</td>
</tr>
<tr>
<td>Ramsey-Reset test</td>
<td>0.177 (0.6780)</td>
<td>2.331 (0.1404)</td>
</tr>
</tbody>
</table>