

## **THE J-CURVE HYPOTHESIS AND THE NIGERIAN OIL SECTOR: THE ARDL BOUNDS TESTING APPROACH**

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### **Abstract**

We have in this paper attempted to shed empirical evidence on unresolved issues regarding the J-curve trade effect of real exchange rate depreciation with special focus on the Nigerian oil sector using the Bounds testing approach on time series data that spans over a 40-year period. Despite the well known argument that a real depreciation initially deteriorates the trade balance but through time, the trade balance improves such that the time path associated with the response of the trade balance generates a tilted J-curve, the present empirical evidence could not establish the classic J-curve exchange rate effect on the trade balance of the Nigerian oil sector. Indeed, the trade balance contemporaneously gains improvement in the short-run making it imperative for us to tag such an observation, the “inverted’ J-curve, a behaviour that took for granted, the predicted J-curve effect, and hence it is concluded that the standard J-curve hypothesis cannot be validated for the Nigerian oil sector. That Nigerian exports and imports are frequently denominated in foreign currency; the US dollar is a possible explanation for the contradicted J-curve effect.

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**Keywords:** J-curve, bounds testing, Nigeria, oil sector, co-integration

### **Introduction**

Nigeria as a country is Africa’s largest oil-producing nation and the eighth largest in the world, with an output of 2.4 million barrels per day (World Bank, 2010). In the 1970s, the finance engine in Nigeria was massive oil revenue. In fact, the growth rate of GDP in Nigeria depends largely on developments in the oil sector. So to speak, 95% of all exports are made up of oil and gas. As a result, the inflow of export receipts is highly dependent on energy

prices and the performance of one main sector, the oil sector. However, despite its enormous oil resources, Nigeria is still far from being “oil-rich” (World Bank, 2010). The Nigerian economy is extremely vulnerable to international oil price shocks. The recent collapse of oil prices in the world market further triggered a series of developments in the country. Budget deficits became escalated. Indeed, the intensification of economic crises led to a drop in the growth rate of real GDP in 1999 as it grew at an average rate of 2.6% from 1992 to 1999 (IMF, 2010). This is far below a rate that can propel the overall economy into sustainable growth. Indeed, the 6.8% growth rate in real GDP recorded in 2008 from 6.2% in 2007 (Table 1.1) has been attributed to non-oil export. While GDP in absolute terms stood at an estimated US\$ 179.7 billion in 2008, GDP per capita was US\$ 1228.3.

As the second largest economy in sub-Saharan Africa, Nigeria is one of the world’s poorest countries, with more than 70% of its population (that is, over 90 million people) living on less than a dollar a day. The country overtook Iran as the second biggest oil exporter with oil export of 2,464 million barrels per day (bpd) in 2010, representing a significant increase of 14.1% from 2,160 million bpd in 2009 (OPEC, 2010). Iran now occupies the third position with 2,248 million bpd and Saudi Arabia maintains the lead with 6,644 million bpd (OPEC, 2011). These statistics presented by OPEC have become a source of worry to some pessimists, who believed Nigeria could not have grown enormously in oil export owing to unrests in the oil producing region. Nigeria suffers from an undiversified export basket and a somewhat inflexible import basket. Imports consist of a wide range of goods including manufactured and capital goods. The inflexibility of the import basket stems from the fact that Nigeria lacks a manufacturing sector and thus has to import almost all of its non-agricultural consumables. This is in addition to the fact that the oil producing sector requires a steady inflow of capital goods.

Exchange rate experts have in the past posited that depreciation in the real exchange rate bring about competitive advantage in international trade. This is because, when a country devalues its currency, its entire domestic exportable become cheaper relative to its trading partners and this induce increases in the quantity demanded of such exports. Thus, exchange rate depreciation as a policy prescription is mainly aimed at improving the international trade balance. As it were, exchange rate as a policy variable plays a vital role in the model of an open economy. Using Nigeria as a case study, a country with population of about 150 million people, Nigeria has the largest domestic market in sub-Saharan Africa. The domestic market is large and potentially attractive to domestic and foreign investors, as attested to by portfolio investment inflow of over N1.2 billion (Central Bank of Nigeria, 2010). Thus, the country

with an enormous base of crude oil export is often dominated by international activities like other economies of the world.

It is against this backdrop that we attempt to examine the possibility of the classic J-curve exchange rate effect on the trade balance of the Nigerian oil sector. In view of the research objective, we hypothesized that the relationship between the trade balance of the Nigerian oil sector and the depreciation of the real effective exchange rate is such that portrays the classic J-curve. The J-curve hypothesis suggests a specific pattern for the response of trade balance to real exchange rate changes. The rest of the paper is structured as follows. Section 2 discusses the oil export profile and the Nigerian trade balance. The theoretical framework, empirical model and methodology are found in section 3. Section 4 is devoted data issues, description, measurement and sources. Section 5 analyses the empirical results. Section 6 provides a synthesis of the empirical results obtained in the present study with other results obtained from previous studies for different countries. Section 7 concludes.

### **The Oil Export Profile And The Nigerian Trade Balance**

Nigeria's trade relations spin around the oil and natural gas sector. Prior to oil production, which surged after the 1970s, agricultural production was the largest export sector for Nigeria. After the country became a largely oil-intensive economy, the agricultural sector took a back seat. Nigeria is the largest United State (US) trading partner in sub-Saharan Africa, based mainly on the high level of petroleum imports from Nigeria. In 2006, total bilateral trade was valued at \$30.8 billion, a 19% increase over 2005 (WTO, 2008). While the country mainly imports machinery, wheat and motor vehicles from the US, she exports oil and rubber products to same. Nigerian exports to the United State<sup>124</sup> under the African Growth and Opportunity Act (AGOA<sup>2</sup>), were valued at US\$25.8 billion in 2006, a 15% increase over 2005. This has been attributed to an increase in oil exports (CBN, 2006). The United States has been the largest foreign investor in the Nigerian oil industry. In 2005, the stock of US foreign direct investment in Nigeria was US\$874 million. This falls short of the US\$2.0 billion recorded in 2004. Inflows of foreign direct investments became stable at 2.6% of GDP (World Bank, 2010). The stock of US investment is mostly in the energy

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<sup>124</sup>In June 2006, the United States met with Nigeria under the existing Trade and Investment Framework Agreement (TIFA) to collaborate on investment issues and to develop a strategy for Nigeria to diversify its export base, especially in manufactured goods. Under the TIFA, the United States and Nigeria pledged to work together on critical issues such as World Trade Organization (WTO), Doha Development (DD), Intellectual Property Rights (IPR) and Trade Capacity Building (TCB). Non-oil AGOA trade such as leather products, cassava, yams, beans, and wood products totaled US\$1.4 million in 2006

sector. Obviously, these investments mostly benefit the oil sector. Indeed, the main destination of oil exports from Nigeria in 2007 was the US, accounting for 47.1% of total exports, followed by Spain (7.0%), Brazil (6.9%), and Ivory Cost (2.6%). Nigeria is currently the 50<sup>th</sup> largest export market for US goods (IMF, 2008)

The US goods trade deficit with Nigeria was US\$25.7 billion in 2006, an increase of US\$3 billion from US\$22.6 billion in 2005. Still in 2006, the US goods exports to Nigeria were US\$2.2 billion, an increase of 38% from the previous year. Nigeria reported trade surplus equivalent to 5.93 billion US dollars in the fourth quarter of 2010. Exports of commodities (oil and natural gas) are the main factor behind Nigeria's growth and they both account for more than 95% of total exports. The country's exports rose by 23.5% in 2008 to an estimated US\$ 76.3 billion from US\$ 61.8 billion in 2007. This has been attributed to higher prices of oil exports during the first half of 2008 (CBN, 2010). US imports from Nigeria were US\$27.9 billion in 2006, an increase of 15% over the 2005. In 2007, Nigerian importation from the US accounted for 8.1% of total imports (World Bank, 2008).

**Table1.1:** Five-Year Average Trend in Trade Flows in Nigeria, (1981– 2006)

Indicator	1971-1975	1976-1980	1981-1985	1986-1990	1991-1995	1996-2000	2001-2007
Exports (US\$ Million)	4939.9	15348.0	13124.5	8072.2	17384.7	36560.7	35280.9
Share of Non-oil Exports in Total Exports (%)	15.2	6.9	3.3	6.0	2.6	2.3	2.7
Share of Oil Exports in Total Exports (%)	84.8	93.1	96.7	94.0	97.4	97.7	97.3
Exports-GDP Ratio (%)	23.1	24.3	16.4	25.8	77.1	39.5	41.7
Exports, Growth Rate (%)	55.7	30.7	-10.6	16.9	65.3	-4.2	23.0
Imports (US\$ Million)	2743.7	12386.0	13327.4	4399.4	13351.5	24312.7	22820.2
Imports-GDP Ratio (%)	13.7	20.3	16.7	14.1	59.6	25.7	26.4
Import Growth Rate (%)	46.9	23.7	-12.1	3.7	80.8	-9.6	26.5
Trade Balance (US\$ Million)	2196.3	2962.0	-202.9	3672.8	4033.2	12248.0	12460.8

Source: NBS (2006), CBN Statistical Bulletin, 2008

The major items of the imports include manufactured goods (US\$ 1.5 billion), chemicals (US\$ 1.1 billion), machinery and transport (US\$ 1.1 billion) and food and live animals (US\$ 291 million). US imports to Nigeria increased by 15.7% to an estimated US\$ 44.9 billion in 2008 from US\$ 38.8 billion in 2007, primarily as a result of higher imports of manufactured goods. A significant portion of US export revenues to Nigeria has been attributed to import tariffs (Egwakhide, 2005).

### Literature Review

The J-curve hypothesis has generated a series of empirical research that investigated the existence of J-curve trade effect of exchange rate depreciation in different countries. Some results are consistent with the J-curve trend while others depict non existence and rather effect other than the J-curve effect. Authors like McPheters and Stronge (1974),

Bahmani-Oskooee (1985), Himarios (1985), Krugman and Baldwin (1987), Carter and Pick (1989), Gupta-Kapoor and Ramakrishnan (1999), Koray and McMillin (1999) and Leonard and Stockman (2001), Singh (2002), Lal and Lowinger (2002), Akbostanci (2002), Hsing (2003), Hacker and Hatemi-J (2004), Narayan (2004) and Stucka (2004), have all find positive evidence in support of the J-curve effect. McPheters and Strone (1974) empirically ascertained that a lag of about two years prior to the US trade balance may perhaps improve subsequent to changes in price level. These indeed, support evidence of J-curve. On a re-examination of Miles (1979)'s data, Himarios (1985) found evidence of a J-curve. Bahmani-Oskooee (1985) investigated the J-curve phenomenon for Greece, India, Korea and Thailand and found evidence in favour of the J-curve effect for all the countries except for Thailand. In particular, it takes two quarters, four quarters and three for the trade balance of Greece, India and Korea to deteriorate after devaluation. For Thailand, the trade balance at the onset improves for five quarters subsequent to a devaluation policy and thereafter deteriorated. Krugman and Baldwin (1987) established empirical evidence of a J-curve in the US data. Carter and Pick (1989) found the J-curve on the US agricultural trade balance. The results exhibited deterioration in the trade balance that lasted for about 9 months following 10% depreciation in the US dollar.

Gupta-Kapoor and Ramakrishnan (1999) used the error correction methodology and the impulse response function to determine the J-curve effect in Japan using quarterly data from 1975:1 -1996:4. Their analysis showed the existence of the J-curve on the Japanese trade balance. On the basis of a structural VAR model and non-parametric methods, Koray and McMillin (1999) and Leonard and Stockman (2001) find positive evidence of J-curve effect. Koray and McMillin (1999) examined the response of real exchange rates and the trade balance to monetary policy shocks. They find that a negative monetary shock which was correlated with an appreciation of the real effective exchange rate, initially improves the trade balance. Subsequently, the trade balance deteriorated. This in essence renders credence to an inverted J-curve. Leonard and Stockman (2001)'s empirical evidence supports the existence of J-curve in the data but not its standard explanation. To be specific, Leonard and Stockman (2001) found that an increase in the current account is associated with a fall in GDP. This however, contradicts the standard theoretical explanation that in the long-run trade balance improves after depreciation through the increase in foreign demand.

Singh (2002) by using a trade balance model *ala* Rose (1991) and an error correction model finds that trade balance of India is sensitive to real exchange rate changes. Employing bilateral trade data to estimate the short and long-run effects of exchange rate changes on the

trade balance Czech Republic, Hungary and Poland against their trade with Germany, Hacker and Hatemi-J (2004) found that in all the three cases, there were some evidence of the J-curve effect after real depreciation of the currencies in question. Stucka (2004) found evidence of J-curve on trade balance for Croatia. His study employed a reduced form model to estimate the impact of a permanent shock on the merchandise trade balance. It was found that one-percent depreciation in the exchange rate improves the equilibrium trade balance between the range of 0.94%-1.3% and it took 2.5 years for equilibrium to be established. Same authors investigated the J-curve effect by replacing the real exchange rate with the nominal exchange rate and the relative German price index and found weak forms of the J-curve effect where the trade balance deteriorates and improves later after the shock but the process was not instantaneous as predicted by the conventional J-curve theory. Even when Narayan (2004) found no co-integrating relationship between the trade balance, real effective exchange rate, domestic and the foreign incomes over the study period for New Zealand, the New Zealand trade balance exhibited a J-curve prototype. Explicitly, preceding a real depreciation of the New Zealand dollar, the trade balance deteriorated for the first three years and improves thereafter.

However, in a series of empirical studies, Miles (1979), Haynes and Stone (1982), Rose and Yellen (1989), Rose (1990), Koch and Rosensweig (1990) and (1991), Felmingham (1998), Bahmani-Oskoe and Brooks (1999), Wilson and Kua (2000), Wilson and Tat (2001) and Bahmani-Oskoe *et al.* (2003) not only is the J-curve hypothesis rejected, but also, it is argued that there is no significant effect of the real exchange rate on the trade balance for both some of the developing countries and the developed countries including the US. Accordingly, Miles (1979) found that devaluations do not improve the trade balance but do improve the balance of payments. He particularly observed that devaluation results in a readjustment in investment portfolio which leads to an excess in the capital account. Himarios (1985) has nevertheless criticized Miles's (1979) results on the ground of being sensitive to units of measurements. Koch and Rosensweig (1990) obtained weaker J-curve effect whereas in theory, the conventional J-curve effect is strong. The empirical results of Bahmani-Oskoe and Brooks (1999) corroborated Rose and Yellen (1989) finding that the real exchange rate has no impact on the trade balance in the short run, but in the long-run, the real depreciation of the US dollar was found to have a favourable impact on the trade balance. Wilson and Kua (2000) found no significant impact of the Singapore's real exchange rate devaluation on the trade balance and as such the J-curve hypothesis was invalidated. Bahmani-Oskoe *et al.* (2003) employed disaggregated data to test the J-curve hypothesis

against India's trading partners. The empirical results of the study did not support the J-curve model in terms of short-run estimates but in the long-run, real depreciation of India's rupee had significant improvement effect on the trade balance.

Rather than the J-curve, a few other empirical studies have found shapes and curves other than the J-curve (or shape) effect in terms of the dynamic response of the trade balance. In their analysis of the J-curve effect, Bahmani-Oskooee and Malixi (1992) found in addition to the J-curve, the N-curve, the M-curve and the I-curve effects of the trade balance in relation to exchange rate depreciation. Backus, Kehoe and Kydland (1994) developed an international real business cycle model to explore the trade balance response to exchange rate devaluation. The authors found that the trade balance is counter cyclical and the cross correlation function of the trade balance and the terms of trade display an S shape. Utilizing a dynamic model where import expenditure is specified as a function of wealth, Roberts (1995) obtained an S-curve in the trade response to exchange rate depreciation. In their determination of adjustment in the trade balance of the US and Canada, Marwah and Klein (1996) found trade balance deteriorated initially to improve afterward. However, after several quarters, the trade balance deteriorated all over again. The overall time path was found to have depicted an S-curve for the US and Canada, an empirical result that was earlier found Backus et al. (1994). Bahmani-Oskooee and Brooks (1999) criticized Marwah and Klein (1996) on the ground that they utilized non-stationary data to derive their results. For the Turkish economy, Rose (1990) argued that real exchange rate has no effect on the trade balance over the study period. The empirical results of Brada, Kutan and Zhou (1997) reveals absence of long-run relationship between the trade balance, real exchange rate, domestic and foreign incomes in 1970's.

### **Theoretical Framework, Model And Methodology Framework**

The theoretical framework of the study has its root in the empirical works of Goldstein and Khan (1985) and Rose and Yellen (1989). The classical model for the J-curve theory explains the trade balance as a function of exchange rate, domestic income and foreign income. Theoretically, the J-Curve hypothesis suggests that the partial derivative  $\partial T_{j,t}^B / Q_{j,t}^R$  will be negative in the short-run and positive in the long-run. By theoretical expectations, the trade ratio is positively related to foreign income. Thus, an increase in foreign income increases demand for domestic goods thus foreign income is positively related to trade balance while domestic income exhibits a negative relationship with trade balance. Since domestic exports are foreign imports and the collorary is true, domestic import demand is

equivalent to foreign export supply and domestic export supply is equivalent to foreign import demand. Therefore, the trade balance is the difference between the value of exports and imports. A negative value in the trade balance implies a trade deficit and is associated with an increase in the value of imports relative to exports and vice-versa.

### Benchmark Model

The model specification is based on the imperfect substitute's model of Goldstein and Khan (1985), and Rose and Yellen (1989) where the reduced form equation of the trade balance is given as follows:

$$T_{j,t}^B = T_{j,t}^B [Q_{j,t}^R, Y_{j,t}^F, Y_t^D] \quad (3.1)$$

Where  $T_{j,t}^B$  is the oil trade balance,  $Q_{j,t}^R$  is the real bilateral effective exchange rate,  $Y_{j,t}^F$  is the real growth rate of foreign income,  $Y_t^D$  is domestic real income growth. For the empirics, we estimated a dual logarithmic bilateral trade balance model which is of the form:

$$\text{Ln}T_{j,t}^B = \varepsilon_0 + \varepsilon_1 \text{Ln}Q_{j,t}^R + \varepsilon_2 \text{Ln}Y_{j,t}^F + \varepsilon_3 \text{Ln}Y_t^D + \mu_t \quad (3.2)$$

To implement the bound testing procedure, model (3.2) is modeled as a conditional ARDL logarithmic model of the  $z^{\text{th}}$  order as follows:

$$\begin{aligned} \Delta \text{Ln}T_{j,t}^B = & \varepsilon_0 + \sum_{i=1}^z \varepsilon_1 \Delta \text{Ln}T_{j,t-i}^B + \sum_{i=1}^z \varepsilon_2 \Delta \text{Ln}Q_{j,t-i}^R + \sum_{i=1}^z \varepsilon_3 \Delta \text{Ln}Y_{j,t-i}^F + \sum_{i=1}^z \varepsilon_4 \Delta \text{Ln}Y_{t-i}^D + \\ & \alpha_1 \text{Ln}T_{j,t-1}^B + \alpha_2 \text{Ln}Q_{j,t-1}^R + \alpha_3 \text{Ln}Y_{j,t-1}^F + \alpha_4 \text{Ln}Y_{t-1}^D + \mu_t \end{aligned} \quad (3.3)$$

The long-run multipliers are given by the coefficients of the lagged-level variables which include  $\alpha_1, \alpha_2, \alpha_3$  and  $\alpha_4$ . The short-run impacts on the oil trade balance are as stated,  $\varepsilon_1, \varepsilon_2, \varepsilon_3$  and  $\varepsilon_4$ . To be able to estimate the short-run dynamic coefficients as an error correcting model while at the same time allowing for the long-run estimates, we constructed a one-year lagged error correction term using the contemporaneous values of equation (3.2) as:

$$ECM_{t-1} = \text{Ln}T_{j,t-1}^B - \varepsilon_0 - \varepsilon_1 \text{Ln}Q_{j,t-1}^R - \varepsilon_2 \text{Ln}Y_{j,t-1}^F - \varepsilon_3 \text{Ln}Y_{t-1}^D \quad (3.4)$$

Given that the  $t^{\text{th}}$  recursive residuals is the ex post prediction error for  $\text{Ln}T_{j,t}^B$ , we thus, utilized the first  $t-1$  observations in estimating the coefficients of our dual logarithmic bilateral trade balance error correction ARDL model:

$$\Delta \text{Ln}T_{j,t}^B = \varepsilon_0 + \sum_{i=1}^z \varepsilon_1 \Delta \text{Ln}T_{j,t-i}^B + \sum_{i=1}^z \varepsilon_2 \Delta \text{Ln}Q_{j,t-i}^R + \sum_{i=1}^z \varepsilon_3 \Delta \text{Ln}Y_{j,t-i}^F + \sum_{i=1}^z \varepsilon_4 \Delta \text{Ln}Y_{t-i}^D + \gamma [ECM_{t-1}] + \mu_t \quad (3.5)$$

The term in square bracket represents the error correction term (ECT). A linear combination of the variables brings about co-integration. Thus, in the sense of Engle and Granger (1987), an error correction representation such as specified in equation (3.5) is empirically required for estimation. The speed of adjustment is ascertained on the basis of  $\gamma$ , that is, is the adjustment coefficient that explains the proportion by which long-run disequilibrium in the balance of trade is corrected annually,  $\mu$  is the error term and, is assumed to be white noise.

### Methodology

In this study, we utilized the Pesaran *et al.*'s (2001) *ARDL* modelling and Bounds testing approach to co-integration. The recently developed Bounds co-integration methodology is advantageous on the ground that both the long-run equilibrium relationship and short-run disequilibrium dynamics can be estimated simultaneously. Also, the combination of  $I(0)$  and  $I(1)$  variables is not permissible under the Johansen co-integration technique. This gives a good justification for using the bounds test approach under the *ARDL* model estimation. Above all, we estimated our model by OLS having determined the order of the *ARDL* model. After regression of Equation (3.5), the Wald test ( $F$ -statistic) was computed to differentiate the long-run relationship between the variables in the study. The Wald test was conducted by imposing zero restrictions on the estimated long-run coefficients of the balance of trade. The null hypothesis of no co-integration as against the alternative hypothesis is as follows:

$$H_0 : \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$$

$$H_1 : \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq 0$$

The computed Wald  $F$ -statistic is compared with the critical values. Pesaran and Pesaran (1997) and Pesaran *et al.* (2001) developed two asymptotic critical value bounds for co-integration test under the *ARDL* specification when the explanatory variables are  $I(d)$  with  $0 \leq d \leq 1$ . The lower (upper) bounds presuppose that all the explanatory variables are  $I(0)$  [ $I(1)$ ]. According to the Pesaran *et al.*'s (2001), if the computed  $F$ -statistic is smaller than the lower bound value, then the null hypothesis is accepted with the conclusion that there is no long-run relationship between Nigerian oil trade balance and real effective exchange rate, domestic and foreign incomes. On the contrary, if the computed Wald  $F$ -statistic exceeds the upper bound value, then oil trade balance real effective exchange rate, domestic and foreign incomes are in a long-run level correlation. For the reason that the computed  $F$ -statistic falls

in between the lower and upper bounds, then the results are inconclusive. Once co-integration has been established, the finishing step of the *ARDL* study involves estimating the coefficients of the long-run relations and making inferences about their values (Pesaran and Pesaran, 1997). In this stage, the foremost requirement is to select the orders of the lags for the *ARDL* model estimation based on *Schwarz Bayesian Information Criteria (SBIC)* or the *Akaike Information Criteria (AIC)* or both. The selected optimal *ARDL* model which must have been restricted to the chosen lag order is then estimated including the short run and error correction model.

### **Data: Description, Measurement And Sources**

The data set covers the period of 1975 to 2009 for both models. In this paper, we measure the real oil trade balance as the ratio of the bilateral oil exports (value) to the bilateral imports value between Nigeria and the United States of American. In other words, it is the ratio of Nigeria's oil export to the US over Nigeria's imports from the US. Real oil trade balance is defined as the difference between the oil exports and imports in constant 1984 prices. The real effective exchange rate is defined as the number of Naira for each US dollar and is measured as,  $(P_{j,t}^W/P_t)E_t$ ,  $E_t$ ,  $P_{j,t}^F$  and  $P_t$  are the nominal exchange rate, foreign and domestic price levels respectively. Thus, the real effective exchange rate is calculated by using the weighted average of real US Dollar exchange rates. The US weight in the Nigerian foreign trade is 0.3. The domestic and foreign income growths are measured as real GDP volume indices. The domestic income series is seasonally adjusted. All the data used are directly obtained from the IMF-IFS CD-Rom database and Central Bank of Nigeria's database.

### **Regression Results**

#### **Results of the Unit Root Test**

To be able to establish possible existence of co-integration link, the benchmark augmented Dickey-Fuller (*ADF*) unit root tests (Dickey and Fuller, 1981) was performed to check the order of integration of oil trade balance, real effective exchange, domestic and foreign real *GDP* volume growth indices. The results obtained are reported in Appendix **A1**. Based on the *ADF* test statistic(s), it was found that all variables have unit root at levels. Thus, under the null hypothesis that the series are non-stationary, or contains a unit root, the unit root variables were transformed by first-stage differencing. Accordingly, the transformed variables were yet again put to the unit root test. As seen in Appendix **A1**, the transformed variables are first-difference stationary. The lag lengths are selected based on SIC criteria.

### **Bounds Testing Co-integration Results**

The results of the Bounds co-integration test as shown in Appendix A2 demonstrate that the null hypothesis of no co-integrating vector is rejected as against the alternative at the 5% significance level. The computed Wald F-statistic of 4.684 exceeds the upper critical bound of 4.224. Thus, the Bounds test indicates the existence of a steady-state long-run relationship amongst the variables, bilateral real trade balance, real exchange rate, real domestic and foreign incomes under study.

### **ARDL Analysis**

Using the Hendry's general to specific approach of dropping extremely insignificant regressor from model estimation; the results of the *ARDL-ECM* short-run estimates of trade balance of the Nigerian oil sector are as reported in the second segment of Appendix A3. Thus, the insignificant variables namely, the first, through to the eighth lag of domestic income growth, the third and fourth lags of the oil trade balance were excluded from the short-run dynamic error correction estimation. Accordingly, a close look at *ARDL* long-run and short-run estimates shows that domestic income has been excluded from the model due to its insignificance in current and lag terms. By implication, domestic income has no effect on the trade balance in the Nigerian oil sector. Mutually, estimates of the *ARDL* reveal the statistical significance of the foreign income variable. In view of its positive coefficient which conforms to theoretical predictions, the interpretation holds that an increase in foreign income induces increase in imports and causes improvement in the trade balance. The consistency in the significance of the foreign income variable in both the long and short runs estimates is a pointer to the high level of oil exports from Nigeria to the US.

The estimated short-run results also reveal positive effects of real depreciation in the exchange rate of the Naira on the Nigerian oil trade balance. Thus, our short-run estimates are not supportive of the J-curve hypothesis in the Nigerian oil sector. The short-run estimates show positive contemporaneous signs for the coefficients of the first, second, third and fourth lags of the real exchange rate. Indeed, all the exchange rate lagged terms, the first up to the fourth lagged real exchange term are negative in the short-run and all statistically significant even at the conservative 99% level. These lagged exchange rate coefficients were theoretically expected to be negative in the short-run subsequent to the depreciation of the Naira. What this observation brings into focus is an "inverted" J-curve trade effect of exchange rate depreciation. Responding to 1% depreciation in the Naira, is 5.2% improvement in the trade balance on average in the short-run. The estimates, as well, reveal negative long-run relationship between the real effective exchange rate and the Nigerian oil

trade balance. By intuition, the trade balance in the Nigerian oil sector on average improved in the short-run and still continues to improve in the long-run though insignificantly. In particular, a “inverted” J-curve effect has been brought into reality. This behaviour however, takes for granted, the standard J-curve effect, and hence it is concluded that the conventional J-curve hypothesis cannot be validated for the Nigerian oil sector. The failure of the J-curve hypothesis to hold in existence in the Nigerian oil sector could be explained by the fact that Nigerian exports and imports are frequently denominated in foreign currency such as the US dollar. This is further re-enforced by the robust significance of the foreign income index. The autoregressive terms in our dynamic short-run Nigerian oil trade balance model are all significant at the 5% level. With their positive coefficients, it thus indicates that previous trade balances in the Nigerian oil sector are an addition to the current level of the balance of trade. The long-run elasticities of the variables, foreign income and real effective exchange rate are computed following Bardsen (1989). The computed elasticities of the Nigerian oil trade balance with respect real exchange rate and foreign income are 0.462 and 1.032 respectively (Appendix A4).

#### **Model Validation, Robustness and Diagnostic Checking**

For the purpose of validating the robustness and stability of the estimated *ARDL* model of the Nigerian oil sector throughout the sample period, we examine the stability of the long-run coefficients together with the short-run dynamics following Pesaran and Pesaran (1997) by apply the *CUSUM and CUSUMSQ* due to Brown, Durbin, and Evans (1975) in addition to conducting some diagnostic tests. The *CUSUM and CUSUMSQ* tests conducted on the model’s residuals. Although, the results of the White test reveal that the residual series were heteroskedastic, the ARCH test substantiated the absence of autoregressive conditional heteroskedasticity. In view of this, the contemporaneous disturbances are adjudged to be homoscedasticity. Also, the Breusch-Godfrey LM test indicates statistical independence of the regressors and the regression disturbance. This is reinforced by a D-W statistic which hovers around 2. The Jarque-Bera test on its part confirms normality of the distribution of residuals. Thus, the error series are white noise. For the reason that the movement of the *CUSUM and CUSUM* squared residuals observations which were updated recursively and plotted against break points fall within the critical lines as shown in figures 1 and 2 of Table 5.3, therefore, we posit that in spite of the recently amplified shocks in the international oil prices and the earlier shift from a *de facto* dollar peg to a managed float exchange rate system that could have affected the variables in our model, the null hypothesis of parameter stability cannot be rejected at the 5% significance level. Hence, we conclude that the *ARDL*

model is correctly specified and the residual series are well behaved. In essence, the plots are highly indicative of absence of systematic structural breaks. In fact, parameter stability for all the long-run coefficients of the ARDL trade balance model. By implication, our model trade balance model for the Nigerian oil sector has policy simulation.

**Table 5.3:** CUSUM and CUSUMSQ Plot of Structural Break Points

Fig. 1: CUSUM

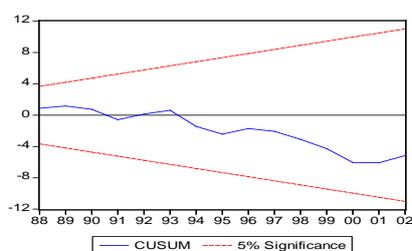
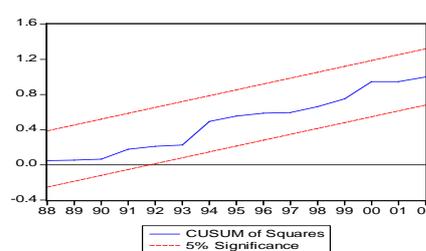


Fig. 2: CUSUMSQ



**Table 5.4:** Diagnostic Test Statistics

Test	F-statistic(s)	Probability
1. Normality		
Jacque-Bera Statistic	1.2008	0.6422
2. Serial Correlation		
Breusch-Godfrey LM test	0.5648	0.2524
3. Durbin-Watson	2.2068	0.0002
4. Specification Error		
Ramsey RESET Test	0.5226	0.6435
5. Heteroskedasticity		
White Heteroskedasticity Test	1.2652	0.5328
6. Autoregressive Conditional Heteroskedasticity		
ARCH-LM Test	0.4426	0.2626

**Synthesis of the Present Empirical Evidence with other Empirical Studies**

The positive short-run effect of a real depreciation on the country’s bilateral trade balance with the US is not supportive of the standard J-curve hypothesis. Therefore, this study could not establish classic J-curve exchange rate effect on the trade balance of the Nigerian oil sector as it has been found in case of Morocco and Japan wherein the trade balances deteriorates almost immediately subsequent to the devaluation of the real exchange rate and recuperates after two years. The finding in the study is in support of an “inverted” and hence, a “delayed” J-curve trade effect of exchange rate depreciation for the Nigerian oil sector. Though, our results show no long-run pattern to support the J-curve effect in the Nigerian oil sector, the empirical evidence may perhaps be linked with those of Marwah and Klein (1996) that a delayed reaction of the aggregate trade balance to exchange rate changes in the US and Canada is real with a discrete propensity for total trade balances to worsen at first when exchange rate devaluation is instituted and to later improves. Further, our evidence of a delayed response effect could as well, be linked to findings of Gylfason and

Risager (1984), Rose and Yellen (1989) and Felmingham (1998) that non-existence of the J-curve effect in developing countries after a real depreciation, is as a result of the fact that exports are largely invoiced in foreign currency. This is further re-enforced by the robust significance of the foreign income index. This finding does not corroborate with the empirical finding of Akbostanci (2002), who in his study of the dynamics of the Turkish trade balance, found no significance for the foreign income variable. The study obtained 0.462 as a long-run trade elasticity of exchange rate for the Nigerian oil sector. Though, this empirical estimate uphold those of Hopper et al. (2000) who obtained an elasticity below unity, Campa (2004) whose aggregate exchange rate elasticity of exports is 0.14 for Spain, Cheung et al. (2009) that estimated low value for the US-China's exchange rate elasticities of imports, Marquez and Schindler (2007) and Thorbecke and Smith (2010) with a low exchange rate elasticity of exports for China, it is somewhat a low value if the oil trade balance is to exhibit the J-curve improvement trend.

### **Conclusion**

We have in this study attempted to shed empirical evidence on unresolved issues regarding the J-curve trade effect of real exchange rate depreciation. The standard argument as regard the exchange rate elasticity of trade, is that, trade balance deteriorates in the short-run and improves in the long-run in view of real exchange rate depreciation which increases the competitiveness of the domestic producers (Marshall, 1923 and Lerner, 1944). Despite the well known argument, the present empirical short-run evidence is not supportive of the classic J-curve exchange rate effect on the trade balance of the Nigerian oil sector.

In the short-run, the trade balance of the Nigerian oil sector exhibited an inverted J-curve trend ensuing from a real depreciation of the Naira. Indeed, the trade balance contemporaneously gains improvement as made evident by the “all through” positive short-run and long-run coefficients of the lagged exchange rate. Though, the long-run effect is insignificant, the inverted and hence a delayed J-curve effect is brought into focus. This behaviour takes for granted, the predicted J-curve effect, and hence it is concluded that the standard J-curve hypothesis cannot be validated for the Nigerian oil sector. The results show that exchange rate depreciation does not provide the predicted J-curve instantaneous deterioration trend on the Nigerian oil trade balance in the short-run. That the Nigerian exports and imports are frequently denominated in foreign currency; the US dollar is a possible explanation for the belated J-curve effect. Other than the real effective exchange rate, foreign income was found to exhibit significant short-run and long-run impacts on the trade balance in the Nigerian oil sector.

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## APPENDIX

## APPENDIX A1: Unit Root Estimation

Variables	Levels	Transformation	Lags/Order	Result/Decision
	ADF: Constant and Trend	ADF: Constant and Trend		
$LnT_{j,t}^B$	-0.5624	-8.2988	4/I(1)	First Difference Stationary
$LnY_{j,t}^F$	-1.8468	-10.662	2/I(1)	First Difference Stationary
$LnY_t^D$	-1.2252	-6.4644	8/I(1)	First Difference Stationary
$LnQ_{j,t}^R$	-2.6584	-13.668*	4/I(1)	First Difference Stationary

ADF 1% critical value is -4.546, \* indicate the rejection of the null hypothesis of non-stationary series at 5%

## APPENDIX A2: Bound Wald F-Test Results

Model	Critical Values		Wald F-statistic	Decision
Equation (3.3)	I(0)	I(1)	4.684	Co-integrated
	2.955	4.224		

5% critical values cited from Pesaran et al. (2001), Table CI (iii), Case 11, Unrestricted Intercept and no Trend

## Appendix A3: Results of the ARDL Long-Run and ARDL-ECM Short-Run Dynamics

## ARDL Long-Run Estimates of Trade Balance of Nigerian Oil Sector

Variable(s)	Coefficient(s)
$LnT_{j,t-1}^B$	-1.2468 (-4.026)
$LnY_{j,t-1}^F$	1.2866 (2.226)
$LnQ_{j,t-1}^R$	0.5762 (1.426)

## ARDL-ECM Short-Run Estimates of Trade Balance of Nigerian Oil Sector

Variable(s)	Coefficient(s)
$\Delta LnT_{j,t-1}^B$	1.6206 (2.002)
$\Delta LnT_{j,t-2}^B$	0.2466 (10.826)
$\Delta LnY_{j,t}^F$	1.2445 (2.226)
$\Delta LnY_{j,t-1}^F$	1.264 (2.024)
$\Delta LnY_{j,t-2}^F$	1.2866 (2.226)
$\Delta LnQ_{j,t-1}^R$	0.2644 (2.062)
$\Delta LnQ_{j,t-2}^R$	1.4296

	(2.962)
$\Delta LnQ_{j,t-3}^R$	0.6482
	(6.426)
$\Delta LnQ_{j,t-4}^R$	1.0226
	(4.426)
Constant	-6.2482
	(-14.426)

---

$R^2$	0.8266
$\bar{R}^2$	0.8042
F-statistic	52.0288

Note: The ARDL estimates are unrestricted and parsimonious. The estimated long-run results are based on Schwarz Bayesian criterion

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#### Appendix A4: Long-Run Elasticity of Nigerian Oil Trade Balance

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Variable(s)	Long-run Elasticity
$LnY_{j,t-1}^F$	1.032***
$LnQ_{j,t-1}^R$	0.462***

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\*\*\* denotes statistical significance of the computed long-run elasticity at the 5% level

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