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Asymmetric cointegration and threshold adjustment between exchange rate and non-crude oil exports in Nigeria

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Abstract
This paper empirically examines the long-run pass-through of the official exchange rate into non-crude oil exports in Nigeria utilizing threshold cointegration and asymmetric error-correction modeling for the sample period from June 1996M01 to December 2018M12. The study provides evidence for nonlinear cointegration between exchange rates and non-crude oil exports, in a form of upward rigidity. This finding shows that the response of non-crude oil exports to any decrease in the official exchange rate is faster than its response when there is a fall in the value of the domestic currency.

Keywords: Exchange rate, non-crude oil exports, threshold autoregression, asymmetric adjustment

1. Introduction

It is commonly contended that the relationship between exchange rates and exports has important implications, especially from the viewpoint of the recent crisis in the international oil market. Such relationships may also affect monetary and fiscal policies of a country. Consistent with the trade-oriented model suggested by Dornbusch and Fischer (1980) which suggests that a country's trade balance and its export competitiveness can be influenced by exchange rates variations. The academic debates on the exchange rate pass-through have also received substantial attention. This academic debate has broad implications on trade balance (Campa & Goldberg, 2005) [3].

In principle, currency depreciation/devaluation may have a positive effect on export performance of a nation through a decrease in the relative price of domestically produced goods. Although this may likely improve the trade balance, the success of such real appreciation of domestic currency would depend on the ability of the home economy to meet up with the surge in demand for domestically produced goods (see, Guittian & Dornbusch in Kandil, Berument & Dincer (2007) [13]. In particular, for an economy like Nigeria that heavily depends on oil exports for its foreign exchange, any negative effect from the foreign exchange may have a serious implication on its export performance, particularly of non-oil. In this scenario, devaluation may not necessarily lead to a corresponding improvement in the export performance of the country, while exchange rate appreciation can be expected to deteriorate its export competitive position. Therefore, as argued, one would expect, a non-linear long-run relationship between exchange rate and non-oil exports of Nigeria. One such reason to expect a relationship is due to its overdependence on crude oil exports, which makes other sectors of the economy globally less competitive (Jibrilla, 2010) [12].

Nigeria is a country with a typical resource-dependent economic system, which is vastly open to the global market. Thus, the change in the value of Naira (Nigerian currency) may affect both exporters and importers significantly in the country. One noticeable feature of the Nigerian economy is that whenever there is a fall in the oil price, the effect is often a sudden and a considerable reduction in export earnings of the government (see also Fasanya & Olayemi, 2018) [13]. This deteriorating condition of export performance with Nigeria has remained unchanged so far. Additionally, as an export-oriented country, Nigeria depends heavily on primary products exported to its major trading partners. In the case when crude oil appreciates, Nigerian non-oil exporters may lose their competitiveness in the international markets usually tumble.

The theoretical relation between exports and exchange rate can be understood from the perspective of the expenditure switching model, which suggests that real depreciation of domestic currency relative to its trading partners makes its exports good more competitive in the global market (see, Sugema, 2005) [19]. This proposition, according to Auty (2001) [2], may, however, be inapplicable to particularly countries such as Nigeria that heavily depend on natural resource exports. Studies investigating the relationship between exchange rate and exports in Nigeria include Oluyemi and Isaac (2017) [16], Odili (2015) [14], Onafowora, Aliyu (2010) [1], Owoye (2008) [17], and Ogun (1998) [15], among others. The common modeling considered by these studies is, however, the conventional linear approach. Such an approach would, however, lead to a misleading conclusion, if the actual relationship is nonlinear. One proposed approach is to consider non-linear procedures instead. Threshold cointegration was introduced by Enders and Siklos (2001) [8] as a suitable technique to combine non-linearity and cointegration. In effect, their model allows for asymmetric adjustment to long-run equilibrium.

This study, in line with Enders and Siklos, departs from modeling symmetric relations between exchange rate and non-oil exports. The study, therefore, assumes that the long-run equilibrium relationship between the official exchange rate and non-oil exports takes asymmetric adjustment. The rest of the paper is organized as follows: the next section describes the data and methodology; section 3 presents and discusses the empirical findings and; finally, section 4 concludes.

2. The Data

Monthly data on Nigerian non-oil exports and an official exchange rate were used. All the monthly data are obtained from the official website of the Nigerian National Bureau of Statistics (NBS) and the Central Bank of Nigeria. Available data for the study were between the periods of January 1996 to December 2018. The start and end periods of the sample used are dictated by data availability, as no official exchange rate data are thus far obtainable beyond December 2018.

3. The models, Methodology and main findings

The possible non-linear long-run relation between non-oil exports and exchange rate can be expressed in the bivariate form as

$$LNCXP_t = \Omega_0 + \Omega_1 LEX_t + \varepsilon_t \quad (1)$$

Where LNCXP is the natural log of non-crude oil exports, while LEX represents natural log of official exchange rate. Ω_0 is the intercept and Ω_1 is the slope coefficient that explains the relationship between exchange rate and non-oil exports. ε_t is the usual error term assumed to be purely random. This error term represents any deviation from the long-run equilibrium between LNCXP and LEX variables, that is $LNCXP_t - (\theta_0 + \theta_1 LEX_t)$. Cointegration is a property. In general, if both the two variables possessed non-stationary characteristics at their levels but are integrated of order one, they can be cointegrated when their linear combination is a stationary process.

Before testing for cointegration on the variables, the analysis follows the conventional practice, by first testing the integration order of the individual series using Augmented Dickey-Fuller (ADF, 1979) and Phillip and Perron (1988) [18] unit root tests.

Since the leading objective of this study is to test for the possible existence of asymmetric relation among the study variables, the analysis follows the methodologies proposed by Enders and Siklos (2001) [8] which was based on the Engle and Granger (1987) [9] two-step cointegration technique. Using a two-stage procedure, the first stage involves estimating the long-run regression (for equation1) using conventional ordinary least squares (OLS); the second stage involves running a stationarity test on the residual from the estimated OLS as follows:

$$\Delta\hat{\varepsilon}_t = \rho\hat{\varepsilon}_{t-1} + \sum_{i=1}^{p}\delta_i\Delta\hat{\varepsilon}_{t-j} + \nu_t \qquad (2)$$

Where ν_t is assumed to be independently and identically distributed with zero mean and a constant variance. The null hypothesis of no cointegration is specified as $\rho = 0$. Rejecting this null hypothesis indicates stationarity of the (estimated) residuals sequence, $\hat{\varepsilon}_t$. In this case, one can conclude that long-run cointegration relationships exist between the exchange rate and non-oil exports in Nigeria for the period under review. However, as mentioned above, such a cointegration relation can only be considered correctly specified if the adjustment process exhibit symmetric behavior. If the adjustment to any deviation of the variables from equilibrium is non-linear, Enders and Siklos (2001) [8] proposed an alternative specification, which is an extended version of Eagle and Granger cointegration test in the form of threshold autoregression (TAR) model based on Tong (1990) [20]. This model requires incorporation of Heaviside indicator function that partitions lagged sequence of residual in equation 1 as

$$\Delta\hat{\varepsilon}_t = I_t\rho_1\hat{\varepsilon}_{t-1} + (1 - I_t)\rho_2\hat{\varepsilon}_{t-1} + \nu_t \qquad (3)$$

Where, It is the Heaviside indicator function. To account for possible serial correlation problem in the residuals and its dynamic adjustment toward long-run equilibrium value, equation 3 can be written in an augmented pth-order process as

$$\Delta\hat{\varepsilon}_t = I_t\rho_1\hat{\varepsilon}_{t-1} + (1 - I_t)\rho_2\hat{\varepsilon}_{t-1} + \sum_{i=1}^{p-1}\delta_i\Delta\hat{\varepsilon}_{t-i} + \nu_t \qquad (4)$$

Where, It as specified in eqn. (3) is the Heaviside indicator function that can be denoted as

$$I_t = \begin{cases} 1 & if\ \hat{\varepsilon}_{t-1} \geq \tau \\ 0 & if\ \hat{\varepsilon}_{t-1} < \tau \end{cases} \qquad (5)$$

The stationary condition of the sequence, $\hat{\varepsilon}$, is satisfied when $-2 < (\rho_1, \rho_2) < 0$. If the deviation of $\hat{\varepsilon}_{t-1}$ is above the threshold, the adjustment is represented by $\rho_1\hat{\varepsilon}_{t-1}$, while the adjustment for the deviation of $\hat{\varepsilon}_{t-1}$ below threshold is denoted by $\rho_2\hat{\varepsilon}_{t-1}$. These adjustments are represented by dummy values: for deviation above threshold, the indicator function will take the value one (1), while for deviation below threshold it takes zero (0) value. Whether positive and negative divergences have different effects on the behaviour of exchange rate – non-oil exports nexus, could be determined by the estimated values of ρ_1 and ρ_2. For instance, if $|\rho_1|<|\rho_2|$, the adjustment is slow for deviation above threshold value.

On the other hand, if the speed of adjustment is characterized by more momentum (that is, if it tend to be more persistent in one direction than the other), then the speed of adjustment can be allowed to depend on the changes of the sequence, $\hat{\varepsilon}_{t-1}$ so that equation (5) becomes

$$I_t = \begin{cases} 1 & if\ \Delta\hat{\varepsilon}_{t-1} \geq \tau \\ 0 & if\ \Delta\hat{\varepsilon}_{t-1} < \tau \end{cases} \qquad (6)$$

This specification is referred to as momentum autoregression (Enders and Siklos, 2001) [8]. The Heaviside indicator variable in equation (6) depends on the previous disequilibrium of the sequence, $\hat{\varepsilon}_{t-1}$. In the case of an adjustment that exhibit more persistence whenever the sequence, $\hat{\varepsilon}_{t-1} < 0$ in a TAR or M-TAR model, Chan (1993) showed that a super-consistent estimate of the threshold can be obtained by searching over all values of the lagged residuals sequence. This is to minimize the sum of squares errors (SSE) from the fitted threshold model(s). As in Enders and Chumrusphonlert (2004) [7] the present study follows the standard procedure of using only 70% of the sample observations as potential thresholds.

The null hypothesis of no cointegration is represented by $\rho_1 = \rho_2 = 0$, for both TAR and M-TAR models. The F-Statistics for this null hypothesis, as denoted by ΦC in Enders and Siklos (2001) [8] has non-standard distribution. The critical values for this tests are found in Tables 1 and 2 of Enders and Siklos (2001) [1] and, as stated earlier, the coefficients of ρ_1 and ρ_2 signify different speed of adjustments for the deviations from the long-run equilibrium exchange rate-non-oil exports nexus. If the null hypothesis is rejected, implying either of ρ_1 and ρ_2 is at least greater than zero, it is then possible to test for the presence of linear (symmetric) adjustment process. This can be done by setting the null hypothesis as $\rho_1 = \rho_2$, which can be tested using standard Fisher test statistic. However, if this null is rejected, one can conclude that the relationship between the variables is non-linear and the adjustment is asymmetric.

Table 1: The Stationarity Tests for non-oil exports and exchange rates

Variables	LNCEXPt	∆LNCEXPt	LEXt	∆LEXt
ADF	-1.411	-15.267*	2.164	-3.475*
PP	-2.768	-32.623*	-2.209	-16.085*
5% critical value	2.872	2.872	-3.426	-2.869

Note: Numbers in parentheses are lag lengths used in the ADF test (as determined by SIC. * denotes rejection of the null hypothesis at the 5 per cent significant level.
Source: own results

Results from Table 1 indicate that both the ADF and PP tests results could not reject the null hypothesis at the levels of the series, LNCEXP and LEX. However, each of the differenced series is found to be stationarity at more than five percent significance levels. These tests support the hypothesis that exchange rate and non-crude oil exports are both integrated of order one. The results, thus, allow for cointegration analysis based on the Engle and Granger (1987) [9, 10] two-step methodology.

In what follows the analysis employed dynamic ordinary least squares (DOLS) to estimate the long-run relations between the study variables and, the estimated results are presented as follows:

$$LNCEXP = -1.683 - 1.5112LEX + \hat{\varepsilon}_t \qquad (7)$$

R^2 =.87, P- value = 0.000

Table 2: Estimated Eagle-Granger, TAR and MTAR cointegration tests

Variables	EG	TAR	MTAR
ρ	-1.780		
ρ_1		-0.2968 (-3.673)	-0.4402 (-5.382)
ρ_2		-0.2144 (-3.884)	-0.1608 (-3.002)
Symmetric tests (S)		13.081*	17.563*
Asymmetric tests (AS)		0.7776	8.975*
Threshold (τ)		1.840	0.6032

Note: "ρ" Entries denotes t-Statistic for EG cointegration tests. Entries of "ρ_1 *and* ρ_2" represent the coefficients that signify positive and negative deviations from the long-run equilibrium *for the TAR and MTAR cointegration, respectively. "S"* Entries represent the F-statistics that follows a non-standard distribution of the sample values for the null hypothesis $\rho_1 = \rho_2 = 0$, and "*AS*" Entries represent the critical values of the F distribution for the null hypothesis of symmetric adjustment $\rho_1 = \rho_2$. The appropriate lags for the TAR and M-TAR adjustment processes were chosen by AIC. The numbers in parenthesis are t-values.
Source: own results

Table 2 reports the estimated results for Eagle–Granger (EG) cointegration, threshold, and momentum adjustments. The EG cointegration was estimated using equation 2, while equations 4 and 5 are used to estimate the TAR model and equations 4 and 6 for the MTAR model. The appropriate lags for the TAR and MTAR adjustment processes were chosen by SIC. The EG test result failed to reject the null hypothesis of no cointegration at the conventional level of significance. This suggests the absence of cointegration when the long-run relationship between the official exchange rates and non-crude oil exports in Nigeria is modeled linearly. Although, the point estimates for ρ_1 and ρ_2 of TAR exhibit convergence, and its estimates rejects the null hypothesis of $\rho_1 = \rho_2 = 0$ at 5% significance levels, which suggest symmetric cointegration between exchange rates and non-crude oil exports, the null hypothesis of symmetric cointegration, $\rho_1 = \rho_2$, could not be rejected at the conventional level of significance. Thus, long-run cointegration fails when asymmetric adjustment is assumed between the variables.

However, for the MTAR model with a threshold value of 0.6032, a strong evidence for cointegration is found at more

than 5% significance level. Notice that the F-statistics of Φ_{μ} = 17.563 is considerably greater than its corresponding simulated critical value of 8.149. Thus, the null hypothesis ($\rho_1 = \rho_2 = 0$) cannot be rejected, which allows for testing symmetry adjustment under the null hypothesis ($\rho_1 = \rho_2$) against the alternative of asymmetry ($\rho_1 \neq \rho_2$) that is clearly rejected based on the standard Fisher F – test (of 3.842). In addition, the point estimates of ρ_1 = -0.4402 and ρ_2 =-0.1608 are also established, which fulfil the condition for convergence (that is, stationarity).
This point estimates suggest that the speed of adjustment is relatively faster for a decrease in the exchange rate and relatively sluggish for a rise in exchange rate relative to non-crude oil exports. This evidence of asymmetry in the MTAR model supports the hypothesis that the adjustment of non-crude oil exports to any change in the exchange rate is not linear or symmetric.

4. Conclusions

This study takes a different method in defining the long-run relationship in a cointegration model of threshold adjustment and non-crude oil exports respond asymmetrically to exchange rate changes in Nigeria in the form of upward rigidity. This finding shows that the response of non-crude oil exports to any decrease in the official exchange rate is faster than its response to an increase in the official exchange rate.

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