



## AN AGNOSTIC ANALYSIS OF EXCHANGE RATE MOVEMENT IN GHANA

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### ABSTRACT

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Based on quarterly data for the period 2006:3-2018:4, the effect of exchange movement on a set of price indices in Ghana is examined via a Bayesian Vector Autoregressive model. Using normal inverted-Wishart priors, the posterior estimates are generated by Markov Chain Monte Carlo draws via a sign restriction algorithm. Findings showed that the response of consumer prices (CPI), producer prices (PPI) and non-food prices (NFP) to exchange rate shocks is low and incomplete. Furthermore, the forecast error variance decomposition (FEVD) indicated that CPI is most responsive to exchange rate impulses than NFP and PPI. In addition, inflationary pressures in Ghana emanated from exchange rate sources other than monetary sources. The paper recommends “pricing in local currency” as a deliberate policy to insulate domestic prices from volatilities in the exchange rate.

**Contribution/Originality:** This study used a new estimation methodology to examine the effect of exchange rate dynamics on prices in Ghana.

## 1. INTRODUCTION

Ghana being a high import dependent economy is likely to be hit by shocks emanating from the foreign exchange market. Prior to the 1980s when the Ghanaian economy was largely plagued with macroeconomic instability and gross economic mismanagement, there was the introduction of Structural Adjustment Programmes (henceforth SAP), Economic Recovery Programmes (henceforth ERP) and financial sector adjustment programme (henceforth FINSAP). However, these reforms impacted the exchange value of the Ghanaian currency (Ghana cedi) in diverse ways. The literature argued that, the adoption of the floating exchange rate regime in 1980s rendered the Ghana cedi uncompetitive relative to many major trading currencies particularly the US dollar. Consistent with the above assertion is data taken from (International Finance Statistics, 2019), where the exchange value of Ghana cedi relative to the US dollar rose from 0.03 in 1990 to 4.82 at the end of 2018.

In this context, the paper’s aim is to examine how dynamics in the exchange rate affected selected price indices in Ghana. In a study referenced to [Bowao et al. \(2003\)](#); [Sowa and Kwakye \(1993\)](#) domestic prices in Ghana is highly responsive to exchange rate movement. The consensus points to the floating exchange rate regime adopted when the Ghanaian economy was liberalized. In another study, [Bhundia \(2002\)](#) argued that the pricing of imported goods

coupled with their weights also had a telling on the responsiveness of domestic prices. He also claimed pass-through may also be endogenous to the monetary policy regime of the central bank.

In this regard, the paper's contribution is to employ an agnostic identification approach in a structural vector autoregression to assess (a) The dynamic effect of exchange rate on producer prices (PPI), non-food prices (NFP) and consumer prices (CPI) in Ghana<sup>1</sup>. (b) Whether inflation in Ghana emanates from exchange rate sources or from monetary sources? This paper is dissimilar to previous studies in that, whilst earlier papers identified structural shocks via a recursive ordering, this study identified shocks by imposing sign restrictions ex-post on a set of orthogonal impulse response functions (IRFs) using the rejection algorithm of Rubio-Ramirez *et al.* (2010)<sup>2</sup>. The sign restriction approach is preferred to the recursive ordering on the account that, the IRFs of the former are not susceptible to the ordering of the variables. The analysis commenced with a specification of a baseline model where the choice of variables followed (Sanusi, 2010). However, the starting period in this paper covered the period when the Bank of Ghana started inflation targeting monetary policy that is, 2006: q3. The IRFs showed that an exchange rate appreciation led to a fall in consumer prices, albeit the impact is not unitary. Findings corroborates the literature (see (Acheampong, 2004; Frimpong and Adam, 2010; Sanusi, 2010; Loloh, 2014; Adu *et al.*, 2015)).

The baseline model is extended to include NFP and PPI. IRFs indicated that exchange rate appreciation indeed led to a fall in NFP and PPI, but the impact is also incomplete. Alternatively, in a forecast horizon of 5 quarters, exchange rate shocks explained 17.33%-24.61% variation in CPI, 17.93%-21.98% fluctuation in NFP and 15.726%-20.37% variation in PPI. The intuition is that innovations to exchange rate are less benign to CPI fluctuations. This evidence contradicts (Loloh, 2014); (Acheampong, 2004) who found exchange rate shocks to explain less variability in CPI than NFP. They justified their result on the notion that the NFP basket contained a large proportion of tradeable goods vis-à-vis the CPI basket. This paper argued that the divergence in results perhaps, gravitates towards the model identification procedure employed<sup>3</sup>.

Furthermore, the paper also examined whether inflationary pressures in Ghana emanated from exchange rate sources or monetary sources. This phenomenon was examined by Sanusi (2010) in a recursively ordered SVAR model where he found exchange rate shocks to explain high variation in domestic prices in Ghana. This paper extended (Sanusi, 2010) model to include monetary policy rate and imposed a negative sign to signify monetary expansion. The forecast error variance decomposition (FEVD) showed that shocks to exchange rate accounted for 16.91%-19.37% in CPI whereas shocks to broad money and policy rate respectively explained 15.66%-18.06% and 16.0%-19.32% in CPI. The paper therefore inferred that inflation in Ghana came from exchange rate sources which is consistent with findings of Sanusi (2010).

Lastly, to ensure that findings are reliable, the IRFs are subjected to diagnostic analysis and robustness checks. The former employed the median target approach of Fry and Pagan (2011) whereas the latter used a different proxy for exchange rate. In an additional robustness check, the paper explored the Uhlig (2005) rejection algorithm. Findings are generally robust.

The rest of the paper is outlined as: the related literature is in *section 2*, the methodology and model identification followed in *section 3*, data description and sources is shown in *section 4*, model estimation is in *section 5*, robustness checks is done in *section 6*, *section 7* gives the concluding remarks and *section 8* provided some acknowledgement.

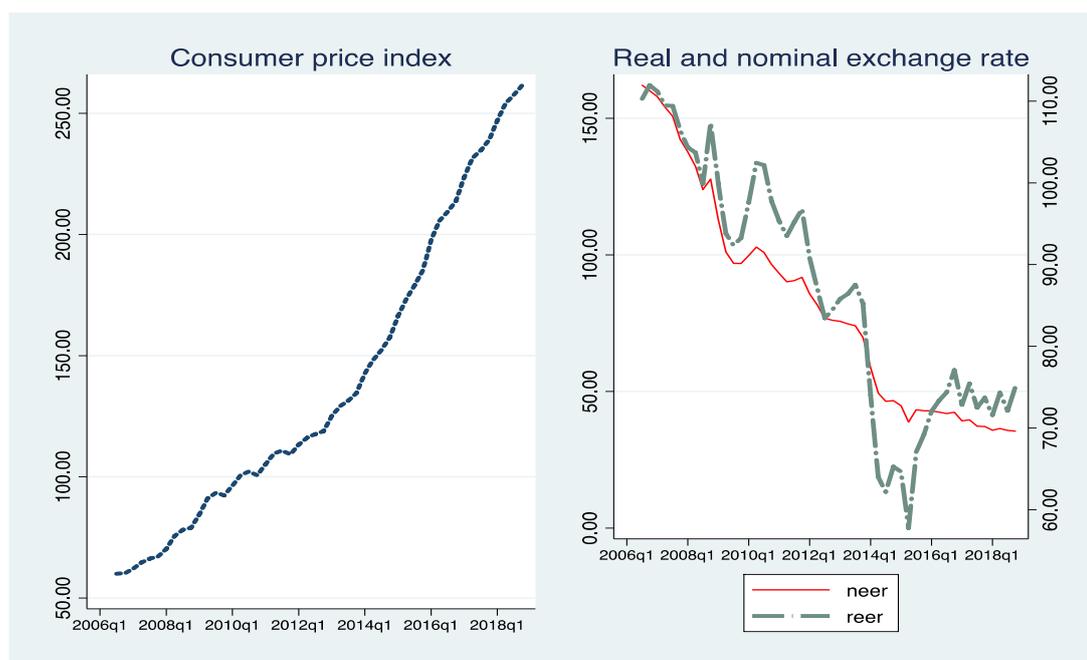
The time series plot see [Figure 1](#) showed movement in exchange rate and inflation for the study period. When the exchange rate falls there is also a corresponding increase in price inflation.

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<sup>1</sup> The study seeks to examine the direction of price responses to exchange rate shock and not the magnitude of pass-through.

<sup>2</sup> This algorithm uses a QR-decomposition to generate an impulse vector from the standard normal distribution.

<sup>3</sup> In an alternative analysis, a recursive ordering was employed on same data and results are consistent with theirs. In effect, this paper concludes that the model identification scheme plays a role in the FEVD results.



**Figure-1.** Dynamics in inflation and exchange rate.

**Note:** The graph shows dynamics in real, nominal exchange rate and consumer price index in Ghana from 2006q1-2018q1. Data is taken from Bank of Ghana and International finance statistics in 2019.

## 2. RELATED LITERATURE

### 2.1. Theoretical Review

This section gives a theoretical underpinning of how dynamics in the exchange rate affects prices. According to (Goldberg and Knetter, 1997) exchange rate pass-through implies variation in local currency import prices which comes from changes in the exchange rate between the exporting and importing countries. This occurs either from exchange rate to import prices or from import prices to domestic prices. Conventionally, many scholarly papers jumped the import price channel that is, exchange rate movement is directly examined on domestic prices. The consensus points to an incomplete pass-through of exchange rate movement to prices. According to Krugman (1986) US import prices do not fully explain exchange rate movements due to a concept known as *pricing to market* by foreign suppliers. In another study by Dornbusch (1987) exchange rate movement do not reflect one-for-one in prices because in a monopolistic market, firms adjust their mark-up in response to exchange rate innovations.

From a different standpoint, Gagnon and Ihrig (2004) argued that macroeconomic policies such as fiscal and monetary policy could be used to dampen the negative impact of exchange rate on domestic prices. Burstein *et al.* (2003) and Burstein *et al.* (2005) emphasized that incomplete passthrough is also owed to the role of non-traded (domestic) inputs and measurement problems associated with consumer price index. In addition, Devereux and Engel (2001); Bacchetta and Van Wincoop (2003) argued that pricing in local is also a reason for incomplete pass-through.

### 2.2. Empirical Review

Adu *et al.* (2015) examined dynamics in exchange rate for Ghana on quarterly data from 1980:1-2012:4. They employed a frequentist VAR as well as time varying parameter VAR with stochastic volatility. They found that the impact of exchange dynamics on domestic prices in Ghana is high.

In addition, their paper identified shocks from the supply side, demand side and from nominal side. Findings showed that the three shocks have a significant impact on exchange rate in Ghana. Loloh (2014) estimates ERPT for Ghana on monthly data from 1994:1-2012:12. He employed a VAR model where shocks are identified using a recursive ordering. Findings showed that exchange rate effects are present in the first 12 months but after 18-24 month, the effect decreases. Furthermore, he also found that exchange rate innovations explained less variability in

CPI than non-food inflation. Frimpong and Adam (2010) used monthly data for the period 1990:1-2009:2 to examine ERPT in Ghana using by way of an error-correctio model. They found a low and incomplete pass-through for the study period. Zorzi *et al.* (2007) employed a VAR model to examine ERPT in 12 emerging markets in Asia, Latin America, and Central and Eastern Europe. Contrary to the conventional belief, they found high passthrough for emerging than developed countries. Also, they found that passthrough for advanced economies is low and equivalent to emerging countries with single digit inflation. Consistent with Taylor's hypothesis, they found a positive relationship between the degree of the exchange rate pass-through and inflation. Acheampong (2004) examined cumulative pass-through for Ghana in a recursive VAR. He found that pass-through is incomplete, modest and slow. In addition, he also found that the pass-through to non-food prices is more pronounced compared to consumer prices. Devereux and Yetman (2003) examined the phenomenon of ERPT and found a very low and zero pass-through for some SSA. He went further to find an insignificant pass-through for Ghana with an elasticity of 0.05 percent. Burstein *et al.* (2002) following investigated the behaviour of consumer prices following large currency devaluations in Argentina (2001), Brazil (1999), Mexico (1994), Korea (1997) and Thailand (1977). They found low pass-through from the exchange rate to consumer prices. Leigh and Rossi (2002) employed a recursive VAR on data for Turkey. They found that effect of exchange rate shock is seen in the first 4 months, but the shock disappears after 12 months. Furthermore, exchange shocks explained more fluctuations in wholesale prices than consumer prices. Chaoudhri and Hakura (2001) examined ERPT in Ethiopia and other African countries from 1997–2000. They found zero pass-through in Ethiopia and incomplete pass-through in other African countries (Rabanal and Schwartz, 2001) investigated the behaviour of inflation in Maldives. They found that the impact of exchange rate shocks was present after 20 months. Goldfajn and Werlang (2000) studied a panel of 71 countries and found that (a) pass-through is correlated with the business cycle (b) pass-through is also connected with the size of the initial real exchange rate misalignment and (c) the initial rate of inflation and the degree of openness of the economy. Furthermore, their paper argued that pass-through coefficient is positively time-varying after devaluation and is maximized after one year.

McCarthy (1999) investigated pass-through on data from 6 industrialized OECD nations. The empirical approach is a recursive VAR. He discovered that exchange rate movements had modest impact on domestic consumer prices. Canetti and Greene (1992) found that exchange rate dynamics and monetary expansion affected consumer prices SSA. In a Granger causality analysis, they also found that exchange rate “Granger caused” inflation in Tanzania, Sierra Leone, and Democratic Republic of Congo. They assert the high inflation in these economies to the above. Lastly, their paper also found that monetary expansion “Granger caused” inflation in the Gambia and Uganda.

### 3. METHODOLOGY (VAR TO SVAR)

The structural vector autoregression uses economic theory to generate the model's structural shocks. However, those structural shocks are generated from a reduced form VAR as:

$$X_t = z + \sum_{j=i}^p \psi_i X_{t-i} + u_t \quad (1)$$

Where  $X_t$  is a vector of endogenous variables,  $\psi_i$  refers to matrix of parameters,  $t = 1, 2, \dots, T$

$u_t$  is reduced – form disturbances that is,  $u_t \sim N(0, \Sigma_u)$ . The reduced-form errors  $u_t$ , are assumed to be uncorrelated and orthogonal across the individual equations. However, since forecast errors might be correlated across the equations in principle, the paper employs a structural model such that:

$$\mathbf{B}X_t = v + \sum_{j=i}^p \mathbf{B}_i X_{t-i} + \boldsymbol{\varepsilon}_t \quad (2)$$

Where  $\mathbf{B}$  is the contemporaneous reaction of variables to structural impulses,  $\mathbf{B}_i$  denotes structural coefficients,  $\boldsymbol{\varepsilon}_t$  denotes uncorrelated structural innovations that is,  $E(\boldsymbol{\varepsilon}_t, \boldsymbol{\varepsilon}_t') = \mathbf{I}$ . The  $\mathbf{I}$ , is a diagonal matrix with elements,  $\sigma_i^2$ , such that  $\boldsymbol{\varepsilon}_t \sim (0, \mathbf{I}_\varepsilon = \text{diag}(\sigma_i^2))$ . Since Equation 2 is unidentified, the paper explains the identification procedure in the next section. Linearly, the reduced form shocks,  $\mathbf{u}_t$  are linear combinations of the structural economic shocks,  $\boldsymbol{\varepsilon}_t$  such that:

$$\mathbf{B}^{-1}\boldsymbol{\varepsilon}_t = \mathbf{u}_t \quad 3$$

### 3.1. Identification

Canova and Pina (2005) posits that IRFs generated using the zero restrictions seldom corroborates theoretical dynamic stochastic general equilibrium models (henceforth DSGE). Against this backdrop, this paper employs sign restriction which imposes sign constraints ex-post on a set of orthogonal IRFs. These signs constraints are based on prior beliefs about the signs of certain shocks derived from theoretical models.

Using the Rubio-Ramirez *et al.* (2010) rejection algorithm, the paper uses uninformative priors from the normal inverted Wishart family (NIW)<sup>4</sup> with a total of 1000 Markov Chain Monte Carlo (henceforth MCMC) draws and 200 sub-draws. This type of prior is very weak since it imposes no specific prior knowledge on the model's parameters.

The shock is one-SD, the median responses are kept in the lower 16<sup>th</sup> and upper 84<sup>th</sup> quantiles, the shock is imposed in the first 4 months and the optimal lag is 3 which is based on the Swartz Bayesian Information Criterion (henceforth SBIC).

## 4. DESCRIPTION OF DATA<sup>5</sup>

The study used quarterly data for the period 2006:3-2018:4 which is sourced from International Finance Statistics (IFS), Federal Reserve Economic Database (FRED) and the Bank of Ghana (BOG). The starting period shows when Ghana adopted inflation targeting monetary policy.

The variables are described as follows: the logarithm of foreign exchange inflows is measured by government's and monetary authorities claims on non-residents, logarithm of broad money (M2), logarithm of nominal effective exchange rate, logarithm of the real effective exchange rate, logarithm of consumer prices index, logarithm of non-food prices, logarithm of producer price index, the level of monetary policy rate.

## 5. RESULTS

### 5.1. Evidence for the Baseline Model

The identification scheme employed to examine the benchmark model is presented in Table 1 whereas Table 2 shows the descriptive statistic both for baseline variables and the extended model. Evidence presented in Figure 2<sup>6</sup>

<sup>4</sup> The NIW is the conjugate prior for the mean and variance of the multivariate normal distribution that is, the regression coefficients are assumed to be normally distributed.

<sup>5</sup> Variables which are not available in quarterly frequency are interpolated.

below showed that a one-SD shock to exchange rate led to an appreciation in nominal effective exchange (NEER). This further led to a fall in domestic price measured by consumer price index in Ghana. Passthrough to domestic price is non-unitary.

**Table-1.** Identification scheme (benchmark model).

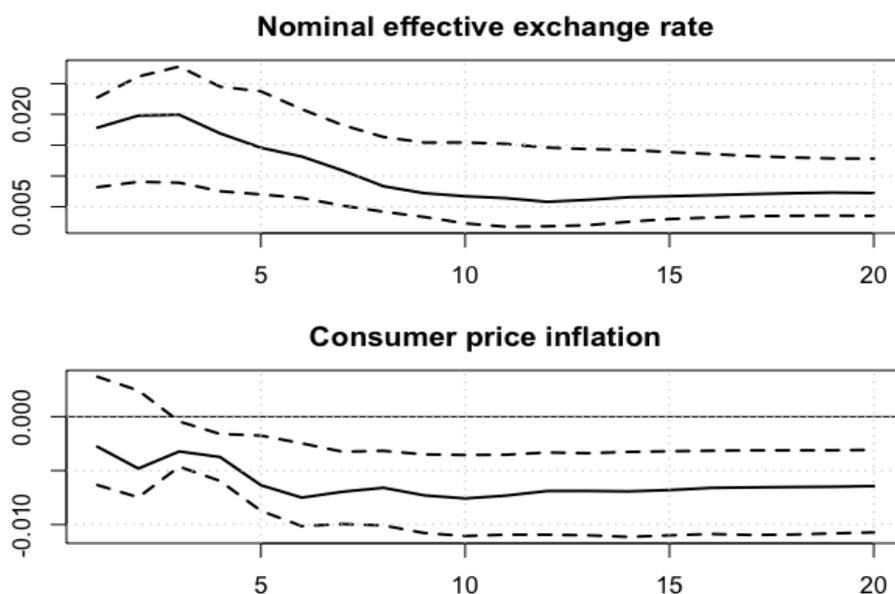
FX	MS	NEER	CPI
?	?	+	?

Note: Exchange rate appreciation/depreciation (+/-), unrestricted (?). FX= Foreign exchange flows, MS= Broad money, NEER= Nominal effective exchange rate, CPI=Consumer price index.

**Table-2.** Descriptive statistics.

Variables	Mean	Std. Dev.
FX	807.2	654.2
MS	21231.3	16748
NEER	81.48	39.87
REER	86.67	15.37
CPI	138.9	61.5
NFP	16.2	4.8
PPI	136.7	85.02
MPR	16.5	5.9

Note: The table shows standard deviation (Std.dev) and mean for the variables for the benchmark and extended model. FX= Foreign exchange flows, MS= Broad money, NEER=Nominal effective exchange rate, REER=Real effective exchange rate, CPI=Consumer price index, NFP=Non-food prices, PPI=Producer prices and MPR=Monetary policy rate.



**Figure-2.** Effect of NEER shock.

Note: The estimation algorithm is Rubio-Ramirez *et al.* (2010). The solid line is the response at each horizon whereas the dashed line depicts the 68% error bands.

### 5.2. Evidence for the Extended Model

Figure 3<sup>7</sup> below showed the response of CPI, NFP and PPI to a positive exchange rate shock. The graph recorded a fall in the three (3) price indices when a one-SD positive shock hits the exchange rate. The implication is that, an exchange rate appreciation led to fall in prices in Ghana. To test the reliability of the IRFs findings, the median target approach of Fry and Pagan (2011)<sup>8</sup> is used. Findings showed a similarity between the median target

<sup>6</sup> Impulse response result is only reported ONLY for the variables of interest..

<sup>7</sup> IRFs are shown only for the variables of interest.

<sup>8</sup> The median target method is a form of diagnostic check to ensure that the IRFs identified by the sign restriction come from a single model. If the median target IRFs is similar to the IRFs of the model under test, then inference from the model is unbiased.

and the IRFs of the model under test (see Figure 4 in Appendix). Table 3 presents the identification scheme for the extended model.

Table-3. Identification scheme (Extended model).

FX	MS	NEER	CPI	NFP	PPI
?	?	+	?	?	?

Note: Exchange rate appreciation/depreciation (+/-), unrestricted (?). FX= foreign exchange flows, MS= Broad money, NEER=Nominal effective exchange rate, CPI=Consumer price index, NFP=Non-food prices and PPI=Producer prices.

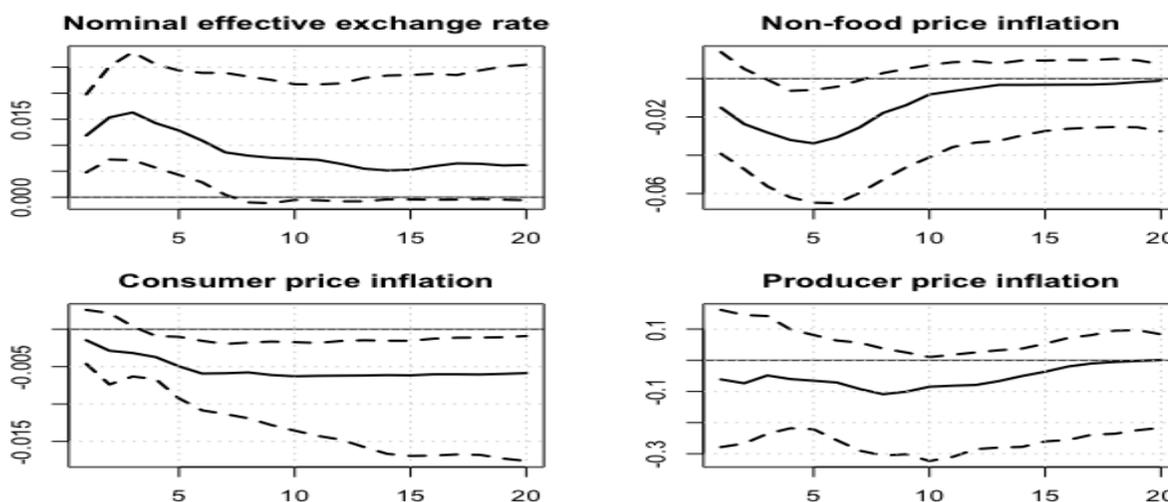


Figure-3. Effect of NEER shock (extended model).

Note: The estimation algorithm is Rubio-Ramirez *et al.* (2010). The solid line is the response at each horizon whereas the dashed line depicts the lower 16<sup>th</sup> and upper 84<sup>th</sup> quantile.

### 5.3. Variance Decomposition

Fluctuations in say variable,  $X$  is explained by shocks to variable say  $\mathcal{I}$ , if variable  $\mathcal{I}$  accounts for a large proportion of  $X$ 's forecast error variance. Using a forecast horizon of 5 quarters, Figure 5 in Appendix indicated that exchange rate innovations explained 17.33%-24.61% variation in CPI, 17.93%-21.98% fluctuation in NFP and 15.726%-20.37% variation in PPI. This implied that CPI is most responsive to impulses coming from exchange rate.

The study further examined the most dominant source of inflation in Ghana using FEVD. Results shown in Figure 6, 7 and 8 in appendix indicated that inflation in Ghana came from exchange rate sources accounting for 16.91%-19.37% in CPI. Furthermore, a positive broad money shock (monetary expansion) and a negative shock in monetary policy rate (monetary expansion) respectively accounted for 15.66%-18.06% and 16.0%-19.32% variability in CPI.

## 6. ROBUSTNESS ANALYSIS

This part of the paper performed robustness checks to different variations to the baseline model. In the first instance, Uhlig (2005) rejection algorithm which is based on Givens rotation replaced the Rubio-Ramirez *et al.* (2010) algorithm which is based on QR-decomposition. In second case, the REER replaces NEER as proxy for exchange rate. Evidence presented in Figure 9 and Figure 10 in appendix showed that an appreciation in the exchange rate led to a reduction in CPI. This is consistent with the baseline results.

## 7. CONCLUDING REMARKS

Using structural vector autoregression estimated from Bayesian perspective, this paper examined the response of selected price variables to exchange rate shocks in Ghana for the period 2006q3-2018q4. The structural model was identified by the help of sign restrictions. With uninformative priors, 3 lags, the posterior is generated using a total of 1000 MCMC with 200 sub-draws.

Findings indicated that an appreciation in the exchange rate led to an incomplete fall in consumer prices, non-food prices and producer prices in Ghana. Furthermore, exchange rate impulses accounted for a higher fluctuation in CPI. Lastly, the paper showed that innovations to exchange rate other than monetary expansion accounted for Ghana's inflationary pressures.

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**Competing Interests:** The authors declare that they have no competing interests.

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## APPENDIX

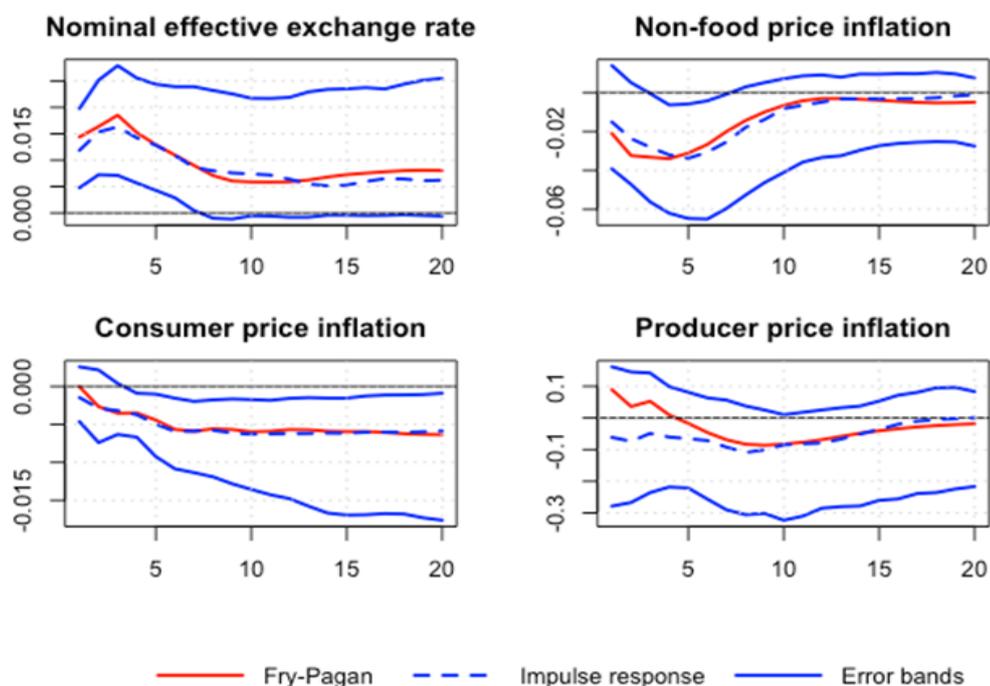


Figure-4. Median target diagnostic plot for extended model.

Note: This graph uses (Fry and Pagan, 2011) median target approach to diagnose IRFs from the main model. The solid red line is the median target of Fry and Pagan, the dashed blue line is the IRFs from the main model and the solid blue line is the lower 16<sup>th</sup> quantile and upper 84<sup>th</sup> quantile.

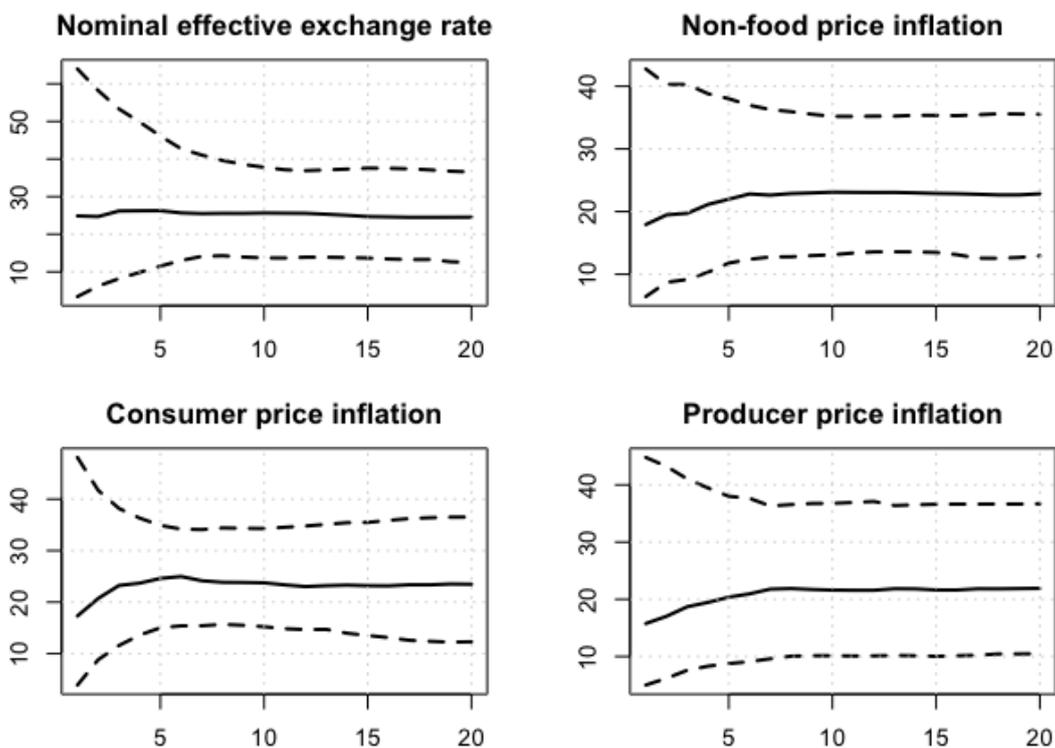


Figure-5. Effect of exchange rate shock (FEVD<sub>1</sub>).

Note: This graph shows percentage of forecast error variance in non-food prices, consumer prices and producer prices when a shock hits the exchange rate. The thick black line represents the response at each horizon whereas the dashed line depicts the 68% error bands.

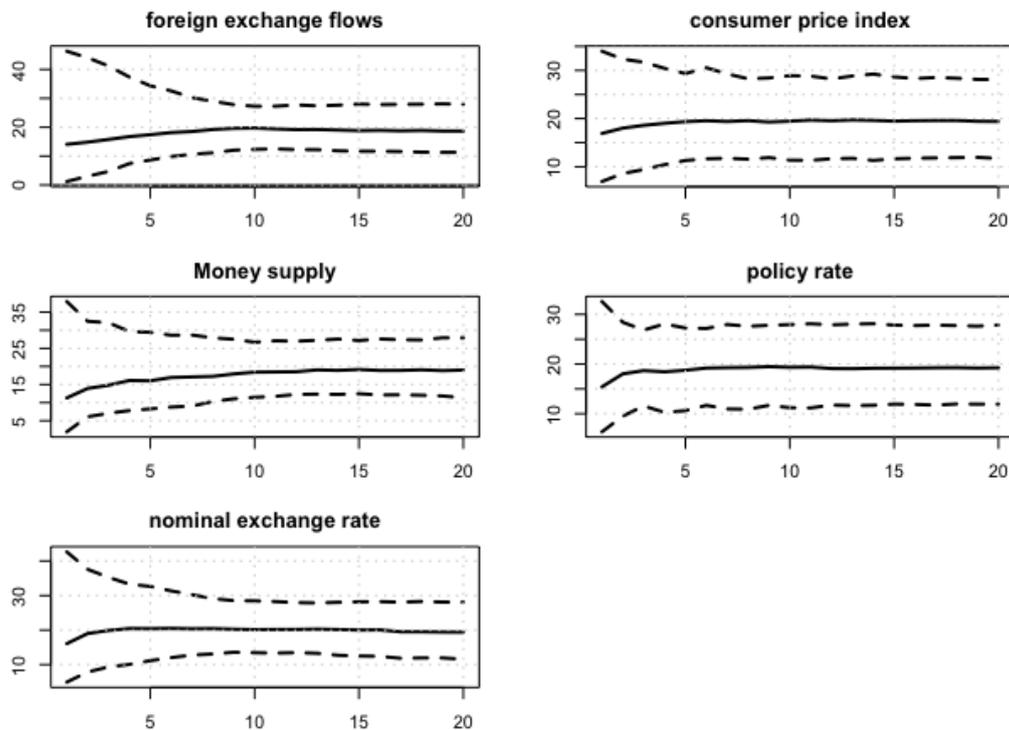


Figure-6. Effect of exchange rate shock (FEVD<sub>2</sub>).

Note: This graph shows percentage of forecast error variance in CPI when exchange rate depreciates. The thick black line represents the response at each horizon whereas the dashed line depicts the 68% error bands.

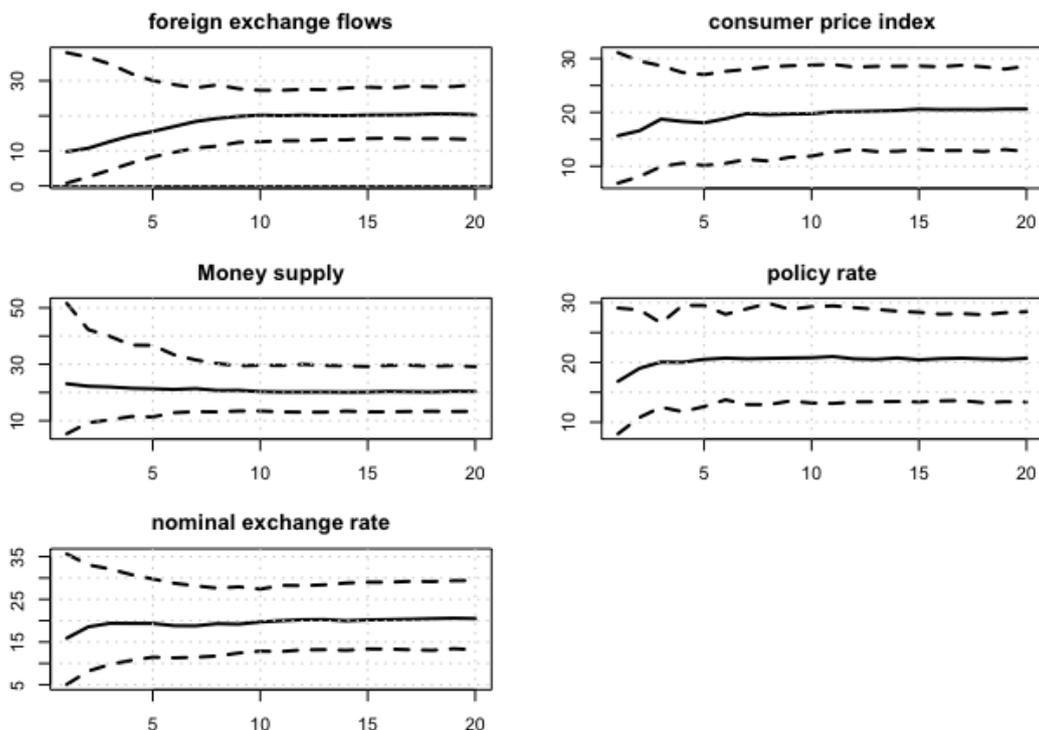


Figure-7. Effect of money supply shock (FEVD\_3).

Note: This graph shows percentage of forecast error variance in CPI when broab money is increased. The thick black line represents the response at each horizon whereas the dashed line depicts the 68% error bands.

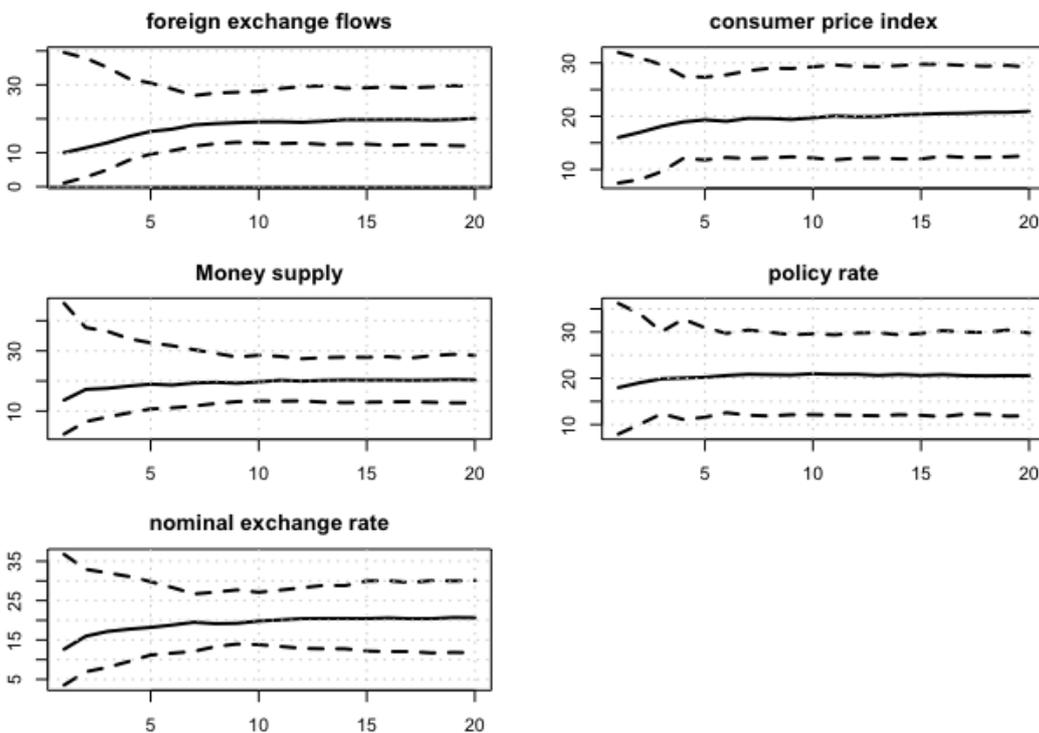
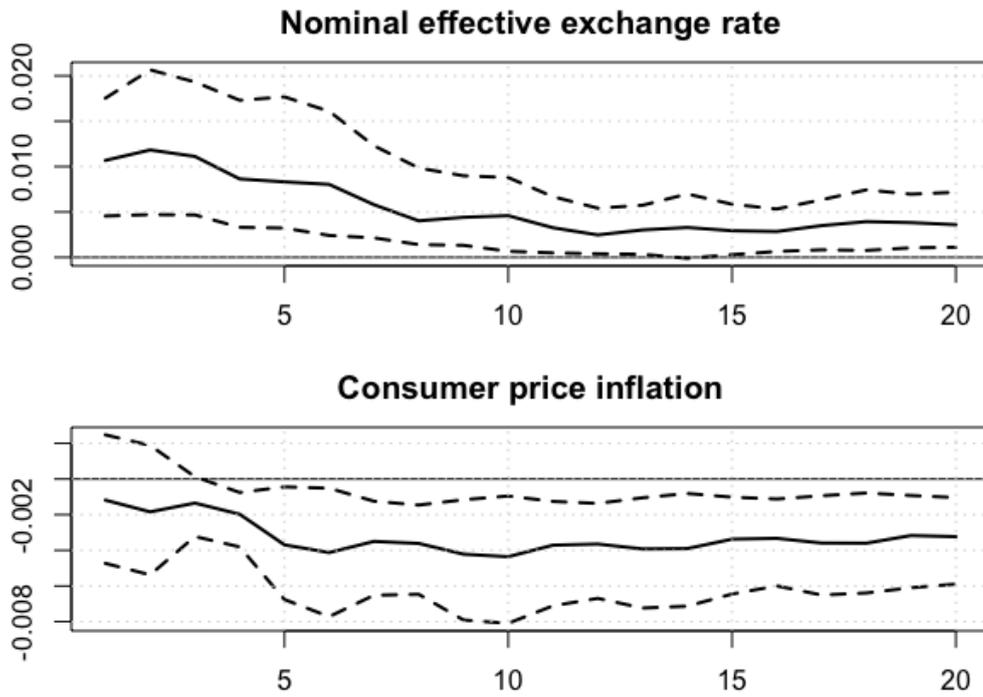


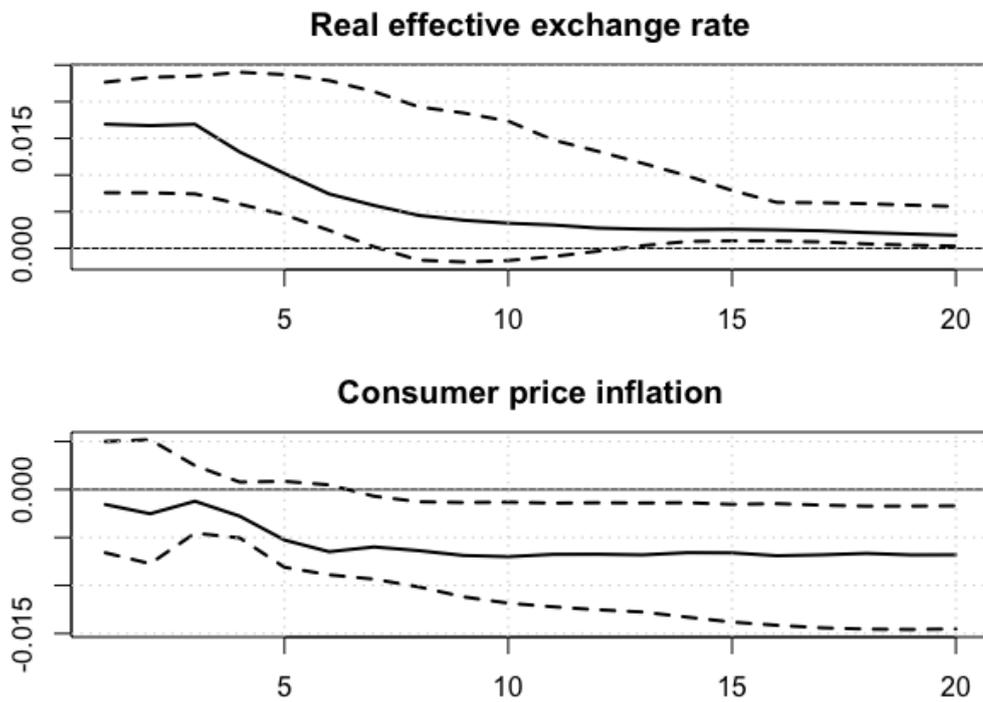
Figure-8. Effect of monetary policy rate shock (FEVD\_4).

Note: This graph shows percentage of forecast error variance in CPI when the policy rate is reduced. The thick black line represents the response at each horizon whereas the dashed line depicts the 68% error bands.



**Figure-9.** Effect of NEER innovation (Robustness 1).

**Note:** This graph employs the rejection algorithm of Uhlig (2005) to examine NEER shock on CPI. The solid line represents the response at each horizon whereas the dashed line depicts the 68% error bands.



**Figure-10.** Impulse response to REER innovation (Robust 2).

**Note:** This graph employs the rejection algorithm of Rubio-Ramirez et al. (2010) to examine the impact of REER shock on CPI. The solid line represents the response at each horizon whereas the dashed line depicts the 68% error bands.

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