Transmission of Exchange Rate Movement to Domestic Prices in Oil Producing Economy: Evidence from Nigeria

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Abstract: Using monthly dataset ranging from January 1980 to December 2016, we explore the case of oil-producing economies namely, Nigeria to evaluate the potential vulnerability of domestic prices to exchange rate movements. Mainly, we utilise the ARDL Bound cointegration testing approach as well the Toda-Yamamoto VAR to determine: (i) the short-run and long-run dynamic of the pass-through and (ii) the magnitude and the direction of the pass-through. Empirically, we find evidence of long-run relationship among exchange rate movement, import price and chain of other prices under consideration. Supporting this evidence is the theoretical appropriateness and significance of the error correction coefficient. Specifically, we find that on average, import prices have the potential of reverting to equilibrium state by 31% of any disequilibrium caused by previous months' shock. However, our finding of no significant EPRT nonetheless the short or long run situations seems puzzled, particularly for a volatile economy such as Nigeria. This may be because exchange rate regimes in the country since independence hovered around the pegged regime and manage float regime. The study further explores TYDL VAR Granger causality test and shows that exchange rate pass-through to import prices is as high as 7%, but mainly when the causality runs from export prices to import and from exchange rate to export prices.

Keywords: Exchange Rate; Pass-through; Domestic Prices; ARDL; TY-VAR

JEL Classification: E3; E4; E6; F3; F4

1. Introduction

The extent to which exchange rate movement affect prices of imported goods and consumer prices has continued to garner attention from researchers across the globe. Conceptually, the process to which domestic prices reflect currency fluctuation termed exchange rate pass-through (ERPT). Theoretically, the ERPT may be complete implying one-to-one in the response of domestic prices changes in exchange rate movement and incomplete ERPT for change in domestic prices that are less than one per cent for a one per cent change in the exchange rate. The

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completeness or incompleteness of the ERPT notwithstanding, that an appreciation of exchange rate reduces for example import prices, while the reverse should hold for exchange rate depreciation. Existing empirical literature on EPRT is categorised into three strands of studies. The first includes studies that focus on disaggregated import prices of specific domestic industries. The second strand of literature includes studies that evaluate the ERPT on aggregated import prices, while the third categories of studies on ERPT measure their domestic prices via consumer price index.

The view that ERPT is a micro-phenomenon started with Dornbusch (1987) seminar paper and had since found support in Campa and Goldberg (2005) who relate the level of (ERPT) to the product composition of imports. However, Marazzi et al. (2005), Taylor (2000), Choudhri and Hakura (2006), Ca'Zorzi et al. (2007), and Bussiere and Peltonen (2008) have rather analysed the ERPT from a macro perspective. While acknowledging this, there has been a large volume of empirical literature documenting the transmission of exchange rate movement into domestic prices. Existing studies have continued to focus on the case of developed economies, with little or no attempt to understand how exchange rate movement transmitted into domestic prices of developing oil-producing economies.

Premising on the increasing integration of the world economy coupled with the assertions that oil-producing economies are mostly imports dependent. Hence, the innovation in this study is to determine the extent to which changes in oil price matters for the degree of ERPT in the context of the oil-producing economy. Essentially, the study utilises an ARDL Bound cointegration test to examine the short and long-run dynamics of ERPT. We further explore the Toda-Yamamoto VAR empirical modelling approach to determine not only the magnitude but also the direction of ERPT.

Following this introductory section, the remaining sections of the paper are divided into four as follows: Section two dwells on existing empirical literature on the dynamics of ERPT. Here, the study reviews some empirical findings on the degree and direction of the pass-through of fluctuations in the exchange rate to domestic prices. Section three discusses the methodology and specified the estimated model. Section four explained the data and carried out a preliminary to understand the statistical features of the variables under consideration and whether the specified model is adequate to capture those features. Section five presents and discusses the empirical results, while section six draws a conclusion and provide policy implications.

2. Literature Review

Motivated by the assertion that movement in exchange rate could impact import, producer and consumer prices via trade distortions, fluctuations in exchange rate, among others, a number of studies, namely; Karagoz et al. (2016), Mirdala (2014), Choudhrin and Hakuar (2013), Ghosh (2013), Jiang and Kim (2013), Odria et al. (2012), Brun-Aguerre et al. (2012), Marazzi and Sheets (2007), Barhoumi (2006), and Choudhrin and Hakuar (2006) have examined the dynamics of ERPT accounting for some of these factors. However, whether the completeness or partial nature of ERPT has been the concern of some of the extant studies, see for example, He, 2015; Mohammed, 2015; Saha and Zhang, 2014; Kumar, 2014; Uddin et al. , 2014; Zubair et al. , 2013; Al-Abri and Goodwin, 2009; Ghosh and Rajan, 2009; Bhattacharya, 2008; and the likes. Using a panel estimation technique, Brun-Aguerre et al. (2012) identify factors such as inflation, exchange rate volatility, openness and relative wealth as significant for explaining ERPT in emerging economies. For Barhoumi (2006), exchange rate regimes, trade barriers and inflation regimes were identified as the accelerator of ERPT into import prices of developing economies. Marazzi and Sheets (2007) attribute the declining nature of ERPT to US import prices to global factors such as; increasing prominence of competition from China, a shift in import pricing pattern which follows up from the Asian financial crisis, and lastly due to the reduced share of material-intensive goods in U. S. imports.

Karagoz et al. (2016), Choudhrin and Hakuar (2013), and Odria et al. (2012) though differs in their methodological approaches, as well as the data-set, utilises in their respective studies, yet their finding unanimously suggests that adopting inflation targeting policy could lower the degree of ERPT. Peon and Brindis (2014), Lin and Wu (2012), Gagnon and Ihrig (2004), Taylor (2002), Mishkin and Schmidt-Hebbel (2002), among others, have also analysed ERPT within the framework of inflationary targeting environment. Using the case of G-7 countries, Jiménez-Rodrígueza and Morales-Zumaquero (2016) show that there is a positive and significant correlation between ERPT and inflation volatility and that the degree of ERPT depends on the exchange rate regime being practised. Using a post-Bretton Woods industry-level dataset, Bhattacharya (2008) analysis EPRT ERPT for the case of the USA, UK, and Japan. Empirical finding from the study shows that the degree varies for the countries. Using a structural autoregressive model to investigate the transmission of exchange rate movements to domestic prices, Zubair et al. (2013) report the ERPT as incomplete in the case of Nigeria. In a similar development, Saha and Zhang (2014) carried out a comparative analysis using the case of Australia, China, and India and their result indicate the ERPT as relatively lower in China and India when compared to ERPT in Australia.

Al-Abri and Goodwin (2009) use a non-linear estimation technique to re-examine the exchange rate pass-through into import prices of 16 OECD countries. Their

finding shows that import prices respond faster and by a larger extent to exchange rate shocks. In a similar development, Aleem and Lahiani (2014) model exchange rate pass-through in Mexico using a threshold VAR and finds that the ERPT is statistically significant above the threshold level of the inflation rate, but insignificant below it. Ahmad and Muda (2013) estimate exchange rate pass-through for Sukuk issuing countries using recursive VAR model. Their finding shows that import and consumer prices pass-through increases in the long horizon in the case of Bahrain and Saudi Arabia, but lower for other countries. Analysing the case of Central and Eastern European member states, Beirne and Bijsterbosch (2011) report ERPT as higher for countries that adopt a fixed exchange rate regime. Yanamandra (2015), Mohammed (2015), Jimborean (2013), Oyinlola and Egwaikhide (2011) also finds evidence of significance ERPT in their respective studies.

Table 1A. Cursory of the Review of Literature on Exchange Rate Pass-Through into Domestic Prices

Author(s)	Title/Country	Data/Period	Methodology	Findings
Ahmad and Muda (2013)	Exchange rate pass-through estimates for Sukuk issuing countries	Annual Time Series: (1970-2010)	Recursive VAR model	Shows that import and consumer prices pass-through increases on the long horizon in the case of Bahrain and Saudi Arabia.
Al-Abri and Goodwin (2009)	Re-examining exchange rate pass-through into import prices of 16 OECD countries	Quarterly Time Series: (1975-2012)	Non-Linear Threshold Cointegration Approach	That the extent of responding of import prices to exchange rate is faster via threshold cointegration approach as against the conventional Model.
Aleem and Lahiani (2013)	A threshold vector autoregression model of exchange rate pass-through in Mexico	Monthly Time Series: (1994-2009)	Threshold VAR model	Shows that the exchange rate pass-through to domestic prices is statistically significant above the threshold level of the inflation rate, but statistically insignificant below it.
Barhoumi (2006)	Differences in long-run exchange rate pass-through into import prices in 24 developing countries	Annual Panel Data: (1980-2003)	The non-stationary Panel estimation technique	Shows that differences in exchange rate pass-through into import prices are due to macroeconomic determinants.
Beirne and Bijsterbosch (2011)	Exchange rate pass-through in central and eastern European EU member states	Monthly Data (1995-2009)	Variant cointegrated VAR and VECM	Finds that ERPT is higher for countries that have adopted some form of fixed exchange rate regime.
Bhattacharya et al. (2008)	Exchange rate pass-through and relative prices: An industry-level empirical investigation for USA, UK, and Japan	Monthly Time Series	VAR model framework	Reveals considerable variation in the extent of pass-through across industries and countries.

	empirical investigation for USA, UK, and Japan			
Brun-Aguerre et al. (2012)	Exchange rate pass-through into import prices revisited: What drives it in 18 emerging markets and 19 developing markets?	Quarterly Data: (1980-2009)	Time Series and Panel Estimation Techniques	That the pass-through is more effective via unobserved country-specific than via observable country-specific.
Choudhry and Hakura (2006)	Exchange rate pass-through to domestic prices of 71 selected developing and industrial countries: Does the inflationary environment matter	Annual Time Series: (1979-2000)	Time series and panel regression approaches	Reports strong evidence of a positive and significant relationship between the pass-through and the average inflation rate across countries and periods.
Choudhria and Hakura (2014)	The exchange rate pass-through to import and export prices: the role of nominal rigidities and currency choice in 18 advanced countries and 16 emerging economies	Quarterly Data: (1972-2010)	Dynamic General Equilibrium Model (DGEM)	That the exchange rate pass-through to import prices for a large number of countries is incomplete and larger than the pass-through to export prices.
Ghosh (2013)	Exchange rate pass-through, macro fundamentals, and regime choice in Latin America	Quarterly Data (1970-2010)	Time Series and Panel Data Estimation Techniques	Finds ERPT to be positively influenced by money supply growth, interest rate volatility and inflation rates.
Ghosh and Rajan (2009)	Exchange rate pass-through in Korea and Thailand: Trends and determinants	Quarterly Time Series (1980-2006)	Dynamic OLS (DOLS)	That ERPT seems consistently higher for Thailand compared to Korea.
He et al. (2015)	Measure the pass-through of the RMB exchange rate to prices of different industries in China.	Monthly Time Series: (1999-2014)	Time series method and Dynamic Bayesian Network method	It shows that wood, chemistry, textile, and other labour-intensive industry prices are sensitive to the fluctuation of the RMB exchange rate, yet the pass-through is not significant for energy, black metal, non-ferrous metals, and other mineral industries prices.
Jiang and Kim (2013)	Exchange rate pass-through to inflation in China	Monthly Time Series: (1999-2009)	A Structural VAR model	Finds that ERPT to the producer price index (PPI) and retail price index (RPI) are generally incomplete
Jimborean (2013)	The exchange rate pass-through in the new EU member states	Quarterly Data (1996-2011)	Panel Model (Generalized Method of Moment)	Reports a statistically significant ERPT to consumer, producer and import prices both in the short and long run
Jiménez-Rodríguez and Morales-Zumaquero (2016)	A new look at the exchange rate pass-through in the G-7 countries	Quarterly Data (1970-2014)	Single equation approach, the VAR approach, and the time-varying approach.	Indicates a robust and positive significant connection between ERPT and inflation volatility and that the ERPT depends on the exchange rate regimes.
Karagoz et al. (2016)	The pass-through effect from	Annual Panel Data: (2002-	Panel VAR model	Shows that the pass-through effect in Asia Pacific economies

	exchange rates to the prices in the framework of inflation targeting Policy: A Comparison of Asia-Pacific, South American, and Turkish Economies	2010)		is lower than pass-through effects in Latin America and Turkey.
Kumar (2014)	Exchange rate pass-through in India	Monthly Time Series: (1995-2013)	A Structural VAR model	Finds that exchange pass-through has no significant impact on domestic prices in India
Lin and Wu (2012)	Exchange rate pass-through in deflation: the case of Taiwan	Monthly Time Series (1981-2008)	Threshold Autocorrelation Model (TAR)	Indicate that the price of oil influences the measurement of the degree of pass-through. Hence, changes in the degree of pass-through are less variable once the price of oil is excluded.
Marazzi and Sheets (2007)	Declining exchange rate pass-through to U.S. import prices: The potential role of global factors	Quarterly Time Series: (1972-2004)	Rolling regressions (with a fixed 10-year window)	Reports a robust and sustained decline in exchange rate pass-through to U.S. import prices.
Mirdala (2014)	Exchange rate pass-through to consumer prices in the European transition economies	Monthly Time Series: (2000-2012)	Vector Autoregression (VAR) model.	Reveals different patterns of exchange rate pass-through to domestic prices according to the baseline period as well as the exchange rate regime diversity.
Mohammed (2015)	Exchange rate pass-through in Algeria	Quarterly Time Series: (2002-2011)	Vector Autoregression (VAR) model.	Shows that the pass-through is complete for EURO/DZ, but modest US dollar /DZ exchange rate.
Odria et al. (2012)	Does the exchange rate pass-through into prices change when inflation targeting scheme is adopted in Peru	Monthly Time Series: (1994-2007)	Dynamic stochastic general equilibrium model (DSGEM) and VAR model	Reveals that the decision to adopt inflation targeting decreased the exchange rate pass-through significantly.
Oyinlola and Egwakhide (2011)	Exchange rate pass-through in Nigeria: A dynamic investigation	Annual Time Series: (1980-2008)	Vector Error Correction Model (ECM)	Reveals evidence of a long-run relationship between exchange rate pass-through and domestic price level, but the short-run impact is not elusive evident.
Peon and Brindis (2014)	Analysing the Exchange Rate Pass-through in Mexico: Evidence Post Inflation Targetng Implementation	Monthly Time Series: (2001-2013)	Recursive Structural VAR with exogenous variables (recursive SVAR-X)	Finds that exchange rate pass-through to consumer prices is quite small and fast and exchange rate surprises are not relevant to explain consumer price inflation variation.
Saha and Zhang (2012)	Do exchange rates affect consumer prices? A comparative analysis for Australia, China, and India	Monthly Time Series: (1990-2011)	A Structural VAR model	The finding suggests that exchange rates have less effect on the rising domestic prices in China and India.
Uddin et al. (2014)	The impact of depreciation on the domestic price level of Bangladesh	Quarterly Time Series: (2000-2011)	A Structural VAR model	Indicate strong evidence of a positive and significant relationship between the pass-through and average inflation rate.
Yanamandra (2015)	Exchange rate changes and inflation in India: What is the extent of exchange rate pass-through to imports?	Monthly Time Series (2003-2013)	Error Correction Model (ECM)	Shows that there is more than complete exchange rate pass-through into Indian import prices in both the short-run long run.
Zubair et al. (2013)	Exchange Rate Pass-Through to Domestic Prices in Nigeria	Quarterly Time Series: (1986-2010)	A Structural VAR model	Suggests that exchange rate pass-through into domestic prices in Nigeria is incomplete, low, and fairly slow.

3. Methodological Framework

3.1. The Model

To empirically evaluate the dynamics of exchange rate pass-through in the context of the oil-producing economy namely Nigeria, this study explores the law of one price which is the same theoretical foundation previous studies such as Al-Abri and Goodwin (2009) and Campa and Goldberg (2002) utilises in their analysis of ERPT. The law of one price posits that changes in the exchange rate are expected to be fully reflected in domestic prices such that, a one per cent change in exchange rate leads to a one per cent change in domestic prices (complete pass-through). Consequently, the law refers to less than one-to-one per cent response of domestic prices to exchange rate as incomplete pass-through.

Following Campa and Goldberg (2005) as cited in Barhoumi (2005), the exchange rate pass-through model represented as the elasticity of import prices to a change in exchange rates could be stated as thus;

$$dp_t = ep_t^* \qquad (1)$$

Where p_t is the home currency price of the good in the local country, p_t^* is the foreign currency price of the good in the foreign country and *e* is the exchange rate of the local currency per unit of the foreign currency. Equation (1) can be expressed regarding import prices p_t^{mp} as:

$$p_t^{MP} = p^{EX} e^{NEER} \qquad (2)$$

Where e^{NEER} is the nominal effective exchange rate and p^{EX} represents export prices. According to Al-Abri and Goodwin (2009), the export prices in equation (2) is a function of both markup (θ) and $\left(c^{EPC}\right)$ the producer's marginal cost and as such can be expressed as:

$$p^{EX} = \theta c^{EPC} \qquad (3)$$

Embracing the assumption of costless arbitrage (i. e. no markup), import prices in local currency can then be represented as:

$$p^{MP} = p^{EX} e^{NEER} = e^{NEER} c^{EPC} \qquad (4)$$

While equations (4) originally imply that import prices are affected by both exchange rate and foreign costs of production, to account for the peculiarity of the concerned economy (Nigeria in this case), we further explore price generating framework to allow for the incorporation of other factors in the pass-through equation. Such factors in the context of this study include world oil price and additional domestic prices indicators. To this end, the empirical specification of the pass-through equation using a log-linear transformation is as follows:

$$\ln MP_t = \alpha + \beta_1 \ln XP_t + \beta_2 \ln NEER_t + \beta_3 \ln OP_t + \beta_4 \ln CPI_t + \beta \ln PPI_t + \varepsilon_i \qquad (5)$$

Equation (5) is the study's baseline equation. This is akin to the standard exchange rate pass-through model, where *(lnMP)* denotes log of import price index, (*lnXP*) is log of export price index, (*lnNEER*) is log of nominal effective exchange rate, (l*nOP*) is log of world oil price movement, (*lnCPI*) is the log of consumer price index, while (*lnPPI*) is log of producer price index.

3.2. Econometric Technique

To examine the long and short-run dynamics of ERPT to domestic prices in Nigeria, we structured our estimation procedure into three phases. The first phase would involve some pre-tests such as unit root and cointegration tests. The second procedure is a concern with the model estimation, while the final phase involves some diagnostic tests meant to ascertain the robustness of the model used for our estimation. In the first phase, the three-unit root tests conducted are Augmented Dickey-Fuller (ADF), Dickey-Fuller GLS and Ng-Perron unit root tests. In an attempt to examine the existence of a long-run relationship among the variables of interest, the study employs the Pesaran et al. (2001) Autoregressive distributed lag (ARDL) test for co-integration.

The use of ARDL co-integration approach rather than the conventional Johansen co-integration testing hinges on some features of the former. These features include a mixture of I(0) and I(1) data, assigned different lag-lengths for different variables as they enter the model. It does not require unit root testing which is a prerequisite in the conventional approach, it could be used regardless of whether the underlying variables are I(0), I(1) or fractionally integrated, and this is coupled with the facts that it involves just a single-equation set-up, making it simple to implement and interpret.

The above nonetheless, to apply the bound test, it is important to make sure that the variables under consideration are not integrated at an order higher than one. In a situation where there is the presence of I(2) variables, the critical value provided by Pesaran et al. (2001) is no longer valid. Thus, the following ARDL representation of equation (5) would be estimated to test the existence of a long-run relationship between exchange rate movement and domestic prices in the model:

$$\ln MP_t = \beta_0 + \sum_{i=1}^{k} \beta_1^i \Delta \ln NEER_{t-i} + \sum_{i=1}^{k} \alpha_2^i \Delta \ln XP_{t-i} + \sum_{i=1}^{k} \alpha_3^i \Delta \ln OP_{t-i} + \sum_{i=1}^{k} \alpha_4^i \Delta \ln CPI_{t-i} + \sum_{i=1}^{k} \alpha_5^i \Delta \ln PPI_{t-i} + \sum_{i=1}^{k} \beta_6^i \Delta \ln MP_{t-i} +$$
$$\beta_7 \ln NEER_{t-1} + \beta_8 \ln XP_{t-1} + \beta_9 \ln OP_{t-1} + \beta_{10} \ln CPI_{t-1} + \beta_{11} \ln PPI_{t-1} + \beta_{12} \ln MP_{t-1} \quad (6)$$

To determine the optimal lag length for the ARDL model, lag selection criteria such as the Schwartz Information Criteria (SIC) and Akaike Information Criteria (AIC) are employed, and the lag combination that minimises these criteria is the optimal lag. Given the chosen lag requires, the F-test is used for testing the existence of a long-run relationship in equation (6), where the null hypothesis of no long-run relationship is defined as $(H_O : \beta_7 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = \beta_{12} = 0)$

The F-test has a non-standard distribution which depends upon: (i) whether variables included in the ARDL model are to be I(0) or I(1), (ii) whether the ARDL model contains an intercept and a trend. Pesaran and Pesaran (1997) reported two sets of critical values (CVs): one set is calculated assuming that all variables included in the

ARDL model are I(1) and the other is estimated considering the variables are I(0). If the calculated F-statistic is higher than the upper bound critical value, it suggests rejection of the null hypothesis of no long-run relationship. If the calculated F-statistic is lower than the lower bound of the critical value, then the null hypothesis cannot be rejected. Finally, if it falls in between the lower and upper bound, then the result is inconclusive. Once the cointegrating relationship is established, the short-run dynamics are also analysed. The error correction model representation of the ARDL model is specified in equation (7) below:

$$\Delta \ln MP_t = \alpha_0 + \sum_{i=1}^{k} \alpha_1^i \Delta \ln NEER_{t-i} + \sum_{i=1}^{k} \alpha_2^i \Delta \ln XP_{t-i} + \sum_{i=1}^{k} \alpha_3^i \Delta \ln OP_{t-i} + \sum_{i=1}^{k} \alpha_4^i \Delta \ln CPI_{t-i} + \sum_{i=1}^{k} \alpha_5^i \Delta \ln PPI_{t-i} + \sum_{i=1}^{k} \beta_6^i \Delta \ln MP_{t-i} + \lambda ECM_{t-1} + \varepsilon_t \quad (7)$$

Where λ is the speed of adjustment parameter and the error correction term (ECM) is the OLS residuals series from the long-run cointegrating regression? The *ECM* coefficient is expected to be significant with a negative sign (this is necessary for it to perform the role of error correction).

Causality Test

To complement this study, we further employ Toda and Yamamoto (1995) and Dolado and Lutkepohl (1996) (TYDL henceforth) causality testing approach to determine the direction and the degree of the pass-through. Although, there are others prominent approaches to implement causality testing namely; a VAR model in the level data; a VAR model in the first difference data (VARD), and a vector error correction model (VECM). But the simulation results by Yamada and Toda (1998), rather suggests that of all the prominent causality procedures, TYDL is relatively the more stable when compared to VAR and VECM. The main rationale behind TYDL is to artificially augment the correct VAR order, *k*, with $_{Dmax}$ extra lags, where $_{Dmax}$ is the maximum likely order of integration of the series contained in the system.

In this present study, however, we follow the TYDL framework and the given lag augmented VAR (k + Dmax) for a distribution chain of prices is represented as follows:

$$\begin{bmatrix} Y_{1t} \\ Y_{2t} \\ Y_{3t} \\ Y_{4t} \\ Y_{5t} \end{bmatrix} = \begin{bmatrix} \delta_{10} \\ \delta_{20} \\ \delta_{30} \\ \delta_{40} \\ \delta_{50} \end{bmatrix} + \sum_{i=1}^{k} \begin{bmatrix} \delta_{11,i} & \delta_{12,i} & \delta_{13,i} & \delta_{14,i} & \delta_{15,i} \\ \delta_{21,i} & \delta_{22,i} & \delta_{23,i} & \delta_{24,i} & \delta_{25,i} \\ \delta_{31,i} & \delta_{32,i} & \delta_{33,i} & \delta_{34,i} & \delta_{35,i} \\ \delta_{41,i} & \delta_{42,i} & \delta_{43,i} & \delta_{44,i} & \delta_{45,i} \\ \delta_{51,i} & \delta_{52,i} & \delta_{53,i} & \delta_{54,i} & \delta_{55,i} \end{bmatrix} \begin{bmatrix} Y_{1t-i} \\ Y_{2t-i} \\ Y_{3t-i} \\ Y_{4t-i} \\ Y_{5t-i} \end{bmatrix} + \sum_{j=1}^{d_{\max}} \begin{bmatrix} \delta_{11,k+j} & \delta_{12,k+j} & \delta_{13,k+j} & \delta_{14,k+j} & \delta_{15,k+j} \\ \delta_{21,k+j} & \delta_{22,k+j} & \delta_{23,k+j} & \delta_{24,k+j} & \delta_{25,k+j} \\ \delta_{31,k+j} & \delta_{32,k+j} & \delta_{33,k+j} & \delta_{34,k+j} & \delta_{35,k+j} \\ \delta_{41,k+j} & \delta_{42,k+j} & \delta_{43,k+j} & \delta_{44,k+j} & \delta_{45,k+j} \\ \delta_{51,k+j} & \delta_{52,k+j} & \delta_{53,k+j} & \delta_{54,k+j} & \delta_{55,k+j} \end{bmatrix} \begin{bmatrix} Y_{1t-k-j} \\ Y_{2t-k-j} \\ Y_{3t-k-j} \\ Y_{4t-k-j} \\ Y_{5t-k-j} \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \end{bmatrix} \quad (8)$$

Where Y_{1t}, Y_{2t}, Y_{3t}, Y_{4t} and Y_{5t} denotes exchange rate movement, import prices, consumer prices, producer prices, and world oil prices. The above five variables TYDL VAR approach modified the original bivariate form of Toda and Yamamoto (1995) to accommodate our variables of interest, where *k* denote the optimal lag length which is determined by the usual information criteria such as AIC and SIC, while $d_{\max}$ is the maximum order of integration.

Essentially, to draw valid causal inferences, the TYDL causality test technique utilises a modified Wald test statistic (MWALD). This technique restricts the parameters of *k-th* optimal lag order of the vector autoregressive. It has an asymptotic chi-square distribution when VAR ($k + {}_{Dmax}$) is estimated. The direction of causality running from exchange rate to import price, from the import price to exchange rate and so on can be reflected as follows:

$H_{01}: \delta_{12,1} = \delta_{12,2} = ... = \delta_{12,k} = 0$, implies that import price does not Granger cause exchange rate movement.

$H_{02}: \delta_{21,1} = \delta_{21,2} = ... = \delta_{21,k} = 0$, implies that the exchange rate movement does not Granger cause import price.

$H_{03}: \delta_{13,1} = \delta_{13,2} = ... = \delta_{13,k} = 0$, implies that consumer price does not Granger cause exchange rate movement.

$H_{04}: \delta_{31,1} = \delta_{31,2} = ... = \delta_{31,k} = 0$, implies that the exchange rate does not Granger cause consumer price (CPI).

Following similar procedures, the direction of causality between exchange rate movement and producer prices, exchange rate movement and oil prices can also be evaluated.

4. Data and Preliminary Analysis

4.1. Data Source and Description

This study utilises monthly time series ranging from 1980 to 2016. The variables which are mainly sourced from IFS includes Import Price Index (IMP) as a proxy for domestic prices, Nominal Effective Exchange Rate (NEER) calculated as the trade-weighted average of the country's exchange rate against other currencies as a measure of the exchange rate. Others are Exporter's Production Cost (XP) measures using export price index, Consumer Price Index (CPI), producers' price (PPI) which measures using manufacturing value index, while the Brent crude oil price is used to proxy for the world oil price. All the data are expressed in natural logarithm term.

4.1.1. Unit Root Test Results

Even though the bound test approach to cointegration does not require pre-testing of variables for unit roots, it is, however, important to perform this test to verify and ascertain that none of the variables is integrated of order higher than one. In addition to the traditional ADF unit root test, a more efficient unit root test such as Dickey-Fuller GLS test and Ng-Perron test were also implemented. The essence is to ascertain some level of consistency to ensure the result is free from any form of spurious regression. The results as presented in Table 2 below shows that the integration properties for the series varies across the three tests, but hover around I(0) and I(1). This, therefore, appears to have affirmed our choice of ARDL as the more appropriate estimation technique.

Table 2. Unit Root Test Results

	ADF			DFGLS			Ng-P		
	Level	***First Diff.***	***I(d)***	***Level***	***First Diff.***	***I(d)***	***Level***	***First Diff.***	***I(d)***
Ln(EXR)	-1.963[b]	-17.614[a]***	*I(1)*	-2.029[b]	-17.501[b]***	*I(1)*	-8.711[b]	-154.996[b]***	I(1)
Ln(MP)	-1.863[a]	-15.897[b]***	*I(1)*	-1.697[a]*	-	*I(0)*	-5.938[a]*		I(0)
Ln(XP)	-3.017[b]	-12.654[b]***	*I(1)*	-1.797[b]	-12.273[b]***	*I(1)*	-6.640[a]*		I(0)
Ln(CPI)	-0.865[a]	-7.452[a]***	*I(1)*	-2.664[a]***	-	*I(0)*	-3.831[b]	-72.195[b]***	I(1)
Ln(PPI)	-1.939[b]	-13.612[b]***	*I(1)*	-1.361[b]	-2.655[b]*	*I(1)*	-4.032[b]	-15.737[b]***	I(1)
Ln(OP)	-2.129[a]	-14.217[a]***	*I(1)*	-1.155[b]	-8.444[b]***	*I(0)*	-6.623[b]	-147.902[b]***	I(1)

Note: [a] Indicates a model with constant but without deterministic trend; [b] is the model with the constant and deterministic trend. Exogenous lags are selected based on the Schwarz Information Criterion. ***, **, * imply that the series is stationary at 1%, 5% and 10% respectively. ADF, DFGLS, and Ng-P denote Augmented Dickey-Fuller, Dickey-Fuller_GLS, and Ng-Perron Unit Root tests. The null hypothesis for ADF, DFGLS, and Ng-P is that an observable time series is not stationary (i. e. has unit root).

5. Presentation and Discussion of Empirical Results

5.1. Short-Run and Long-Run Dynamics

Following the establishment of a long-run relationship among the variables, the study proceeds to estimate both the short and long-run coefficients using OLS regression technique on equations (6) and (7). For instance, the computed F-statistic of 7. 67 in Table 3 seems to be greater than the upper critical bound value irrespective of the chosen levels of significance considered. This, therefore, portends that the null hypothesis of no cointegration does no hold in the case of Nigeria. More importantly, the indication of cointegration as evident herein implies that, even if there are shocks in the short run, which may affect movement in the individual series, they can still converge with time, in the long-run.

Table 3. ARDL Bound Testing Cointegration Results

Dependent Variable	**F-Statistic = *7. 6673***		
	Critical Value	Lower Bound	Upper Bound
Ln(MP), Ln(EXR), Ln(XP), Ln(CPI), Ln(PPI), Ln(OP)	1%	3. 42	4. 68
	5%	2. 62	3. 28
	10%	2. 26	3. 35

Note: Asymptotic critical value bound is obtained from table *CI* (iii) case II: unrestricted intercept and no trend for $k = 6$ (*Pesaran et al. 2001*)

The evidence of strong rejection of the null hypotheses across virtually all the post-estimation tests reported in Table 4 is a validation of the empirical estimates obtained from the estimation of the specified ARDL model. Essentially, the error correction mechanism of the model is both theoretical and empirically viable. The error correction coefficient, which is both negatively sign and significance, suggests that on average, import prices in the short run adjust to equilibrium in Nigeria by 31% of any disequilibrium caused by previous months' shock.

Consequently, the short-run and the long-run coefficients of NEER are negative and positive, respectively. However, the insignificance of the coefficients means that nonetheless the depreciation or appreciation channels of exchange rates, the ERPT may not be significant in the case of Nigeria. Although the insignificance of EPRT may seem puzzled, particularly for a volatile economy such as Nigeria, this, however, may not be unconnected to the fact that exchange rate regimes in the country since independence hoover around peg regime and manage float regime.

Consistent with the economic theory of international trade is the evidence of a positive relationship between import prices and export cost of production. The evidence of significant short and long-run coefficients of export prices which proxies for exporters' production are an indication that increasing import prices in Nigeria

can be significantly linked to risen of the cost of production in the exporting countries. In a similar development, the positive and significant response of import prices to domestic prices (consumer price index) is also in consonance with economic reasoning. Relatively, risen domestic prices would drive up import demand and consequently import prices.

Table 4. Empirical Estimates of (ARDL 2, 0, 0, 0, 0, 0)

	Short-Run Estimates		
	Coefficient	***Standard Error***	***T-Statistics***
Constant	5. 5395**	2. 7875	1. 9873
$\Delta \ln MP_{t-1}$	-0. 2345***	0. 0560	-4. 1866
$\Delta \ln NEER_t$	0. 1749	0. 0634	2. 7589
$\Delta \ln XP_t$	0. 1031***	0. 0485	2. 1248
$\Delta \ln CPI_t$	0. 1749**	0. 0634	2. 7589
$\Delta \ln PPI_t$	-0. 7135	0. 5237	-1. 3625
$\Delta \ln OP_t$	0. 1563	0. 1031	1. 5157
ECM_{t-1}	-0. 3102***	0. 0482	-6. 4332
Short-Run Estimates			
	Coefficient	***Standard Error***	***T-statistic***
Constant	17. 8589***	8. 5829	2. 0807
$\ln NEER_t$	-0. 1434	0. 1037	-1. 3821
$\ln XP_t$	0. 5639***	0. 2002	2. 8162
$\ln CPI_t$	0. 3325**	0. 1460	2. 2767
$\ln PPI_t$	-2. 3002	1. 6832	-1. 3666
$\ln OP_t$	0. 5039	0. 3149	1. 6006
Diagnostic Test Results			
Post Estimation Statistics		***Residual-Based Diagnostic***	
R-squared 0. 7876 Adjusted R-squared 0. 7827 F-statistic 160. 0088 (0. 000) Durbin-Watson Stat. 2. 0695		Ramsey RESET Test: 0. 0088 (0. 9252 ARCH LM heteroscedasticity test: 1. 7915 (0. 1355) Serial Correlation LM test: 7. 8315 (0. 0316)	

Note: ***, ** and * denotes 1, 5 and 10 per cent levels of significance respectively.

Taking cognisance of the fact that the significance and magnitude of the exchange rate pass-through into import price and another chain of prices considered may be sensitive to the channel of transmission. This study further employs TYDL VAR Granger causality test to accommodate this possibility. However, given the sensitivity of TYDL causality testing approach to the choice of lag length, we conducted a series of nested likelihood ratio tests on level VARs to determine the optimal lag length (p) before performing the TYDL causality test. The VAR lag order selection criteria results in Table 5 seems conflicting. To this end, we follow the standard practice in the literature to favour the maximum lag length identified by the following modified LR test statistics.

Table 5. VAR Lag Order Selection Criteria

Endogenous Variables: Ln(MP) Ln(XP) Ln(EXR) Ln(CPI) Ln(PPI) Ln(OP) **Exogenous Variable:** C Included Observation: **31**					
Lag	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	NA	7. 31e-07	2. 898671	2. 972034	2. 928018
1	5736. 381	3. 79e-15	-16. 17890	-15. 66536*	-15. 97347
2	154. 2822	2. 83e-15	-16. 47224	-15. 51853	-16. 09073*
3	68. 66516	2. 82e-15*	-16. 47633*	-15. 08244	-15. 91874
4	62. 85338	2. 85e-15	-16. 46477	-14. 63071	-15. 73110
5	52. 69501*	2. 99e-15	-16. 42095	-14. 14671	-15. 51120
6	34. 40016	3. 34e-15	-16. 31294	-13. 59853	-15. 22712
7	45. 01984	3. 58e-15	-16. 24859	-13. 09401	-14. 98668
8	43. 54471	3. 84e-15	-16. 18251	-12. 58776	-14. 74453

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

To estimate the chosen multivariate VAR(5) model via TYDL causality testing approach, we select two as our maximum order of integration ($_{Dmax}$), and this is due to the outcomes of our unit root test results. The TYDL VAR causality test results in Table 6 show that exchange rate pass-through to import prices is as high as 7%. But similar to our previous findings, the pass-through is only significant when the causality runs from export prices to import and from exchange rate to export prices. This again further reaffirms our earlier position that there is a significant link between the cost of export production and import prices. The link in this present instance has been proven to be unidirectional as its only run from export to import.

Consequently, the causality shows no significant pass-through from exchange rate to consumer and producer prices, respectively. Rather, it is the oil price that seems to be granger causing consumer prices and producer prices, respectively. Similar to the causal relationship between oil price and export prices, the causality between oil price and consumer prices is bidirectional. This, however, may not be unconnected to the peculiarity of the economy that is under consideration.

Table 6. Summary of the TYDL VAR Granger Causality Test Results

Equation / Variable	Equation 2	Equation 3	Equation 4	Equation 5	Equation 6	Equation 7
	Ln(MP)	***Ln(EXR)***	***Ln(XP)***	***Ln(CPI)***	***Ln(PPI)***	***Ln(OP)***
Ln(MP)	*D. V*	2. 0368 (0. 8440)	7. 2726 (0. 2011)	7. 5156 (0. 1850)	1. 0153 (0. 9617)	5. 1895 (0. 3932)
Ln(EXR)	7. 04145 (0. 2176)	*D. V*	12. 9481** (0. 0239)	3. 0395 (0. 6939)	5. 7049 (0. 3360)	8. 8425 (0. 1155)
Ln(XP)	10. 0132* (0. 0749)	0. 9019 (0. 9701)	*D. V*	0. 5867 (0. 9886)	3. 2657 (0. 6591)	27. 6031*** (0. 0000)
Ln(CPI)	4. 8645 (0. 4326)	5. 1784 (0. 3945)	7. 7565 (0. 1702)	D. V	0. 7004 (0. 9821)	10. 3843* (0. 0651)
Ln(PPI)	5. 6318 (0. 3437)	1. 1325 (0. 9512)	2. 7776 (0. 7304)	21. 9828*** (0. 0005)	D. V	5. 5581 (0. 3516)
Ln(OP)	4. 5710 (0. 4704)	14. 2214** (0. 0143)	13. 2932** (0. 0208)	13. 2532** (0. 0211)	27. 7921*** (0. 0000)	D. V
ALL	34. 9999* (0. 0882)	29. 9386 (0. 2266)	53. 4566*** (0. 0008)	37. 9675** (0. 0466)	52. 5204*** (0. 0010)	57. 6341*** (0. 0002)

Note: D. V. denotes dependent variable and the probability values are in parentheses while ***, **, and * indicates significance at 1%, 5%, and 10%.

The Impulse Response Functions (IRFs) represented in Figure 1 is meant to show the response of import prices and another chain of prices included in the model to shocks due to exchange rate pass-through. The impulse response functions (IRFs) shows the effects of shocks on the adjustment path of the variables in the TYDL VAR model. As shown in the figure below, the response of import prices to shocks due to pass-through from the exchange rate remains insignificant in the first and second months. The exchange rate pass-through to import prices becomes

significantly pronounced in the third to the sixth month of the pass-through, and after that responded gradually and persistently up to the 12th month.

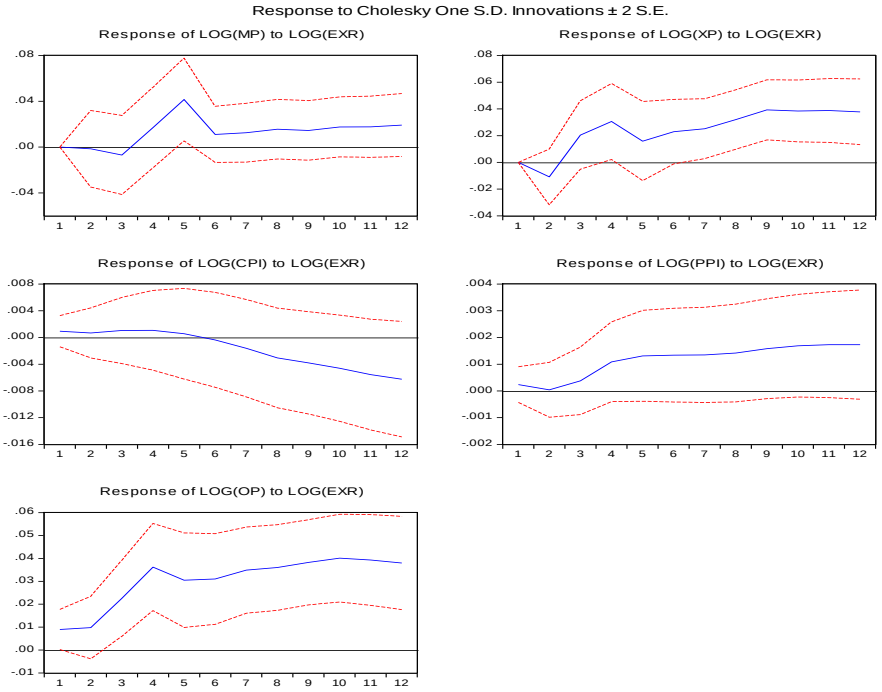

Figure 1. Impulse Response Function

Consistent with our findings thus far, the response of export cost of production to shocks due to exchange rate movements is mainly positive and significantly pronounced across all the periods considered. Oil prices and consumer prices also responded positively to shocks due to exchange rate movements. Regarding magnitude, however, the pass-through to oil prices seems to be more pronounced. However, consumer prices in the first to fifth months respond positively to the pass-through and then negatively from the sixth month through to the 12th month.

Table 7. Summary of Variance Decomposition Percentage of 12 Months-Period Error Variance

Per cent of forecast error variance in:	Typical Shock in					
	Ln(MP)	***Ln(XP)***	***Ln(EXR)***	***Ln(CPI)***	***Ln(PPI)***	***Ln(OP)***
Ln(MP)	83. 2764	4. 0790	3. 7129	3. 7129	0. 4044	5. 0519
Ln(XP)	8. 7275	73. 6699	4. 1235	4. 123509	7. 5902	4. 5742
Ln(EXR)	3. 0992	12. 2390	1. 8366	1. 836564	5. 3074	28. 2909
Ln(CPI)	0. 7119	0. 71001	71. 1898	71. 18980	0. 0403	0. 43562
Ln(PPI)	1. 1447	0. 0722	4. 2215	4. 221488	82. 7917	10. 4056
Ln(OP)	3. 0403	9. 2298	14. 9157	14. 91570	3. 8660	51. 2417

Computed by the Author using EViews09

To complement the impulse response results that graphically illustrate the response of import prices to exchange rate movements, we further present the forecast error variance decomposition (FEVD) results. The essence is to understand not just the direction, but also the magnitude of innovation in the import prices that are due to changes in the exchange rate. Thus, the FEV results reported in Table 7 though, attribute 83% of the innovations in import prices to own shocks, yet 8% and 3. 1% of the innovations are due to changes in export prices and fluctuations in the exchange rate, respectively. Next, to the exchange rate pass-through, shocks due to oil prices tend to be responsible for 3% of the innovations in import prices. This suggests that import prices in the context of the Nigerian economy are relatively more sensitive to the export cost of production.

6. Conclusion and Policy Prescription

This study investigates the dynamics of exchange rate pass-through in the context of the oil-producing economy (i. e. Nigeria). Methodologically, the study used both single and multivariate approaches to estimate the degree and direction of ERPT. Essentially, it explores the ARDL Bound cointegration approach to explain the short run and long dynamic of exchange rate pass-through into domestic prices of the oil-producing economy. More so, it utilises TYDL VAR Granger causality testing technique to determine the direction and magnitude of the pass-through. Overall, it can be inferred that changes in exchanges rate has little or no significant direct impact on domestic prices in Nigeria. However, as expected of an oil-export dependent economy, the ERPT may yet be significant if the pass-through is the channel through

export prices. Thus, any policy initiative towards mitigating the adverse effects of the pass-through must be wary of which of the price chains that have the potential for accelerating the degree of the pass-through.

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