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Examination of the Exchange Rate and Import Price Pass-through to Inflation: A View from Nigeria

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Abstract

We examine the effect of exchange rate and import price pass-through to inflation in Nigeria using headline inflation and import price data, with the aid of a non-recursive Structural Vector Autoregression model. Our results indicate mostly incomplete ERPT and IPPT to inflation. Specifically, we found that (i) the ERPT to the INF is incomplete at all horizons. (ii) IPPT to the INF is incomplete at all horizons. (iii) IPPT to inflation is relatively more rapid than the ERPT to inflation. The findings further suggest that the monetary authority should be wary of using devaluation of the domestic currency as a way of propping up the economy as that would not only aggravate domestic inflation but likely to also increase the ERPT. Similarly, harmonizing the disparate exchange rate windows in the economy might reduce import price pass-through to domestic inflation. Also, the size and speed of both ERPT and IPPT from the study suggest that relevant authorities need to strengthen domestic industries and instill confidence in consumers, to reduce reliance on imports.

JEL Classification: C32; E31; F31; O55

Keywords: Exchange rate pass-through, import price pass-through, SVAR, inflation

1.0. INTRODUCTION

Over the last 20 years, the Nigerian economy has experienced spikes in its inflation mostly due to 'imported inflation', which is a result of significant dependence on imported items. Imported inflation may be caused by an increase in the prices of

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foreign goods, which could, in turn, exert upward pressure on prices of domestic goods that uses imports as raw materials. It could also be caused by a depreciation of the currency, which leads to higher prices of imported goods, and an increase in the general prices of all goods and services. With more economic openness, several countries, especially in the emerging market and developing economies (EMDEs) have been known to grapple regularly with exchange rate volatility and the attendant impact on inflation. Lopez-Villavicencio and Mignon (2017) reckoned that with the adoption of floating exchange rate regimes, inflation targeting monetary policies and removal of capital controls, emerging markets may likely face more exchange rate volatility and imported inflation. Fischer (2015) observed that fluctuations in the exchange rate are key drivers of inflation with implications for monetary policy decision making. Comunale and Kunovac (2017) noted that the extent of the exchange rate pass-through and its speed of transmission help to improve domestic inflation anchoring and forecasting. Consequently, it is important to understand and correctly assess the pass-through of the exchange rate to inflation to avoid severe policy slip-ups.

Evidence from the literature suggests that the exchange rate regime, the source of exchange rate shocks, the monetary policy framework, the level of transparency of monetary policy decisions as well as other country-specific characteristics could affect the extent of exchange rate pass-through to inflation. Ha et al (2019) found that EMDEs have more significant increases in consumer price inflation based on large depreciation episodes than in advanced economies. In terms of the nature of shocks, they found that higher exchange rate pass-through stems mostly from monetary policy shocks compared to other domestic shocks, while global shocks have different effects. Also, countries with more flexible exchange rate regimes and a credible commitment to an inflation target experience lower exchange rate pass-through to inflation. Lopez-Villavicencio and Mignon (2017) also showed that the exchange rate pass-through to consumer prices reduces with more transparency in monetary policy.

While most of the studies examined found partial or incomplete exchange rate pass-through to inflation (Campa and Goldberg, 2005; Jiang and Kim, 2013; Bada et al, 2016; Baharumshah et al, 2017), others found complete and higher ERPT in economies

with high imports (Ogundipe and Egbetokun, 2013; Bada et al, 2016; Çiftçi and Yılmaz, 2018).

This study contributes to the existing literature on ERPT, especially in the EMDEs, and specifically in Nigeria where exchange rate movements had been quite volatile in the past decade. The study assessed the effect of exchange rate and import price pass-through to inflation in Nigeria with three specific objectives: a) the completeness or otherwise of the exchange rate pass-through to inflation, b) the magnitude of exchange rate and import price pass-through to inflation, and, c) the speed of exchange rate and import price pass-through to the general price level. The analysis is based on a structural Vector Autoregressive (SVAR) model with a non-recursive identification scheme to recover the exogeneous import price and exchange rate shocks.

A summary of our empirical results reveals that the exchange rate and import price pass-through to inflation are incomplete at all horizons. Also, import price pass-through to inflation is relatively more rapid than the exchange rate pass-through to inflation.

The rest of the paper is organized as follows. A review of the relevant theoretical and empirical literature is presented in section two. The model specification and results of the model estimation are contained in section three and section four respectively, while section five presented the conclusions.

2.0. Literature Review

The theoretical literature on the exchange rate pass-through is drawn from the monetary theory to exchange rate determination, the law of one price and the purchasing power parity theory. Subsequently, there is an interplay between the exchange rate and a country's price level, in that the level of inflation and the dynamics associated with it influence the purchasing power of a currency. Further, depending on the extent to which a nation depends on imported goods and services, its domestic inflation could be impacted through the exchange rate, a phenomenon that is known as exchange rate pass-through (ERPT). Goldberg and Knetter (1999) define exchange rate pass-through as the "percentage change in import prices caused by a 1 percent change in the bilateral currency exchange rate between an

exporting and importing countries". By implication, the depth and speed of exchange rate pass-through are, therefore, dependent on the extent to which a nation relies on foreign goods or services.

The literature on exchange rate pass-through gained prominence in the 1970s in response to an increase in the price of oil which generated inflationary shocks. In high inflation environments, the concern is expressed by central banks on the movements of the exchange rate and its reflection on prices because of currency depreciation. A low pass-through gives a central bank a higher degree of independence when it conducts its monetary policy operations and it makes it possible for a central bank to implement an inflation-targeting framework. However, in countries with a higher degree of exchange rate pass-through (countries with high imports), changes in prices of imports can result in a much larger change in the consumer price index.

Exchange rate volatility influences exchange rate pass-through even to investment decisions as high volatility will tend to make them more cautious given their profit motive. Ca'zozzi et al (2007) and McCarthy (2007) examined the exchange rate and import price pass-through in emerging markets and industrial countries and found ERPT to be lower in countries with higher volatility, but also higher aggregate demand.

As such, the size and speed of the exchange rate pass-through depend on factors such as expectation regarding the length of currency depreciation and the level of aggregate demand. The depreciation of the currency is expected to be reflected in higher prices of imported goods. If the depreciation is not fully reflected in the prices of the imported goods, the exchange rate pass-through to prices is incomplete. An incomplete pass-through reflects the partial transmission of exchange rate changes into prices and affects Macroeconomic policy, as noted by Shitile and Usman (2020).

The law of one price (LOOP) lays the foundation for the relationship between exchange rate and inflation. The law states that in the absence of trade frictions and under a system of free competition and flexible pricing, identical goods sold at different places must be sold at the same unit price when expressed in the same currency. Hence, when price changes in the home currency market it would have an equal change in price at the foreign market despite it being two different countries.

The monetary approach to exchange rate determination principally relies on Krugman's (1986) monetary exchange rate model which uses the LOOP and PPP to explain how changes in the exchange rate affect the price level. Authors concluded that all things being equal, an increase in money supply growth should be proportionate to the increase in the inflation rate and rate of exchange rate depreciation. This method emphasizes that in the long-run money supply, inflation, interest rate, and exchange rate are intertwined.

The literature of models on 'industrial organization' has attempted to explain the nexus between inflation and exchange rate through import penetration, oligopolistic competition, market concentration, and the degree of substitution between foreign and domestic goods produced. Dohner (1984) attempts to explain the divergence in the prices of traded goods across markets using a dynamic model of pricing by forward-looking and profit-maximizing exporters. The model assumes that consumers adjust slowly to price changes. He finds that the level of pass-through is determined through the speed and expectation of consumers of the duration of the exchange rate changes. This conforms with Kreinin et al (1987) who provide evidence that industry characteristics determine the extent to which exchange rate movements are passed on to the dollar price of foreign goods. Krugman (1986) in his work entitled "pricing to Market", explains that the reason for incomplete exchange rate pass-through to prices of imported goods is due to the behavior of firms.

Dornbusch (1987) developed a static model to explain the degree of pass-through regarding the competition between firms, both foreign and domestic. The analysis revealed that an incomplete pass-through can occur even if goods are perfect substitutes. Fisher (1989) also lays out a model of exchange rate pass-through using a partial equilibrium model in which firms (domestic and foreign) set their prices based on the expected exchange rate. The study discovered that the changes in the exchange rate could lead to changes in import prices. However, the degree of pass-through depended on the market structure existing in domestic and foreign markets. On market structures, Baldwin (1988) uses a model sunk market-entry cost where temporary fluctuations in the exchange rate alter the domestic market structure to influence the pass-through of the exchange rate to the prices of imports.

Obstfeld and Rogoff (1995) using a micro-founded dynamic general equilibrium model, introduce nominal rigidities and market imperfections. They found that purchasing power parity was always still maintained, and the pass-through was complete. Also, Betts and Devereux (1996, 2000) developed an extended version of the Obstfeld-Rogoff model allowing for pricing-to-market. They only differ from Obstfeld and Rogoff (1995) model by changing the assumption on the pricing strategy of firms, whereas, Obstfeld and Rogoff (1995) assume nominal prices are set in producers' currencies. Therefore, a fluctuation in the nominal exchange rate cause equal feedback in prices of imported goods, i.e. the pass-through in the short-run exchange rate is then complete. The implication for policy is that flexible exchange rate regimes act as a substitute for flexible nominal prices, and therefore help to achieve relative price adjustments, making it a more desirable exchange rate regime. However, Betts and Devereux (1996, 2000) propose a model in which a segment of firms can set prices in the foreign currency market. This diminishes the effect of exchange rate volatility on domestic prices.

In recent times, the literature on exchange rate pass-through has begun taking the view that imports are intermediate goods that undergo non-traded production or distribution processes before being consumed. This process might weaken the impact of exchange rate volatility on prices. Subsequently, the exchange rate changes only affect the final goods price, and the pass-through to consumer prices is likely to be small.

The commitment of central banks to maintain a low inflation environment play a critical role in firms transmitting their prices. Using a microeconomic model of staggered pricing, Taylor (2000) produced a theoretical framework where the degree of pass-through depends on the inflation environment. He finds that a lower pass-through is caused by lower perceived persistence of cost changes. Additionally, the author finds a positive correlation between the persistence and level of inflation in the USA. The paper concludes that low inflation causes low pass-through. Drawing on Taylor (2000), the links between pass-through and inflation has been further examined by (Gagnon and Ihrig, 2004) who carry out an analysis of twenty industrialized

countries. They concluded that the pass-through wilted in countries whose central banks have adopted inflation targeting since the 1990s.

Critical role in determining ERPT is played by the composition of a country's import basket in determining the pass-through, and this assumption has been confirmed by Campa and Goldberg (2005) who conclude that changes in the pass-through are mainly caused by changes in the composition of a country's import basket. They stress that moving away from energy which has a high pass-through to manufactured goods which the pass-through is comparatively low will reduce the pass-through to import prices, leading to lower prices for consumers.

Campa and Goldberg (2005), one of the commonly cited papers in the literature on the subject matter, analyzed pass-through elasticities for 23 OECD countries using quarterly data from 1975 to 2003. The authors showed that there was a partial pass-through effect of the exchange rate on import prices in the short-run, particularly in manufacturing companies. Also, OECD countries that had lower rates of the exchange rate and inflation volatility had a lower pass-through impact on import prices. For example, they found that the United States had one of the lowest pass-through elasticities, at approximately 25 percent in the short run and 40 percent in the long run. The Authors observed that changes in pass-through effects in import prices could be associated with shifts in the composition of the import components in these OECD countries.

Some studies have carried out an empirical analysis of the subject matter in Nigeria using an SVAR. Leading the way is Zubair et al (2008) who find the the ERPT to be incomplete while it takes eight quarters for the full impact of the pass-through to be felt. Ogundipe and Egbetokun (2013) adopted the SVAR approach for the period 1970-2008 in estimating the pass-through effect of the exchange rate to inflation in Nigeria. The Authors found a substantially large pass-through from the exchange rate to inflation and asserted that the depreciation of the currency over the period influenced the results. They further observed that when the depreciation of the currency is persistent, the attendant increase in costs gets passed on to consumers by firms and importers. The Authors also noted that the large share of imports in the consumption basket coupled with high and persistent inflation in Nigeria during the

examined period could explain the degree of exchange rate pass-through. Similarly, Bada et al (2016) examined the exchange rate pass-through to import and consumer prices for the period 1995 – 2015. The study also found that the pass-through from the exchange rate to inflation was incomplete in Nigeria, utilizing the Johansen approach to cointegration and a vector error correction model. Also, the exchange rate pass-through was found to be higher in import prices than in consumer prices.

For papers on other climes that adopted an SVAR framework (see e.g. Kim and Roubini, 2000; McCarthy, 2007; Ito and Sato, 2008; Shambaugh, 2008; Jiang and Kim, 2013; Saha and Zhang, 2013; Amoah and Aziakpono, 2016; Hajek and Horvath, 2016; Vo et'al (2018); Forbes et al., 2018; and Anc, Chi and Duc (2019)). Specifically, McCarthy (2007) examined the pass-through of exchange rates and imported prices to the inflation, in selected industrialized countries. He finds CPI has a reduced response to exchange rate shocks compared to PPI inflation. Also, Jiang and Kim (2013) use an SVAR framework to examine the ERPT to inflation in china. Jiang and Kim (2013) show that an incomplete and rapid pass-through exist from exchange rates to domestic price inflation. Hajek and Horvath (2016) used different model specifications of the SVAR framework to show that the Czech Republic had an average pass-through of approximately 20 percent from exchange rate movements to the CPI over the 1998–2013 period. To conclude, Forbes et al. (2018) incorporates an SVAR model with sign restrictions as well as short and long-term restrictions for selected developing countries. They find the ERPT is higher following monetary shocks and low following a demand shock. For literature on the assymetric effects of the ERPT see (Caselli & Roitman,2019; Cheikh et al. 2018; Turner & Wood 2017; Faryna, 2016 and Mototsugu et al (2013) ;

3.0. Model Specification

The objective of this paper is to determine the impact of changes in the exchange rate and import price on prices along the value chains, i.e. the general price level in the economy, given domestic monetary policy influence. Our focus rests on three objectives: a) the completeness or otherwise of the ERPT to inflation, b) the magnitude of ERTP and IPPT to inflation, and, c) the speed of ERPT and IPPT to the general price level. The paper follows (Choudhri et al, 2002; Gueorguiev, 2003; McCarthy, 2007; Ito &

K, 2008; and Jiang & Kim, 2013) who also have investigated ERPT through structural analysis. Similarly, SVAR, through its two potent tools, impulse response and variance decompositions, is capable of individually or collectively providing more information in regards to the impact of macroeconomic shocks and policy innovations (Aarle et al, 2003).

In the model, the pass-through from the exchange rate to prices is occasioned by supply and demand shocks and assessed through the consumer price index. We, however, being conscious of the country's propensity for the consumption of foreign-produced goods, decided to see the effect of changes in import prices alongside those of exchange rate on inflation.

All the data were sourced from the Central Bank of Nigeria database. We adopted a non-recursive identification system to recover exogenous monetary policy shocks and exchange rate shocks. According to Jiang & Kim, (2013), a VAR analysis of the ERPT makes it easier to account for the feedback between exchange rate and other prices; it allows for a proper investigation of the effect of exchange rate shocks and monetary policy shocks on domestic inflation in an integrated framework, and lastly, it simplifies the task of tracking the ERPT into a set of domestic prices along the distribution chain in a single framework.

Our VAR model takes the following general form:

$$A(L)Y_t = \varepsilon_t \tag{1}$$

Where $A(L)$ represents the path order matrix polynomial in the lag operator, L ; to the extent that $A(L) = A_0 - A_1L - A_2L^2 - A_nL^n - \dots - A_nL^n$; where $A_0 =$ non-singular matrix normalized to 1 on the diagonal and explains the contemporaneous relationships between the endogenous variables in the $n \times 1$ vector Y_t, ε_t in an $n \times 1$ vector of structural disturbances. In association with this, the reduced form VAR is estimated as

$$\beta(L)Y_t = \mu_t \tag{2}$$

Where $\beta(L)Y_t$ is an n^{th} order matrix polynomial in the lag operator L ; μ_t is an $n \times 1$ vector of reduced form disturbances.

Relationships between Eq (1) and eq (2) could be expressed as follows:

$$\beta(L) = A_0^{-1}A(L) = I - \beta_1L - \beta_2L^2 - \dots - \beta_nL^n \quad (3)$$

$$\text{And } \mu_t = A_0^{-1}\varepsilon_t \text{ or } \varepsilon_t = X_0\mu_t \quad (4)$$

Being a short-run SVAR, identification is obtained by placing restrictions on the non-singular matrices A and B. Given that there are $\frac{K(K+1)}{2}$ free parameters in ε_t , this allows for as many as possible parameters to be estimated in the A and B matrices. Given a $2K^2$ parameters in A and B, the sequential position for identification requires that $2K^2 - \frac{1}{2}K(K+1)$ restrictions be imposed, implying that our five variables would require thirty-five (35) restrictions based on literature and economic theory to achieve proper identification of the structural parameters. This is appropriate considering the short-run nature of our model and the absence of exogenous variables.

Our VAR model comprises of a vector of five endogenous variables, $Y_t = (MPR_t, NEER_t, INF_t, IMPI_t, GOP_t)$, where MPR_t connotes monetary policy rate; $NEER_t$ represents the exchange rate, a more realistic measure of the interest rates available in the real sector; INF_t is consumer price index; $IMPI$ import price index; $NEER_t$ is the nominal effective exchange rate, and GOP_t is global oil price.

The selection of these variables follows both Jiang & Kim (2013) and McCarthy (2007) but without the intermediate prices as in Jiang & Kim (2013), due to unavailability of these data within the selected periods.

The choice of inclusion of these variables: nominal effective exchange rate, the consumer price index, and the import price, is to enable us to evaluate the extent of the ERPT into domestic prices along the distribution chain. The money stock as represented by the broad money and interest rate as proxied by the monetary policy rate is included for two reasons, (1) to gauge monetary policy reaction to contemporaneous or previous exchange rate movements, and (2) given the fact that monetary policy has a significant influence on exchange rates and domestic inflation. International oil price was included as a veritable proxy for global activity, and with contemporaneous feedback into the supply side of the Nigerian economy via the two domestic prices.

While Nigeria is considered the largest open economy in Africa, albeit a small to medium-sized in a global context, the country's monetary policy decisions have no

effect whatsoever on the global interest rate, global oil prices are considered to be contemporaneously exogenous in terms of the domestic economy. Import price index and inflation, as represented are included to serve as a proxy for the demand-side factors.

In our VAR model, we imposed a non-recursive identification scheme only on the contemporaneous structural parameters, X_0 . Our identification scheme based on $\varepsilon_t = X_0\mu_t$ is summarized in the following equations.

$$\begin{bmatrix} \varepsilon_{MPR} \\ \varepsilon_{NEER} \\ \varepsilon_{INF} \\ \varepsilon_{IMPI} \\ \varepsilon_{GOP} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & a_{23} & a_{24} & a_{25} \\ a_{31} & a_{32} & 1 & a_{34} & a_{35} \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \mu_{MPR} \\ \mu_{NEER} \\ \mu_{INF} \\ \mu_{IMPI} \\ \mu_{GOP} \end{bmatrix} \quad (5)$$

where ε_{MPR} , ε_{NEER} , ε_{INF} , ε_{IMPI} , and ε_{GOP} represent the structural disturbances, to wit: monetary policy shocks, exchange rate shocks, Cost push shock, structural shocks to import prices, and Oil price shock, respectively; and μ_{MPR} , μ_{NEER} , μ_{INF} , μ_{IMPI} , μ_{GOP} represent the residuals from the corresponding equations in the reduced form VAR.

The details of our identifying restrictions are as follows: The monetary policy framework of the central bank of Nigeria is monetary targeting, as such, the monetary policy rate equation represents the reaction function of the central bank in its efforts to regulate inflation. According to Sims & Zha (1998), as cited by Jiang & Kim (2013), monetary policy, despite our data, cannot respond immediately to price developments due to information lags, and neither can it respond to developments in the global oil market. Given this reality, we suppressed the monetary policy reaction to import prices and changes to global oil prices, but we allow it to affect inflation.

For the exchange rate equation, we reckoned that changes in the bilateral exchange rate are caused, among other factors, change in interest rate, change in inflation rate and change in a country's current account position, and changes to global oil price movements, but not necessarily vice-versa, as such, we excluded contemporaneously the policy rate, inflation, import prices, and commodity prices. For the inflation equation, we assumed that exchange rate shocks and import prices would affect

investors' perception contemporaneously, but the effects of interest rate and commodity price changes would come with a lag because of economic agent's initial cautious response and possible planning delays (Sims & Zha, 1998). The real activity in our model is assumed to be affected by inflation and the nominal exchange rate with a one-period lag, (Jiang & Kim, 2013), as such we allowed commodity prices to affect exchange rate contemporaneously, given that Nigeria's bulk of the country's foreign exchange reserve comes from oil export. It's pertinent to mention that our structural model is overidentified with contemporaneous restrictions as shown in equation (5). This implies that our equation contains more zero restrictions than required for our model to be just identified.

4.0 Pre-Estimation Tests

Stationarity Test: The results displayed in Table 3.1 show that our time series data are of the integrated order I(1) at level, i.e., we failed to reject the null hypothesis of no unit root, indicating that our data are non-stationary at level. However, we rejected the null hypothesis of no unit roots for all the time series at their first difference in the second columns of both the ADF and PP, given that the values of the Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) test statistics are less than their critical values at 1% level of significance. As such the variables became stationary with no trace of unit root at their first difference.

Table 1 Conventional unit root tests

	ADF		PP	
	Level	1st Difference	Level	1st Difference
MPR	-2.054 (0)	-9.795***	-2.037	-9.819***
NEER	-0.206 (0)	-9.031***	-0.298	-9.003***
INF	-1.904 (2)	-4.973***	-1.701	-11.199***
IMPI	-2.654 (0)	-11.642***	-2.651	-11.609***
GOP	-1.242 (1)	-8.231***	-1.171	-8.227***

Notes:

***denotes rejection of the null hypothesis of unit roots at a 1% level of significance. Both the Augmented Dickey-Fuller (1981, ADF) and Phillip-Peron (1988, PP) tests were conducted, following (Jenkins and Katircioglu, 2011) and per (Enders and Granger, 1998). Tests were carried out with the aid of E-Views 11

Table 2 depicts the lag length criteria that we followed in choosing the optimal lag length for our VAR analysis. As can be seen, of the five criteria, one recommended a single lag, i.e., SC, while another (FPE) recommended twelve. However, LR, AIC, and

HQ supported three lags. While using one lag resulted in serial correlation in the VAR residuals, hence not capable of adequately modeling persistence in the data, twelve lags rendered the SVAR model unstable with resultants explosive impulse responses. Given this consideration and the monthly nature of our data, we included three lags in the SVAR model, following some empirical studies in which VAR was estimated with monthly data. The AIC and HQ statistics supported our choice of 3 lag as can be seen in table 3. Consequently, we did not observe evidence of serial correlation in the VAR residuals and the stability condition for the VAR model is satisfied.

Table 2. Lag length Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1976.94	NA	240.10	41.33	41.52	41.41
1	-1159.56	1498.53	235.52	25.32	26.82*	25.93
2	-1122.98	61.72	309.83	25.58	28.39	26.72
3	-1089.52	47.14*	445.69	16.91*	30.02	22.57*
4	-1051.78	52.68	609.36	26.14	31.56	28.33
5	-1000.10	64.60	658.22	26.09	32.82	28.81
6	-954.81	50.01	876.61	26.16	34.20	29.41
7	-891.42	60.75	889.77	25.86	35.21	29.64
8	-805.40	69.89	653.39	25.09	35.75	29.40
9	-731.46	49.30	764.79	24.57	36.54	29.41
10	-640.94	51.59	881.50	23.71	36.98	29.07
11	-489.42	56.82	498.63	21.57	36.16	27.47
12	-221.19	61.47	77.27*	17.00	32.90	23.43

Table 3. Reduced form diagnostics for the SVAR model

Model	Lag order	Order of serial correlation ²	Multivariate LM test statistics ³	Significance Level ⁴	Stability condition ⁵
SVAR	3	AR(1)	17.89	0.85	Yes
		AR(2)	19.74	0.76	
		AR(3)	20.28	0.73	
		AR(4)	22.81	0.59	
		AR(5)	29.80	0.23	
		AR(6)	11.03	0.99	
		AR(7)	37.83	0.05	
		AR(8)	25.94	0.41	
		AR(9)	28.56	0.28	
		AR(10)	33.09	0.13	
		AR(11)	28.52	0.28	
		AR(12)	30.82	0.20	

The sample period is 2010M01 – 2018M12

²The column displays the specified order of serial correlation for our reduced-form VAR residuals

³Report of multivariate LM test statistics for the VAR residuals for serial correlation up to the order reported in the third column.

⁵The column indicates the stability or otherwise of the VAR model. In other words, it shows whether the roots of the characteristic polynomial for the estimated VAR are greater than 1 in absolute values. The "Yes" indicates that the VAR model satisfies the stability condition.

4.1. Results of Estimation

In this section, we report our impulse response functions, then, we looked at the exchange rate pass-through elasticities, followed by the variance decomposition, and finally, we take a look at the historical decomposition.

In table 5, we report the estimated coefficients of relevant variables in their various blocks. As can be seen in the first equation, the contemporaneous interest rate elasticity (as represented by the policy rate, MPR) is positive, indicating that the central bank of Nigeria will attempt to smooth interest rates by increasing the money stock in the system in line with its price stability mandate. However, the contemporaneous administered CPI elasticity carries a positive sign, implying that the monetary authority might attempt a palliative short-term policy measure by increasing the money stock, likely through the open market operations (OMO) to meet money demand pressure. The market-determined CPI elasticity, however, is surprisingly negative, a seemingly a posteriori outcome, indicating that market prices react negatively to interest rate movement rather than changes in the money stock.

In the interest rate equation, the positive exchange rate elasticity implies that the central bank of Nigeria would attempt to increase the policy interest rate to shore up the value of the domestic currency against the major convertible currencies, subsequently, any reduction in policy rate causes a depreciation of the domestic currency. The market price elasticity in the output equation, as proxied by the purchasing managers index is positive, an outcome that aligns with theoretical expectation, in that businesses would respond positively to higher market prices as it is an indication of upbeat consumer sentiments. In the exchange rate equation, the elasticity coefficient for both the market prices and output are negative, implying that market prices on goods will decline as domestic currency appreciates via cheaper import prices. Similarly, manufacturers' sentiments rise when the value of the domestic currency rises, that is, investors become more sanguine as less amount of domestic currency is used in exchange for a unit of foreign currency, or put another way, investors, tend to value the naira less, demanding for more of it in exchange for one

unit of foreign currency. The likelihood ratio (LR) test statistics indicate that our identifying restrictions are not rejected at 1% significant level by the over-identifying restriction (OIR) test, $\chi^2(2) = 13.239$; $p = 0.0013$. This could be attributed to the combination of a relatively small sample size and the number of estimated parameters.

Figure 1 depicts the non-accumulated impulse response functions (IRFs) spanning 24 months for all the variables to a one positive standard deviation shock to the exchange rate and import price equations. In response to a positive (depreciation) one standard deviation innovation in the exchange rate equation, interest rate rises sharply through the first month, an a priori response, and then, declines slightly through the eighth month before it levels up and appears persistent into the horizon. In response, inflation declined almost proportionally to the rise in interest rates. Inflation rose again, just in the second month, but it maintained a gradual decline through the twelfth month when it resumed another stretch of gradual ascent which persisted through the convergence line. The exchange rate in response to its own shock remained flat in the first month, then declined through to the fourth month. It again rose slightly for another two months and started to decline then after. Prices of imported items assumed a steep descent in the first two months, pointing to a possible reduction in the consumption of foreign-produced goods. This reduced prices, however, only lasted that much before it picked up steam in the second month up to the horizon. Output falls in the first quarter in response to the depreciation of the domestic currency. While we included the response of the global oil price in the IRF results, interpreting it would be of little use, as activities in the Nigerian exchange rate market is not expected to have any implications for global oil prices.

Figure 1 Impulse Response Functions (IRFs)

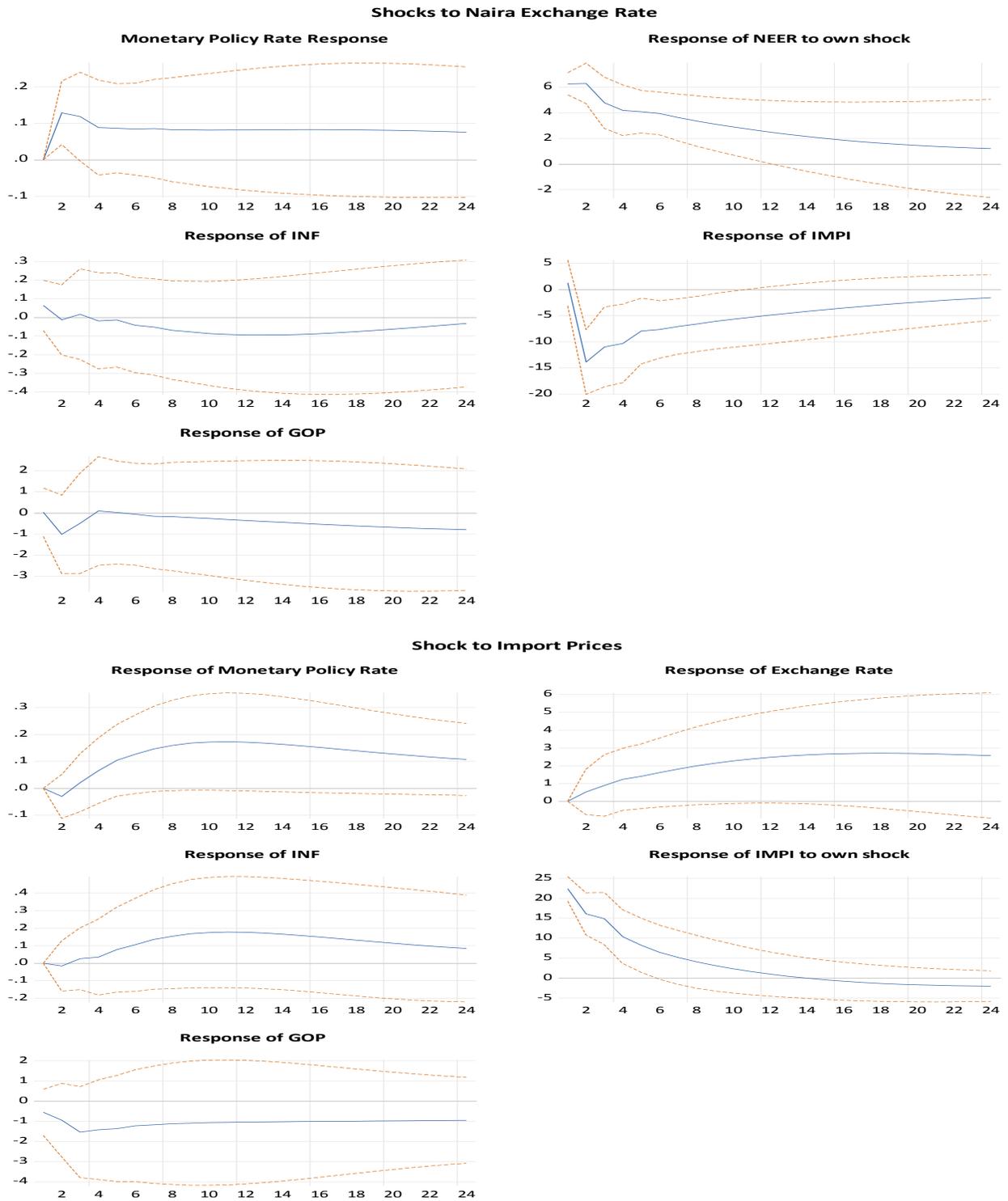


Fig. 1. Impulse responses to a positive one standard deviation of selected shocks. 2010M01-2018M12. The first graph shows responses of relevant variables in the structural equation to the money exchange rate of the domestic currency to the US dollar, while the second graph shows responses to shocks resulting from the external sector.

In response to a positive one standard deviation innovation import equation, the monetary policy rate drops drastically dropped for in the first two months, then gradually rose for the next 10 months, before it began to soften in the 12th month. Consequently, the exchange rate rose through to the 12th month before retracting and leveling up at a lower level. Inflation on its own, responded with a lag, declining in the first month before assuming a gradual ascent through to the 11th month. Except for the one month lagged responses of inflation and bilateral exchange rate, these responses follow a conventional view or a priori outcome, in that, a rise in the prices of imports is expected to be accompanied by a depreciation of the domestic bilateral exchange rate, as a result of higher demand for the domestic currency to offset the increased gap. In effect, the results are generally in accord with theoretical expectation, in that a weakened bilateral exchange rate of the domestic currency induces higher prices in the domestic market, and ultimately attracts higher costs of fund. Higher demand for local currency is expected to be accompanied by an increase in interest rates and vice versa. The response of import prices to its own shock is negative and immediate up to the 16th month, after which it levels up. Global output responded by declining for the first three months, then, started to rise, albeit at a statistically insignificant rate.

We now study the impact of the exchange rate and imports price changes on prices along the distribution chain by following (Kim W. J. 2007) who argued that only the ERPT from a structural VAR can capture the unbiased exchange rate pass-through when one or more of the import price variables is endogenous. Accordingly, we also estimated the exchange rate pass-through elasticity coefficient through the structural VAR's impulse response or the normalization of our inflation responses to the exchange rate and import price shock through the response of the exchange rate and import price to their own shocks within the same horizon.

The dynamic pass-through elasticity could be stated in the following form:

$$PT_{t,t+i} = \frac{\sum_{i=1}^T \rho_{t,t+i}}{\sum_{i=1}^T \bar{e}_{t,t+i}} \quad (6)$$

Where $PT_{t,t+i}$ represents the cumulative pass-through between month t and month $t + i$; $\bar{e}_{t,t+i}$ represents the cumulative change in the price level between the corresponding months. Table 5 presents the estimated pass-through elasticities for our

two analytical price measures for up to 36 months horizon. As can be seen, the ERPT and import price pass-through to the inflation are incomplete at all horizons. The magnitude (0.006 to 0.084) indicates the extent at which the inflation moves with the nominal exchange rate, and the range (0.061 to 0.23), the extent at which inflation moves with import prices. While the general price level appears to move less than one-for-one with the nominal exchange rate, the rate of movement with import prices is higher than the rate at which inflation moves with the exchange rate. This is in line with (McCarthy, 2007), and invariably points to the high extent at which foreign-made goods have infused the country's landscape or consumers' preference for imported goods. Another reason why exchange rate infusion into inflation might appear low is that the available exchange rate data is that of the official exchange rate window, with data on the parallel market mostly inexistent, as such, most transactions in the foreign exchange market usually go unreported or underreported. Secondly, the impact of exchange rate depreciation in the country could have been muffled by the price stickiness in some sectors of the economy that resulted from government subsidy and menu costs.

Similarly, the pass-through to inflation from import prices is observed to be higher than to EXPT at all horizons, a phenomenon that is also evidenced by the impulse response analysis. However, both the import price pass-through to inflation and exchange rate pass-through reach their maximum within the first 12 months and ranges from 0.025 to 0.177, for the IPPT and 0.010 to 0.094 (in absolute term) for the ERPT. Incidentally, most of the impacts from import prices are felt within 12 months, while most for the ERPT is within 18 months. Almost half of the changes in the exchange rate is passed to the inflation within the first 3 months, the corresponding share for import price pass-through is about one-third. One reasonable assumption that can be deduced for the rapid pass-through is the insufficient industrial capacity in the country given the huge population, to the extent that citizens rely more on foreign-produced goods to sate their consumption appetites. Another reason could be attributed to the lack of an efficient foreign exchange forward market where investors can hedge against exchange rate risks (Lafleche, 1996; Kim W. J., 2007).

Table 5. Estimated ERPT and Import Price Pass-through Coefficients, 2010M01 – 2018M12

Months	NEER→INF	IMPI→INF
1	0.064	0.000
3	0.017	0.025
6	0.042	0.105
9	0.078	0.168
12	0.094	0.177
15	0.091	0.158
18	0.076	0.132
21	0.056	0.105
24	0.032	0.084
27	0.010	0.068
30	0.011	0.057
33	0.028	0.051
36	0.048	0.047

To further assess the impact of different shocks on movements in domestic prices, we estimated the forecast error variance decomposition (FEVD) analysis for the SVAR model. Table 6 presents the variance decomposition of all our variables over a forecast horizon of 36 months. The first column in the table consists of the forecast horizon, the second column contains the forecast error of the variable at each forecast point. In the remaining 5 columns, we present the percentage of the forecast error variance stemming from each shock and with each row summing up to 100. For exchange rate, the largest and second-largest contributions to its forecast error variance came from NEER and oil prices during the entire forecast horizons, with NEER contributing about 99.1 percent at the peak, while oil prices contributed about 50 percent at the end of the horizon, essentially, reducing the contribution from the NEER to just about 20 percent, as contributions from the remaining variables picked up steam.

Table 6

Variance Decomposition for the SVAR: selected variables 2010M01 – 2018M12

Variance Decomposition of NEER

Period	S.E.	MPR	NEER	INF	IMPI	GOP
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1	0.393	0.90 (1.98)	99.10 (1.98)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
3	0.691	2.24 (3.54)	95.63 (4.99)	1.10 (2.49)	1.01 (2.55)	0.03 (1.33)
6	0.978	5.87 (6.32)	85.27 (9.94)	4.42 (5.91)	4.04 (4.93)	0.40 (2.82)
9	1.182	9.27 (8.48)	72.31 (13.75)	8.08 (9.09)	7.40 (7.21)	2.95 (5.39)
12	1.322	11.50 (9.64)	59.75 (15.79)	10.17 (11.12)	10.34 (9.19)	8.24 (9.13)
15	1.417	12.48 (10.28)	49.06 (16.47)	10.47 (12.10)	12.45 (10.67)	15.54 (12.70)
18	1.482	12.60 (10.57)	40.55 (16.39)	9.64 (12.40)	13.70 (11.64)	23.51 (15.51)
21	1.528	12.28 (10.64)	34.05 (16.00)	8.39 (12.30)	14.29 (12.19)	30.10 (17.41)
24	1.562	11.83 (10.64)	29.19 (15.59)	7.18 (12.06)	14.45 (12.42)	37.34 (18.54)
27	1.589	11.42 (10.64)	25.62 (15.28)	6.21 (11.85)	14.41 (12.41)	42.32 (19.17)
30	1.613	11.13 (10.70)	23.03 (15.06)	5.52 (11.76)	14.30 (12.26)	46.01 (19.55)
33	1.634	10.97 (10.79)	21.16 (14.94)	5.08 (11.82)	14.20 (12.06)	48.59 (19.80)
36	1.654	10.95 (10.90)	19.83 (14.89)	4.82 (11.10)	14.13 (11.88)	50.27 (19.99)

Standard Errors are in parenthesis, using Monte Carlo with 100 repetitions

Variance Decomposition of IMPI

Period	S.E.	MPR	NEER	INF	IMPI	GOP
1	0.393	10.27 (5.39)	0.28 (1.78)	0.278 (1.82)	89.18 (5.36)	0.00 (0.00)
3	0.691	12.76 (7.63)	20.92 (7.91)	1.02 (2.80)	65.10 (8.76)	0.21 (1.74)
6	0.978	12.97 (8.69)	25.44 (10.29)	3.12 (6.53)	55.98 (10.71)	2.49 (3.24)
9	1.182	11.52 (8.24)	27.57 (11.08)	3.07 (7.32)	51.03 (10.96)	6.81 (6.15)
12	1.322	10.72 (7.73)	28.27 (11.53)	3.02 (7.43)	46.82 (11.17)	11.17 (8.83)
15	1.417	10.58 (7.54)	28.16 (11.95)	3.67 (7.84)	43.59 (11.56)	13.10 (10.55)
18	1.482	10.75 (7.59)	27.80 (12.25)	4.75 (8.39)	41.55 (11.87)	15.14 (11.48)
21	1.528	10.99 (7.69)	27.46 (12.40)	5.89 (8.90)	40.46 (12.09)	15.20 (11.86)
24	1.562	11.17	27.14	6.84	39.94	14.91
27	1.590	11.25 (7.78)	26.81 (12.30)	7.49 (9.76)	39.62 (12.39)	14.83 (11.71)
30	1.613	11.23 (7.82)	26.40 (12.11)	7.81 (10.12)	39.29 (12.47)	15.26 (11.55)
33	1.634	11.13 (7.88)	25.92 (11.89)	7.89 (10.37)	38.85 (12.50)	16.22 (11.49)
36	1.654	10.98	25.38	7.80	38.29	17.55

(7.92) (11.64) (10.50) (12.48) (11.49)

Standard Errors are in parenthesis, using Monte Carlo with 100 repetitions

For the imports, contributions to the forecast error variance came largely from its own shock, while exchange rate contribution came a distant second, and oil prices came third throughout the forecast horizons. It is quite noteworthy that for both the NEER and IMPI, own innovation is the most significant source of fluctuation at all forecast horizons, comprising 99 percent and 89 percent, respectively at the peak before shrinking to 20 percent and 38 percent at the tail end of the horizon. Another very important point to note here is the fact that the impact of import prices on inflation is greater than that of the exchange rate on inflation. This is in line with the results obtained from the ERPT and impulse response functions.

5. Conclusion

This paper examines the effect of the exchange rate and import price pass-through to inflation in Nigeria. The analysis is based on a structural VAR model with a non-recursive identification scheme to recover exogenous import price and exchange rate shocks. Our results indicate mostly incomplete ERPT and IPPT to inflation. Specifically, we found that (i) the ERPT to the INF is incomplete at all horizons. (ii) IPPT to the INF is incomplete at all horizons. (iii) IPPT to inflation is relatively more rapid than the ERPT to inflation.

As in most economies, exchange rate stability constitutes a significant part of price stability in Nigeria. Our results, although, revealed that the size and speed of the exchange rate pass-through (ERPT) to inflation is less than that of import prices, meaning that a positive one standard deviation shock to the exchange rate and import prices tends to elicit a positive but disproportional response in inflation. Put another way, the rate of reaction of inflation to a one percentage point change in the exchange rate is less than the rate of reaction inflation exhibits to a one percentage change in import prices. In effect, the response of inflation to shocks coming from import prices is higher than that of those coming from the exchange rate. In response, monetary policy stance turned contractionary for the first two periods, then loosened up slightly before it normalized about 7 months later. The implication here is that monetary policy can offset only a part of the effect of exchange rate shock on domestic inflation.

The results also showed that ERPT and import price pass-through to inflation are incomplete at all horizons. The magnitude (0.010 to 0.094) indicates the extent to which the inflation moves with the nominal exchange rate, and the range (0.025 to 0.177), the extent of co-movement between inflation and import prices. In both cases, is less than one-for-one with the exchange rate. The rate of movement with import prices is higher than the rate at which inflation moves with the exchange rate. This invariably points to the rather high rate of infusion of foreign-made goods into the Nigerian landscape. Another reason why exchange rate infusion into inflation might appear lower is that the available exchange rate data is that of the official window, with data on the parallel market mostly inexistent, leading to most transactions in the foreign exchange market being unreported or underreported.

Consequently, the ability to achieve harmonization across disparate exchange rates and maintain stability in the exchange rate market is essential to achieving the central bank's price stability mandate. That role of the exchange rate in stabilizing prices across the entire price spectrum cannot be supplanted just by targeting money growth, as in the current framework. It is also clear that prevailing domestic inflation had some extemporaneous effects on the pass-through of import prices. Also, the findings revealed that the monetary authority should exercise caution in using devaluation of the domestic currency to promote economic growth, as that would not only exacerbate domestic inflation but also likely increase the ERPT. This is even more so, given that exchange rate devaluation is unlikely to improve the country's chances in the international market vis-à-vis its exports.

Declarations:

- ❖ **Ethics approval and consent to participate** – Not Applicable
- ❖ **Consent for publication** – All participating authors have given their consent for publication of the manuscript.
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- ❖ **Authors' contributions** – Samuel F. Onipede and Nafiu Bashir were responsible for the model estimation, discussions and interpretation, while Kodili Nduka and Nuruddeen Usman were responsible for the theoretical and empirical literature.
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List of Abbreviations:

- ADF:** Augmented Dickey-Fuller
AIC: Akaike Information Criterion
CBN: Central Bank of Nigeria
CPI: Consumer Price Level
EMDEs: Emerging Market and Developing Economies
ERPT: Exchange Rate Pass-Through
FEVD: Forecast Error Variance Decomposition

FPE: Final Prediction Error
GLS: Generalized Least Squares
GOP: Global Oil Price
HQ: Hannan–Quinn Information Criterion
IPPT Import Price Pass-through
INF: Inflation
IRF: Impulse Response Function
LOOP: Law of One Price
LR: Likelihood Ratio
MAIC: Modified Akaike Information Criterion
MKDP: Market Distributed Inflation
MPR: Monetary Policy Rate
NEER: Nominal Effective Exchange Rate
OIR: Over-Identifying Restriction
OMO: Open Market Operations
PP: Phillip-Perron
PPI: Producer Price Index
PPP: Purchasing Power Parity
STAR: Smooth Transition Autoregressive
SVAR: Structural Vector Autoregressive
VAR: Vector Autoregressive

Figures

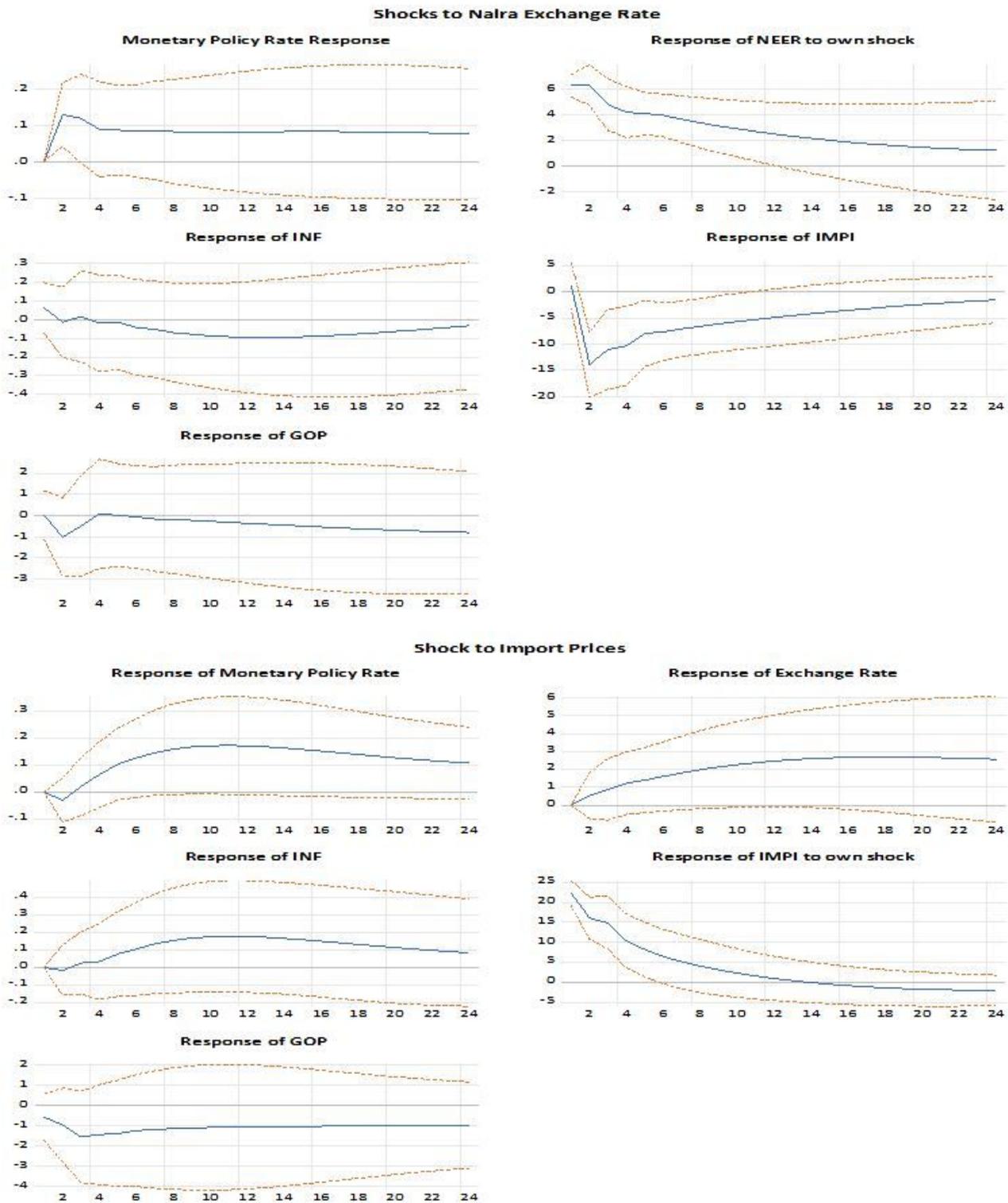


Figure 1

Impulse Response Functions (IRFs). Impulse responses to a positive one standard deviation of selected shocks. 2010M01-2018M12. The first graph shows responses of relevant variables in the structural

equation to the money exchange rate of the domestic currency to the US dollar, while the second graph shows responses to shocks resulting from the external sector.