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# Asymmetric Pass-Through of Exchange Rate Changes to CPI Inflation in Ghana

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## ABSTRACT

This paper examined asymmetric response of CPI inflation to changes in the nominal exchange rate of Ghana. The Structural Vector Autoregressive Regression (SVAR) model was deployed with a careful selection of variables consistent with the New Keynesian macroeconomic theory. Examining both symmetric and asymmetric ERPT, this paper found strong evidence of a response in CPI inflation to changes in exchange rate. The response is not immediate but it featured prominently three months into the future and dissipates thereafter. Pass-through to non-food prices is complete but incomplete in the case of food prices. ERPT is found to be asymmetric with depreciation having a positive effect on CPI inflation as expected within the first three months. Appreciation on the other hand has little impact on CPI inflation and has no statistical significance. It is evident that, the size of the changes in exchange rate does not affect pass-through. Examining the role of inflation environment in pass-through, this paper found that, in periods of increasing inflation, CPI inflation responds strongly to output gap and exchange rate than in periods of decreasing inflation. The variation in CPI inflation explained by changes in exchange rate is very low due to increasing productivity which absorbs the impact.

**Keywords:** *CPI inflation, ERPT, Asymmetric, SVAR, Expectation, Ghana*

## 1. INTRODUCTION

1948 was a watershed year in the history of Ghana. Political disturbances then jolted the British into finally allowing the indigenous representation and participation in the governance of their country. In the same year, the Watson Commission, formed to investigate the causes of the unrest in the country, emphasized the need for political reforms to grant more autonomy to the locals over the legislative and regulatory framework. For Ghana, the retreat of colonialism was completed in full on March 6, 1957 when it finally gained independence from British rule. The pre-independence era marked a benign growth period for the economy until 1964 when the economy slumped into recession (Aryeetey and Fosu, 2002). Military coup d'états, oil-supply shocks and fallen commodity prices, particularly cocoa, plunged the economy into a trend of contraction, only rarely interspersed with fleeting and short-lived economic growth, until 1983 when the Economic Recovery Program (ERP) came into force. The worst negative growth recorded before the intervention of the ERP was 12.4% in 1975 but growth took a sharp upward turn and peaked at 8.5% in 1978.

The ERP, implemented in 1983 to reverse the downward spiral, could, in part, be praised for rescuing the economy from the throes of economic collapse at a time when the economy was at its most vulnerable. Despite an oscillating growth rate, it can be said that the Structural Adjustment Program (SAP), implemented in 1986, brought considerable stability for well over two decades. However, the adoption of the floating exchange rate regime in 1988 has subjected the cedi to a trajectory of consistent depreciation. Within the sample period, the USD/GHS spot rate depreciated on a monthly average of 27.33% accounting for 87% of the changes in the spot rate while appreciation averaged 4.43% accounting for a 13% share. The currency was exposed to massively substantial volatility particularly between 1990m01 and 2001m01.

A corollary to the changes in the exchange rate is the monthly CPI inflation which increased on an average of 24.31% and decreased on an average of 10.68%, accounting for 87% and 13% shares respectively, of the changes in the CPI. CPI inflation reached a record high in 2003m02 at 124% but shortly thereafter, fell dramatically, hitting 6% in 2003m04 and settling down with some moderation immediately afterward. Movements in CPI inflation and the USD/GHS spot rate provide strong evidence that changes in exchange rate and CPI inflation in Ghana are highly correlated.

Another intriguing phenomenon is the growing dollarization of the Ghanaian economy. This has the potential of hastening the extent of pass-through of exchange rate fluctuations to CPI inflation as observed in the case of Turkey by Leigh and Ross(2002). The Bank of Ghana, however, noted that the state of the currency is consistent with economic fundamentals but the continuing depreciation is accounted for by speculative activities of market participants[1]. The depreciative pressure on the Ghana cedi has raised serious concerns in recent times, particularly because of its linkage to domestic prices.

In fact, no empirical literature had been able to decouple fluctuations in nominal exchange rate from the variations in domestic prices in Ghana. The continuous depreciation pressure on the cedi but with stable inflation seems puzzling. This has continued to fuel political bickering in recent years even among veteran practitioners on the macroeconomic forefront and those hailing from credible government institutions. The proponents assert

[1] *Monetary Policy Committee(Band of Ghana) Press release April 27, 2012*

that, given the declining CPI inflation rate but growing depreciative pressure on the cedi which was projected to hit 1USD/2.1GHS, the Central Bank might run the risk of misconducting its monetary policies[2]. Credible public institutions quickly refuted this assertion on the grounds that the Ghanaian economy is characterized by market imperfections that can cause low exchange rate pass-through[3]. Besides, the small composition (10%) of imported products in the CPI could also cause low exchange rate pass-through[4].

Against this backdrop, an extensive empirical study on the impact of exchange rate fluctuations to CPI inflation is paramount for the Ghanaian economy. However, no empirical literature to date has yet examined asymmetric ERPT in the Ghanaian economy; more widely speaking, even literature conducted on ERPT in general is also rare. This paper seeks to contribute in any way possible to fill in at least part of the research need, with ascertaining asymmetric pass-through as the central purpose.

Whether domestic inflation responds asymmetrically to changes in the exchange rate is a key question for Central Banks, especially those of a developing economy like Ghana. The answer to this question has implications for the conduct of monetary policy, particularly the level and speed with which monetary authorities attempt to adjust the inflation and exchange rates. The Central Bank occasionally fine-tunes the prime rate to respond to the exchange rate movements. However, the use of monetary policy rate as a reaction to exchange rate must be deployed with much thoughtful consideration.

This paper explores four key questions in the attempt at proving asymmetric ERPT in Ghana. First, does the level change in the cedi`s exchange rate play a significant role in the second-step impact of ERPT? Second, does size of changes in exchange rate play a role in the extent to which changes in the cedi exchange rate affect CPI inflation? Third, if ERPT is asymmetric, which level is more pronounced in the short run and long run? Fourth, is pass-through affected by the inflation environment?

The remaining part of this paper is organized as follows: Section 2 discusses related literature on the topic. Section 3 discusses possible reasons for the asymmetric ERPT. Section 4 discusses Ghana`s trade structure and pass-through. Section 5 discusses and presents the empirical model and data. Section 6 presents and discusses the estimation result. Section 7 discusses the sensitivity analysis of the result. Finally, Section 8 discusses the conclusion and policy implication of the findings of this paper.

## 2. REVIEW OF RELATED LITERATURE

A healthy-dose of empirical research has been carried out to ascertain the ERPT to domestic prices in both developed and developing countries but those that dealt with asymmetric ERPT are few. Most of the literature found complete pass-through in the first-step impact and, in most cases, pass-through is incomplete in the second-step impact. See Ito and Sato (2007), Jonathan McCarthy (1999), and Wickremasinghe and Silapule (2004) for more details. Two categories of literature exist in relation to the assumption of asymmetric pass-through to domestic prices. The first category uses firm level studies focusing primarily on products and industries. Coughlin and Pollard (2003) used OLS with U.S. import prices for 30 industries and found that more than half of the firms in the selected industries respond asymmetrically to appreciation and depreciation. Using disaggregated data covering 17 3 and 4 digit SITC products in Japan from 1980-1988, Marston (1990) observed that pass-through is higher during periods of appreciation compared to depreciation for 5 out of the 17 products. The empirical work done by Khosla (1991) using 14 2 digit ISIC data in Japan from 1974q1 to 1987q4 showed that pass-through varied with respect to appreciation and depreciation of the yen in only four firms out of the fourteen industries.

The second category includes those that explore the issue from a macro perspective. Nidhaleddine (2012), using nonlinear smooth transition models, found evidence of asymmetric pass-through with respect to size but a mixed outcome in relation to the direction of asymmetry in 12 Euro Area (EA) countries. Anne-Laure and Antonia (2010) used prices of G7 countries and found that prices respond asymmetrically to appreciation and depreciation in most countries. They buttressed their finding on asymmetric pass-through with reasons of high entry barriers in some countries, menu cost and pricing-to-market behavior of firms. Wickremasinghe and Silvapulle (2004) using asymmetric models with co integration tests observed an asymmetric exchange rate pass-through on manufactured import price in Japan with pass-through coefficient of 0.98 for appreciation and 0.83 for depreciation. Peltzman (2000), using symmetry test of correlation, observed that exchange rate asymmetries are persuasive, substantial and durable during periods of high and low inflations. Most of the previous literature assessing asymmetric ERPT deployed models compatible with linearity and non-linearity and in most instances, they identified asymmetric ERPT.

## 3. REASONS FOR ASYMMETRIC PASS-THROUGH OF EXCHANGE RATE

The conventional economic theory premised on the theory of Purchasing Power Parity (PPP) underscores a one-to-one relationship between changes in exchange

[2] *For details see a speech delivered by Dr. Mahamadu Bawumia , former Deputy Governor of the Central Bank of Ghana on the "State of the Ghanaian Economy 2012"*
[3] *MoFEP, Re: State of the Ghanaian Economy 2012, 3rd May 2012)*
[4] *GSS, Re: State of the Ghanaian Economy2012, July 2012*

rate and domestic prices. However, empirical works performed by Krugman (1987) and Dornbusch (1987) posit that such a relationship may not always hold due to pricing-to-market behavior of firms under imperfect competition. The previous studies on the topic used the pricing-to-market strategy by firms, quantity rigidity and menu cost adjustment to explain possible reasons for asymmetric ERPT. This paper argues out asymmetric pass-through via the expectation channel and follows previous studies to consider the behavior of firms and time horizon.

### 3.1 Expectation of Market Participants

Expectation plays an important role in both CPI inflation and nominal exchange rate determination. The adaptive and rational expectation hypotheses offer a theoretical framework to analyze asymmetric ERPT. The historical movements of the NEER and USD/GHS spot rate depicts continues depreciation trend with short-lived appreciation trends as shown in fig 1. Firms are therefore less likely to change prices in periods of appreciation of the currency than they would with depreciation.

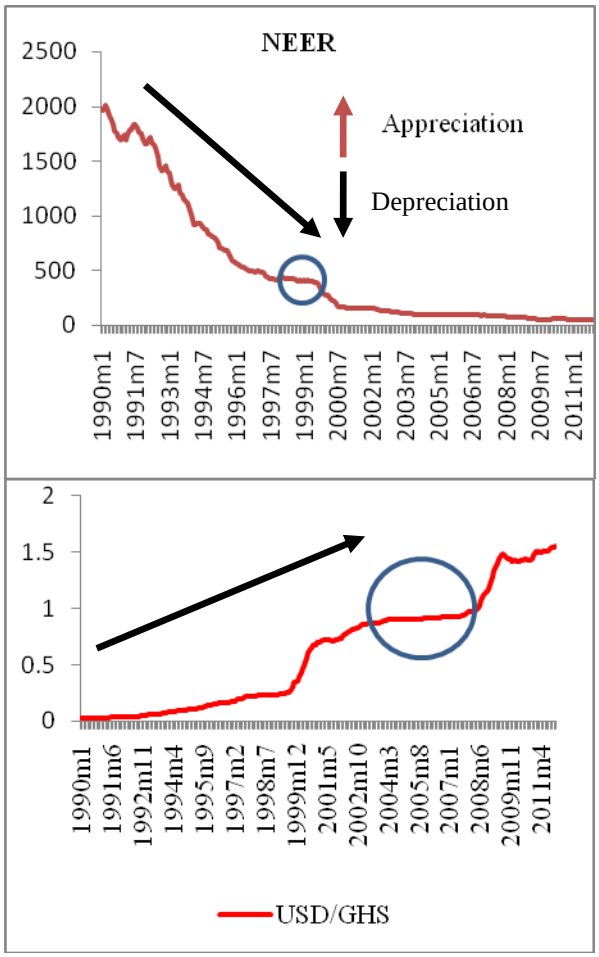



**Fig 1:** Trend in the changes in the NEER and USD/GHS movement (1990m1-2011m12)

Source: Own computation using data from IFS (IMF)

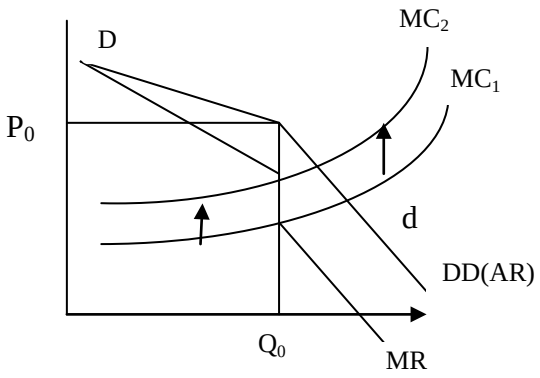
Domestic importers faced with a long period of depreciation of the home currency will always increase their prices to make up for any loss arising out of an exchange rate risk. The only condition that can restrain this behavior of domestic importers is when imported products have a high degree of substitution. However, the substitution effect is weak in Ghana since the country relies heavily on imported products due to a slimmer industrial sector. Inflation expectation could further trigger prices to rise faster than they would fall, thus encouraging economic agents to respond more to depreciation than appreciation (Peltzman, 2000).

Faced with continuing trend of depreciation, domestic importers will never reduce prices during periods of appreciation because of the expectation of future depreciation. Similarly, firms will never change prices due to the costly nature of menu cost adjustment. Firms may pass on the changes in exchange rate during period of depreciation due to expectation of long lasting trend in depreciation.

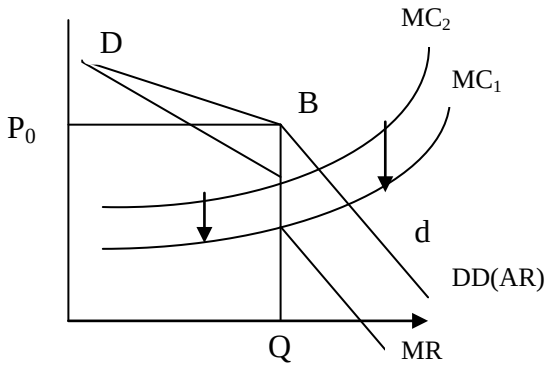
### 3.2 The Behavior of Firms

Firms, in an attempt to maintain market share under imperfect market competition, may prefer to reduce prices during periods of appreciation rather than increasing prices during periods of depreciation. This is because a firm in an oligopolistic market may conjecture that its rival would match its price if it initiates a price reduction instead of a price increase. This results in a kink in the firm`s perceived demand curve (Sweezy, 1939 and Hall and Hitch, 1939). Depreciation of an importing country`s currency makes imported goods relatively expensive. The reverse is true for appreciation. This affects the demand situation for imported products in the importing country. Foreign firms may therefore attempt to adjust their mark-up and maintain it during periods of depreciation and appreciation respectively so as to maintain market share.

From figure 2(a), when price is at point B, DB becomes the demand curve for the firm when rivals respond by changing their price contemporaneously. Line dB is the demand curve when rivals also fix their price at B. The oligopolistic competitive firm therefore faces the kinked demand curve DBd. As a result, changes in marginal cost does not affect price and quantity as the marginal revenue curve is also kinked at Q0.



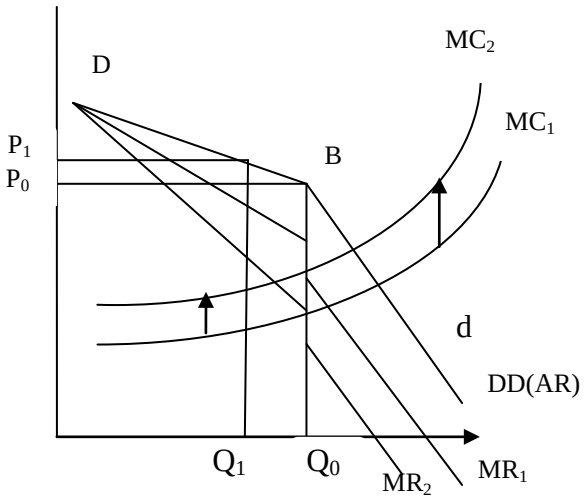

Panel (a) Increase in MC



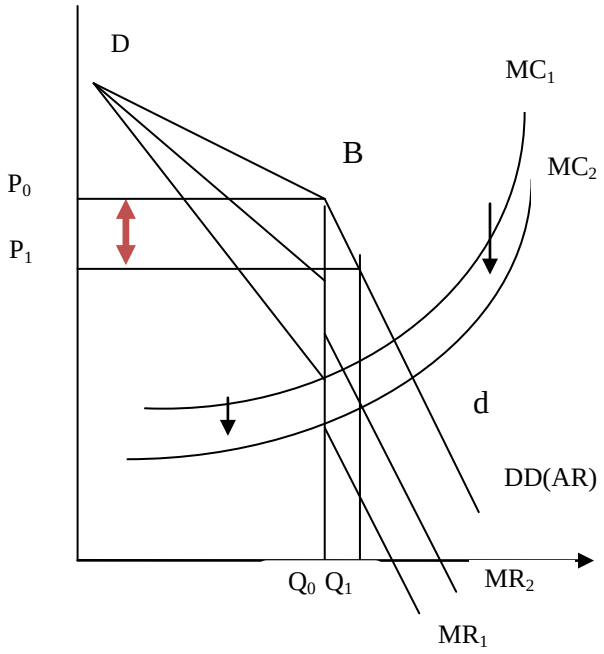

Panel (b) Decrease in MC

**Fig 2(a):** The Kinked Demand Curve

The dynamics of the kinked demand curve vividly explains why firms` behavior could make pass-through increase for appreciation than depreciation. Depreciation in domestic importing currency means a concurrent increase and decrease in marginal cost and marginal revenue respectively. The reverse is true for appreciation. The $MC_2$ and $MR_2$ are the new MC and MR curves in both panel (a) and (b) of fig 2(b).




Panel (a): Depreciation




Panel (b) Appreciation

**Fig 2(b):** The Kinked Demand Curve and Exchange Rate Pass-Through

Since rival firms take an action following an action by the other firm, we can assume a sequential move game. Thus backwards induction strategy implies that firms would fix their price where MC=MR with the demand curve as the benchmark so as to maximize the pay-off stream. It can be deduced from figure 2 that firms have the laxity to reduce prices more under conditions of appreciation as in panel (b) rather than increasing price during depreciation as in panel (a) due to strategic interaction among firms.

### 3.3 Time Horizon

Time horizon plays an important role in the extent to which firms respond to changes in demand. In a like manner, firms may respond to changes in exchange rate differently within short run or the long run. In the short run, firms face constraints on their production capacity and can only adjust production in the long run. In such circumstances, firms consider their objective function of maximizing profit to react to changes in market conditions.

Besides the time horizon, trade regulations, such as quotas, could also affect quantity of export or import. When an importing country`s currency appreciates, it becomes benign for foreign exporters to gain a competitive posture in the importing market and so they can reduce prices. However, foreign exporting firms faced with quantity rigidity in the short run, may attempt to increase prices rather than reduce prices as the opportunity for increasing sales in the importing country becomes limited. The reverse holds in cases of

depreciation. This phenomenon may trigger, comparatively, higher pass-through in periods of deprecation

## 4. TRADE STRUCTURE IN GHANA AND PASS-THROUGH

The pricing-to-market (PTM) behavior of importing firms in the destination country and exporting firms in the trading partner country plays significant role in the pass-through. Recent empirical study on the choice of invoicing currency by global firms by Ito et al (2012) shows that, Japanese firms exhibit PTM behavior by invoicing in the local currency so long as the destination country is a developed economy. The reverse holds if the destination country is a developing economy. To the extent that firms in the trading partner countries of Ghana exhibit similar behavior, fluctuations in the cedi would by all means affect the pass-through. Ghana's trading partner countries are displayed by table 1. Import to the EU 27 countries constitutes 23.9% with export of 51.2% as at year 2011. Other major import partners are China (20.3%), Nigeria (12.3%), U.S (7.8%) and India (5.6%).Exports to the U.S, India, China and Turkey are 8.5%, 4.1%, 3.9% and 3.1% respectively.

It worth noticing that, the country annual imports has continually exceed its exports driving economy to continuously record trade deficits. The year-on-year variation in imports as at the first quarter of 2012 was 43.1% as against the year-on-year variations in exports of 22.4% as shown in fig 3.

**Table 1:** Ghana's Major Trade Partners as at 2011

| Country | Share | Country | Share | Country | Share | Country | Share |
|---|---|---|---|---|---|---|---|
| EU 27 | 33.1 | Australia | 0.8 | Angola | 0.3 | Algeria | 0.1 |
| China | 14.8 | Indonesia | 0.8 | Hong Kong | 0.3 | Argentina | 0.1 |
| Nigeria | 8.5 | Russia | 0.7 | Belarus | 0.2 | Georgia | 0.1 |
| U.S.A | 8.0 | Cameroon | 0.6 | UAE | 0.2 | Chile | 0.1 |
| India | 5.1 | Switzerland | 0.6 | Norway | 0.2 | Syria | 0.1 |
| Turkey | 2.0 | Benin | 0.5 | Colombia | 0.2 | Tunisia | 0.1 |
| Brazil | 1.9 | Vietnam | 0.5 | Lebanon | 0.2 | Philippines | 0.1 |
| South Africa | 1.9 | Cuba | 0.5 | N. Korea | 0.2 | | |
| Thailand | 1.8 | Burkina Faso | 0.5 | Israel | 0.2 | | |
| Malaysia | 1.6 | Singapore | 0.5 | Niger | 0.1 | | |
| South Korea | 1.5 | Morocco | 0.5 | Sri Lanka | 0.1 | | |
| Ukraine | 1.5 | New Zealand | 0.4 | Saudi Arab. | 0.1 | | |
| Japan | 1.4 | Togo | 0.4 | Kazakhstan | 0.1 | | |
| Canada | 1.4 | Egypt | 0.3 | Senegal | 0.1 | | |

Source: EUROSTAT (Comext, Statistical regime 4) Trade shares are in percentages (Trade to the respective countries is mostly U.S dollar denominated)

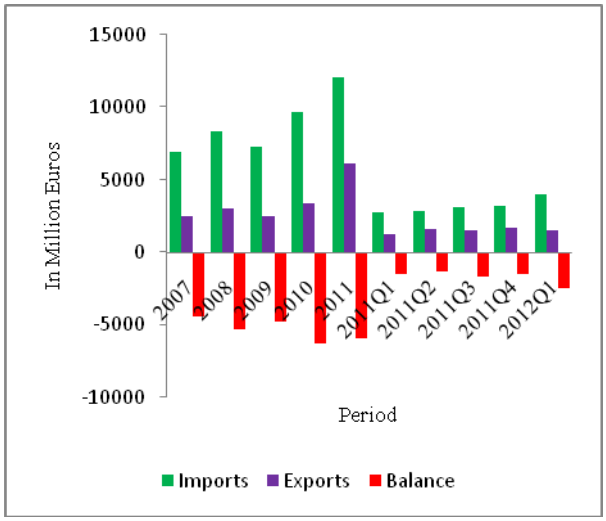



**Fig.3:** Ghana`s Trade with the World

Data Souce: IMF(DoTS)

## 5. EMPIRICAL MODEL AND DATA

Christopher Sims (1982) argued that VAR models stand out in the ability to provide a coherent and credible methodology for describing data, making forecasts, making structural inferences and are best for policy analysis. The VAR model is an n-variable linear model which allows the variables to be explained by their own lagged values as well as the current and past values of the remaining n-1 variables (Stock and Watson, 2001). It has the strength of capturing the dynamic relation among the n-variables without the use of conventional economic theory ("theoretical"). However, the Structural VAR has the strength of using economic theory to capture the contemporaneous relationship among the n-variables by identifying assumptions which permit the correlations to be interpreted causally (Bernanke, 1986). Premised on this, this paper uses the New Keynesian macroeconomic framework to identify the endogenous variables of the SVAR model.

### 5.1 The Econometric Model

The structural VAR approach adopted in this paper is based on a long-run restriction over crucial macroeconomic variables; Interest rate (MPR), Output gap (outgap), CPI inflation (CPI), and Nominal Effective

Exchange Rate (NEER). Oil price was included as exogenous variable in the VAR model. The general VAR model is defined as:

$$X_t = A_0^{-1}\mu + A_0^{-1}Ax_{t-1} + \cdots + A_0^{-1}Cx_{t-i}^{*} + A_0^{-1}Bu_t \quad (1)$$

where $X_t$,[$\text{mpr}_t$, $\text{outg}_t$, $\text{cpi}_t$, $\text{neer}_t$] and is a 4×1 column vector of the endogenous variables, $x_t^*$ is exogenous variable, $u_t$ is a 4×1 column vector of error terms which are not serially correlated, and $A_i$ is 4 × 4 matrices of coefficients. The subscripts t and i denote time and lagged values of the variables respectively. In model (1), each element of vector x, $\{x_1 \ldots x_n\}$, is a symmetric function of its own lagged values and of the lagged values of all the other components of X. The VAR model in (1) is then modified to incorporate asymmetries along the same line of the corresponding univariate specifications. The general asymmetric version of model (1) is:

$$X_t = A_0^{-1}\mu + A_0^{-1}A^{-}x_{t-1}^{-} + \cdots + A_0^{-1}C^{+}x_{t-q}^{**} + A_0^{-1}C^{-}x_{t-q}^{*-} + A_0^{-1}Bu_t$$

(2), where the $\text{neer}_t$ element of vector Xt is split into positive and negative values according to appreciation and depreciation respectively. The SVAR model (1) is transformed into a linear simultaneous form as:

$$\Delta(mpr_t) = \sum_{i=1}^{k}[\alpha_{i1}\Delta(mpr_{t-i}) + \beta_{i1}\Delta\ln(outgp_{t-i}) + \delta_{i1}\Delta ln\,(neer_{t-i}) + \theta_{i1}\Delta ln\,(cpi_{t-i}) + \; exog + \; u_{t1}$$

$$\Delta\ln(outgp_t) = \sum_{i=1}^{k}[\alpha_{i1}\Delta(mpr_{t-i}) + \beta_{i1}\Delta\ln(outgp_{t-i}) + \delta_{i1}\Delta ln\,(neer_{t-i}) + \theta_{i1}\Delta ln\,(cpi_{t-i}) + \; exog + u_{t2}$$

$$\Delta\ln(neer_t) = \sum_{i=1}^{k}[\alpha_{i1}\Delta(mpr_{t-i}) + \beta_{i1}\Delta\ln(outgp_{t-i}) + \delta_{i1}\Delta\ln\,(neer_{t-i}) + \theta_{i1}\Delta\ln\,(cpi_{t-i}) + \; exog + u_{t3}$$

$$\Delta\ln(cpi_t) = \sum_{i=1}^{k}[\alpha_{i1}\Delta(mpr_{t-i}) + \beta_{i1}\Delta\ln(outgp_{t-i}) + \delta_{i1}\Delta ln\,(neer_{t-i}) + \theta_{i1}\Delta ln\,(cpi_{t-i}) + \; exog + u_{t4}$$

The SVAR model (2) incorporating appreciation and depreciation impact is also transformed into the linear simultaneous form as:

$$\Delta(mpr_t) = \sum_{i=1}^{k}[\alpha_{i1}\Delta(mpr_{t-i}) + \beta_{i1}\Delta\ln(outgp_{t-i}) + \delta_{i1}^{+}neer_{t-i}^{+} + \delta_{i1}^{-}neer_{t-i}^{-} + \theta_{i1}\Delta\ln\,(cpi_{t-1}) + \; exog + u_{t1}$$

$$\Delta\ln(outgp_t) = \sum_{i=1}^{k}[\alpha_{i1}\Delta(mpr_{t-i}) + \beta_{i1}\Delta\ln(outgp_{t-i}) + \delta_{i1}^{+}neer_{t-i}^{+} + \delta_{i1}^{-}neer_{t-i}^{-} + \theta_{i1}\Delta\ln\,(cpi_{t-1}) + \; exog + u_{t2}$$

$$\text{neer}_t^{+} = \sum_{i=1}^{k}[\alpha_{i1}\Delta(mpr_{t-i}) + \beta_{i1}\Delta\ln(outgp_{t-i}) + \delta_{i1}^{+}neer_{t-i}^{+} + \delta_{i1}^{-}neer_{t-i}^{-} + \theta_{i1}\Delta\ln\,(cpi_{t-1}) + \; exog + u_{t3}$$

$$\text{neer}_t^{-} = \sum_{i=1}^{k}[\alpha_{i1}\Delta(mpr_{t-i}) + \beta_{i1}\Delta\ln(outgp_{t-i}) + \delta_{i1}^{+}neer_{t-i}^{+} + \delta_{i1}^{-}neer_{t-i}^{-} + \theta_{i1}\Delta ln\,(cpi_{t-1}) + \; exog + u_{t4}$$

$$\Delta\ln(\text{cpi}_{t-1}) = \sum_{i=1}^{k}[\alpha_{i1}\Delta(mpr_{t-i}) + \beta_{i1}\Delta\ln(outgp_{t-i}) + \delta_{i1}^{+}neer_{t-i}^{+} + \delta_{i1}^{-}neer_{t-i}^{-} + \theta_{i1}\Delta ln\,(cpi_{t-1}) + \; exog + u_{t5}$$

To ensure the robustness and reliability of the SVAR estimation, the following econometric techniques have been deployed in the empirical analysis: (1) Granger-causality was conducted to examine the predictive capacity of the lagged values of the variables to each other. In fact, n-2 variables Granger causes CPI inflation in a unidirectional manner.

(2) Macroeconomic time series variables are characterized by non-stationary which presents serious complications for simultaneous equation models like the VAR. Stationary makes the variables to be mean reverting but non-stationary makes temporal shocks persist into the long run (Dimitrios and Stephen, 2011). To circumvent the problem caused by non-stationary, the variables were seasonally adjusted and their first-difference was taken. The Augmented Dickey-Fuller (ADF) test of unit root was conducted and in fact the variables are stationary in their first-difference.

(3) The lag length for the SVAR estimation is chosen on the basis of the LR, FPE and AIC. The result shows an optimal lag length of two. In testing the

hypotheses 4, the lag length was extended to four (4) to fairly capture the response.

(4) The Quandt Andrews break point test was deployed to check for potential structural breaks. Besides, the Chow test carried out to test for structural breaks during periods of monetary policy changes such as inflationary targeting and redenomination of the exchange rate produced similar result. It is therefore concluded that structural break is not identified in the data.

(5) A two variable VAR was estimated to examine the contemporaneous impact between the CPI inflation and the nominal effective exchange rate. This was motivated by the fact that conventional economic theory presents the argument as whether prices determine exchange rate or exchange rate changes determines prices. This paper found strong evidence of CPI inflation responding to the nominal effective exchange rate than the reverse. The paper therefore impose a cholesky order of; Monetary policy rate (MPR) ⇒ Output gap (outgap) ⇒ Nominal Effective Exchange Rate (NEER) ⇒ CPI Inflation (CPI)

### 5.2 Data

The macroeconomic variables used in the study include: (1) Monetary Policy rate (MPR) defined by Bank of Ghana as the Prime rate, and obtained from Bank of Ghana(2) Output gap (outg) for which electricity production was used as a proxy variable. Ghana`s quarterly GDP computation only started in 2006 and not available for the sample period. Interpolation of annual GDP into a monthly frequency involves severe econometric complications and therefore not reasonable to be used in this study. The use of electricity production was motivated by the fact that it is highly correlated with economic activities and is closely dependent on various economic variables (Jianzhou et al, 2009). The data was obtained from the Ghana Statistical Service (3) Consumer Price Index (CPI) as constructed by Ghana Statistical Service. The index was converted using 2006 as the base year, (4) Nominal Effective Exchange Rate (NEER) as defined by IMF International Financial Statistics, (5) Oil price. The sample period spans from 1990m01 to 2011m12 on a monthly frequency.

## 6. EMPIRICAL ANALYSIS AND FINDINGS

The impulse response function (IRF) and the Variance Decomposition are the most widely used in the literature to interpret VAR models. This paper focused exclusively on the IRF to test the five hypotheses of interest. The IRF shows strong evidence of ERPT in Ghana. Symmetrically, a one percent temporary shock to the nominal exchange rate causes a negative effect on CPI inflation by -0.19 percent in the second month. The impact hits -0.15 percent in the third month and quickly disappears thereafter as indicated by fig 4.

This paper further estimates the pass-through for food and non-food prices. The paper finds complete pass-through to non-food prices and incomplete pass-through in the case of food prices as shown in fig 5. The situation is the same for asymmetries.

### 6.1 Hypothesis 1

$H_0$: Pass-through is the same for depreciation and appreciation. $H_1$: Either depreciation or appreciation has higher pass-through. To test this, $\Delta\ln(\text{neer}_t)$ in the SVAR model was separated into positive and negative signs as: $\delta_{i1}^{+}(\text{neer}_{t-1}^{+}) + \delta_{i2}^{-}(\text{neer}_{t-1}^{-})$. Based on the construction of the index of the NEER, positive sign indicates appreciation and negative sign indicates depreciation. Test $H_0$: $\delta_{i1}^{+} = \delta_{i2}^{-}$ and $H_1$ $\delta_{i1}^{-} > \delta_{i2}^{+}$. IRF shows strong evidence of asymmetric ERPT. A one percent temporary shock to depreciation affects CPI inflation by 0.2 percent and the impact dissipates gradually five months into the future. IRF shows evidence of CPI inflation response to appreciation but the response is small compared to depreciation as depicted in fig. 7[5]. The null of symmetric ERPT is rejected.

### 6.2 Hypothesis 2

$H_0$: Size of exchange rate changes does not matter for pass-through. $H_1$: Size of exchange rate changes matter for pass-through. To test this, a squared term was created to incorporate nonlinearities. Thus $\text{neer}_t$ in the simultaneous equation form of the SVAR model (1) is separated into $\delta_{i1}\Delta\ln(\text{neer}_{t-1}) + \delta_{i2}[\Delta\ln(\text{neer}_{t-1})]^2$.

This manipulation was motivated by the fact that, unrestricted VAR models are “atheoretic”. Test $H_0$: $\delta_{i2}=0$ and $H_1$: $\delta_{i2} > 0$ The IRF is not significant statistically. The result seems to defy the notion that firms would adjust their menu cost to absorb large exchange rate changes. The null of no asymmetric pass-through of the size of exchange rate changes cannot be rejected.

### 6.3 Hypothesis 3

$H_0$: None of the level changes is persistence in both short run and long run. $H_1$: Either depreciation or appreciation has persistent effect into the future. To test this, a sign restriction was imposed on the VAR equation used in hypothesis 1 to capture the impact of depreciation and appreciation. It is evident from fig. 8 that depreciation tends to persist and is more pronounced into the future than appreciation.

[5] Though IRF shows response of CPI inflation to appreciation, the response function is not statistically significant.

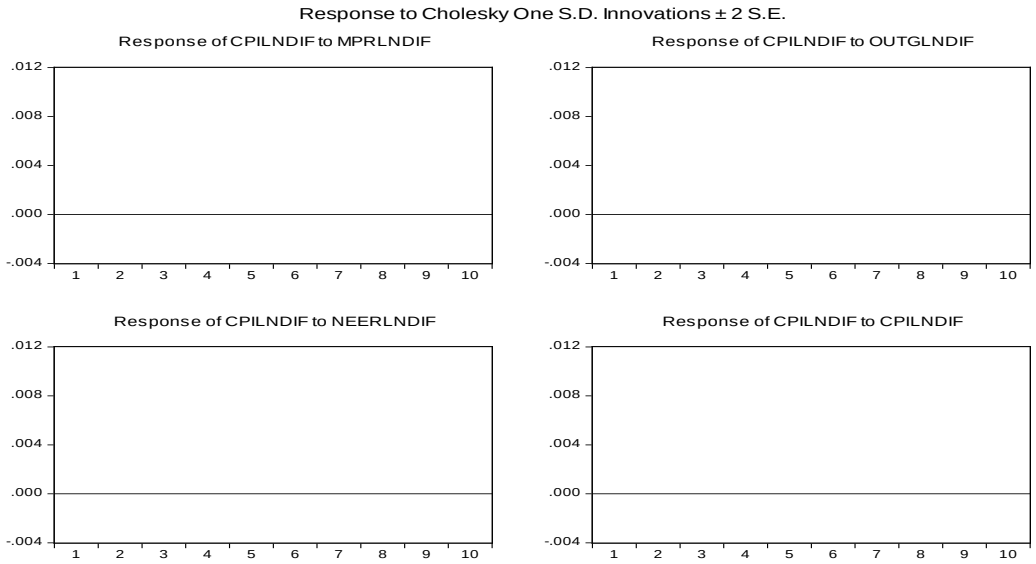
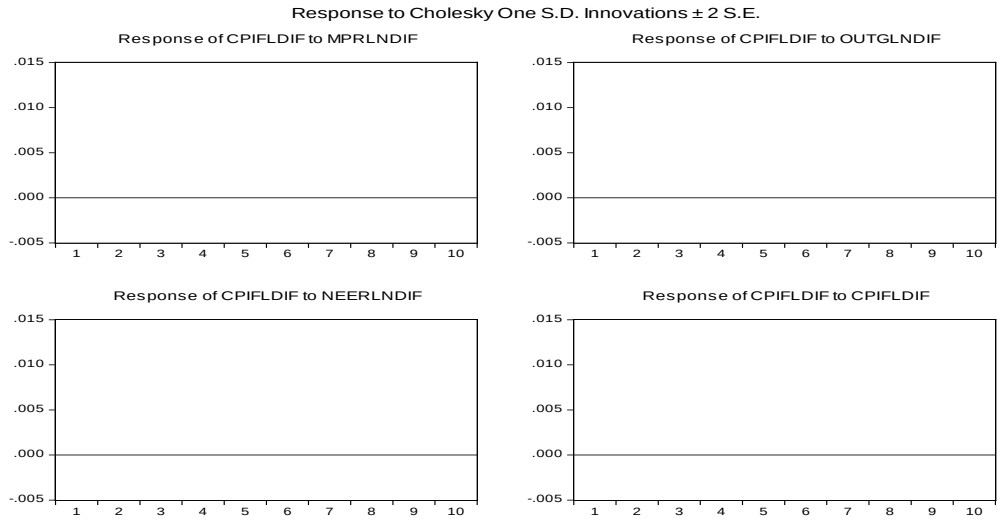
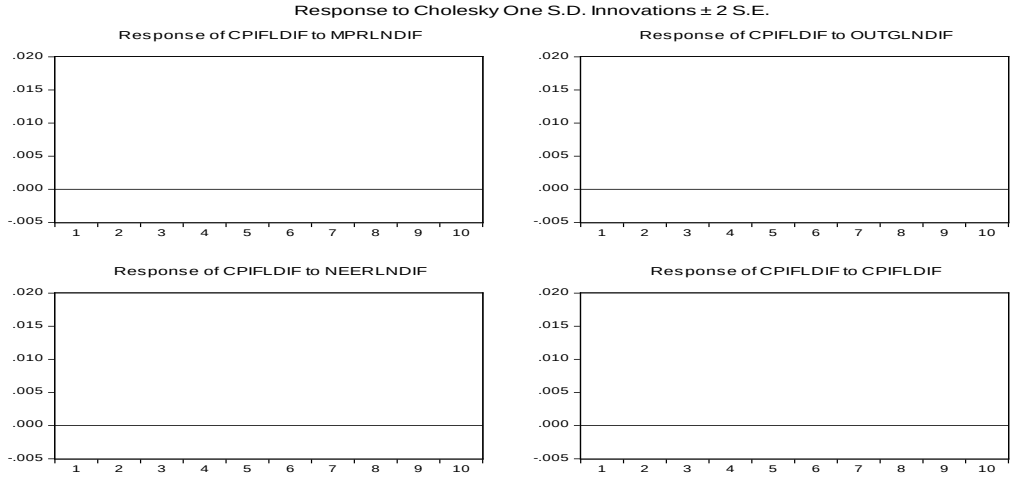



**Fig 4:** Impulse response graph on symmetric ERPT




(a) Pass-through for Nonfood Prices




(b) Pass-through for Food Prices

**Fig 5:** Pass-through between Food and Non-Food prices

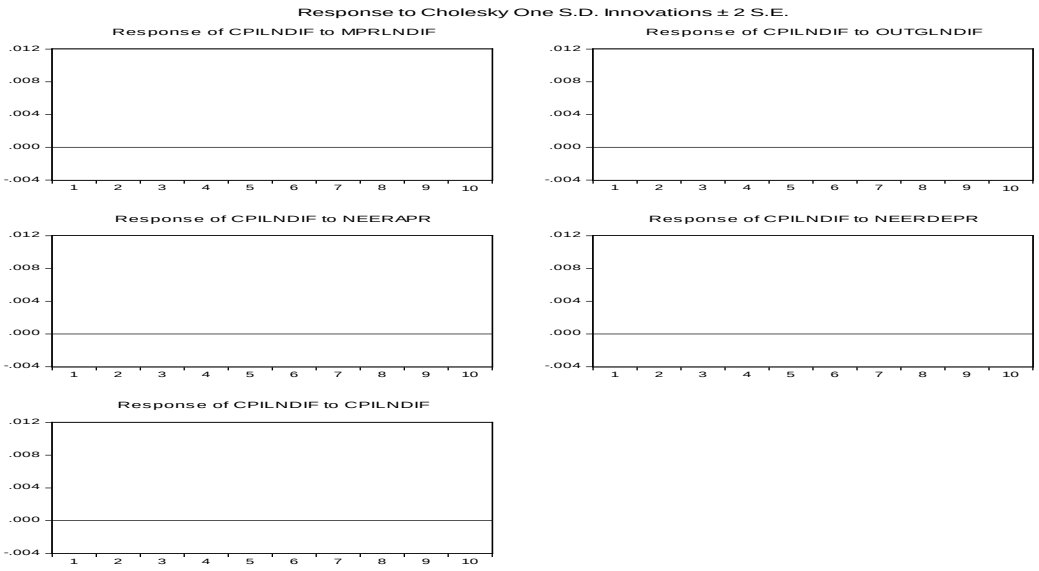



**Fig 6:** IRF for Hypothesis 1: Asymmetric in Levels

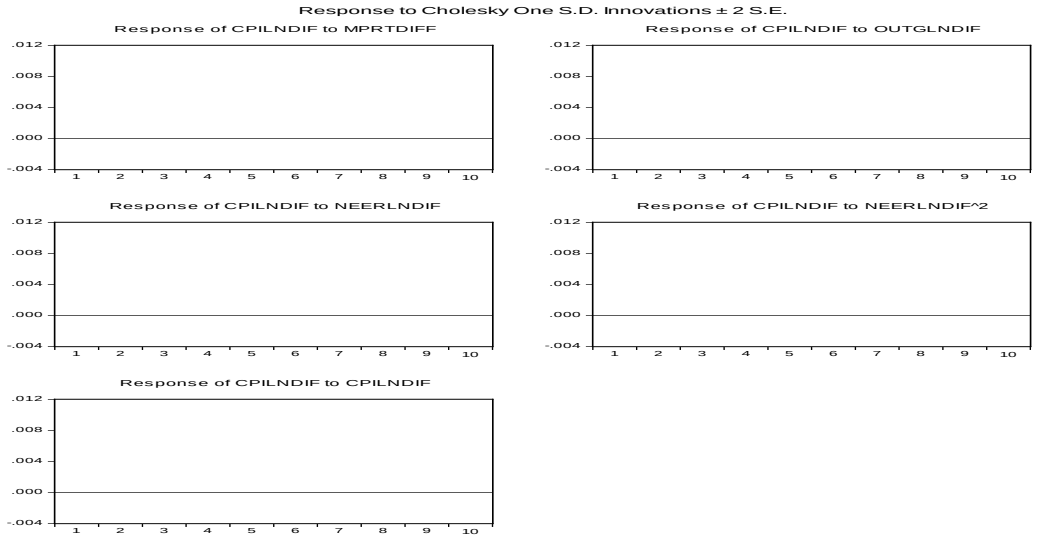



**Fig 7:** IRF for Hypothesis 2: Size influences Pass-Through

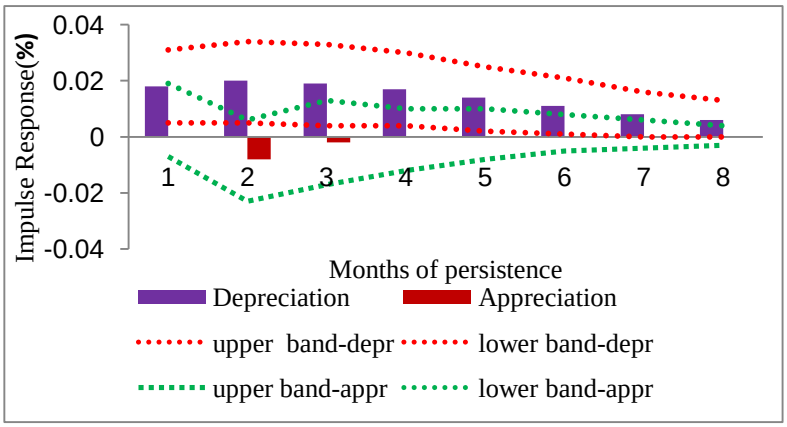
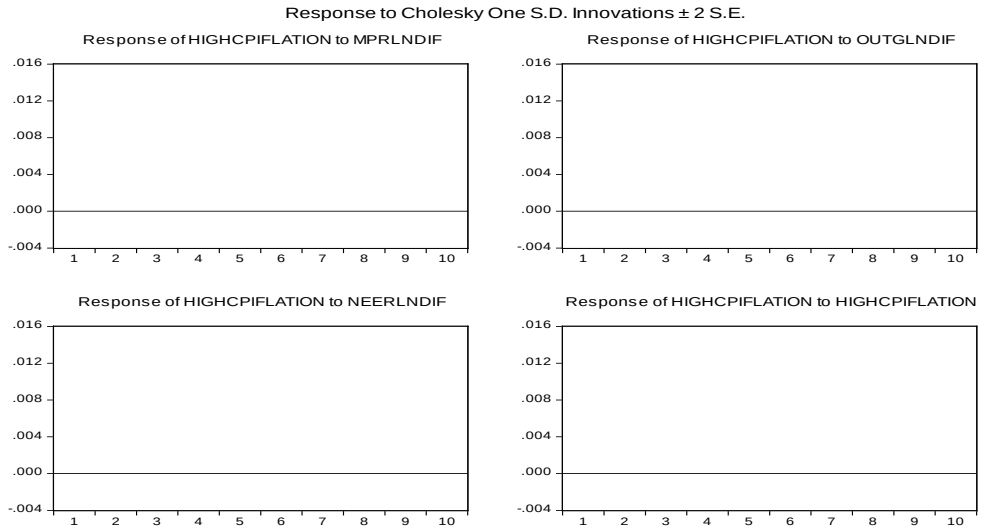
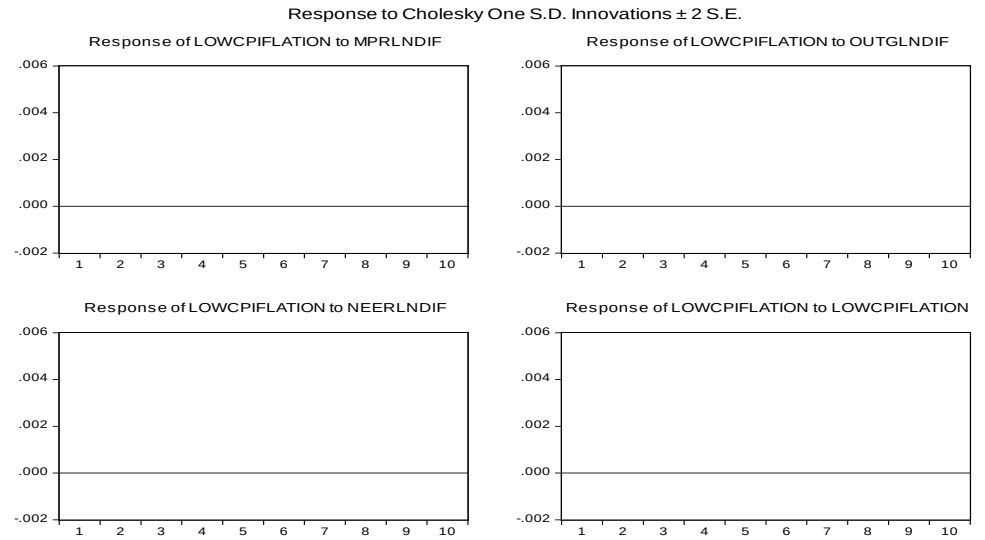



**Fig 8:** Hypothesis 3: Persistence of depreciation and appreciation
Source: Author's computation from IRF graph




(a) Pass-through in periods of increasing inflation




(b) Pass-Through in periods of decreasing inflation

**Fig 9:** Hypothesis 4: Inflation environment affects pass-through

### 6.4 Hypothesis 4

$H_0$: Inflation environment does not affect the degree of pass-through. $H_1$: Inflation environment affects the degree of Pass-Through. Inflation environment is defined in terms of periods of increasing and decreasing inflation in the economy. To test this hypothesis, the New Keynesian Phillips curve was deployed. A modified expectation augmented Phillips curve; $\pi_t = k(y_t - y^*) + \alpha E_t\pi_{t+1} + \beta_1 e_t + \beta_2 E_t e_{t+1}$ implies that, inflation is a function of expected inflation, output gap and exchange rate-contemporaneous and expected (Woodford, 2003).

The Phillips curve can be linear but recent empirical works in countries like Japan and the U.S shown non-linearity of the curve. The implication arising out of the linearity and non-linearity of the Phillips curve is premised on the slope of the curve, which in turn determines the inflation behavior. Linearity of the New Keynesian Phillip curve implies that the curve has a constant slope and the behavior of inflation is determined by the backward-looking inflation case.

Non-linearity of the curve implies that the slope is not constant, and the behavior of inflation is determined by the output gab depending on which stage of the business cycle the economy is operating, inflation expectation and exchange rate (Filardo, 1998). To examine pass-through depending on the inflation environment, this paper assumes a non-linear New Keynesian Phillips Curve for Ghana.

The VAR model in (1) was modified to incorporate asymmetries in CPI response. The $CPI_t$ in the simultaneous specification was split into positive and negative values according to increasing CPI inflation and

decreasing CPI inflation respectively. Thus $\theta_{i1}\Delta\ln(cpi_{t-1})$ in the model (2)

becomes $\theta_{i1}^{+}\Delta\ln(cpi_{t-1}^{+}) + \theta_{i2}^{-}\Delta\ln(cpi_{t-1}^{-})$.

Test; $H_0$: $\theta_{i1}^{+}=\theta_{i2}^{-}$ and $H_1$: $\theta_{i1}^{+}>\theta_{i2}^{-}$. The IRF shows strong evidence of asymmetries. Pass-through is higher in periods of increasing inflation than in periods of decreasing inflation for both output gap and the nominal effective exchange rate as shown in figure 10. CPI inflation response to output gap and exchange rate during increasing inflation is within the 3rd to 4th months and 7th to 8th months respectively. The effect disappears thereafter.

The result is consistent with the findings of Filardo (1998). He noted that a positive output gap engineers a convex Phillips curve with a steep slope which makes firms to have more laxity to increase prices. On the other hand, negative output gap drives a concave Phillips curve which means the slope flattens out making firms to lower prices than increase prices. Exchange rate pass-through according to the findings of this paper in a given inflation environment is consistent with Taylor's hypothesis[6].

## 7. SENSITIVITY ANALYSIS

To ensure that a valid conclusion is drawn from the empirical analysis, the following cholesky ordering was considered: (i) mpr ⇒ outgp ⇒ CPI ⇒ NEER and (ii) CPI ⇒ mpr ⇒ outgp ⇒ NEER. The IRF of the different cholesky ordering produced relatively similar result. However, the persistence of the impact differs a bit from the estimated result analyzed in this paper.

This paper deployed the Portmanteau test for autocorrelation to test for the presence of white noise in the model. In fact, the hypothesis that up to 12 lags, the autocorrelation of the residual vectors are jointly zero cannot be rejected.

To make policy analysis from the estimation a plausible exercise, ascertaining the extent to which fluctuations in nominal exchange rate accounts for the variations in CPI inflation is key. The Cholesky Variance Decomposition was used in this regard and shown in the figure 10. Symmetrically, fluctuations in the nominal exchange rate explain not more than 6 percent of the variations in the CPI inflation within 12 months. Asymmetrically, depreciation, though having inflationary pressure in the economy, explains not more than 10 percent of the variations in the CPI inflation. Appreciation explains not more than 0.72 percent of the variations in the CPI inflation.

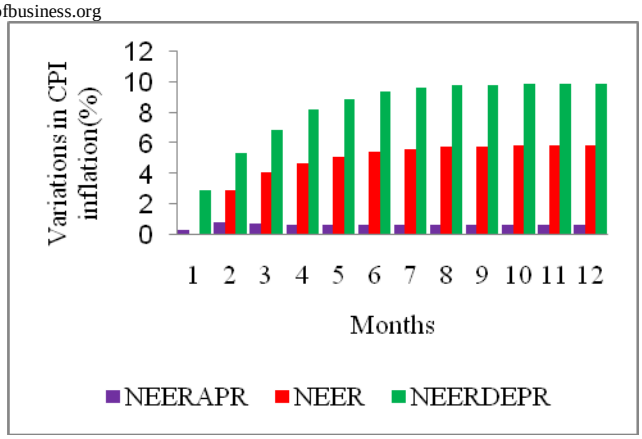



**Fig 10:** Cholesky Variance Decomposition of CPI Inflation
Source: Author's computation from variance decomposition table

Low variations in CPI inflation explained by appreciation as compared to depreciation further confirm asymmetries by the cholesky variance decomposition consistent with the IRF. The small variations in CPI inflation caused by changes in exchange rate could be explained by the small proportion of imported products in the consumer price index. Besides, it can further be explained by the fact that high productivity growth absorbs the price effect of exchange rate fluctuations.

## 8. CONCLUSION AND IMPLICATION

Recent developments in the Ghanaian economy, particularly, changes in exchange rate and its linkage to domestic prices, call for extensive research in that regard. This paper examined the direct and indirect effect of exchange rate changes to CPI inflation. The assumption of asymmetric ERPT had been a crucial issue thoroughly investigated. This paper concludes that, ERPT in Ghana is asymmetric except for size of exchange rate changes. Exchange rate changes explain small proportion of the variations in the CPI inflation

Besides price stability, the Bank of Ghana has the mandate of ensuring sustainable economic growth. Exchange rate stability must be of utmost priority to policy makers to curb the large depreciations of the currency. Changes in the exchange rate explain small proportion of the variations in the CPI inflation and there is no evidence of large changes in exchange rate affecting pass-through. As a result, the continuing depreciation of the currency has implications on profit margins of firms and the spillover effect to the real economy.

Asymmetric pass-through has implication for the speed of monetary policy stance. Hastening monetary policy hike to react to depreciative pressure may not be helpful due the output cost inherent in such action. The Central bank could embark on a gradual hike while issuing local currency denominated securities to encourage investment in the local currency. Besides, the weight of local currency in the reserve requirement of

[6] *Taylor (2000) noted that pass-through will be higher in a higher than lower inflationary environment*

banks could be increased. These among others could help stabilize the currency given the depreciation trend and incomplete pass-through for appreciation.

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