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This study is partly based on Fahad Adamu's Master's thesis (supervised by Ergun Doğan) entitled "Trade Openness and Industrial Performance in Nigeria: Evidence from ARDL Models".

Trade Openness and Industrial Growth: Evidence from Nigeria

Summary: This study examines the long-run and short-run relationship between industrial production and trade openness in Nigeria during the period from 1986 to 2008 by using quarterly data. It employs the ARDL bounds testing methodology developed by M. Hashem Pesaran, Yongcheol Shin, and Richard J. Smith (2001). The results of both the long-run analysis and the short-run error correction model (ECM) indicate that trade openness has a significant and positive impact on industrial production. The Toda-Yamamoto causality analysis shows that there is one-way Granger causality, running from trade openness to industrial production.

Key words: Trade openness, Nigeria, Co-integration, ARDL method.

JEL: C22, F00, O55.

Establishing a causal relationship between openness to trade and economic growth or industrial performance has proven quite challenging because of numerous complicating factors. This is an unsettled issue; some studies find that openness causes industrial growth, while others find the opposite. In this study, we aim to contribute to this debate by exploring the relationship between openness and industrial performance in Nigeria. Nigeria is a good choice for this because it has successfully liberalized its trade recently, and also has been trying to diversify its economy to avoid being heavily dependent on the oil industry.

Our study contributes to the literature in several ways. First, we study openness and growth relationship in an important African economy that receives less attention than it deserves. Although the empirical literature on the relationship between openness to trade and industrial growth in both developed and developing countries is large, empirical studies exploring this issue for Nigeria are still small. Second, unlike other studies, we concentrate on a time period when it is most likely to observe the effect of openness on growth, which is the period after 1986 when trade was liberalized. Third, unlike most previous studies, we use quarterly instead of annual data together with the ARDL bounds testing approach.

The rest of the study proceeds as follows: Section 1 reviews the literature; Section 2 provides an overview of relevant Nigerian policies; Section 3 describes the data and the methodology used in the study; Section 4 reports the empirical results; and Section 5 concludes.

1. Review of Recent Literature

The empirical literature on the relationship between openness to trade and industrial growth in both developed and developing countries is large. We reviewed the most relevant studies in what follows, starting with the major cross-country studies, and then moving to the country-specific studies. Some of the cross-country studies, like Halit Yanikkaya (2003) and Bülent Ulaşan (2015), specifically deal with the question of how best to select an openness indicator. Other cross-country studies illustrate the diversity of findings in the literature. As for the single-country studies, we selected countries that have gone through a trade liberalization period similar to that of Nigeria, such as India and Pakistan.

Although the early studies on growth and trade openness have used mostly conventional econometric estimation methods, recent empirical studies have started to employ co-integration testing and vector autoregression and vector error correction models. The studies we review illustrate this methodological diversity as well. We reviewed more studies that use the methodology we employed in this study, Autoregressive Distributive Lag (ARDL) approach, which is not used by many researchers who study the Nigerian case.

As mentioned above, one aim of the papers by Yanikkaya and Ulaşan is to compare a number of openness indicators. To this end, Yanikkaya (2003) uses openness indicators based on trade volumes and trade restrictions to empirically test the trade openness and economic-growth relationship by using panel data on over 100 developed and developing countries. His results based on openness indicators constructed by using trade volumes show that openness has a positive effect on economic growth, and this holds for both the developed and developing countries**.** However, when trade restrictions are used as the indicators of openness, this conclusion is reversed, that is, higher trade barriers can be beneficial for economic growth, especially in developing countries. Ulaşan (2015) uses four categories of openness indicators: trade volumes; direct trade policy measures, such as tariff rates and black market premium for exchange rate; measures that indicate the difference between predicted and actual trade; and subjective measures, such as real exchange rate distortion index. Empirical analysis of the relationship between trade openness and growth in a panel of 119 countries was conducted by using dynamic panel data methods (difference and system GMM) for the period from 1960 to 2000. The study "does not support the proposition that openness has a direct robust relationship with economic growth in the long-run" (p. 47).

The cross-country studies can be divided into two groups: those that include a wide range of countries including both the developed and developing ones, and those that focus on developing countries. For instance, Prabirjit Sarkar (2008) studies the link between openness and growth by using cross-country panel data analysis by taking a sample of 51 countries. The results from panel data analysis indicate a significant and positive relationship between trade openness and GDP growth for the 16 rich countries, but the results on individual countries indicate that most of the developing countries, including the East Asian ones, did not exhibit positive long-term relationship between openness and growth. Dong-Hyeon Kim (2011) also finds a differential effect of trade openness on economic growth. The results of the study, which was done by using data on 61 countries that cover the period from 1960 to 2000, show that while openness has a positive effect on growth in high income economies, it has the opposite effect in low-income economies. The authors used fixed effects models to obtain the results. Vlad Manole and Mariana Spatareanu (2010) construct a trade restrictiveness index to measure the degree of trade protection, which was then used as an openness indicator. Their sample included 131 countries and covered the period from 1990 to 2004. The results from both the OLS and instrumental variable regressions show that the lower the trade protection is, the higher the GDP *per capita* is.

Gilles Dufrenot, Valerie Mignon, and Charalambos Tsangarides (2010) examine the issue at hand for a group of 75 developing countries over the period from 1980 to 2006. They used quantile regressions analysis to show that the effect of openness on growth is higher in low-growth countries than its effect in high-growth countries. They also found that while openness has beneficial effect on growth in the long-run, its effect might be detrimental in the short-run. Ching-Cheng Chang and Michael Mendy (2012) demonstrate that openness affects growth positively in 36 African countries over the period from 1980 to 2009. The cross-country studies mentioned above suggest that the strength of the openness-growth relationship might depend on whether a country is developed or not, and on how fast a country is growing.

Some of the studies done on countries similar to Nigeria in terms of development level and the experience of trade liberalization report opposite results. Qazi Muhammad Adnan Hye (2012) finds that openness to trade and economic growth are negatively related in the case of Pakistan. This result was obtained by using several econometric methods including the Johansen and ARDL bounds testing approaches to co-integration, and with data from 1971 to 2009. Muhammad Shahbaz (2012) finds that trade openness positively affects economic growth in Pakistan. The study used ARDL bounds testing and VECM Granger causality test methods and covered the period from 1971 to 2011. By using similar methods and annual data from 1971 to 2009, Hye and Wee-Yeap Lau (2015) find a positive relationship between trade openness and economic growth in India in the short run, but a negative one in the long run.

Evidence from the studies on Nigeria is mixed as well. Okon J. Umoh and Ekpeno L. Effiong (2013) find that there is a relationship between trade openness and manufacturing output both in the short-run and the long-run in Nigeria. They used annual data for the period from 1970 to 2008, and employed ARDL bound testing approach to obtain the results. Saibu Muibi Olufemi (2004) shows that economic growth and trade openness are co-integrated by using Johansen co-integration methodology and annual data from 1970 to 2000. However, Granger causality tests indicate that there is only causality from economic growth to openness, not the other way around.

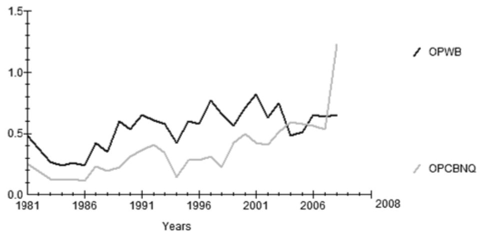
2. An Overview of Economic Policies in Nigeria

Nigeria has formulated different policies, institutions, and incentives to stimulate industrial development since its independence. Like many other developing countries, Nigeria has adopted an import substitution industrialization (ISI) policy in its early years of independence. The main aims and objectives of the ISI policy, which the Nigerian government started implementing immediately after the independence in 1960, include promotion of industrialization, reduction of reliance on foreign imports, and saving hard currency by import substitution (Louis N. Chete et al. 2014).

Starting in 1970, the Nigerian trade policies have gone through several periods of varying degrees of restrictiveness. While the trade policy was less restrictive in early 70s, it had become more restrictive starting in 1976 with the introduction of restrictions on selected types of products. Tariff hikes on additional products and other types of restrictions, such as the requirement of specific import licenses for certain items, took effect in 1982 (Umoh and Effiong 2013).

The Nigerian government adopted the Structural Adjustment Programme (SAP) in June 1986 to prevent an economic crisis in the wake of dropping oil prices. The aims and objectives of SAP included privatization, promotion of industrial efficiency and private sector development, stimulation of non-oil economy, and downsizing the public sector. The adoption of SAP in 1986 led to the emergence of trade liberalization in Nigeria, which was accompanied by elimination of import licenses, removal of foreign exchange, and price controls (World Bank 1994).

To have an idea about the degree of openness of the Nigerian economy after 1986 compared to the previous period, we refer to Figure 1. The graph shows plots of two indicators: OPWB is the annual trade to GDP ratio from World Bank's World Development Indicators database, and the indicator used in this study, OPCBNQ, is the annualized trade ratio series constructed by using the quarterly nominal trade and GDP data from the Central Bank of Nigeria. Both indicators show a clear upward trend from the pre-liberalization to post-liberalization period.



Source: Authors' estimations.

Figure 1 Trade Openness in Nigeria, 1981-2008

3. Data and Methodology

When time series data are not in the same order of integration, which is the case in this study, conventional co-integration tests cannot be used. Therefore, we use the bounds testing approach developed by Pesaran and Shin (1997), and Pesaran, Shin, and Smith (2001) and to investigate the co-integration relationship among the variables used in the study.

Bounds testing approach has some advantages over the conventional approach of co-integration models. First, the bounds testing approach can be employed irrespective of whether the regressors are stationary in their level forms (integrated of order zero), or stationary in first differences (integrated of order one) or fractionally integrated. Second, the bounds testing approach has superior properties in small samples than other multivariate co-integration approaches. Third, the error correction model can be obtained from the ARDL through a simple linear combination that amalgamates both short-run adjustments with long-run information without losing previous information. Fourth, the ARDL model is capable of dealing with endogenous regressors. Pesaran and Shin (1997) have shown that "appropriate modification of the orders of the ARDL model is sufficient to simultaneously correct for the residual serial correlation and the problem of endogenous regressors" (p. 16). Thus, when there is no serial correlation in an ARDL model, endogeneity is not a problem (see also Kamiar Mohaddes and Pesaran 2016, p. 19).

The ARDL modeling approach can be illustrated by a simple two-variable model, ARDL (1, 1):

$$y_t = \alpha_0 + \beta_1 y_{t-1} + \delta_0 x_t + \delta_1 x_{t-1} + v_t, \tag{1}$$

where v_t is the random error term. Error correction model can be derived as follows: set $x_t = x_{t-1} + \Delta x_t$ and $y_t = y_{t-1} + \Delta y_t$. Replacing these in the above equation yields:

$$\Delta y_t = \alpha_0 - (1 - \beta_1) y_{t-1} + \delta_0 \Delta x_t + (\delta_0 + \delta_1) x_{t-1} + v_t. \tag{2}$$

We can obtain the error correction model by rearranging:

$$\Delta y_t = \delta_0 \Delta x_t - (1 - \beta_1)[y_{t-1} - \frac{\alpha_0}{1 - \beta_1} - \frac{(\delta_0 + \delta_1)}{1 - \beta_1} x_{t-1}] + v_t \tag{3}$$

where the term in brackets is the error correction term. Coefficients $\frac{\alpha_0}{1-\beta_1}$ and $\frac{(\delta_0+\delta_1)}{1-\beta_1}$ are the long-term coefficients.

The ARDL procedure is conducted in two stages. The first stage is the co-integration analysis by means of the bounds testing developed by Pesaran and Shin (1997) and Pesaran, Shin, and Smith (2001). In the second stage, long-run relationship implied by the model and indicated by the co-integration analysis is estimated. At this stage, error correction model illustrating the short-run dynamics is estimated as well.

We use the following variables in our estimations: industrial production index (IND) as our dependent variable, which is hypothesised to be determined by openness (OPNS), nominal effective exchange rate index (NEER), and the inflation rate (INF), which is calculated by using the consumer price index (see Table 1 for definitions and sources of data). The ratio of the sum of the value of imports (M) and exports (X) of goods to GDP is our measure of openness.

As pointed out by Yanikkaya (2003), there are several types of indicators for openness that are commonly used in the literature: indicators based on trade volumes, trade restrictiveness (tariff rates, etc.), bilateral payments arrangements, exchange rate (e.g. black market premium), and a variety of trade orientation indices. In a study on openness, it would be best to use several of these measures to check the sensitivity of the results to the choice of indicator. There is no data (or long enough series) to calculate these measures except for the ones that are based on trade volumes. Thus, we are limited to using the trade openness index like in most of the studies.

Table 1 Data Sources

Variable	Data source	Unit
Value of exports (goods)	CBN	Naira
Value of imports (goods)	CBN	Naira
Nominal GDP	CBN	Naira
Nominal exchange rate (end of period)	IFS	National currency per US dollar
Nominal effective exchange rate	IFS	Index, 2005 = 100
Consumer prices, all items	IFS	Index, 2005 = 100
Industrial production	IFS	Index, 2005 = 100

Notes: CBN - Central Bank of Nigeria; IFS - International Financial Statistics; Nominal Effective Exchange Rate is calculated by using the Consumer Price Index.

Source: Authors' construction.

While our main variable of interest is openness, we include two other variables, inflation rate and NEER, to control for macroeconomic policy and the exchange rate policy, respectively. Note that the exchange rate effect might be negative or positive depending on whether the export intensity channel or the input cost channel dominates. When the share of the cost of the imported inputs in total input cost is very high, an appreciation of the domestic currency could stimulate growth by outweighing the negative effect arising from the decrease in exports.

To do the bounds testing, the following estimating equation is used:

$$\Delta LIND_t = \alpha_0 + \sum_{i=1}^{p} \delta_i \Delta LIND_{t-i} + \sum_{i=0}^{p} \gamma_i \Delta LOPNS_{t-i} + \sum_{i=0}^{p} \tau_i \, \Delta LNEER_{t-i} + \sum_{i=0}^{p} \theta_i \, \Delta INF_{t-i} + \mu_1 LIND_{t-1} + \mu_2 LOPNS_{t-1} + \mu_3 LNEER_{t-1} + \mu_4 INF_{t-1} + \varepsilon_t \quad (4)$$

where α_0 and ε_t are the intercept and random error terms, respectively, while Δ is the first difference operator. All variables are expressed in natural logarithms except for the inflation rate. The short-run relationships are measured by δ, γ, τ and θ, while long-run relationships are by μs.

The test has the null hypothesis of H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4 = 0$ against the alternative hypothesis H_1: $\mu_1 \neq 0$, $\mu_2 \neq 0$, $\mu_3 \neq 0$, $\mu_4 \neq 0$. Null hypothesis indicates the absence of a long-run relationship. To perform the test, which is a familiar coefficient restriction test (F-test), critical values provided by Pesaran, Shin, and Smith (2001) are used.

In the second step, long-run relationship is estimated by using the following equation:

$$LIND_t = \alpha_0 + \mu_1 LIND_{t-1} + \mu_2 LOPNS_{t-1} + \mu_3 LNEER_{t-1} + \mu_4 INF_{t-1} + \varepsilon_t. \quad (5)$$

Estimating equation for the error correction model (ECM) can be expressed as follows:

$$\Delta LIND_t = \alpha_0 + \sum_{i=1}^{p} \delta_i \Delta LIND_{t-i} + \sum_{i=0}^{q} \gamma_i \Delta LOPNS_{t-i} + \sum_{i=0}^{r} \tau_i \Delta LNEER_{t-i} + \sum_{i=0}^{s} \theta_i \Delta INF_{t-i} + \varphi ECM_{t-1} + \varepsilon_t, \tag{6}$$

where the error correction term, ECM_{t-1} captures the short-run dynamics.

ECM_{t-1} guides the variables in the system to restore back to the long-term equilibrium relationship which shows at what rate the short-run disequilibrium is eliminated. Its coefficient should be negative and statistically significant after the estimation, which subsequently validates that there is long-run equilibrium relationship among the variables.

Before conducting the ARDL estimation and co-integration tests, we use the Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) unit root tests to make sure we do not have any variables that are I(2). After the estimation, the overall stability of the empirical model is checked by using cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) methods by R. L. Brown, J. Durbin, and J. M. Evans (1975). We also check for serial correlation, normality, and heteroscedasticity.

If the series are co-integrated, there must be causality at least in one direction. We prefer the Hiro Y. Toda and Taku Yamamoto (1995) approach to determine the direction of causality since it can be used with a series of mixed order of integration, which is a distinct advantage over Engle-Granger's causality method. It is only necessary to specify the maximum order of integration (d_{max}) among the series. Then a $(p + d_{max})^{th}$ order VAR is run in levels, and a Wald test is performed by using the first p lags in the model. The Toda and Yamamoto Granger causality test does not require the series to be co-integrated either.

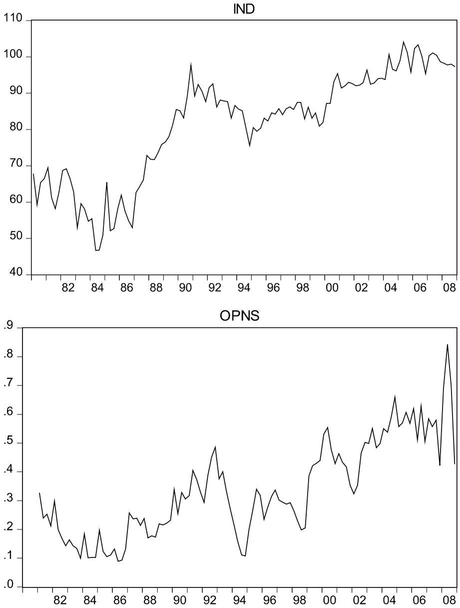
The equation for testing that LOPNS, LNEER, and INF cause LIND can be written as follows:

$$LIND_t = \sum_{i=1}^{p} \delta_i LIND_{t-i} + \sum_{i=1}^{p} \gamma_i LOPNS_{t-i} + \sum_{i=1}^{p} \tau_i LNEER_{t-i} + \sum_{i=1}^{p} \theta_i INF_{t-i} + \varepsilon_t. \tag{7}$$

Failing to reject the null hypothesis of $H_0: \gamma_1 = \cdots = \gamma_p = 0$ would mean that LOPNS does not Granger-cause LIND. The hypotheses that LNEER does not Granger-cause LIND and INF does not Granger-cause LIND can be tested similarly. To test for reverse causality, the same procedure must be repeated with the LOPNS, LNEER, and INF as the dependent variables in successive regressions, that is, a four-equation VAR model must be estimated.

The studies done on Nigeria mostly use annual data, and cover the period that spans the years before the liberalization as well as the ones after. We think it would be more appropriate, given the nature of the issue at hand, to concentrate on the period when the economy was more open to trade due to the trade liberalization that started in 1986. As can be seen from the plots of industrial production (IND) and openness (OPNS) over the period of 1980Q1 to 2008Q4 shown in Figure 2, both

IND and OPNS have downward trends before 1986, which means that our use of data from the period after 1986 only is unlikely to introduce any bias into the estimations. If the IND had been increasing when the economy was less open, limiting the sample to a period in which both IND and OPNS were increasing would bias the estimates upwards since the information from the earlier period suggesting a lower effect of OPNS on IND would be lost.



Source: Authors' estimations.

Figure 2 Industrial Production and Openness, 1981-2008

This study employs quarterly time series data. All data except for nominal GDP, and data on exports and imports, which were obtained from the Central Bank of Nigeria (CBN), came from the International Financial Statistics (IFS) database compiled by the International Monetary Fund (IMF). Descriptive statistics are given in Table 2.

Table 2 Descriptive Statistics

	Maximum	Minimum	Mean	Standard deviation
IND	104.05	62.59	88.18	8.937
OPNS	0.84	0.11	0.38	0.152
NEER	2040.28	96.58	459.61	490.16
INF	0.22	-0.05	0.05	0.06
LIND	4.64	4.14	4.47	0.106
LOPNS	-0.17	-2.23	-1.04	0.43
LNEER	7.62	4.57	5.65	0.96
Observations	88	88	88	88

Source: Authors' calculations.

4. Empirical Results

4.1 Unit Root Tests

We used two conventional unit root tests: Augmented Dickey-Fuller (ADF) test and Philips-Perron (PP) test. In ADF and PP methods, the null hypothesis is that the time series have a unit root, that is, they are non-stationary. If the calculated test-statistics for our variables in their level forms were more negative than the critical values, the null hypothesis was rejected, suggesting that variables are stationary in their level forms, that is, they are I(0). In cases where a variable is not stationary in levels, we investigated its stationarity in the first differencing. The result of Augmented Dickey-Fuller and Philips-Perron tests are given in the bottom and upper panels of Table 3, respectively (note that all variables, except for INF, are in natural logarithms).

Table 3 Unit Root Tests

Variables	Level		First difference	
	Intercept	Trend and intercept	Intercept	Trend and intercept
	Augmented Dickey-Fuller (ADF) test			
LIND	-5.431**	-5.086**	-11.15**	-11.598**
LOPNS	-2.874	-4.188**	-7.217**	-7.231**
LNEER	-2.130	-1.590	-11.098**	-11.161**
INF	-2.805	-3.280	-9.788**	-9.748**
	Philips-Perron (PP) test			
LIND	-4962**	-5.328**	-11.040**	-11.607**
LOPNS	-2.932*	-3.883**	-9.132**	-9.115**
LNEER	-2.130	-1.817	-11.098**	-11.015**
INF	-5.518**	-5.824**	-16.481**	-16.617**

Notes: The table entries are *t*-statistics. * and ** indicate 1% significance and 5% significance levels, respectively, to test the null hypothesis of unit root. Sample period: 1987:01-2008:04. Lag length selection criterion for the ADF test: Schwarz Information Criterion. Bandwidth selection method for the PP test: Newey-West automatic using Bartlett kernel.

Source: Authors' calculations.

The ADF test results indicate that only industrial production is stationary, that is, LIND~I(0). The other variables, openness, inflation, and nominal effective exchange rate became stationary after first differencing, that is, LOPNS~I(1), INF~I(1), and LNEER~I(1). Results of the PP method test indicate that industrial production, openness, and inflation are stationary, that is, LIND~I(0), LOPNS~I(0), and INF~I(0), whereas nominal effective exchange rate becomes stationary after first differencing, that is, LNEER~I(1). However, for us, the most important thing is that all variables are stationary after first differencing (with or without a trend variable included). Since none of the variables are I(2), we proceeded with the bounds testing for co-integration.

4.2 Bounds Testing

Bounds test results are reported in Table 4 and reveal that the optimal lag length is four. Our main interest is the relationship between LIND as the dependent variable and LOPNS, LNEER and INF as independent variables. We also report the test results obtained from running models with each one of independent variable taken as the dependent variable in turn.

The reported F-statistics are compared with the critical values for the lower and upper bounds. If the estimated F-statistic is higher than the upper bound of the critical values, then the null hypothesis of no co-integration is rejected. If the estimated F-statistic is lower than the bottom bound of critical values, that is, no co-integration relationship between the series null hypothesis cannot be rejected; if the calculated F-statistic is between the bottom and upper critical values, then, no exact opinion can be made.

The critical values shown in Table 4 are for the case of unrestricted intercept and no trend for the 5% significance level, which come from Pesaran, Shin, and Smith (2001), Table CI(iii) Case III (critical values for the 1% significance level are 4.29 and 5.61 for the lower and upper bounds, respectively). As shown in Table 4, the calculated F-statistic is 11.628 which is higher than the upper critical value at the 5% level of significance. Consequently, there is long-run relationship among industrial production, openness, nominal effective exchange rate, and inflation rate in Equation (5).

Table 4 ARDL Bounds Test of Co-Integration

Dependent variable	*F*-stat.	I(0) bound	I(1) bound	Test result
F(LIND|LOPNS,LNEER,INF)	11.628	3.23	4.35	Co-integration
F(LOPNS|LIND,LNEER,INF)	4.5753	3.23	4.35	Co-integration
F(LNEER|LIND,LOPNS,INF)	3.1764	3.23	4.35	No co-integration
F(INF|LIND,LOPNS,LNEER)	18.628	3.23	4.35	Co-integration

Notes: Critical values are from Pesaran, Shin, and Smith (2001), Table CI(iii) Case III, when the number of independent variables (k) equals three and the significance level is 0.05.

Source: Authors' calculations.

4.3 Long-Run Estimates

The long-run coefficients in Equation (4) calculated from the ARDL (3, 0, 3, 0) are given in Table 5. The results indicate that trade openness (LOPNS) has a positive and significant impact (p-value < 0.001) on Nigeria's industrial production (LIND): a 1% increase in trade openness increases industrial production by about 0.18%. The coefficient of the nominal effective exchange rate (LNEER) and the inflation rate (INF) are not significant. Consequently, these variables do not have any effect on industrial production in the long-run.

Table 5 Estimated Long-Run Coefficients

Repressors	Coefficient	*T*-ratio	Probability
$LOPNS_t$	0.18	5.098	0.0000
$LNEER_t$	0.019	0.998	0.3210
INF_t	-0.25	-1.299	0.1977

Notes: ARDL (3, 0, 3, 0) selected based on Akaike Information Criterion. Dependent variable is LIND and 88 observations were used for estimation from 1987Q1 to 2008Q4.

Source: Authors' calculations.

4.4 Short-Run Dynamics

We employed the error correction representation for the selected ARDL model to proceed with the short-run estimation. Table 6 shows the results of the estimation of Equation (6). Apart from the first and second differences of the dependent variables ($\Delta LIND_{t-1}$ and $\Delta LIND_{t-2}$), and the change in trade openness (ΔLOPNS) and the second difference of LNEER ($\Delta LNEER_{t-2}$) are the only variables that exert a statistically significant impact on the change in industrial production (ΔLIND) in the short-run. The lagged error correction coefficient, ECM(-1), is negative and statistically significant (p-value < 0.001). The measurement of the speed of adjustment back to long-run equilibrium following a shock, its coefficient of -0.34, implies that 34% of the previous quarter's shock adjusts back to long-run equilibrium in the current quarter.

Table 6 Error Correction Representation for the Selected ARDL

Regressor	Coefficient	*T*-ratio	Probability
$\Delta LIND_{t-1}$	-0.24	-2.91	0.0047
$\Delta LIND_{t-2}$	-0.31	-3.86	0.0002
$\Delta LOPNS_{t}$	0.06	3.36	0.0012
$\Delta LNEER_{t}$	0.04	1.22	0.2245
$\Delta LNEER_{t-1}$	0.03	1.34	0.1838
$\Delta LNEER_{t-2}$	0.05	2.08	0.0408
ΔINF_{t}	-0.06	-0.99	0.3206
ECM_{t-1}	-0.34	-7.57	0.0000

Notes: ARDL (3, 0, 3, 0) selected based on Akaike Information Criterion. Dependent variable is LIND and 88 observations were used for estimation from 1987Q1 to 2008Q4.

Source: Authors' calculations.

4.5 Diagnostic Tests

The ARDL model passes all diagnostic tests, such as the Lagrange multiplier test of residual serial correlation (we also checked the correlograms of residuals squared, and found no evidence of serial correlation), Ramsey's RESET test using the square of the fitted values (functional specification), Jarque-Bera normality test, and Breusch-Pagan-Godfrey test of heteroscedasticity (see Table 7).

Table 7 Diagnostic Tests

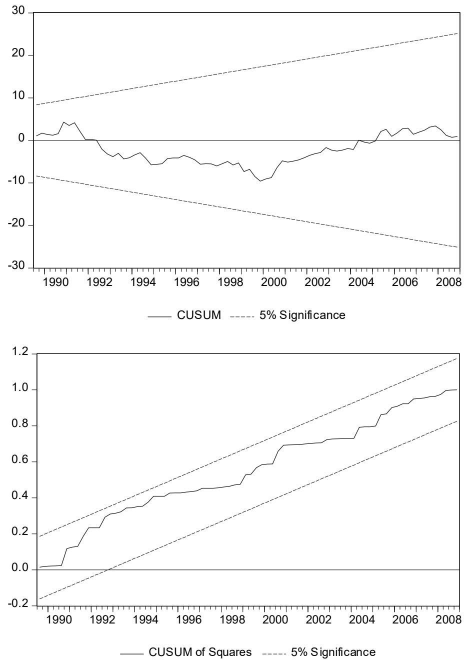
Test	Type	Test statistics	d.f.	Probability
A: Serial correlation	χ^2	2.1991	2	0.3330
B: Normality	χ^2	2.6815	2	0.2614
C: Heteroscedasticity	χ^2	9.5917	2	0.3845
D: Functional form	F	0.1465	(1,77)	0.7029

Notes: Based on ARDL (3, 0, 3, 0) selected by using Akaike Information Criterion. A: Breusch-Godfrey Lagrange multiplier test of residual serial correlation; B: Jarque-Bera residual normality test; C: Breusch-Pagan-Godfrey test of heteroscedasticity; D: Ramsey's RESET test.

Source: Authors' calculations.

Figure 3 shows the stability test results of the model obtained by using the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests by

Brown, Durbin, and Evans (1975). The plots shown in Figure 1 indicate that the dependent variable (industrial production) and short-run model parameters satisfied the stability condition of the model. This means that the null hypothesis that all coefficients in the regression models are stable cannot be rejected because both plots of CUSUM and CUSUMSQ lie within the critical bounds of 5% significance levels.



Source: Authors' estimations.

Figure 3 Plots of the CUSUM and CUSUMSQ Stability Tests

4.6 The Results of the Toda and Yamamoto Causality Analysis

The first step in the Toda and Yamamoto causality analysis is the lag selection. The AIC criterion indicates that the optimal lag length is three. However, the residuals from the estimations with three lags are found to be serially correlated. When the lag length is increased to four, this problem is solved, that is (p = 4). This model also passes the stability test as there are no inverse roots outside the unit circle.

As mentioned previously in the Toda and Yamamoto analysis, an extra lag for all the variables must be included in the model. The lag length is determined by the maximum order of integration in the model (d_{max}). Since $d_{max} = 1$, we estimate ($p + d_{max}$) = (4+1) = 5th order VAR. This step can be done by treating the extra lags as exogenous variables in estimations just like the constant.

VAR Granger causality/Block Exogeneity Wald Test results are given in Table 8. These results show that LOPNS Granger-causes LIND (at the 10% significance level), but there is no reverse causality from LIND to LOPNS.

Table 8 Toda-Yamamoto Granger Causality Test Results

Excluded	Chi-square	d.f.	Probability
		Dependent variable: LIND	
LOPNS	8.6758	4	0.0697
LNEER	2.2745	4	0.6854
INF	1.8015	4	0.7722
All	15.928	12	0.1945
		Dependent variable: LOPNS	
LOPNS	6.3994	4	0.1712
LNEER	13.242	4	0.0102
INF	3.1099	4	0.5396
All	18.871	12	0.0917
		Dependent variable: LNEER	
LOPNS	2.4256	4	0.6580
LNEER	7.2224	4	0.1023
INF	1.4137	4	0.8418
All	14.008	12	0.3002
		Dependent variable: INF	
LOPNS	4.9102	4	0.2966
LNEER	3.7066	4	0.4472
INF	8.5786	4	0.0725
All	18.838	12	0.0925

Notes: This table reports the results of VAR Granger causality/Block Exogeneity Wald Test. The null hypothesis is *x* does *not* cause the dependent variable (*x* being one of the variables listed in the first column). There were 88 observations used for estimations from 1987Q1 to 2008Q4.

Source: Authors' calculations.

4.7 Robustness Checks

Repeating the empirical analysis presented so far by using the Schwarz Criterion (SIC) does not change the results much. The long-run coefficient of LOPNS remains positive and significant, and those of LNEER and INF remain insignificant with their signs unchanged. The ECM term is also significant and negative. SIC selects the ARDL (3, 0, 0, 0) model, and the estimated model passes all diagnostic tests. Our findings are also robust to include restricted constant or restricted trends instead of an unrestricted constant, and increasing the maximum lag length from four to eight.

The results reported above were obtained by using data that are not seasonally adjusted. We seasonally adjusted all data series and repeated the above analysis (we used 1 + INF instead of INF to avoid the problems that the negative values create for the seasonal adjustment software). The X-13ARIMA-X11 seasonal adjustment method developed by the United States Census Bureau was used for seasonal adjustment. We found that there is co-integration among the variables when seasonally adjusted series are used to run Equation (4) (see Table 9).

After establishing co-integration, we proceeded with the ARDL (3, 0, 0, 0) model selected based on AIC, which yielded the results for the long-run and short-run reported in Tables 10 and 11, respectively. The long-run coefficients reported in Table 10 shows that apart from the coefficient of the seasonally adjusted (1 + INF) being more negative than the coefficient of INF reported in Table 10, there are no important changes. In the error correction model, the ECM term is less negative compared to the one obtained when there was no seasonal adjustment (see Table 11). Diagnostic tests results are reported in Table 12, and show no indication of any problems. Figure 4 shows the stability test results.

Table 9 ARDL Bounds Test of Co-Integration (Obtained by Using Seasonally Adjusted Data)

Dependent variable	*F*-stat.	I(0) bound	I(1) bound	Test result
F(LIND|LOPNS,LNEER,INF)	13.739	3.23	4.35	Co-integration
F(LOPNS|LIND,LNEER,INF)	3.3479	3.23	4.35	Inconclusive
F(LNEER|LIND,LOPNS,INF)	3.8383	3.23	4.35	Inconclusive
F(INF|LIND,LOPNS,LNEER)	5.1073	3.23	4.35	Co-integration

Notes: Critical values are from Pesaran, Shin, and Smith (2001), Table CI(iii) Case III, when the number of independent variables (k) equals three and the significance level is 0.05.

Source: Authors' calculations.

Table 10 Estimated Long-Run Coefficients (Obtained by Using Seasonally Adjusted Data)

Repressors	Coefficient	*T*-ratio	Probability
$LOPNS_t$	0.18	3.55	0.0006
$LNEER_t$	0.021	0.823	0.4128
INF_t	-0.48	-1.573	0.1195

Notes: ARDL (3, 0, 0, 0) selected based on Akaike Information Criterion. Dependent variable is LIND and 88 observations were used for estimation from 1987Q1 to 2008Q4.

Source: Authors' calculations.

Table 11 Error Correction Representation for the Selected ARDL (Obtained by Using Seasonally Adjusted Data)

Regressor	Coefficient	*T*-ratio	Probability
$\Delta LIND_{t-1}$	-0.24	-2.98	0.0038
$\Delta LIND_{t-2}$	-0.19	-2.37	0.0202
$\Delta LOPNS_t$	0.03	1.58	0.1172
$\Delta LNEER_t$	0.02	0.51	0.6076
ΔINF_t	-0.11	-1.42	0.1581
ECM_{t-1}	-0.25	-8.13	0.0000

Notes: ARDL (3, 0, 0, 0) selected based on Akaike Information Criterion. Dependent variable is LIND and 88 observations used for estimation from 1987Q1 to 2008Q4.

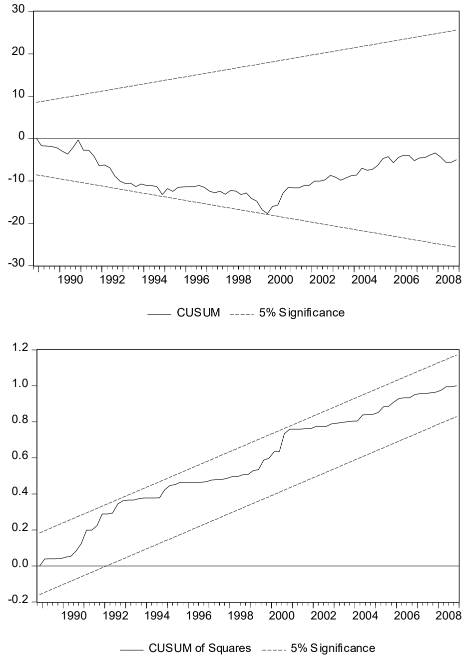
Source: Authors' calculations.

Table 12 Diagnostic Tests (for the Model Using Seasonally Adjusted Data)

Test	Type	Test statistics	d.f.	Probability
A: Serial correlation	χ^2	0.947	2	0.6228
B: Normality	χ^2	2.237	2	0.888
C: Heteroscedasticity	χ^2	3.735	2	0.7125
D: Functional form	F	0.0000	(1,80)	0.9926

Notes: Based on ARDL (3, 0, 0, 0) selected by using Akaike Information Criterion. A: Breusch-Godfrey Lagrange multiplier test of residual serial correlation; B: Jarque-Bera residual normality test; C: Breusch-Pagan-Godfrey test of heteroscedasticity; D: Ramsey's RESET test.

Source: Authors' calculations.



Source: Authors' estimations.

Figure 4 Plots of the CUSUM and CUSUMSQ Stability Tests (with Seasonal Adjustment)

The results from the Toda-Yamamoto analysis with seasonally adjusted data are given in Table 13. The results show that Granger causality runs from openness to industrial production, but not in the reverse direction. This is the same result obtained with unadjusted data.

Table 13 Toda-Yamamoto Granger Causality Test Results (Obtained by Using Seasonally Adjusted Data)

Excluded	Chi-square	d.f.	Probability
		Dependent variable: LIND	
LOPNS	9.7604	4	0.0447
LNEER	2.8164	4	0.5890
INF	1.2893	4	0.8632
All	15.9057	12	0.1956
		Dependent variable: LOPNS	
LOPNS	4.8899	4	0.2988
LNEER	9.79	4	0.0441
INF	1.419	2	0.8409
All	11.7227	12	0.4682
		Dependent variable: LNEER	
LOPNS	2.445	4	0.6545
LNEER	9.1252	4	0.058
INF	6.5594	2	0.1611
All	17.922	12	0.1181

	Dependent variable: INF		
LOPNS	1.9192	4	0.7506
LNEER	3.254	4	0.5163
INF	12.132	2	0.0164
All	21.4647	12	0.044

Notes: This table reports the results of VAR Granger causality/Block Exogeneity Wald Test. The null hypothesis is *x* does *not* cause the dependent variable (*x* being one of the variables listed in the first column). There were 88 observations used for estimations from 1987Q1 to 2008Q4.

Source: Authors' calculations.

5. Conclusion

This study employed the ARDL bounds test co-integration technique of Pesaran, Shin, and Smith (2001) to investigate the impact of openness to trade, along with nominal effective exchange rate and the inflation rate on industrial performance in Nigeria using time series data from 1986 to 2008. We examined whether a long-run relationship exists in Nigeria between industrial production, openness to trade, nominal effective exchange rate, and the inflation rate. We also examined the short-run dynamics of the model by using the error correction model. The results were checked and confirmed by the diagnostic tests and stability test of Brown, Durbin, and Evans (1975), the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) methods.

We found that openness to trade has a significant relationship with industrial production in the period that followed the inception of the Structural Adjustment Programme (SAP) in 1986 both in the long-run and the short-run. This is similar to the results obtained by others, for example, Olufemi (2004), Adegbemi B. O. Onakoya, Ismail Fasanya, and M. T. Babalola (2012), and Umoh and Effiong (2013). In the long-run, a 1% increase in trade openness increases industrial production by about 0.18%. The results show that inflation rate and nominal effective exchange rate do not have an effect on industrial production neither in the long-run nor in the short-run. The Toda-Yamamoto causality analysis indicates that trade openness Granger-causes industrial production; there is no indication of reverse causality. When seasonally adjusted data are used, results do not change, and the Toda-Yamamoto causality analysis still indicates one way Granger causality in the same direction as before.

Concerning the case of Nigerian policy objectives, our results suggest that openness to trade could be beneficial for economic growth, although in the Nigerian case, export diversification policies must also be pursued to reduce the overdependence of the economy on crude-oil exports. Alongside reducing the remaining trade barriers to further open the economy to trade, Nigeria could also foster regional trade integration as proposed by the Economic Community of West African States (ECOWAS), and boost international trade integration as a means of improving economic growth and poverty alleviation, which is one of the aims of the current administration following the Millennium Development Goals of the World Bank.

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