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Exchange Rate Pass-Through to Domestic Prices in Nigeria: A Dynamic Investigation

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Abstract: Exchange rate pass-through to different measures of domestic price in Nigeria is examined using a vector error correction model that incorporates exchange rate, money supply, world export price, income and tariff rate on annual data from 1980-2008. This study observes that long run relationship exist between exchange rate and domestic price level; nevertheless, the short run impact is not elusively evident. Short run variations in exchange rate might be anticipated and hence, the impact would be dampened. Government policy should refrain from using devaluation to address domestic price in the short term; such policy might be considered in the long term.

Key words: Exchange rate pass-through, domestic prices, vector error correction model, money supply, policy, anticipated

INTRODUCTION

There has been an upsurge in the investigation of the impact of exchange rate variations on macroeconomic variables, especially on domestic prices. Theoretically, changes in exchange rate are expected to be fully reflected on domestic prices, a la Law of One Price (LOOP) which states that at equilibrium, the price of tradable goods in two markets cannot differ when expressed in the same currency.

If a 1% change in exchange rate leads to a 1% change in prices then pass-through is complete. Less than one-to-one response of prices to exchange rate is referred to as incomplete exchange rate pass-through. The pass-through occurs in two stages. First, exchange rate variations affect prices of imported consumption and intermediate (inputs) goods. Increases in prices of intermediate goods affect the cost of production and hence prices of domestically produced goods. In addition to this, the domestic prices also increase due to a shift in demand away from the now expensive imported goods to the local ones.

The second stage happens through prices of domestically produced goods via supply and demand channels. Several researchers have empirically examined the sensitivity of domestic prices to exchange rate movements. Campa and Goldberg (2005) found that exchange rate shows higher pass-through to import prices than to consumer price. Other empirical inquiries into the relationship reported varying degrees of pass-through estimates; the diversity comes from use of different methodologies and measures of domestic prices and exchange rate. The macroeconomic implications of the extent of exchange rate pass-through on domestic prices have also been investigated by some studies (Taylor, 2000; Hakura and Choudhri, 2001; Devereux and Engel, 2002; Devereux *et al*., 2004; Mirdala, 2009). A recent study on Nigeria by Omisakin (2009) submits that there is no significant impact of exchange rate variations on domestic prices and output. This is contrary to earlier studies by Oladipo (2007) and Oyinlola (2009) who found a significant positive impact of exchange rate on domestic prices.

There is a good reason to believe that the different outcomes of these investigations might have come from the different methodologies used. While Oladipo (2007) and Oyinlola (2009) used the Johansen multivariate estimation technique, Omisakin (2009) used the vector autoregressive model which is criticized for its inability to capture the potential long run relation among variables. There are arguments in some quarters that the Exchange Rate Pass-through (ERPT) concept is a long run phenomenon (Barhoumi, 2005). Therefore, Omisakin's result of no short run impact is not surprising.

This study re-examines the relationship between exchange rate and domestic prices using the Vector Error Correction Model (VECM). This model considers the long run and the short run dynamics of exchange rate variation on domestic prices. This study observes that long run relationship exist between exchange rate and domestic price level measured by CPI. The impact of exchange rate on domestic price ranges from 0.18-0.47% from 1%

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variation in exchange rate while the impact in the short run is dampened. Other factors such as money supply, world export price and income have significant influence on the variations of all measures of domestic price in this study. The study is able to shed some light on the following cogent questions: do changes in exchange rate have a significant long term effect on domestic price? What is the magnitude of this impact if any? Are there other factors influencing the variations in domestic price and does the measure of domestic price matter in this regard?

Exchange rate pass-through: Explanation on exchange rate pass-through phenomenon leans on the equality (or otherwise) of prices of traded goods in two markets when expressed in the same currency, a la purchasing power parity. Pass-through is said to be complete if this equality holds and incomplete if it does not. In other words, less than one to one response of prices to exchange rate is referred to as incomplete exchange rate pass-through. The underlining theoretical underpinning of exchange rate pass-through is the Purchasing Power Parity (PPP) hypothesis. Goldberg and Knetter (1996)'s literature survey on exchange rate pass-through suggested that one can surmise a semblance between the failure of PPP to hold and the general finding that pass-through is incomplete.

Krugman (1987) and Dornbusch (1987) in their seminal paper developed a mechanism to capture incomplete pass-through to import prices through the use of an oligopolistic market framework in which a firm's mark-up varies and attune to an exchange rate shock. The adjustment of the mark up price are observed as temporary or a deliberate effort of firms to maintain their market share (Hooper and Mann, 1989; Kasa, 1992). These arguments and that of Knetter (1989) formed the basis for the pricing to market hypothesis. Other researchers like Devereux and Engel (2001) explained low exchange rate pass-through via a related phenomenon of local currency pricing. The framework shows that an exporting firm sets its price in the currency of a country to which it exports and that currencies of countries with low exchange rate variability or stable monetary policies are more likely to be chosen for transaction invoicing and hence, more likely to exhibit low exchange rate pass-through.

Finally, Taylor (2000) postulated that the observed decline in pass-through may be attributed to improved credible monetary policy framework. Others studies explored the link between inflation environment and pass-through (Hakura and Choudhri, 2001). Generally, empirical investigations into pass-through can be divided into three: micro (product level) industry and cross country industry based analyses. Existing evidence shows that pass-through to import prices across industries in the US hovers around 50% (Goldberg and Knetter, 1997). Other studies focused across industries include Yang (1997) and Olivei (2002).

They concluded that pass-through varies across industries. There is a long range of studies in this category. One of the findings in the empirical literature on exchange rate pass-through relates to the observed decline in estimates of pass-through especially over the past two decades in both developed and developing countries (McCarthy, 1999).

Some of the reasons attributed to this include increased international competition in goods markets which reduces the pricing power of firms; reduced labor unions participation and more competitive labor markets and aggressive monetary policy anchored on inflationary expectations. This claim has been debated in some quarters. The evidence 1 year pass-through is mixed across European countries. This claim was supported by Campa and Goldberg (2005) who posited that it is difficult to make a case that pass-through into import prices has systematically declined.

A different dimension on variation across countries, specifically between developing and developed countries was introduced into the debate by Hakura and Choudhri (2001). Their study showed that average 1 year pass-through is 26% in emerging markets while that of group of three industrialized countries is only 7%. Explanations proffered on this differential include the possibility of the fact that developing countries on the average are more inflation-prone than the developed countries. This finding supports Canetti and Greene who found that exchange rate changes and monetary growth affect consumer price inflation in sub-Saharan Africa (SSA) with particular reference to the significant Granger causal on prices in Tanzania, Sierra Leone and Democratic Republic of Congo. Other researchers that have documented pass-through in developing countries (Kiptui *et al*., 2005; Oladipo, 2007; Frimpong and Adam, 2010).

MATERIALS AND METHODS

The model and data sources: The VECM used restricts the long run behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short run adjustment. Hence, it poses to be a better methodology than the Vector Autoregressive model (VAR). The model is specified as:

$$\Delta y_t = \alpha\beta' y_{t-1} + \sum_{i=1}^{g-1} \Gamma_i \Delta y_{t-i} + \pi + \zeta_t, t = 1,..., T \qquad (1)$$

where, y_t is a vector of endogenous variables (domestic price, exchange rate, money, income and world export price). The α_s parameters measure the speed at which the variables in the system adjust to their long run values and the β' vectors are estimates of the long run cointegrating relationships between the variables in the model. Next comes the drift parameter, π and can also be expressed as a matrix of parameters associated with the exogenous variables while the stochastic error term is ζ.

We adopted the following specification for estimating the degree of exchange rate pass-through to domestic prices in Nigeria. The specification emanates from a price generating process that incorporates other factors such as money supply and tariff rate. These factors also influence the domestic price level:

$$\ln DPL_t = \alpha_0 + \alpha_1 \ln Y_t + \alpha_2 \ln WXP_t + \alpha_3 \ln EXC_t + \alpha_4 \ln TRF_t + \alpha_5 \ln MS_t + \zeta_t \quad (2)$$

Where:

DPL_t = Domestic price captured by CPI
Y = Real GDP of Nigeria
WXP = World export price
E_t = Nominal effective exchange rate
TRF = Tariff rate and MS is money supply at time t

The analysis is carried out in the following order. First is the descriptive statistics of the variables and followed by stationarity tests. This is done through the Augmented Dickey Fuller (ADF) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. If stationarity is confirmed, the long run estimates are obtained through the Ordinary Least Squares (OLS) method. The cointegration of the variables is tested through the application of Johansen cointegration tests. The adjustment of the short-rum to the long run equilibrium is obtained through the Vector Error Correction Model (VECM). The confirmation of the short run dynamics is also done through the impulse response analysis. In the pursuit of the exchange rate-domestic price nexus, this study employs annual data series of the following variables: Exchange rate (EXC), captured by the nominal effective exchange rate (a fall in its value implies depreciation while an increase is appreciation); Domestic Price (DPL), captured by three measures; Consumer Price Index (CPI), Gross Domestic Product Deflator (GDPD) and Aggregate Import Price (AMP), Money Supply (MS), measured by broad money supply, Tariff rate (TRF), World Export Price (WXP), output (Y) proxied by GDP as shown in Fig 1-3. Data were obtained from the World Development Indicators, 2007 and International Monetary Fund's International Financial Statistics (IFS) yearbook. The estimation covered the period 1980-2008.

Characteristics of the variables: Table 1 shows the summary statistics for the variables. The skewness values for most of the variables are nearly zero with four having negative signs indicating skewness to the left while the other two with positive signs are skewed to the right. The kurtosis which measures whether the data are peaked or flat relative to a normal distribution with an expected value of 3.0, shows that the tariff variable satisfies this condition.

Variables are required to have normal distribution before they are used in any parametric statistical method. Skewness and kurtosis give indications as to the nature of distribution of variables. Skewness is a measure of symmetry or more precisely, the lack of symmetry. The skewness for a normal distribution is zero and any symmetric data should have skewness near zero. The probability value of all variables are high, accepting that the normal distribution for all the variables indicating a normality of their unconditional distributions. The Jarque-bera (JB) test is used to check hypothesis about the fact that a given sample x_S is a sample of normal random variable with unknown mean and dispersion. JB test has the null hypothesis of normal residuals hence, its rejection requires low probability that is the probability that a Jarque-bera statistic exceeds the observed value. In addition, the mean to median ratio of each variable is within the unit proximity and standard deviations are

Table 1: Descriptive statistics of the variables

Variables	TRF	WXP	EXC	DPL	MS	Y
Mean	3.522	4.643	6.143	3.151	26.059	27.493
Median	3.540	4.670	5.624	3.493	26.310	27.843
Maximum	4.335	4.947	9.066	5.480	28.852	30.246
Minimum	2.622	4.353	4.217	0.313	23.389	24.640
Std. dev.	0.483	0.156	1.793	1.833	1.937	2.045
Skewness	-0.251	-0.272	0.561	-0.190	0.013	-0.149
Kurtosis	2.889	2.385	1.838	1.450	1.495	1.472
Jarque-bera	0.319	0.815	3.154	3.077	2.736	2.926
Probability	0.852	0.665	0.206	0.214	0.254	0.231
Sum	102.161	134.657	178.149	91.385	755.718	797.321
Sum sq. Dev.	6.532	0.683	90.067	94.126	105.117	117.189
Observations	29.000	29.000	29.000	29.000	29.000	29.000

Researchers's computation

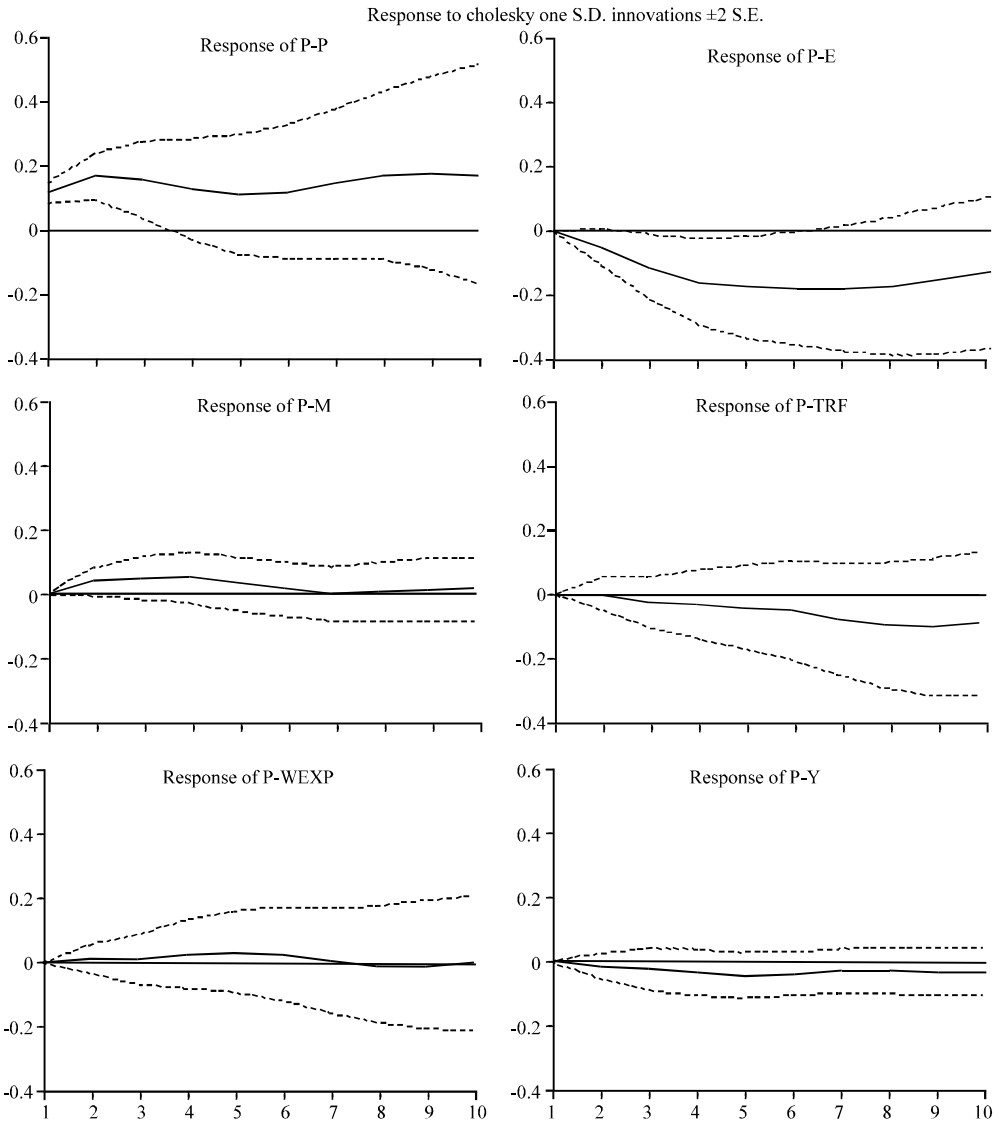

Fig. 1: Responses of domestic price (CPI) to shock in veriables

Table 2: Unit root tests

	Level		First difference	
Factors	ADF	KPSS	ADF	KPSS
lnEXC	-1.147	0.640	-4.503*	0.206
lnMS	-0.230	0.674	-2.960***	0.162
lnTRF	-0.905	0.645	-5.293*	0.163
lnWXP	-0.164	0.514	-3.477**	0.137
lnY	-0.554	0.667	-3.652**	0.182
lnDPL	-1.385	0.670	-3.316***	0.211

researchers's computation; the Mackinnon critical values are -3.68919and -2.97185 at 1 and 5% levels of significance, respectively. The KPSS critical values (Kwiatkowski *et al*., 1992) are 0.739 and 0.463 at 1 and 5% levels of significance, respectively. The null hypothesis of KPSS tests for stationarity I(1) while that of ADF tests for no unit root I(0). *, **, ***indicate significance at 1, 5 and 10%, respectively

relatively low showing small variability. The results of the unit root tests of the variables are in Table 2. Test statistic shows that all the variables are integrated of order one. The KPSS test was carried out and the results indicate that all variables are stationary since, the null hypothesis of stationarity is accepted when the t-statistic is less than its critical level at 1% level of significance. Since all the variables are non-stationary or random walk stochastic processes and they are integrated of the same order, the linear combination of these variables are stationary and thus, they are cointegrated. We then proceed to estimate Eq. 1 by Ordinary Least Squares (OLS) method. The results of the long run estimation are provided in the Table 3.

Cointegration analysis: In order to test for cointegration, we employ the Johansen (1988) cointegration approach.

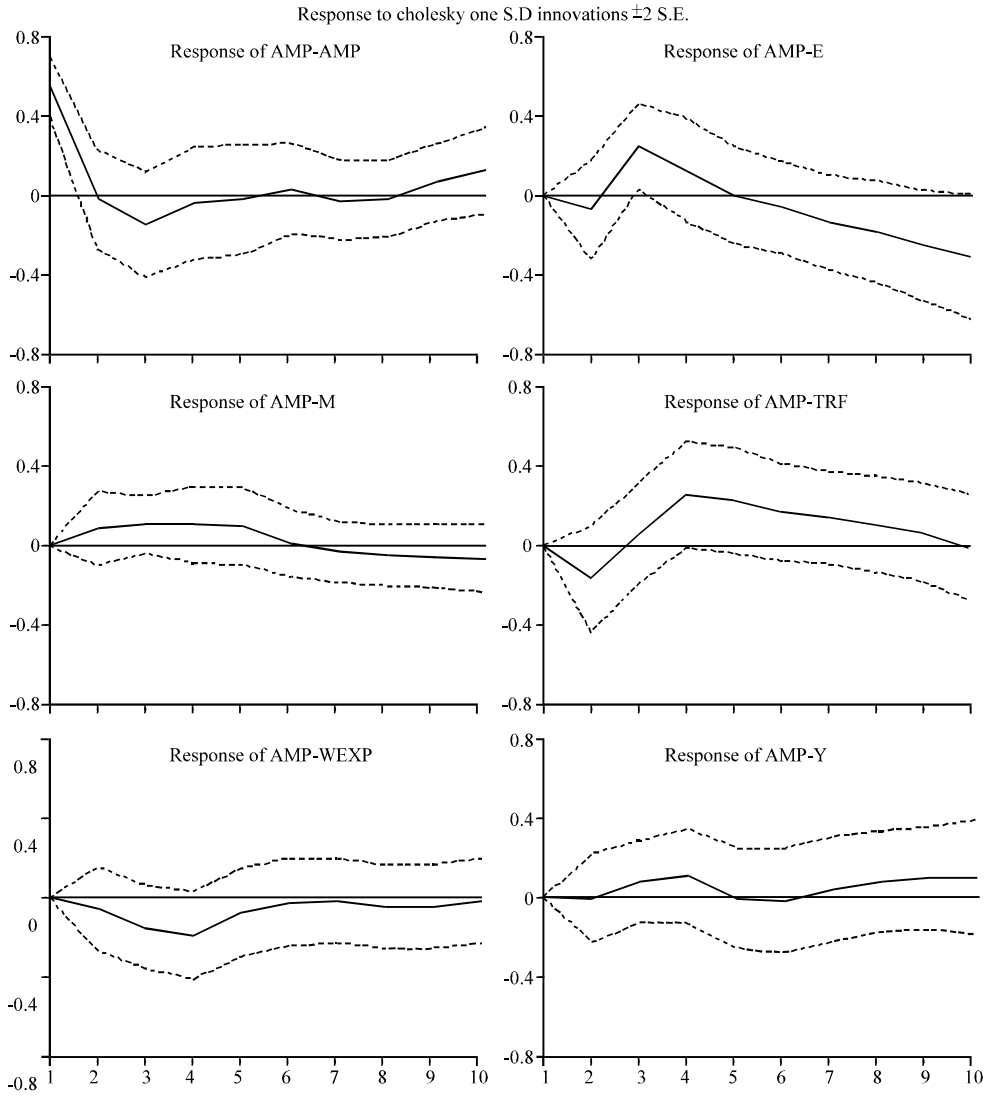

Fig. 2: Response of domestic price (AMP) to shocks in varibales

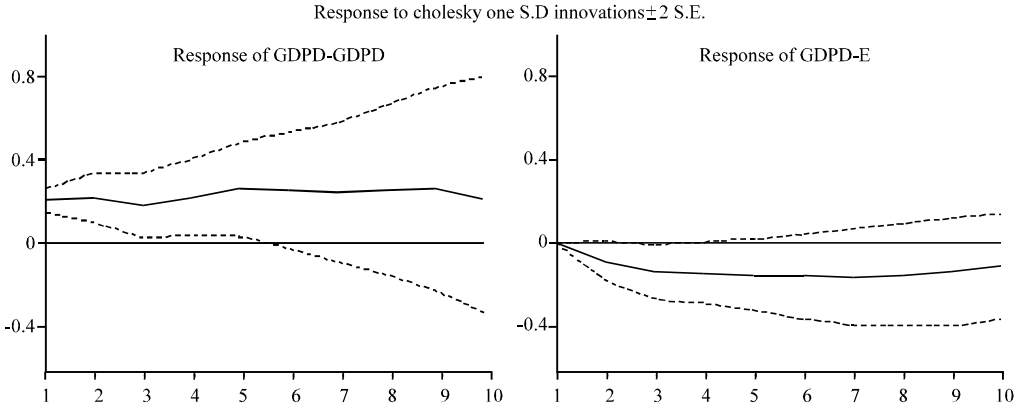

Fig. 3: Continued

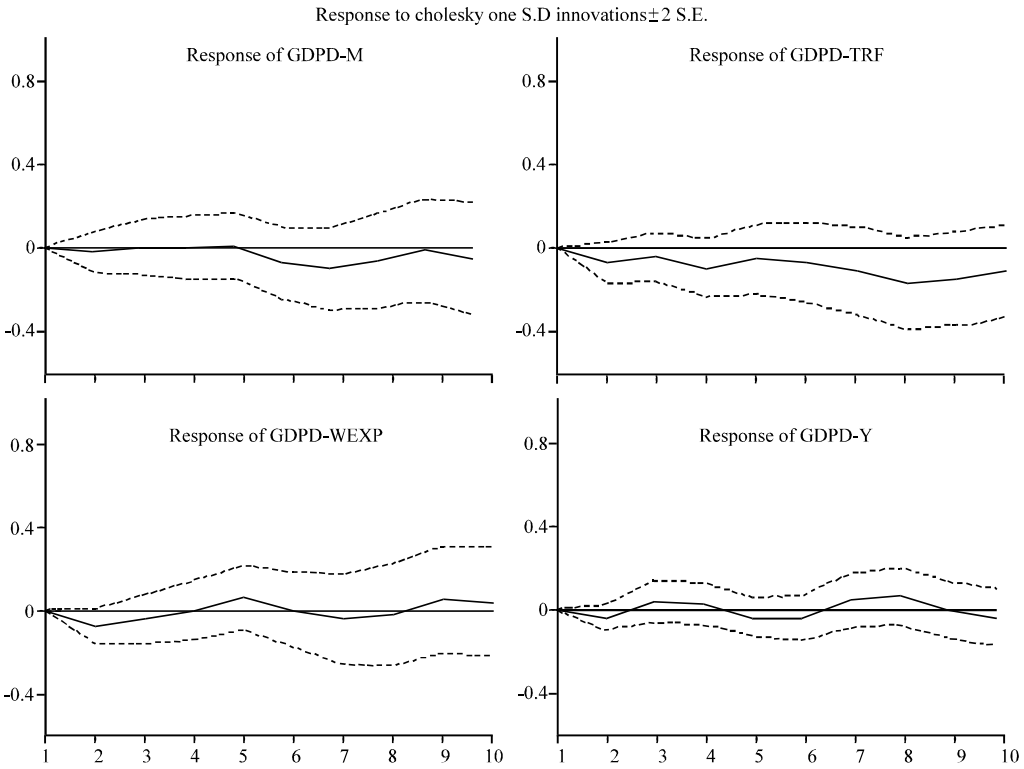

Fig. 3: Responses of domestic price (GDPD) to shocks in variables

Table 3: Long run OLS estimation

	Dependent variable: Domestic Prices (DPL)		
Variables	CPI	GDPD	AMP
Constant	-16.385*(3.197)	-6.353(4.500)	20.898(14.435)
Exchange rate	-0.009(0.069)	-0.277*(0.098)	0.140(0.315)
Money supply	-0.293***(0.148)	-0.591*(0.208)	0.615(0.667)
Tariff rate	-0.191(0.125)	0.221(0.175)	-1.455**(0.563)
World export price	-1.018**(0.396)	-1.972*(0.558)	-5.158*(1.792)
Income	1.187*(0.167)	1.264*(0.234)	-0.174(0.752)
R-squared	0.995	0.988	0.641
Adjusted R-squared	0.994	0.985	0.563
S.E. of regression	0.137	0.193	0.621
Sum squared resid	0.435	0.863	8.879
Log likelihood	19.727	9.808	-23.988
Durbin-Watson stat	1.494	1.470	1.911
F-statistic	989.479	383.395	8.235
Prob(F-statistic)	0.000	0.000	0.0001

Researcher's computation; (i) *, **, ***indicate significance at 1, 5 and 10%, respectively. Figures in parenthesis are standard errors; (ii) Domestic prices are captured by Consumer Price Index (CPI), Gross Domestic Product Deflator (GDPD) and Aggregate Import Price (AMP)

Table 4: Cointegration analysis

Hypothesized No. of CE (s)	Eigenvalue	Trace statistic	5% CV	1% CV	Max-eigen statistic	5% CV	1% CV
None**	0.832	126.063	82.49	90.45	48.225	36.36	41.00
At most 1**	0.669	77.838	59.46	66.52	29.902	30.04	35.17
At most 2**	0.610	47.936	39.89	45.58	25.433	23.80	28.82
At most 3	0.439	22.502	24.31	29.75	15.639	17.89	22.99
At most 4	0.203	6.863	12.53	16.31	6.156	11.44	15.69
At most 5	0.025	0.706	3.84	6.51	0.706	3.84	6.51

*(**) denotes rejection of the hypothesis at the 5% (1%) level. Trace test indicates 3 cointegrating equation(s) at both 5 and 1% levels. Max-eigenvalue test indicates 1 cointegrating equation(s) at both 5 and 1% levels

Table 5: Normalized cointegrating coefficients (standard error in parentheses)

DPL	MS	WXP	EXC	Y	TRF
1	0.647	6.876	-0.899	-2.050	3.097
	(0.422)	(0.812)	(0.151)	(0.472)	(0.360)

The model developed consists of 6 endogenous variables: z = [lnEXC, lnMS, lnWXP, lnY, lnDPL, lnTRF]. The maximum lag length, k of 1 is chosen. Based on the trace test of cointegration, there were 3 cointegrating vectors. For any conflict between trace statistic and maximum eigenvalue, the maximum eigenvalue should prevail for inferences (Johansen and Juselius, 1990). The maximum eigenvalue test suggests one cointegrating vector. The results of the cointegration tests are contained in Table 4. Table 5 shows the suggested vector error correction term (ect) or long run relationship among the variables following normalization on DPL.

RESULTS AND DISCUSSION

Table 6 shows the estimation results using the VECM with a 5 endogenous variables. Tariff is treated as an exogenous variable because its value is administratively determined and often retained over a long period of time; its inclusion as endogenous variable leads to insufficient numbers of observations problem as a result of the annual data used in the study. The finding suggests that about 85% of disequilibrium in domestic price, captured by CPI is corrected each year. It is worthy to note that the error correction term for the domestic price measured by GDPD and AMP are statistically flawed.

The error term for GDPD (-0.51) is not significant while that of AMP (-1.6) is beyond the conventionally acceptable level of >-1 (i.e., -1<error term<0). The long run cointegrating equation results emanating from the use of different measures of domestic price show different signs. Domestic price response to variations in exchange rate shows negative signs when CPI and AMP are used and positive with GDP deflator. Care must be taken in interpreting these because of the nature of the indicator used to capture exchange rate.

As earlier stated, a fall in the value of the exchange rate implies depreciation. For a bilateral exchange rate, a rise in its nominal value implies depreciation and the domestic price is expected to increase. Hence, the coefficient of the bilateral exchange rate would be positive. But in the present case, we expect a negative coefficient.

Therefore, we can say that the result provided earlier in the normalized cointegrating coefficient in Table 5 is rightly signed and statistically significant and in accord with the results from CPI and AMP equations in Table 6. When compared to the OLS estimation results in Table 3, the converse holds. Only the response of exchange

Table 6: Long-run cointegrating equations

	Dependent variable: Domestic Prices (DPL)		
Parameters	CPI	GDPD	AMP
WXP(-1)	0.756389	2.84415	2.124764
	(0.17874)	(0.07582)	(0.59549)
	[4.23174]	[37.5111]	[3.56807]
EXC(-1)	-0.18204	0.310652	-0.47222
	(0.04749)	(0.01942)	(0.17966)
	[-3.83349]	[15.9969]	[-2.62835]
MS(-1)	1.067798	0.895937	-1.39444
	(0.06584)	(0.02569)	(0.22814)
	[16.2182]	[34.8814]	[-6.11222]
Y(-1)	-2.03918	-1.57334	0.418745
	(0.08039)	(0.03266)	(0.28929)
	[-25.3677]	[-48.1778]	[1.44748]
C	22.6793	1.915651	13.8698
Vector error correction for domestic Prices (P)			
Error correction:	D(CPI)	D(GDPD)	D(AMP)
Coint Eq. 1	-0.85316	-0.51674	-1.60203
	(0.21912)	(1.0801)	(0.48516)
	[-3.89354]	[-0.47842]	[-3.30210]
D(DPL (-1))	0.608262	0.231063	0.491164
	(0.22395)	(0.62666)	(0.31883)
	[2.71612]	[0.36872]	[1.54054]
D(DPL (-2))	-0.04818	-0.32852	0.267839
	(0.20154)	(0.75463)	(0.23117)
	[-0.23906]	[-0.43534]	[1.15865]
D(WXP (-1))	2.242458	1.020333	0.83515
	(0.60067)	(2.59466)	(2.97351)
	[3.73325]	[0.39324]	[0.28086]
D(WXP (-2))	1.19284	0.624538	-1.65963
	(0.53731)	(1.91545)	(3.70577)
	[2.22004]	[0.32605]	[-0.44785]
D(EXC (-1))	-0.04261	-0.16567	-1.5555
	(0.07567)	(0.32882)	(0.81777)
	[-0.56307]	[-0.50383]	[-1.90213]
D(EXC (-2))	-0.23055	-0.0668	-0.36166
	(0.08271)	(0.28576)	(0.67631)
	[-2.78752]	[-0.23375]	[-0.53475]
D(MS (-1))	0.874588	0.204951	-2.39617
	(0.25897)	(1.18733)	(1.71588)
	[3.37720]	[0.17261]	[-1.39647]
D(MS (-2))	1.616487	0.99504	-2.04406
	(0.43184)	(0.80582)	(1.85575)
	[3.74328]	[1.23482]	[-1.10147]
D(Y (-1))	-1.24341	-0.84274	0.564108
	(0.31867)	(1.08542)	(1.29636)
	[-3.90182]	[-0.77642]	[0.43515]
D(Y (-2))	-0.98989	0.18902	1.502841
	(0.29309)	(1.00954)	(1.17023)
	[-3.37738]	[0.18723]	[1.28423]
C	-0.16862	-1.3044	-1.26136
	(0.21576)	(0.91414)	(1.53748)
	[-0.78154]	[-1.42691]	[-0.82040]
TRF	0.030773	0.375987	0.400402
	(0.06032)	(0.26989)	(0.4187)
	[0.51015]	[1.39312]	[0.95630]
R^2	0.843011	0.350922	0.647224
Adj. R^2	0.698099	-0.24823	0.321584
Sum sq. resids	0.093041	0.96631	4.856804
S.E. equation	0.084599	0.272638	0.611229
F-statistic	5.817379	0.585701	1.987544
Log likelihood	36.33421	5.908373	-15.0821
Akaike AIC	-1.79494	0.54551	2.160161
Schwarz SC	-1.16589	1.174558	2.789209
Mean dependent	0.188593	0.153057	0.037335
S.D. dependent	0.153969	0.244028	0.742088
Determinant residual covariance	3.63E-11	2.80E-11	2.94E-09

Table 6: Continued

	Dependent variable: Domestic Prices (DPL)		
Parameters	CPI	GDPD	AMP
Log likelihood	173.1128	176.4568	115.9688
Log likelihood (d.f adjusted)	128.0582	131.4023	70.91422
Akaike information criteria	-4.46602	-4.72325	-0.07032
Schwarz criteria	-1.07884	-1.33607	3.316859

rate in GDPD equation is statistically significant and rightly signed. Overall, there is a long run impact of exchange rate on domestic price ranging from -0.18% (CPI) to -0.47% (AMP) from 1% variation in exchange rate. Though slightly higher than Aliyu result of -0.10% for CPI in absolute terms, the import price result however, differs.

The second part of the VECM is the short run dynamics of measures of domestic prices and the determinants. Here, the lags of exchange rate (first and second lags) are rightly signed however only its second lag in the CPI equation is significant. This tends to suggest that short run variations in exchange rate might have been anticipated hence, there is no visible impact in the short run.

Other factors especially the money supply, income and world export price are significant and drive the variations in domestic price (CPI). Interestingly, none of these variables are statistically significant in the other two equations (GDPD and AMP).

The impulse response is analyzed and presented in the Appendix. The responses of domestic prices captured by two of the measures are similar. A casual inspection of these responses shows that the initial shock given by exchange rate does not show any profound influence on Consumer Price Index (CPI) and GDPD. The prices maintain the negative territory all through the 10 periods. Only marginal influence is evident in the response of GDPD though, it still lies in the negative territory but tilts towards the zero line and might cross the line with a longer time horizon.

The response of aggregate import price from exchange rate shock is short lived. Its impact is felt just after the second period and dies out in the 5th period. This tends to support the results obtained from VECM that show that exchange rate has impact on the domestic price measured by CPI but mainly in the long run. This study therefore, partly supports on the other hand, the findings of Omisakin (2009) that no short run impact of exchange rate on domestic price exist and that other factors such as money supply and income in addition to its own shock drive the variation in domestic price but differs on the other hand in the conclusion on the long run impact.

CONCLUSION

This study examined the relationship between exchange rate and domestic price in Nigeria during the period between 1980 and 2008. Domestic price is captured by three different measures: Consumer price index, gross domestic product deflator and aggregate import price. The results show that long run relationship exist between exchange rate and domestic price measured by CPI and there seems to be no evident short run impact of exchange rate on domestic price except in the instance where the second lag period of exchange rate in the CPI equation is significant. Short run variations in exchange rate might be anticipated and hence, the impact would be dampened. Further studies in this area could look at the impact of the anticipated and unanticipated exchange rate variations on domestic price and other methodologies could also be used especially, the Markov-switching vector error correction which is believed to be more appropriate for non-linear estimations. This could improve on the reliability of the error correction term. Government policy should refrain from using devaluation to address or shore up domestic price in the short term however such policy might be considered in the long term.

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