An Empirical Analysis of Exchange Rate Dynamics and Pass-Through Effects on Domestic Prices in Ghana

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Abstract

As a small open economy with high dependence on the external sector, the Ghanaian economy has over the years remained susceptible to external shocks, as fluctuations in commodity prices such as gold, cocoa and crude oil has implications for government revenue. More so, the economy has experienced several episodes of currency crises with dire consequences for maintaining fiscal balance and macroeconomic stability. To this end, this paper investigates the exchange rate dynamics in Ghana via identifying the sources of the exchange rate movements and their implications for price stability. Using a battery of tests, we find supply, demand and nominal shocks as significant drivers of exchange rate movements in Ghana albeit with varying magnitude and direction. The results also reveal a high but incomplete pass-through effect of exchange rate movements on domestic prices. The policy implication from the main findings from the paper is that a mix of demand management policies (responsible fiscal and monetary policies) and structural policies (e.g. tax and labour market reforms, property rights protection to encourage innovations, among others) are recommended to ensuring exchange rate and domestic macroeconomic stability. Further, reduction in excessive dependence on primary commodities as a major source of foreign exchange has the potential of reducing the exposure of the economy to disturbances in the international commodities markets.

1. Introduction

Since the liberalization of the foreign exchange market in the mid-1980s (as a component of the broad structural adjustment and economic reforms programmes), the rate at which a unit of Ghana's currency (the cedi) exchanges for the US dollar and the currencies of her major trading partners has seen substantial swings. On the average, the cedi has depreciated against the US dollar since the adoption of managed floating exchange rate regime in 1986. For instance, during the first quarter of 1986, about 0.01 cedis could exchange for a dollar; however, by the end of April 2015, the rate had risen to 3.84, representing a depreciation of 98.7% over the period[1]. The objective of this paper is to examine both real and nominal exchange rate dynamics in Ghana and their implications for domestic price stability. In particular we identify the sources of exchange rate movements and estimate the degree of exchange rate pass-through effect on consumer price inflation.

A study of exchange rate dynamics and their relationships with economic fundamentals and shocks (real and nominal) in Ghana is motivated by the following reasons. First, both the real and nominal exchange rates play a key role in the international transmission mechanism and therefore changes in their dynamic behavior have important consequences for a small open economy like Ghana. Second, changes in the nominal and real exchange rates affect foreign currency denominated assets and liabilities, with dire consequences for the stability of the financial system. For instance, with the government of Ghana issue of international (Euro) bonds, changes in the nominal and real exchange dynamics have implications for debt servicing and eventual payment of the principal on maturity. Third, changes in nominal exchange rate dynamics have repercussions on domestic price stability. The knowledge of the precise magnitude of the pass-through effect is therefore important for the conduct of monetary policy under inflation targeting regime. Last but not least, the study will provide a clear understanding on the relative importance of various kinds of shocks (nominal/monetary, demand, and supply) on both the exchange rate dynamics and the pass-through effect on prices. This will aid policy prescription in the sense that it will inform the appropriate mix of demand and supply side policies for effective management of exchange rate movements and pass-through effect on inflation.

In line with the above motivation, there has been a number of studies on the sources of real exchange fluctuations since the collapse of the Bretton Woods system which saw many countries shunning fixed exchange rate regimes to the adoption of different forms of floating regimes (Mussa, 1982, 1986; Stockman, 1987, 1988; Huizinga, 1987; Cambell and Clarida;

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[1] International Financial Statistics (2013) and http://www.tradingeconomics.com/ghana/currency

1987; Meese and Rogoff, 1988; Clarida and Gali, 1994; Chowdhury, 2004; Hamori and Hamori, 2011; Mumtaz and Sunder-Plasssmann, 2012).

According to the disequilibrium models of exchange rate determination (Dornbusch, 1976), variations in both real and nominal exchange rates are due to nominal disturbances which is expected to have a transitory effect on the real exchange rates. On the contrary, equilibrium models of exchange rate determination rely on permanent real shocks to explain movements in the real and nominal exchange rates (Stockman, 1987). However, the empirical studies following these earlier theoretical contributions have produced mixed results on the relative importance of real and nominal shocks in accounting for movements in the real and nominal exchange rates. Lastrapes (1992) reported that fluctuations in the real and nominal exchange rates are primarily due to real shocks of all frequencies, thus lending support to equilibrium models of Stockman (1987). Clarida and Gali (1994) found nominal shocks play important role in the movements in real exchange rate in Germany and Japan while having virtually no role in accounting for real exchange rate movements in the United Kingdom and Canada. Dibooglu and Kutan (2001) in a comparative study on Poland and Hungary also found mixed results on the relative importance of real and nominal shocks in explaining real exchange rate behavior. They also found nominal shocks to have larger influence in explaining the changes in the real exchange rate in Poland, whereas real shocks exert larger influence in Hungary.

Chowdhury (2004) also revealed that real shocks explain most of the real exchange rate fluctuations in emerging market economies. Hamori and Hamori (2011) estimated that real shocks explain more than 95% of the forecast error variance of the real exchange rate. This is consistent with the results reported in earlier studies (Lastrapes, 1992; Enders and Lee, 1997; Chowdhury 2004).

Muntaz and Sunder-Plasmann (2013) using time-varying structural vector autoregression (SVAR) reported substantial evidence that real exchange rate dynamics have changed over time in the UK, Euro Area and Canada. Results from their paper suggest strong response of real exchange rate to nominal shocks after the mid-1980s compared to the 1970s and early 1980s. This evidence of time-varying real exchange dynamics appears to be consistent with a fall in exchange rate pass-through effect.

Among the reasons why sources of fluctuations in the real exchanges rate attracted the attention of researchers and policy makers is the fear that exchange rate variability could be an important source of macroeconomic instability (e.g. domestic price instability). Small open economies (such as Ghana) are generally viewed as being susceptible to exchange rate pass-through (ERPT) effects in domestic prices (Ghosh and Rajan, 2009). A number of empirical

studies have been undertaken to estimate the degree of ERPT into prices of imported commodities and aggregate domestic price indices (see: Ito, et al, 2005; Sasaki, 2005; Gagnon and Ihrig, 2004). However, the evidence produced so far indicates that the degree of pass-through effects is both country and "policy regime" specific (Choudhri and Hakura, 2006; Barhoumi, 2006; Bouakez and Rebei, 2008; Ito and Sato, 2008; Lin and Wu, 2011; Junttila and Korhonen, 2012). This suggests that exchange rate pass-through effect on domestic prices could be time-varying, which when ignored can introduce substantial biases in the estimated pass-through effects.

In this paper, we follow Clarida and Gali (1994) and identify the sources of real exchange dynamics using the SVAR approach. In addition to estimating the fixed-coefficient SVAR (FC-SVAR) model, as done in Clarida and Gali (1994), we also examine dynamics of the real exchange rate using time-varying SVAR (TV-SVAR) model. The augmentation of the analysis in this paper with the time-varying structural VAR model is motivated by the following. First, Ghana has a history of both fixed and managed floating exchange rate regimes and hence the real exchange rate might have behaved differently under these regimes. Second, Ghana has moved away from monetary targeting to an inflation targeting monetary policy regime. Since both inflation and money supply (nominal shocks) have implications for both the nominal and real exchange rate, the dynamics of the real exchange rate might differ under these monetary policy regimes. Third, elections and political regimes in Ghana have had significant impact on the relative tightness of fiscal and monetary policies and the degree of harmony between the conduct of fiscal and monetary policies. There is thus the likelihood that the dynamics of the real exchange rate to behave differently under different regimes and election cycles. If these potential sources of time-variation in the real exchange rate dynamics are significant (in statistical sense), then the estimates from the fixed-coefficient SVAR model could be biased. We thus propose a TV-SVAR model to investigate the sources of exchange rate movement in Ghana. However, in order not to impose any structure on the data generating process (DGP), both the FC-SVAR and TV-SVAR are subjected to various model diagnostics tests to assess the relative performance in fitting the data.

This study makes an important contribution to both the academic literature and the conduct of monetary policy in Ghana and other developing countries. First, we do not know of any recent study on Ghana that has applied TV-SVAR model to examine the sources of exchange rate fluctuations in Ghana and explores the implications of exchange rate pass-through effects on consumer price inflation. Thus, the evidences on the sources of exchange rate movements reported in this study are more robust and reliable than reported in previous studies. Second, though Acheampong (2004), Sanusi (2010) and Loloh (2014) have reported

some estimates on the exchange rate pass-through effects, these studies ignored the question of what causes fluctuations in the cedi-dollar exchange rate and the potential time-varying nature of both the sources of variations in exchange rate and the pass-through effects to domestic prices. In this paper, we explore both the effects of economic fundamentals and structural shocks in accounting for the sources of exchange rate fluctuations in Ghana and pass-through effects on consumer price inflation and the policy implications thereof.

The rest of the paper is structured as follows. Section 2 presents some stylized facts about exchange rate and inflation in Ghana since 1960. The empirical model and estimation procedures as well as data sources and variable descriptions are presented in Section 3. Section 4 and Section 5 describe the data and some summary statistics; present the results from the FC-SVAR model and TV-SVAR models, respectively. Section 6 concludes the paper with policy implications.

## 2.   Stylized Facts about Inflation and Exchange Rate in Ghana

As a small open economy with high dependence on the external sector, the Ghanaian economy has over the years remained vulnerable to external shocks, thus making developments in the forex market an important factor for macroeconomic stability. The foreign exchange market in Ghana has undergone myriads of regime changes since independence, with several episodes of controls and liberalization, often linked to the prevailing economic conditions over the period. During the period before the economic reforms in 1983, particularly between 1972 and 1982, the economy generally operated a fixed exchange rate system where the exchange rate was held constant, subject to exchange rationing, infrequent devaluations and currency inconvertibility (Harrigan and Oduro, 2000; Aryeetey and Harrigan, 2000).

Following periods of poor economic management and macroeconomic instability, a chain of reforms were implemented between 1983 and 1993. These include Economic Recovery Program, Structural Adjustment Program and Financial Sector Adjustment Program (FINSAP). The core aim of these reforms was to liberalize the economy and transition it towards a market oriented one. These reforms include among other things a gradual transition from a controlled to a liberalized forex market. The series of exchange rate reforms in the post 1983 era, as summarized by Harrigan and Oduro (2000) include "a step-wise devaluation in 1983-6, introduction of foreign-exchange auction in 1986, legalizing the parallel exchange market through the introduction of foreign exchange bureau in 1988 and the establishment in

1992 of an interbank market". Prior to the reforms, exchange rate was an influential political tool, as adverse developments in the exchange rate had serious political repercussions. Therefore by the early 1990s, after the gradual transition towards a floating exchange rate regime, the degree of politicization of nominal exchange rate changes had reduced (Harrigan and Oduro, 2000), even though it still remains an influential factor in the political outcomes of the governments in Ghana.

The performance of the forex market in the post reform era has not been overly impressive. The Ghanaian currency has since the 1990s witnessed consistent depreciation in nominal exchange rate with the US dollar with isolated episodes of appreciation (see Fig 1). Annual depreciation in nominal exchange rate (cedi-dollar) averaged 29% in 1990-99; 17% in 2000-09 and 10.1% in 2010-12 (IMF, 2013). A similar trend is recorded for the trade-weighted effective exchange rates which in this case refer to the weighted average of exchange rate between the Cedi and currencies of the major trading partners. Both the nominal effective exchange rate (NEER) and real effective exchange rate (REER) indices shows a general trend of depreciation of the cedi (fig 1).

Fig. 1: Evolution of Exchange rate and inflation in Ghana
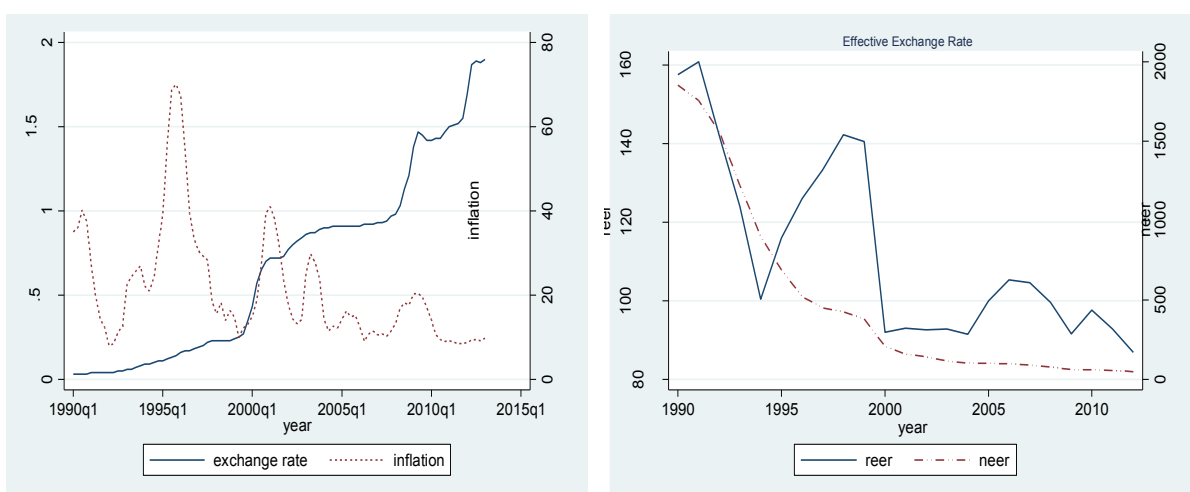
However, unlike the NEER, the REER shows some episode of appreciation after accounting for relative prices (see: panel B in fig 1). Domestic price levels have also witnessed significant variations over the period, albeit with a general decline over the period (see: panel A in fig 1). As shown in table 1, average annual inflation reduced from 48.3% in the period 1990-99 to 18.5% in 2000-09, and further to 9.2% in 2012.

It is interesting to note that performance of the economy in terms exchange rate and inflation misalignment have strong linkages to election cycles. These phenomena have been attributed to the fiscal and monetary slippages via ambitious expansionary fiscal and monetary policies

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during election years, all in a bid to secure political power. In consequence, public debt remains high in most cases exceeding 50% of GDP. Rising public debt, coupled with declining donor support, falling commodity prices and a surge in demand for imports cumulatively puts pressure on the exchange rate, often resulting in recurrent currency crises in the country such as the recent one in 2013-2014 where the Ghanaian cedi depreciated (nominal) by over 40%.

Overall, the growth of the economy in the post reform era has been robust with real GDP growth increasing from an average of 1.6% in 1990-99 to 5.6% in 2012 (World Bank, 2013).

Table 1: Selected Macroeconomic Indicators

	1970-79	1980-89	1990-99	2000-09	2010	2011	2012
GDP growth % (nominal)	1.4	2.0	4.3	5.4	8.0	15.0	7.9
Real GDP growth (%)	-0.8	-1.0	1.6	2.8	5.5	12.4	5.6
Debt % GDP	18.2	22.5	64.5	62.7	46.3	43.8	50.2
Inflation (%)	38.8	48.3	27.6	18.5	10.7	8.7	9.2

Source: World Bank (2014) and IMF (2013)

3. The empirical model

Our modelling strategy is in two steps. First, we model the exchange rate dynamics using fixed coefficient SVAR (FC-SVAR). In the second step, we allow for more flexibility in modelling the VAR coefficients and the variance-covariance matrix in order to capture the evolution of the various shocks over our sample time period, hence the use of a time-varying SVAR. Since the FC-SVAR model is very common in the literature, we rather refer the reader to Clarida and Gali (1994) and Lutkepohl (2007) for details.

The time varying version of the SVAR is however new in this area of research, therefore we present a brief account of the model before applying it to the data. Note that the basic model for our analysis is that of a SVAR in a multivariate setting (trivariate model) similar to the model presented in Carida and Gali (1994). We however extend it to allow for time variations in the coefficients of the underlying SVAR and the covariance matrices in the same spirit as the model presented in Primiceri (2005), Nakajima (2011), Mumtaz and Sunder-Plassmann (2013). The SVAR model with time varying parameters in the literature is generally referred to as time varying parameter vector autoregressive (TVP-VAR) model. The basic VAR model is specified as:

$$y_t = c_t + \sum_{l=1}^{L} \theta_{l,t} y_{t-l} + u_t \qquad (1)$$

$$\theta_{l,t} = \theta_{l,t-1} + \eta_t \tag{2}$$

where y_t is a $k \times 1$ vector of observed variables, L denote the lag length, $\theta_{l,t}$ is the time varying VAR coefficients and η_t is the hyper parameter for the specification in (2). Moreover, the variance matrix of the innovations u_t is expressed as $\Omega = A_t^{-1} H_t (A_t^{-1})'$, where H_t is the diagonal matrix and A_t is the lower triangular matrix expressed as

$$H_t = \begin{bmatrix} h_{1,t} & 0 \ldots \ldots 0 \\ 0 & h_{2,t} \ldots 0 \\ . & . \quad . \\ 0 & \ldots \ldots h_{k,t} \end{bmatrix}, \quad A_t = \begin{bmatrix} 1 & 0 \ldots . 0 \\ \alpha_{21,t} & 1 \ldots . 0 \\ . & . \quad . \\ \alpha_{k1,t} & \alpha_{k2,t} \ldots 1 \end{bmatrix} \tag{3}$$

It follows that

$$y_t = c_t + \sum_{l=1}^{L} \theta_{l,t} y_{t-l} + A_t^{-1} H_t \varepsilon_t \tag{4}$$
$$Variance(\varepsilon_t) = I_n$$

If we stack the coefficients of the model in equation (4) into a vector of coefficients β_t, where $\beta_t = \begin{bmatrix} c_t, \theta_{1,t}, \theta_{2,t}, \ldots \end{bmatrix}$ and defining $x_t = I_K \otimes (1, y'_{t-1}, \ldots \ldots y'_{t-L})$, where $\otimes$ represent the Kronecker product, we can present the TVP-VAR model compactly as

$$y_t = x'_t \beta_t + A_t^{-1} H_t \varepsilon_t \tag{5}$$

The non-zero coefficients in matrix H_t are assumed to evolve as a geometric random walk, while that of the non-zero and non-one elements in matrix A_t evolve as random walk and are respectively presented as

$$\ln h_{i,t} = \ln h_{i,t-1} + v_t \tag{6}$$

$$\alpha_t = \alpha_{t-1} + \psi_t \tag{7}$$

where the coefficients β_t and the parameters A_t and H_t are time varying. Additionally, each of the hyper parameters in equations (2), (6) and (7) and the innovations in equation (4) are assumed to be jointly normally distributed as

$$\begin{bmatrix} \varepsilon_t \\ \eta_t \\ \psi_t \\ v_t \end{bmatrix} \sim N \left(0, \begin{bmatrix} I_n & 0 & 0 & 0 \\ 0 & Q & 0 & 0 \\ 0 & 0 & S & 0 \\ 0 & 0 & 0 & G \end{bmatrix} \right) \tag{8}$$

where I_n is an identity matrix as defined in (4), while Q, S and G are positive definite matrices. The specification of the variance–covariance matrix in (8) with all off diagonal elements restricted to zero is to allow for structural interpretation of the innovations as noted in Primceri (2005). Our estimations will be based on the model in (4) rather than that in (1), since we are interested in interpreting structural innovations and dynamic impact of these on the observable variables. Note that the above specification is general but in our implementation on the Ghanaian data, we focus on three variables case as done in previous literature due to the difficulty in obtaining reasonable estimates for more than three variables in a TVP-VAR framework. Specifically we follow the two-country open-economy model of Dornbusch (1976) and Obstfeld (1985) in determining our variable choice. The three variables are output proxied by real GDP, prices and real exchange rate. Both the output and price series are express in relative terms to the United States output and prices, respectively in the same spirit as in Muntaz and Sunder-Plassmann (2013), partly to be consistent with Dornbusch and Obstfeld model and most importantly to reduce the number of variables that enter the underlying VAR model in our econometric strategy, to be consistent with the small-scale TVP-VAR restriction.

Identification of Shocks

Following Clarida and Gali (1994), we decompose the innovations into supply, demand and nominal shocks and use the implied long run effects of these shocks for our model identification. Our definition and classification of shocks in this paper follows the two-country open-economy of Dornbusch (1976) and Obstfeld (1985) as in the seminal papers of Clarida and Gali (1994) and Muntaz and Sunder-Plassmann (2013). Supply shocks refer to shocks that affect the supply side of the economy, such as productivity shocks. Demand shocks refer to shocks that affect aggregate demand, such as shocks to real balances, fiscal policy shocks. Last but not least, nominal shocks refer to monetary disturbances such as unexpected changes in nominal money supply, and short term nominal interest rates. For the details of the derivations of how real exchange rate movements are decomposed into the above described shocks, we refer the interested reader to Clarida and Gali (1994, pp 24-26).

Based on the long-run equilibrium concept with flexible prices, Clarida and Gali (1994) showed that these three shocks drive the long-run dynamics of output, prices and real exchange rate. Specifically in the long run, only supply shocks affect output, while both supply and demand shocks affect the real exchange rate. Finally, supply, demand and nominal shocks affect prices in the model. These restriction placed on the innovations allows for identification of our TVP-VAR model. Irrespective of the criticism of this form of triangular identification

strategy in the literature, it still turns out to be the most used identification strategy in this area of research, though in recent time, the sign restriction identification strategy has also been used in the literature, for example, Farrant and Peersman (2006). This is basically a short-run sign restriction on the impact matrix. As a matter of convenience, we opt for the triangular identification strategy and also since from the literature, the sign-restriction and triangular restriction tend to produce similar results.

4. Data

This paper uses quarterly time series data spanning the period 1980-2012. The variables used in the study include real GDP, money supply (M2+), consumer price index, interest rate and international prices of gold, cocoa and crude oil. Due to computational restrictions on the number of variables included in the model, all variables are expressed in relative terms using the US as a reference economy, except for the international commodity prices. Thus, for example, relative interest rate as used in this study is measured as the ratio of the Bank of Ghana policy rate and the US Feds fund rate. All data on Ghana were sourced from the International Financial Statistics 2013 database of the International Monetary Fund, and Bank of Ghana, except real GDP obtained from the World Bank's World Development Indicators database. Data on CPI for the US were obtained from the US Federal Reserve Bank of St. Louis while remaining US data were retrieved from DataStream database. Data on variables such as real GDP of Ghana which were available in annual frequencies from official sources were disaggregated into quarterly series using the ECOTRIM statistical software.

5. Results of the Fixed-Coefficient SVAR Estimates

5.1 Results of unit root tests

Prior to estimating our SVAR models, we found it paramount to assess the time series properties of the variables in the model in order to avoid interpreting spurious results. The idea is that if the time series properties of each of the variables follow non-stationary process $(I(1) \text{ or more})$, we will need to transform the variables to achieve stationary series before implementing them in our VAR model. Another approach is to implement the non-stationary series in an error-correction type of framework, if there is evidence of cointegration in the variable set. Given that our benchmark econometric model (TVP-VAR) does not incorporate cointegration processes in the estimation, we will rely on differencing technique if there is evidence that each of the series is non-stationary. We implement both Augmented Dickey Fuller (ADF) and Phillip-Perron unit root tests to assess the stationary properties of each of the variables. The results are reported in Table A1 in the appendix. The general conclusion

from the unit root tests is that, each of the series could not reject the null hypothesis of unit root in the levels; however the null of unit root is rejected after first differencing each of the series. This implies that, each of the series in our data set follow a $I(1)$ process, hence the need to transform each of the series by first differencing. The three variables set in our bench mark model is $(\Delta rgdp, \Delta e, \Delta p)$, where $rgdp$ is relative output, e is real exchange rate defined such that increases mean depreciation and p is relative price proxy by consumer price index. Each of the series is in natural logarithms, implying changes reflects growth rate for both the output and exchange rate series, while the price series reflect inflation.
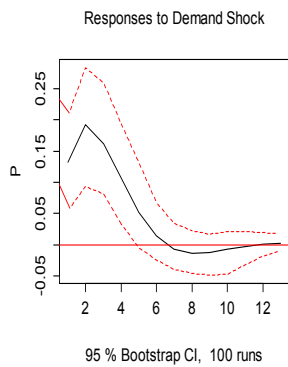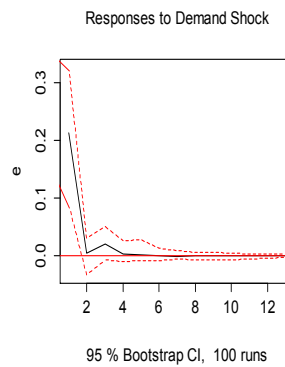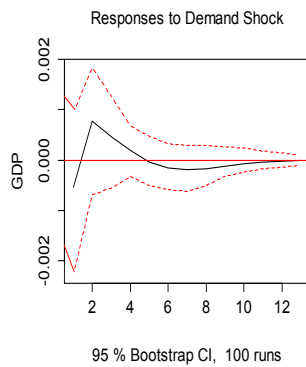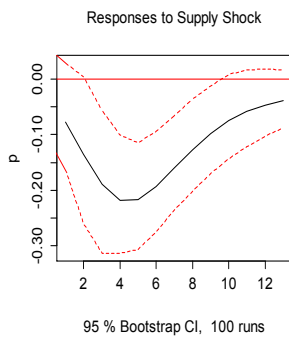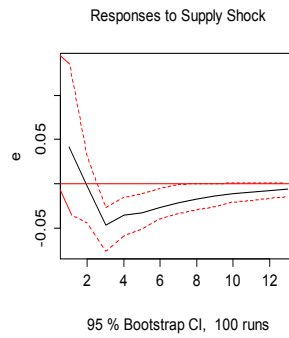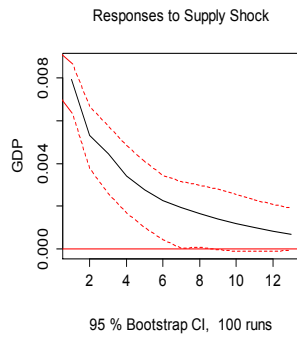
5.2 Response of real Exchange Rate and Inflation to Shocks (Fixed-Coefficient SVAR Estimates)

We first estimate the fixed-coefficient SVAR model using three variables set $(\Delta rgdp, \Delta e, \Delta p)$, the impulses responses are reported in figure 2. The results reveal that real exchange rate respond negatively to positive supply shock after the second quarter and stay negative thereafter, but the size of the effect become insignificant after the 6th quarter. The effect is however small as it ranges from -5% to -1% after the 2nd quarter. This means that the Ghanaian cedi appreciates against the US dollar in response to positive supply shock albeit a small rate of response that only last slightly more than a year. The implication from this finding is that an adverse supply shock (e.g. recent energy crisis and technological gap between Ghana and United States) produces the reverse effect on the real exchange rate.

Demand shocks have a significant positive effect on real exchange rate in Ghana, but the effect only last for two quarters, implying that demand shocks only have a very short term effect on real exchange rate dynamics in Ghana. Its effect on initial impact is around 20% but this quickly dissipates to around 0% after the 2nd quarter following the shock. The implication is that a positive demand shock within the first quarter causes the real exchange rate to depreciate by 20%, but only last until the second quarter when the effect dies-off completely.

Figure 2 also show that a positive nominal shock tends to have positive effect on real exchange rate after the 2nd quarter, but dies-off after the 4th quarter, and remains insignificant thereafter. This implies that the depreciation effect of nominal shocks lasts longer than that from demand shocks, the size of the effects from the nominal shocks relative the demand shocks is very small. Whereas both supply and nominal shocks tend to have a relatively long lasting effect (4 to 6 quarters) in comparison to demand shocks (1 to 2 quarters), the size of

their impacts is small relative to demand shocks. Thus, on the basis of the FC-SVAR estimates, real demand shocks play a significant role in quarter-to-quarter variations in the cedi-dollar exchange rate.

Responses to Supply Shock

95 % Bootstrap CI, 100 runs

Responses to Supply Shock

95 % Bootstrap CI, 100 runs

Responses to Supply Shock

95 % Bootstrap CI, 100 runs

Responses to Demand Shock

95 % Bootstrap CI, 100 runs

Responses to Demand Shock

95 % Bootstrap CI, 100 runs

Responses to Demand Shock
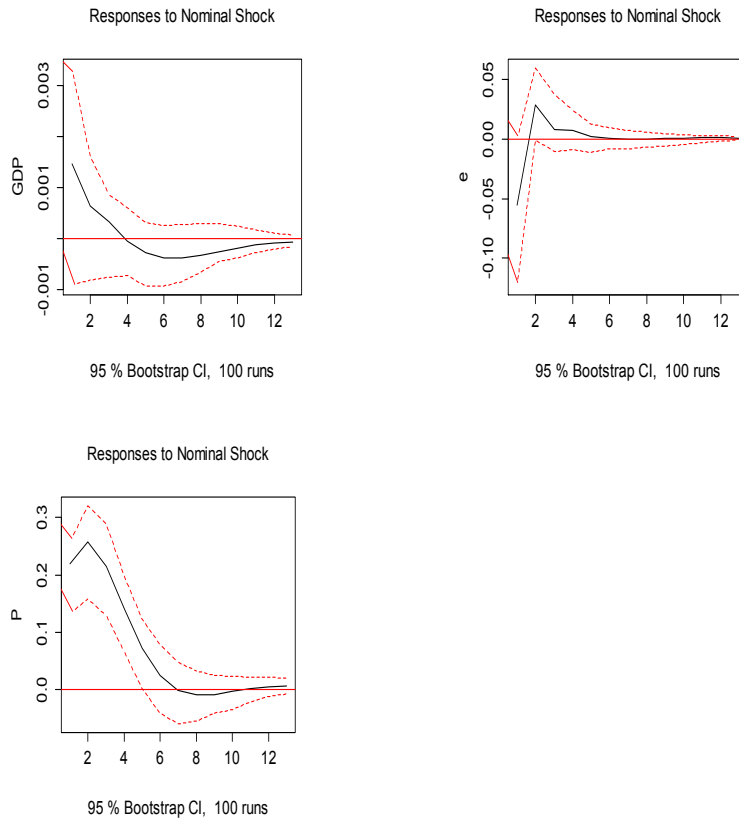
95 % Bootstrap CI, 100 runs

Figure 2: impulse responses from SVAR Model, solid line is the response, while the dashed lines are the 95% bootstrap confidence intervals

The various macroeconomic variables such as output and inflation also responded differently to supply, demand and nominal shocks. For example, output responded positively to supply shocks, but the size of the impact is very small. Prices on the other hand responded negatively to positive supply shock; it stays negative throughout the 12 horizon. The size of the responses of prices to positive supply shock is significant and range from -5% to -20%. Whereas price responded positively to both demand and nominal shocks, the response of output to both shocks is only positive till the 4th quarter, where it turns negative. A key feature of the impulse responses as presented in figure 2 is that, most of the effects of the shocks tend to dissipate quickly after a few quarters of significant impact.

Further, we decompose the variance of the change in real exchange rate to assess the contribution of the various shocks. The result of the decomposition is presented in table 2 and shows that demand shocks explain much of the variance of the change in real exchange rate in Ghana, followed by supply shocks. For instance, within 6 to 12 quarters 79% of the variance of the change in real exchange rate is attributed to demand shocks, 14% to supply shocks and 7% to nominal shocks. However, if we consider the decomposition of the variance

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of inflation, supply shocks dominates after the 6th quarter, accounting for 47% of the variance of inflation in Ghana, while 35% and 18% are attributed to nominal and demand shocks, respectively. Before the 6th quarter, nominal shocks tend to dominate in terms of percentage share of inflation variance.

Table 2: Variance decomposition of real exchange rate and inflation

	Fraction of Δe variance due to			Fraction of π variance due to		
Horizon	Supply	Demand	Nominal	Supply	Demand	Nominal
1	0.034	0.903	0.061	0.082	0.246	0.671
2	0.034	0.889	0.076	0.124	0.283	0.592
3	0.073	0.852	0.073	0.199	0.267	0.532
4	0.094	0.832	0.072	0.283	0.242	0.473
5	0.112	0.816	0.071	0.356	0.217	0.425
6	0.123	0.805	0.070	0.406	0.201	0.392
7	0.130	0.799	0.070	0.437	0.190	0.372
8	0.134	0.795	0.069	0.454	0.185	0.360
9	0.137	0.792	0.069	0.464	0.181	0.354
10	0.139	0.791	0.069	0.469	0.179	0.350
11	0.140	0.790	0.069	0.473	0.179	0.348
12	0.141	0.789	0.069	0.475	0.178	0.346

Notes: Δe denotes change in real exchange rate, π is inflation

5.3 The pass-through effects of exchange rate to prices (The Basic FC- SVAR and extensions)

The second key objective of this paper is to assess the pass-through effects of exchange rate dynamics to prices. First, we decompose the variance of relative price to assess how much of the variance of relative prices in Ghana is attributable to real exchange rate shocks. This will enable us determine the contribution of exchange rate shocks on price dynamics in Ghana. This decomposition is presented in table 3 (expressed in percentages) and shows that from 8 to 12 quarters, 18% of the variance in relative price (inflation) are attributable to real exchange rate shocks for the constant coefficient-SVAR model. The results further indicate that, a relative price shock explains more than 1/3 of the inflation variance, suggesting significant inertia in the price process in Ghana, consistent with the findings reported by Adu and Marbuah (2011). The pass-through elasticity (PT) is calculated from the impulse responses by dividing the cumulative impulse response from inflation by the initial exchange rate shock. The calculated PT elasticity value varies significantly from the 1st quarter (0.15%) to the 12 quarter (0.68%). The cumulative impulse responses from inflation and the initial exchange rate shock used in calculating the PT elasticity is reported in Table A2 in the appendix.

Table 3: Percentage of relative price variance attributed to exchange rate shocks and pass-through elasticity from SVAR

	Constant Coefficient-SVAR		
Horizon	Exchange rate shock	Relative Price shock	Pass through-elasticity
1	25	67	0.15
2	28	59	0.36
3	27	53	0.54
4	24	47	0.66
5	22	43	0.71
6	20	39	0.73
7	19	37	0.72
8	18	36	0.71
9	18	35	0.69
10	18	35	0.68
11	18	35	0.68
12	18	35	0.68

This result suggests that exchange rate pass-through effect is relatively large but still less than unitary, implying an incomplete pass-through effect of changes in exchange rate to prices in Ghana. One possible explanation for the high but incomplete pass-through effect is that, import prices are relatively flexible in Ghana though not fully flexible to generate a full pass-through effect (i.e. import price are less rigid but not fully flexible). If import prices were more rigid, the pass-through effect as a result of a shock to exchange rate would be low as suggested by theory, especially in inflation targeting models. Further, transitory exchange rate shocks are expected to result in low pass-through and the opposite is true for permanent shocks. This dynamics is due to expectation about future price development. However, the effect of exchange rate shock (transitory or permanent) on pass-through depend crucially on the degree of import price stickiness.

6. Results of Time-Varying SVAR Estimates

As argued in the introduction to this paper, the real exchange dynamics and the corresponding pass-through effects on domestic prices are potentially time-varying. We account for these potential time-varying real exchange rate dynamics in this section of the paper. Specifically, we estimate the variable set $\left(\Delta rgdp, \Delta e, \Delta p\right)$ based on the TVP-VAR model and the impulse responses of each of the variables to supply, demand and nominal shocks are presented in figure 3. In order to see the macroeconomic dynamics in our estimated model, we present the

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impulse responses from our benchmark TVP-VAR model. Here we are interested in the dynamics of the real exchange rate to supply, demand and nominal shocks. The result as presented in figure 3 indicates that real exchange rate decreased in response to positive supply shock over the sample period. In contrast, real exchange rate increased (depreciated) in response to both a positive demand and nominal shock (does not have significant effect until after the year 2000). The evolution of the various shocks reveals variation over time for each of the variables to supply, demand and nominal shocks. The impulse responses of relative prices to demand shock is positive, the size of the impact increases over the sampled period and range from 5% to 20%. In sharp contrast, the relative price responses to supply shock stay negative throughout the time period, but with varying degree in terms of its size over the years (with the later years showing larger sizes in absolute terms). Nominal shock does not have a significant effect on relative prices in the pre-1990 period; it however has a significant positive effect in the post-1990 period.
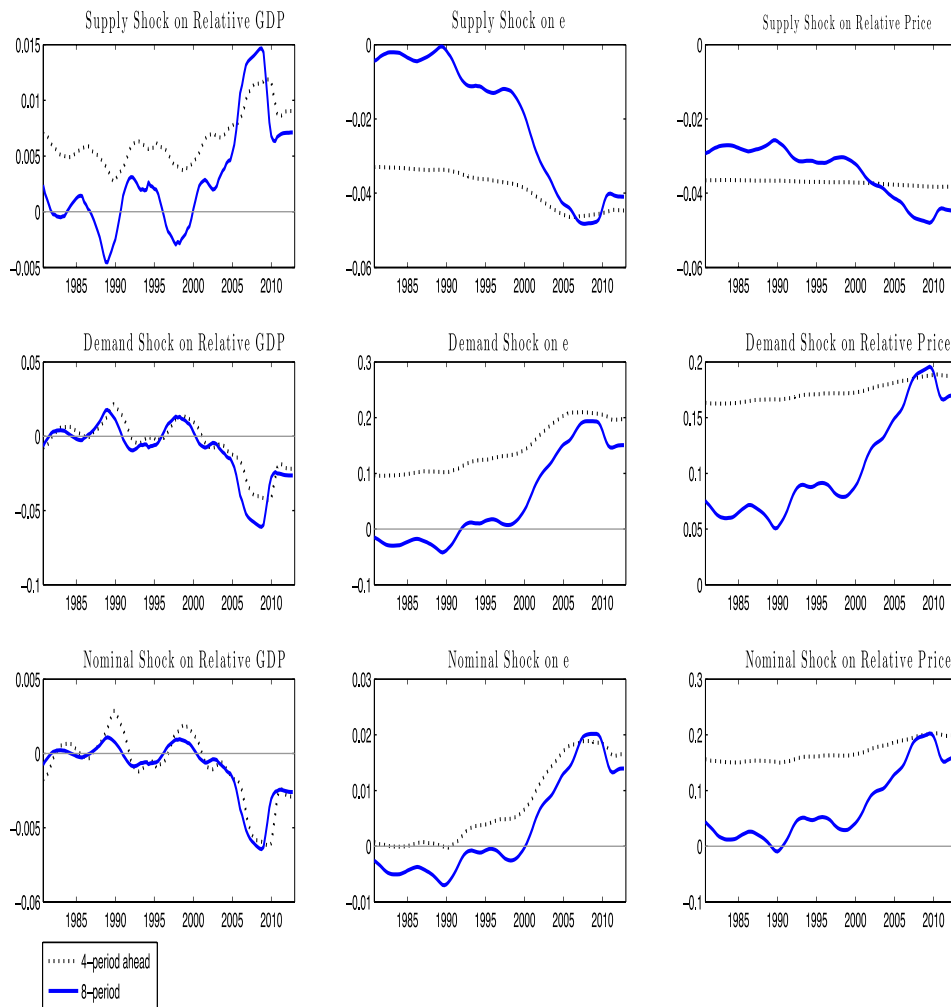

Figure 3: Impulse response for variable set $(\Delta rgdp, \Delta e, \Delta p)$ to supply, demand and nominal shock for one-year (dashed line) and two-year (solid line) horizons for TVP-VAR model.

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In summary, we find significant effects of supply, nominal and demand shocks on real exchange rate dynamics. However the responses tend to vary over time, especially the 8 period ahead shocks. We also find no significant effect of nominal shock on real exchange rate in Ghana for the pre-2000 period (based on the 4 quarters-shocks); it however has a significant positive effect for the post-2000 period. Demand shocks have a significant positive effect and range from 10% in 1980 to around 20% in 2010 based on the 4 quarters-shocks. There is also significant difference between 4 and 8 quarters (1 and 2 years) shocks. The 4 quarters shocks tend to have larger effects in absolute terms relative to the 8 quarters for most of the shocks.

The pass-through effects of exchange rate to prices (TVP-VAR model)

The pass-through elasticity for each of the years is presented in Table 4, which revealed a slightly varying elasticity from 0.58% in 1985 to 0.61% in 2010. These values indicate insignificant variations of the pass-through elasticity across the sampled years. Irrespective of the slight increase in the pass-through effect of exchange rate shocks to inflation in 2010 relative to 1985, we can generally conclude that the pass-through elasticity is stable in Ghana for the period under consideration. The values are however slightly lower than those found based on the constant coefficient SVAR model.

In order to discriminate the two models (constant coefficient SVAR model and TVP-VAR model), we used the Bayesian deviance information criterial (DIC)[2], where the model with smallest DIC is judged the best in fitting the DGP. The results from this exercise are reported in Table 4 and it reveals that the TVP-VAR model fit the DGP better relative to the constant SVAR.

Table 4: DIC values for model comparison: TVP-VAR verses constant SVAR models

Year	1985	1990	1995	2000	2005	2010
Pass-Through Elasticity	0.58	0.59	0.60	0.60	0.61	0.61
			TVP-VAR		*Constant SVAR*	
DIC			897.628		987.879	

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[2] The DIC is a generalization of Akaike information criteria introduced by Spiegelhalter et al. (2002). Model with a smaller DIC value is preferred to a model with a large DIC value. The DIC is defined as: $DIC = \bar{D} + p_D$, the first term measure the goodness of fit, while the second term measure the model complexity.

Robustness check

The previous results are based on three variables model and as a consequence, there exist the possibility of omitted variable bias. To address this we extend our benchmark model to include real interest rate, money supply, gold price, cocoa price and oil price in addition to the three variables in our benchmark model. The choice of these additional covariates is premised on their relative importance in the macroeconomic stability of the Ghanaian economy. For instance, as a small open economy with high dependence on export of gold, cocoa and a net-importer of crude oil, any exogenous shock in the price of these tradable commodities has implications on the performance of the economy, hence their consideration in the extended model. In particular, changes in the prices of these commodities in the international markets have implications for the foreign reserve position of the economy and hence real exchange rate dynamics.

Moreover, the extended model will also help us account for different monetary policy tools (such as the policy rate) on exchange rate dynamics as well as the impact of exchange rate shocks on macroeconomic stability (specifically on price, money supply and interest rate dynamics). Such a large scale VAR can only be implemented in a constant coefficient framework; we therefore apply this exercise via the constant coefficient SVAR model and use the outcome from this exercise to validate the small-scale VAR models. The impulse responses are presented in figure A2 in the appendix and they tend to be consistent with the impulse responses from the three variables SVAR model. For example, the impulse responses of output, real exchange rate and inflation to supply shocks depicts the same pattern as those from the three-variable SVAR presented in figure 2 their respective sizes of the impact are the same, except that of output that differ slightly. The implication is that the impulse responses from the three-variable SVAR model do not suffer from omitted variable bias. We therefore take this as evidence even for the three variables TVP-VAR model. The results from this exercise show varying responses of inflation, interest rate, output and money supply to real exchange rate shocks. We observe that a positive real exchange rate shock (depreciation) results in rising inflation and interest rate levels, while the response of output and money supply is negative. Also, the effects of the shock pertain at least for about 6 quarters. These results confirm the negative impact of exchange rate crises in engendering a chain of reactions thereby creating macroeconomic instability via the pass-through effects on domestic prices and cost of credit with their resultant effects of reduced growth and money supply.

7. Conclusion and Policy Implications

In this study we analyze real exchange rate dynamics and its response to supply, demand and nominal shocks based on both a constant coefficient and a time varying SVAR models. Additionally, we extend the analysis to examine the response of exchange rate to monetary policy shocks and more generally the response of key macroeconomic variables (such as output, interest rate and inflation) to exchange rate shocks. The key finding from the study based on quarterly data for the period 1980Q1-2012Q4 revealed the following; first we find significant effects of supply, demand and nominal shocks on real exchange rate dynamics in Ghana; however the effects vary in terms of direction and magnitude.

Whereas a positive supply shock has an appreciating effect on real exchange rate in Ghana, both demand and nominal shocks have depreciating effect on real exchange rate. More so, demand shocks tend to have larger effects on real exchange rate dynamics relative to both supply and nominal shocks. We also find significant evolution of the impact of most of the shock. For instance, the 4-period ahead demand shock had a 10% impact on real exchange rate for the pre-1990 period. This impact increased gradually over time to 20% for the 2005 to 2012 period. Whilst nominal shocks had no significant effect pre-1990, its impact become significant post-1990 and range from 1% in 2000 to 2% in 2010.

The second key result is the high pass-through elasticity of change in real exchange rate to consumer prices in Ghana. Irrespective of the high pass-through elasticity, it is however less than one, implying an incomplete pass-through effect. We argue that the high pass-through elasticity is due to the depreciation of the cedi to the dollar for most of the period in our sample, coupled with the fact that the country largely depend on imported goods and services (both for consumable goods and raw materials for industries). Further, and more importantly, the less import price rigidity in Ghana tends to result in high but incomplete pass-through. This means that any depreciation of the cedi that leads to higher import prices is likely to be passed on to the final consumer, hence the high pass-through elasticity.

We also find evidence from our extended model that, positive exchange rate shocks have a negative impact on output, a positive impact on prices and a negative impact on money supply, implying that depreciation of the real exchange rate has negative consequences on macroeconomic stability. Moreover, we find no significant effect of both positive oil price and gold price on output in Ghana. Positive cocoa price tends to have a significant positive impact on output, partially reflecting the dependence of the Ghanaian economy on cocoa and

therefore price shocks in the world market for cocoa appear to transmit to the economy via output. This provides support for the need to diversify the economy to reduce the shocks of world cocoa prices on the economy.

Last but not least, there appear to be a significant price puzzle in Ghana; prices reacted positively to positive interest rate shocks (contractionary monetary policy) until the 6th quarter when it becomes insignificant, implying monetary policy in terms of interest rates do not have the intended effect on prices (price reduction) which may be due to a weak policy transmission mechanism and also the fact that in inflation targeting regime, the policy maker is more interested in reducing the variability in output and interest rate than try to hit pre-announced annual inflation target at all cost. As a consequence the policy rate set by the monetary authorities might not be at a level that could induce a strong transmission mechanism to a level that will reduce inflation. This means that interest rate as a policy tool in price stabilization is ineffective and that monetary authorities should not rely on this as the main tool in controlling inflation dynamics in Ghana.

Another candidate explanation for the positive reaction of inflation to interest rate shocks is that much of the inflation pressures in the Ghanaian economy emanate from the supply side; hence a contractionary demand management policy may be counter-productive if the supply side responds negatively. This evidence could be one of the reasons for non-attainment of inflation targets on a number of occasions.

The following policy lessons are derived from the findings reported in this paper. First, demand shocks depreciate the real exchange rate implying that relying on fiscal policy such as increasing government spending, such as deficit spending that is not financed via taxes (expansionary fiscal policy) tend to raise interest rates, especially if the spending is supported by domestic borrowing. This is supposed to make domestic assets attractive if the debt will be serviced through taxing future growth in the economy which has the effect of reducing current inflation as a consequence of lower future inflation expectation. However if they believe is that the debt will be paid for via seignorage (either as a result of past experience or the spending is not generating the needed growth to support the repayment from taxes), future inflation expectation will be high and will increase current inflation level, making domestic assets unattractive in the process and consequently increase demand for foreign assets that will cause the domestic currency to depreciate. In this regard, a switch from the

current discretionary fiscal policy to rules based fiscal policy could have substantial effect on exchange rate and price stability in Ghana.

Additionally, whether positive demand shocks such as an increase in deficit spending will depreciate the real exchange rate depend crucially on the size of the deficit created by the fiscal policy, the future trend of the debt to the gross national product (GNP) of the country and the type and nature of the spending (spending on consumption or investment spending). If the size of the debt is large and a greater part of it goes into recurrent expenditure, inflation expectation is likely to be high. This high future inflation expectation will feed into current inflation and create a situation where domestic assets will be unattractive relative to foreign assets and cause the domestic currency to depreciate. In the case of Ghana, given the high debt to GNP ratio, deficit spending, especially domestic borrowing is most likely to be inflationary. This will increase the possibility for real interest rates to be higher than the growth of the economy, which will create depreciating pressure on the country's currency. Even if the authorities rely on foreign reserves to finance the debt (a policy tool to increase the value of a country's currency), its effect on currency appreciation is usually not sustainable and in the case of Ghana, given the size of the debt, it will only have a very short- at best stabilizing effect on the real exchange rate.

Ghana's expansionary fiscal policy over the years have resulted in government debt levels that cannot easily be supported with further debt spending without creating more instability in the macroeconomic environment of the country. Further expansionary fiscal policy will likely generate more instability as it will likely crowd-out more private investors from the capital market via high interest rates that such a policy will generate. However if the debt is spent efficiently on investment projects, it will help in reducing the instability in the medium term via increases in output and employment that will eventually support government revenue generation potentials to service some of the debt.

The second key finding is that nominal socks such as expansionary monetary policy through increase in money supply depreciate local currency. The implication is that if rather contractionary monetary policy such as a decrease in money supply will have a stabilizing effect on the exchange rate as it decreases the inflationary pressure in the country and therefore reduces inflation premium on asset returns. This is likely to make domestic assets attractive and reduce the exchange rate requirement in purchasing foreign assets in the asset portfolio. However a policy tool based entirely on directly controlling interest rate in order to

stabilize prices will not help in achieving the intended objective as our finding provide evidence in support of a positive reaction of price to positive interest rate shocks (a price puzzle which tend to last for 6 quarters). A possible reason for this might be that, the commercial banks and other financial institutions do not react directly to the central bank's interest rate policy indicating the existence of a weak link between the interest rate set by the central bank and the lending and borrowing rates charged by commercial and other financial institutions. The indication from this is that a monetary policy tool that directly controls money supply is likely to be more effective in controlling inflation than a policy that directly controls interest rate, given the weak transmission mechanism between policy rate and inflation.

Finally, the results indicate an appreciating effect of supply shocks on exchange rate in Ghana. This therefore means that, expanding the real sector of the economy such as increasing productivity and output level of the various sectors of the economy will have positive implications on the forex outlook of the economy. However, supply side management will have to be well-planned out, since this will depend on the level of both private and public investment and whether these investments are into the most productive sectors to generate the needed growth in output and employment to stabilize the macroeconomic fundamentals. Narrowing the technological gap between the country and its major trading partners (using United-States as proxy) through investment in R&D activities will increase factor productivity in the economy and thus strengthen the macroeconomic fundamentals necessary for exchange rate stabilization.

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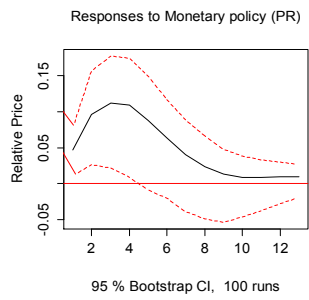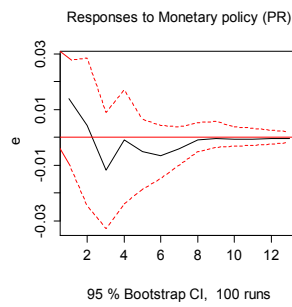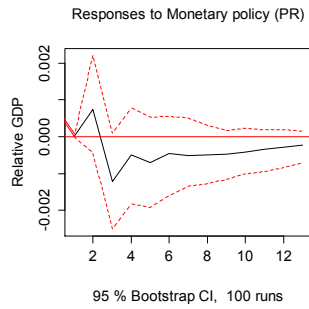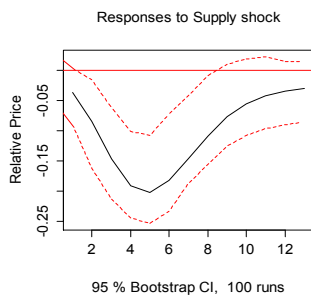World Bank (2014). World Development Indicators Database.

Appendix

Table A1: Unit root test results for the series in the data set

Variable	*ADF-Unit Root Test*		*PP- Unit Root Test*	
	Level	Difference	Level	Difference
Relative GDP	0.770	-6.528	0.007	-6.815
	(1.000)	(0.000)	(0.994)	(0.000)
Relative Price	-2.577	-7.743	-2.528	-7.602
	(0.291)	(0.000)	(0.314)	(0.000)
Real exchange rate	-1.494	-7.822	-1.854	-7.574
	(0.831)	(0.000)	(0.678)	(0.000)
Oil Price Index	-1.927	-9.431	-1.908	-9.261
	(0.640)	(0.000)	(0.650)	(0.000)
Cocoa Price Index	-2.291	-9.981	-2.459	-9.965
	(0.438)	(0.000)	(0.348	(0.000)
Gold Price Index	-0.497	-10.303	-0.606	-10.316
	(0.983	(0.000)	(0.978)	(0.000)
Money	-2.029	-14.692	-1.674	-15.110
Supply(M2)	(0.585)	(0.000)	(0.762)	(0.000)
Prime rate	-1.625	-9.371	-1.743	-9.263
	(0.782)	(0.000)	(0.731	(0.000)
Treasury Bill rate	-1.961	-8.038	-2.352	-7.931
	(0.622)	(0.000)	(0.405)	(0.000)

Table A2: Cumulative IRF from inflation, initial exchange rate shock and PT elasticity for FC-SVAR

Cummulative IRF from Inflation	Initial exchange rate shock	Pass through (PT)-Elasticity
0.132432	0.903811	0.146526
0.324974	0.903811	0.35956
0.486594	0.903811	0.538381
0.593119	0.903811	0.656242
0.645273	0.903811	0.713948
0.658911	0.903811	0.729037
0.651806	0.903811	0.721176
0.637899	0.903811	0.705788
0.625446	0.903811	0.69201
0.617777	0.903811	0.683524
0.615008	0.903811	0.680461
0.61574	0.903811	0.681271
0.618267	0.903811	0.684067

Note: the PT elasticity is calculated by dividing the first column by the second column.

Responses to Supply shock

Relative GDP

95 % Bootstrap CI, 100 runs

Responses to Supply shock

e

95 % Bootstrap CI, 100 runs

Responses to Supply shock

Relative Price

95 % Bootstrap CI, 100 runs

Responses to Monetary policy (PR)

Relative GDP

95 % Bootstrap CI, 100 runs

Responses to Monetary policy (PR)

e

95 % Bootstrap CI, 100 runs

Responses to Monetary policy (PR)

Relative Price

95 % Bootstrap CI, 100 runs

27

Responses to Cocoa Price Shock

Responses to Oil Price Shock

95 % Bootstrap CI, 100 runs

95 % Bootstrap CI, 100 runs

Responses to Gold Price Shock

95 % Bootstrap CI, 100 runs

Responses to real exchange rate shock

Responses to real exchange rate shock

95 % Bootstrap CI, 100 runs

95 % Bootstrap CI, 100 runs

Responses to real exchange rate shock
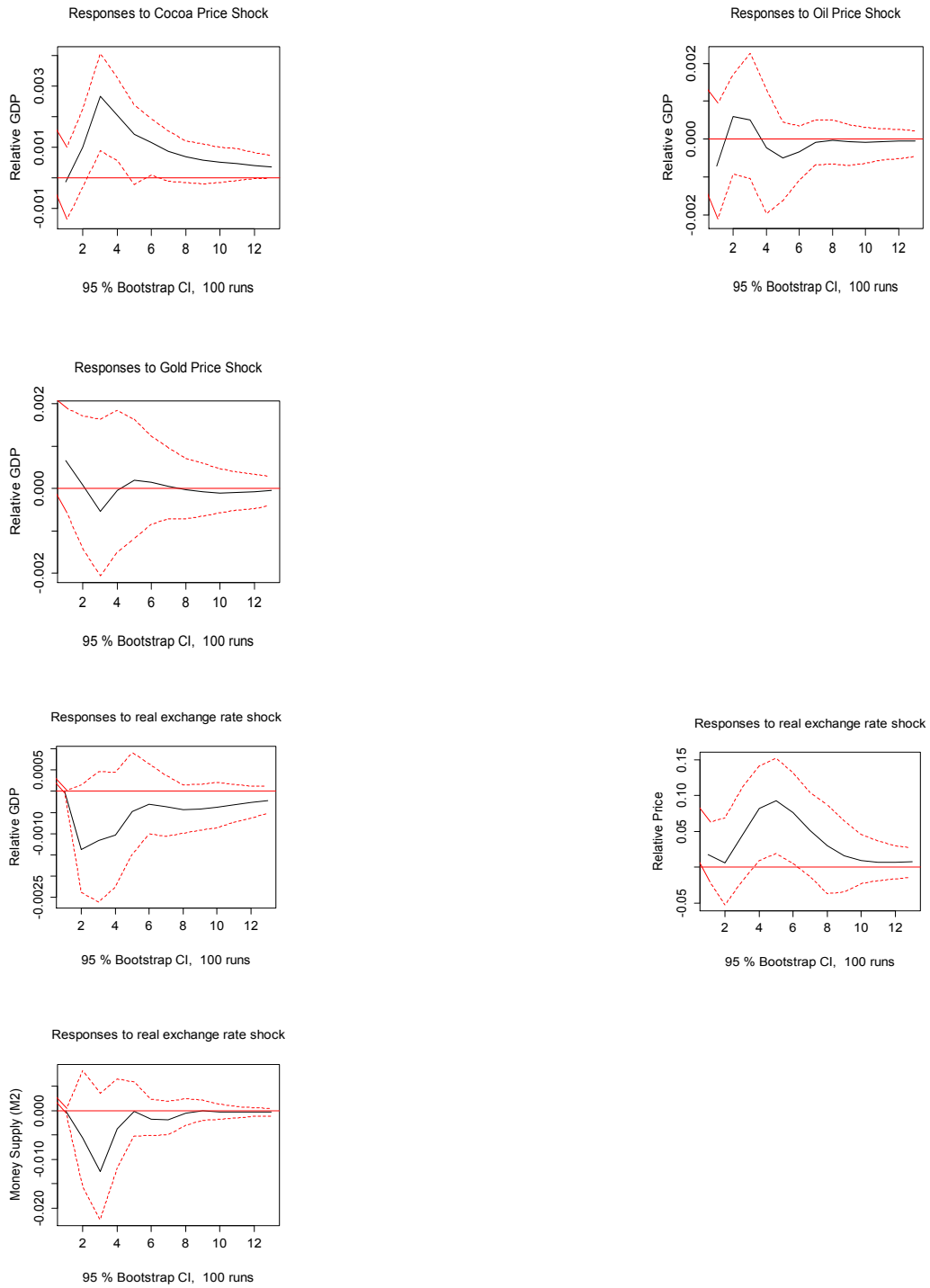
95 % Bootstrap CI, 100 runs

Figure A2. Impulse responses from constant coefficient extended –SVAR model

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