Exchange Rate Pass-Through (ERPT): The Inter-Connectivity between Exchange Rate and Consumer Price Index in Ghana

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ABSTRACT

The effect of exchange rates movements and its associated volatility has remained a crucial issue in a small open economy such as Ghana. The subject plays a key role in international financial and macroeconomic management and policy formulation. This need induced a considerable measure for looking into the pass-through effects of exchange rates. This study employs co-integration and error correction model to explore the pass-through effects of exchange rate changes to consumer price index for Ghana, being extended from January 2000 to March 2016. The investigation looks to give answers to various inquiries like the degree of exchange rate pass-through (ERPT) to consumer prices, issues of asymmetry effects, the validity of purchasing power parity and exchange rates models. The empirical evidence indicates that, fluctuations in the exchange rate either affect inflation through direct changes in import prices or through aggregate demand, which is issued as part of changes in the relative price between foreign and domestic commodities. However, the low ERPT to consumer prices suggests that inflation is most likely affected by other factors than the exchange rate. The model included variables like, inflation, consumer price interest rate which responded significantly to shocks in external price. An increase (positive shock) in the foreign price variable results in domestic prices being increased significantly an indication that Ghana is exposed to global price shocks (imported inflation). Using variance decomposition test in this study, demonstrates the importance of shocks within the imports and the consumer price themselves verse shocks from the exchange rate and other variables in the economy. The findings suggest that sound monetary policies and economic management environment should focus on achieving stable exchange rate inflation since monetary policies has no positive effect on commodities.

Keywords: Rate Pass-Through, Consumer Price Level, Interest Rate, Co-Integration, Exchange

INTRODUCTION

An expansive research has shown that the extent of exchange rate pass-through effect has important implications for the timing of current account adjustments (Adu, Karimu, & Mensah, 2015; Krugman & Obstfeld, 2003), the conduct of fiscal policy (Aron, Farrell, Muehlbauer, & Sinclair, 2014; Aron, Macdonald, & Muehlbauer, 2014; Corsetti, Dedola, & Leduc, 2010; Dufrênot, 2011; Warsh, 2013), the choice of exchange rate regime, and the international transmission of shocks (Căpraru & Ihnatov, 2012; Klein & Shambaugh, 2012).

The pass-through effect of exchange rate movements to domestic monetary value occupies a very dominant position in international finance and remains on the much-debated questions among both professionals and academia. Traditional open-economy macroeconomic models paid little care to pass-through, because in such exemplar markets are characterized by perfect competition, prices are assumed to be fully flexible, and purchasing power parity is assumed to be valid at all times, which suggested a complete and immediate ERPT. According to (Gust, Leduc, & Vigfusson, 2010; Helen, 2012; Kochen & Sámano, 2016; Saunders & Cornett, 2014), the pass-through effect operates broadly through prices of imported goods in the consumer price index and price setting and expectations. Although mainstream open-economy
macroeconomic models examined the exchange rate pass-through, most of the research in this area are based on the extent of pass-through at firm or industry level. In contrast Cheikh (2013) found that more differentiated products are distinguished by lower pass-through mainly because they involve higher mark-ups and hence higher scope for pricing-to-market. Important empirical observation led economists to assess the degree of ERPT as well as its determinants and the corresponding pricing-to-market behaviour (Asprilla, Berman, Cadot, & Jaud, 2014, 2015; Junttila & Korhonen, 2012). For instance, Van Wincoop & Warnock (2010) shows that more differentiated goods may be characterised by higher market power and therefore higher pass-through. Recent examinations of the pass-through impact have focused on the aggregate perspective, drawing both on the common finding in the writing that ERPT tends to be piecemeal. There are however as it may, a mountain of empirical evidence that indicates changes in ostensible trade rate influence import prices as it were only in incomplete and gradual manner. The concept has been described as the affectability of domestic currency prices to exchange rate movements. Betts & Devereux, (2000) extended this model to allow for pricing-to-market, and therefore incomplete pass-through (Fuji & Bailliu, 2004). The idea that pass-through is related to indicators that are directly related to fiscal policy such as inflationary environment was primarily proposed by Taylor, (2000).

Depending on his hypothesis, reactivity of prices to exchange rate fluctuation depends positively on inflation. Despite the fact that PPP holds and pass-through is complete in the framework originally presented by Devereux & Engel (2003). Those studies proposed imperfect competition (such as product differentiation), and firms’ behaviour of pricing to market as an explanation for the occurrence of incomplete pass through.

1.1 Statement of the Problem

In the event that the level of pass-through is high, changes in the exchange rate will change the relative prices of gradable and non-tradable, so that the adjustments in trade balances will be relatively prompt (Coulibaly & Kempf, 2010) across the globe for most of them being on the developed or emerging economies. Fiscal policymakers, then again, are primarily interested in the extent and timing of ERPT as a fundamental ingredient of fiscal policy and inflation forecasting (Frimpong & Adam, 2010). The degree of ERPT has critical ramification for expenditure switching effect and hence the current account adjustment, which results from the exchange rate motion.

Since the exchange rate and inflation rate are supposed to be influencing each other in many theoretical models, it seems more appropriate to estimate a system that would treat both of them endogenous. Thus, the utilization of VAR models would permit the reverse causality from price indices to the exchange rate which avoids arbitrary assignment of variables as endogenous and exogenous.

The international financial aspect is concerned about the role of ERPT in determining the adjustment mechanism of international prices which in turn influences the adjustment of balance of payment. In 2009 and 2010, when Ghana recorded single digit inflation rates for 36 months, it raised a number of questions because the domestic currency was depreciating in the meantime. However, several recent empirical studies suggested the use of Vector Autoregressive models (VAR) or Structural VAR (SVAR) in analysing ERPT. There are insufficient studies on the issue in the Ghanaian context (Frimpong & Adam, 2010; Loloh, 2014; Sanusi, 2010). A standout amongst the most crucial issues in small open economies like Ghana is ERPT.

1.2 Significance of the study

Consequently, as import price is one of the foremost channels through which the exchange rate affects domestic prices, it is worth examining the pass-through impact to consumer prices in order to improve the proper standpoint towards inflation-forecasting and fiscal policy as well as the external policy of an economy. Extensive exchange rate pass-through suggest that the response of the trade adjustment to nominal exchange rate changes will be huge (Aron, Farrell, et al., 2014; Junttila & Korhonen, 2012; Liu, Chen, & Elliott, 2017) (International Monetary Fund (IMF), 2006).

For developing nations with substantial and diligent exchange deficiency, the examination of exchange rate pass-through to consumer price is a vital issue since it influences the nation's aggressiveness in the global market. A commitment to the assortment of information of the degree and speed of exchange rate pass-through, to consumer prices is essential for the Ghanaian fiscal policy experts for a few reasons. Picking up this knowledge would prepare fiscal specialists to build up whether the devaluation of the exchange rate since the initiation of the Economic
Recovery Program is contributory to the trouble in achieving low (single digit) and stable inflation. For instance, if the Administration of Ghana issues international debt securities (Eurobonds), changes in exchange rate dynamics can have implications for debt servicing. Also, possible instalment of the foremost at development. In addition to this, exchange rate pass-through also has implications for external adjustment

2. LITERATURE REVIEW

2.1 The level of ERPT in consumer price in Ghana

It is a building piece of various macroeconomic models that Purchasing Power Parity (PPP) is the most established speculations of exchange rate assurance. The PPP is a very useful theory for policy makers of central banks, multinational firms, and exchange rate market players. It has been seen as an equilibrium condition of exchange rate determination theory for international comparison of income (Baharumshah, Lau, & Nziramasanga, 2010; Njindan Iyke, 2015; Sideris, 2006). The conceptual base for PPP is the “law of one Price”, (Taylor, 2000).

Mathematically, \[ S_i = \frac{P_i}{P_f^i} \], where \( S_i \), \( P_i \), and \( P_f^i \) are nominal exchange rate between the domestic and foreign countries, domestic price, and foreign prices respectively. In other words, \( P_i = S_i P_f^i \) which translates into the following logarithmic forms: \[ p_{it} = s_i + p_{it}^f \] where \( p_{it} = \text{logarithm of the home price of good } i \) expressed in local currency,
\[ p_{it}^f = \text{logarithm of the foreign price of good } i \] expressed in foreign currency,
\( s_i = \text{logarithm of the nominal exchange rate expressed as the domestic price of foreign currency.} \)

This suggestion is empirically questionable in light of the fact that: those components that hinder the LOP additionally influence the PPP; the national and foreign baskets of goods are required to be equivalent. But national price indices used to test the PPP typically have different weights for the same good. For this situation it is required for the PPP to have a high level of substitution in global exchange so money related stuns won’t have genuine impacts and deviations from the PPP caused by financial events will be transitory (Alagidede, Tweneboah, & Adam, 2008; Dufrenot, 2009, 2011). Besides these temporary deviations, there can be lasting takeoffs caused by genuine occasions that influence the balance relative costs, because of efficiency differentials crosswise over areas as the “Balassa-Samuelson” impact, contrasts in factor endowments and rewards crosswise over nations, financial receptiveness, among others.

The legitimacy of the PPP has vital ramifications for Real Exchange Rate (RER). Since the log of RER, is:
\[ r_t = s_t - p_{it} + p_{it} \] ……………..(2)
On the off chance that the PPP holds as expressed in (2), ought to be equivalent to zero or on the off chance that we use price indices rather than levels ought to be equivalent to a self-assertive steady. Regardless, the RER is utilized to quantify deviations from the PPP. In the event that the RER is a stationary variable that tends to come back to a steady mean, henceforth deviations from PPP are passing and PPP holds over the long haul; while if the RER is non-stationary then PPP does not hold (Alagidede et al., 2008). Various econometric research have rejected the Law of One Price (LOP) for a wide number of assessable products, with the exception of a couple of standardized goods firmly presented to global exchange like gold (Holmes and Wang, 2003; Rogoff, Froot, and Kim, 2001). The dismissal has been ascribed to the accompanying reasons: national and foreign merchandise are not flawless or even close substitutes; the presence of tax and non-tax exchange boundaries, and of transaction costs; the nonappearance of focused markets; and varieties of non-tradable parts of products crosswise over nations. Notwithstanding opposite confirmation, the LOP is a critical base of most models of open economies by and large, and for PPP specifically.

2.1.1Channels and determinants of ERPT

As per (Akofio-Sowah, 2009; Shakeri and Dim, 2013), these impacts are subject to components, for example, market structure, export partners’ production costs, estimating conduct of firms, and additionally factors, for example, swelling steadiness on costs, size of the economy, exchange rate instability, size of open obligation, share of imports and the synthesis of imports in a nation and the level of exchange receptiveness in a nation (Shakeri and Dark, 2013). As per Chiparawasha (2015), exchange rates development can influence domestic costs specifically through changes in the cost of imported finished goods and imported sources of info, for example, raw materials and capital products.
The impacts of exchange rate developments are transmitted to buyer costs through three noteworthy channels: costs of imported utilization products, locally produce goods priced in foreign money, and costs of imported halfway goods.

By changing the costs of production directly, exchange rate movement influence local prices, while the impact of exchange rate movements is correct in the initial two channels (Ivohasina, 2012; Nogueira Jr & León-Ledesma, 2008).

According to Hyder & Shah (2004), the exporter confronts in that market. The export market and the level of competition the variables that decide the level of ERPT are the size of that point exporter costs might be to some degree less confront much competition for their items, at business is exceedingly separated and, exporters don't confront much competition for their items, at that point exporter costs might be to some degree less receptive to exchange rate changes. Among the variables that decide the level of ERPT are the size of the export market and the level of competition the exporter confronts in that market.

### 2.1.3 Pricing behaviour of firms

According to (Al-Abri & Goodwin, 2009; María-Dolores, 2010), when exporting firms have a higher market share in an industry they are most likely to set their prices in their own currency. The pricing behaviour of firms is also another factor that influences exchange rate changes onto prices.

### 2.1.4 Inflation

In investigating further determinants of ERPT, (Taylor, 2000) set forward the claim that the responsiveness of prices to exchange rate variances depends emphatically on inflation. Various investigations across the board (Campa and Goldberg, 2005a; Devereux, Smith, and Yetman, 2012; Mwase, 2006) appear overall supportive of the Taylor claim. In other words, the more steady inflation is, the less exchange rate developments are viewed as momentary and in this way firms may react by changing costs. This is because of the way that developing economies have higher rates of inflation, with a few nations battling with double digit rates.

### 2.1.5 Degree of trade openness

According to Khundrakpam (2007), the bigger the share of imports in the consumption basket the more prominent the extent of imported inputs and the more noteworthy the effect of the exchange rate on producer costs which will in the end be passed onto buyer costs. An essential angle that could likewise have an impact on how much exchange rate developments are passed on to household costs is the share of imports of the consumption basket of a nation. As indicated by Ca'Zorzi, Hahn, and Sánchez (2007), the more open a nation is, the higher the impacts of developments in exchange rates are alluded to domestic prices through import prices. According to Akofio-Sowah (2009), the impact of exchange rate volatility on pass-through is dependent on whether the effects are supposed to be passing or permanent.

However, if the effects are viewed as permanent then prices would be changed resulting in exchange rate development affecting prices to a greater degree.

### 2.2 Empirical prove on the impacts of exchange rate development

Likewise this investigation demonstrated that the impact of exchange rate fluctuations on investment is more grounded for firms with low restraining infrastructure control, confronting a high level of imported infiltration in the local market and of a little size and that the level of substitutability between locally produced and imported inputs influences the impacts through the expenditure side.
For the impacts of genuine successful exchange rate volatility, a huge antagonistic effect of exchange rate volatility on investment is accounted for by the real piece of the studies (Bleaney and Greenaway, 2001; Serven, 2002). The outcomes featured the significance of differentially investment response between a high and low exchange rate variability regime and that not only the level of the exchange rates but also the volatility matters for the firm’s total investment decisions. Opposite, in a domain with insignificant receptiveness and high budgetary advancement, exchange rate instability tends to act emphatically on investment (Serven, 2002).

Additionally, Nucci and Pozzolo (2001) researched the connection between exchange rate fluctuations and the investment choices of a sample of Italian assembling firms. Caglayan and Torres, (2011) utilized industry-level information for 22 Canadian assembling enterprises to inspect the connection between real exchange rate and investment amid the period 1981-1997. They came up with the findings that support the view that a depreciation of the exchange rate has positive effects investment through the revenue channel, and a negative impact through the cost channel. Dummy factors representing industry classifications of the firms were also incorporated into the board information estimations and were observed to be together huge, indicating the significance of industry contrasts in deciding the impacts of the exchange rate varieties. They likewise found that depreciations (appreciations) seem to have a positive (negative) effect on investment when the exchange rate volatility is moderately low.

### 2.3 Effect of Exchange Rate Volatility on Inflation

Przystupa and Wróbel (2011) utilizing unbalanced models with cointegration tests observed unbalanced exchange rate pass-through on manufactured import price in Japan with pass-through coefficient of 0.98 for appreciation and 0.83 for depreciation.

In the summative studies, the empirical writing recommends that exchange rate pass-through is a long way from complete changes across over nations relying upon their size and transparency. Initially, exchange rate pass-through is by and large deficient, and the pass-through to import costs has a tendency to be higher in both size and speed than that of consumer prices. Ben Cheikh (2012) utilized nonlinear smooth progress models and discovered proof of deviated pass-through concerning size yet a blended result in connection to the heading of asymmetry in 12 Euro Range nations. Delatte, Gex, & López-Villavicencio (2012) used prices of G7 countries and found that prices respond asymmetrically to appreciation and depreciation in most countries. Besides, there is a general decrease in the level of pass-through in the late 1990s, for the most part credited to the low inflation environment accomplished in most industrialized nations (Campa & Goldberg, 2005b; Gopinath, Itskhoki, & Rigobon, 2010; Marazzi et al., 2005).

The greater part of exchange rate pass-through have focused on industrialized nations and the outcome can be summarized as follows. The conceivably higher cost of imported inputs related with exchange rate depreciation increases the minimal cost and leads to higher prices for locally produced goods (Boivin, Kiley, and Mishkin, 2010).

To a specific degree, a change in exchange rate for domestic and foreign demand for goods and services results in net exports and hence aggregate demand (Chari, Kehoe, and McGrattan, 2002). Mwase (2006) and Sanusi (2010a) utilized a Structural VAR model to measure the exchange rate pass-through for Tanzania utilizing quarterly information for the period 1990-2006. The greater part of empirical research on exchange rate pass-through are industry and product specific. Exchange rate developments can impact local prices through their impact on aggregate supply and demand. An exchange rate stun leads to a sharp increase in inflation that vanishes after four quarters, with the exchange rate explaining 46 percent of inflation variability. Exchange rate fluctuations could have an indirect supply effect on domestic prices.

The ERPT has declined regardless of the depreciation of the currency. Various investigations have been conducted to ascertain the ERPT to local prices in both developed and developing nations however those that managed with asymmetric ERPT are few. The degree of such price change relies upon a variety of factors such as market structure, nature of government, exchange rate policy and product substitutability.

### 2.4 Evidence from Ghana

The factors discussed above reflect the significance of directing a study on the idea of exchange rate pass-through impact, especially in developing nations, for example, Ghana that are portrayed by floating exchange rates, open exchange approach, and the way that the Ghanaian economy has been battling with double digit inflation rates. Lolo (2014) utilizes a recursive VAR in light of Leigh to assess the pass-through effect of exchange rate developments on domestic prices between January 1994 and December 2012. For instance, he reports...
14.5 percent pass-through for CPI inflation a year ostensible exchange rate stunt. A recent study, Siaw Frimpong & Anokye M Adam (2010), use vector error-correction (VEC) approach to estimate the ERPT to inflation for Ghana. The model comprises of six variables, which are: oil prices, output gap, exchange rate, non-food prices, overall consumer prices, and money market interest rates with the verifiable supposition that the recognized stuns contemporaneously affect variables requested after the stunt without a contemporaneous input. Low ERPT is a common finding for countries that have low inflation environment, stable exchange rate, and small share of imports in their consumption basket (Akofio-Sowah, 2009; Choudhri & Hakura, 2006; Devereux & Engel, 2001; Griffin, Nardari, & Stulz, 2006). According to the authors, this finding of low pass-through in Ghana is to some degree confounding since the effect of exchange rate developments is extremely noteworthy at domestic price (Siaw Frimpong & Anokye M Adam, 2010). For South Africa, for example, (Ocran, 2010) finds that pass-through of a 1 percent exchange rate shock is just 8.3 percent after four (4) quarters and 12 percent after eight (8) quarters. Within three months, 14.79% and 5.64% of the exchange rate development reflect into non-food and overall consumer prices respectively.

The impact of ostensible exchange rate shock on domestic prices is inadequate and comprehensively modest and fades within 1.5 - 2 years, however such effects are generally felt inside a year.

3. Data collection and Process

Ghana exceedingly dollarized with drifting exchange rate frameworks, the relative price of the US dollar in the local currency is therefore an essential variable in explaining price volatility in the economy. In this research, secondary data is collected from the Research Department of the Bank of Ghana and the International Financial Statistics Database managed by the International Monetary Fund. The study is based on quantitative research of time series analysis of some variables and the causal relationships. The time series properties of the data are analyzed using two unit root tests (DF-GLS and ADF) and one stationarity test (KPSS).

The design mainly focuses on the structure of the study and traverses the choices on a broad assumptions to detail strategies for data collection and investigation. In the event that the KPSS test rejects the null yet ADF and DF-GLS test does not, we can state that all the three tests support a similar conclusion; that is, the series being referred to is an I (1) process. The decision of quantitative procedure over subjective research is supported by the research topic and the handiness or suitability of the quantitative research to address the research questions set for the objectives. Inflation is measured by the log of the consumer price index, as there is no accessible data on import prices. The reason for this study is to explore the exchange rate pass-through in Ghana the period 2000 to 2016. The KPSS tests the null hypothesis of stationarity, while ADF and DF-GLS tests the null hypothesis of a unit root.

3.1 Model Specification and Estimation procedure

3.1.1 Empirical Model

The analysis begins by considering PPP relation in logarithm in equation (1)

\[ p^d_t = \phi e_t + \lambda p^f_t \] .... (1)

where \( e \) is the nominal exchange rate expressed of domestic currency per unit of US dollar, \( p^d \) and \( p^f \) are the domestic and foreign price levels respectively, and all variables are expressed in logarithms. The “law of one price” implies that \( \phi = \lambda = 1 \), in which case changes in the exchange rate completely pass through to the domestic price of the traded good. This simple expression forms the basis of analysing the long-run pattern ERPT.

The analysis takes account of the Bank of Ghana’s behaviour and includes interest rates. This supports that most central banks in the world by now target short-term interest rates. This yields the following equation:

\[ p^d_t = \phi e_t + \lambda p^f_t + i^d_t \] .... (2)

Central banks that target consumer price inflation will endeavour to protect price from exchange rate movements. Disregarding the conduct of strategy factors may distort the genuine outcomes of exchange rate variations on customer prices. By including policy factors, the observed connection amongst prices and exchange rates would consider the national bank's conduct instead of the immediate impact of exchange rates on prices.

3.1.2 VAR Lag Length Selection Criteria

The most popular ICs are the Akaike information criterion (AIC), Schwarz’s Bayesian information criterion (SBIC), and the Hannan-Quinn information criterion (HQIC). The objective of the information criteria (IC) method is to select the number of parameters which minimize the value of the IC. To
3.1.3 Impulse response functions

An impulse response function follows the impact of a one standard deviation shock to one of the innovations on present and future estimations of the endogenous factors. On account of this paper, the impulse response function will have the capacity to uncover the sign, size, and perseverance of stuns from the exchange rate and import and consumer prices respectively. However, this paper uses the Cholesky decomposition in the base line model because it incorporates a small sample degrees of freedom adjustment when estimating the residual covariance matrix used to derive the Cholesky factor (Lutkepohl, 1991). The primary advantage of the generalised impulse response is that it doesn’t require orthogonalization of innovations and is invariant of the ordering of the variables in VAR (Stulz, 2006). A shock to the i-th variable directly influences the i-th variable, and is likewise transmitted to the greater part of the endogenous variables through the dynamic structure of the VAR (Stock and Watson, 2012).

3.1.4 Variance Decomposition

While impulse response functions trace the effects of a shock to an endogenous variable on the variables in the VAR, variance decomposition decomposes variation in an endogenous variable into the component shocks to the endogenous variables in the VAR. For our situation, variance decomposition shows the significance of shocks within the import and consumer prices themselves versus shocks from the exchange rate and other variables in the system. More specifically, it highlights the proportion of the movements in the dependent variables that are a result of their own shocks, versus shocks from the other variables (Stock & Watson, 2012)

3.1.5 Granger causality test

Aside the impulse response functions and variance decomposition, Granger causality tests is used to determine the causal relationships between the variables under consideration (Granger, 1969). The purpose of this test is to determine the direction of the causality between the variables and whether the exchange rate changes bring about any changes in the price level. If $p^d$ is the price level and $e$ is the nominal exchange rate, a test within the VAR model is specified as follows:

\[
p^d_i = \alpha + \sum_{i=1}^{n} p^d_{i-1} + \sum_{i=1}^{n} e_{i-1} + \epsilon_i \quad \text{………………..(3)}
\]

\[
e_i = \alpha + \sum_{i=1}^{n} e_{i-1} + \sum_{i=1}^{n} p^d_{i-1} + \nu_i \quad \text{………………..(4)}
\]

Where $\alpha$ represents the constant term in the Granger regression and $n$ denotes the lag length selected for the analysis of causal relations. To be able to define the relevance of a variable in determining or forecasting the other variable(s), the Granger causality test employed. Equation (3) above tests the null hypothesis that exchange rate does not Granger cause inflation whereas equation (4) tests the null hypothesis that inflation does not granger cause exchange rate.

This study aims to estimate the pass-through effects of exchange rate changes to consumer prices in Ghana for the period January 2000 to March 2016. In this paper, the results and discussion of the findings are presented. The paper presents the descriptive statistics, unit root test, stationary tests, co-integration, impulse response functions, variance decomposition, and Granger causality tests.

4. RESULTS

4.1 Descriptive statistics

As shown in figure 1, the Treasury bill rate in Ghana which shows stepwise, all the others have trended upwards.

Source: Field survey, Azibah (2016)

From a minimum figure of 2.88, the price level in Ghana increased to a maximum of 5.25. The interest rate variable reached its maximum of 3.84 in July.
2001 and attained a minimum of 2.20, in November 2011. Comparing the price level in Ghana with that of the United States detects a marked growth rate for Ghana. Whereas the range for price level in Ghana is 2.37 that of the US is 0.35 (with a minimum of 4.35 and a maximum of 4.70). This is not surprising because Ghana has been grappling with high rates of inflation since her independence in March 1957. The nominal exchange rate in Ghana too has seen persistent depreciation over the years. In January 2000, the price of 1 US dollar was GH¢0.36. This grew in the period to its maximum of 4.19 in June 2015, before declining slightly. Summary statistics of the variables – mean, standard deviation, kurtosis, skewness, and others – have been reported in Table 1.

Table 1 Descriptive statistics

<table>
<thead>
<tr>
<th>Statistics</th>
<th>LN(GHP)</th>
<th>LN(NER)</th>
<th>LN(TBR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.225</td>
<td>0.198</td>
<td>2.929</td>
</tr>
<tr>
<td>Median</td>
<td>4.230</td>
<td>-0.030</td>
<td>3.074</td>
</tr>
<tr>
<td>Maximum</td>
<td>5.250</td>
<td>1.432</td>
<td>3.845</td>
</tr>
<tr>
<td>Minimum</td>
<td>2.577</td>
<td>-1.020</td>
<td>2.202</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.617</td>
<td>0.506</td>
<td>0.444</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.267</td>
<td>0.393</td>
<td>-0.003</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.072</td>
<td>2.941</td>
<td>2.105</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>9.181</td>
<td>11.274</td>
<td>6.413</td>
</tr>
<tr>
<td>Probability</td>
<td>0.010</td>
<td>0.004</td>
<td>0.041</td>
</tr>
<tr>
<td>Observations</td>
<td>192</td>
<td>192</td>
<td>192</td>
</tr>
</tbody>
</table>

Source: Field survey, Azibah (2016)

4.2 Unit Root and Stationarity Properties

Including intercept only, the KPSS test rejects the null hypothesis for all the variables except TBR, where the statistic is 0.43 (less than 0.46). With intercept and trend included, the ADF and PP tests rejected the null hypothesis of a unit root for GHP. The results show that the variables do not contain unit roots in their first differences since all the test statistics are more negative than the critical values and the probabilities are less than 5%. The KPSS test rejected the null hypothesis of stationarity since the test statistics were greater than the 5 percent critical value (0.15) for all the variables. The results presented in Table 2 suggest that both ADF and PP tests fail to reject the null hypothesis that the variables contain unit roots. The stationarity and unit root properties of the variables were tested by the ADF, PP, and KPSS tests. The variables were tested in their first difference to see whether they contain unit roots, having the same procedures.

For the KPSS test, the null hypothesis of stationarity is rejected if the test statistic is greater than the critical value. ADF and PP tests accepted the existence of unit roots in the variables in their log levels since all the probabilities are more than 5%.

4.3 Tests for Co-integration

Having established the level of integration of the variables, the next step is tantamount to explore the short-run and long-run relationships that exist among them. Although our main focus is not on establishing the existence of a long-run connections that exist among the variables, it is worth exploring the co-integration between prices in Ghana, the nominal exchange rate, interest rate in Ghana, and the price level in the US. The results of the Trace and Maximum Eigenvalue test are shown in table 3. Both tests provide estimates that suggest that the variables have a long-run relationship. The null hypothesis that there exists no co-integrating equation is rejected in favour of the alternative that there is one co-integration equation.

Table 3: Results of Co-integration Test

<table>
<thead>
<tr>
<th>Source: Field survey, Azibah (2016)</th>
<th>ADF</th>
<th>PP</th>
<th>KPSS</th>
<th>ADF</th>
<th>PP</th>
<th>KPSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trend Intercept</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GHP</td>
<td>-2.07</td>
<td>-2.75</td>
<td>1.66**</td>
<td>-8.12**</td>
<td>-8.28**</td>
<td>0.49</td>
</tr>
<tr>
<td>NER</td>
<td>-2.31</td>
<td>-2.48</td>
<td>1.25**</td>
<td>-8.58**</td>
<td>-17.11**</td>
<td>0.67</td>
</tr>
<tr>
<td>TBR</td>
<td>-2.20</td>
<td>-1.93</td>
<td>0.43</td>
<td>-6.58**</td>
<td>-5.44**</td>
<td>0.12</td>
</tr>
<tr>
<td>USD</td>
<td>-1.42</td>
<td>-1.72</td>
<td>1.69**</td>
<td>-8.55**</td>
<td>-6.77**</td>
<td>0.23</td>
</tr>
<tr>
<td>GHP</td>
<td>-4.02**</td>
<td>-4.17**</td>
<td>0.52**</td>
<td>-8.62**</td>
<td>-8.37**</td>
<td>0.14</td>
</tr>
<tr>
<td>NER</td>
<td>-0.99</td>
<td>0.23</td>
<td>0.32**</td>
<td>-9.64**</td>
<td>-18.41**</td>
<td>0.18</td>
</tr>
<tr>
<td>TBR</td>
<td>-2.12</td>
<td>-1.76</td>
<td>0.28**</td>
<td>-6.55**</td>
<td>-6.65**</td>
<td>0.05</td>
</tr>
<tr>
<td>USD</td>
<td>-1.61</td>
<td>-1.75</td>
<td>0.54**</td>
<td>-8.98**</td>
<td>-6.82**</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Note: The null hypothesis for the ADF and PP tests is that the data process under examination contains a unit root. Critical values for 1% and 5% are -3.43 and -2.86 respectively (see MacKinnon, 1991). KPSS critical values for 1% and 5% are 0.73 and 0.46 respectively, from Kwiatkowski et al (1992). **, * indicates significance at the 1% and 5% levels respectively. In the ADF test, lag length of 4 was appropriate, whereas the Newey-West bandwidth was employed in the case of KPSS.
4.4 Estimates of Long Run Coefficients

The results of the Vector Error Correction (VEC) estimates are that inflation in Ghana is positively related to exchange rates, interest rates, and the US inflation rate. In terms of magnitude, both exchange rate and US inflation have statistically significant coefficients, although with different coefficients. The interest rate variable is not significant. The outcomes are reported in Table 4, points out that, a 1% increase (depreciation) in the exchange rate leads to 0.25% increase in inflation. This long-run pass-through estimate suggests that the effect is not complete. Only about 1 quarter of the effect of exchange rate depreciation feeds through domestic prices. The significant estimate of the exchange rate effect is not consistent with (Frimpong & Adam, 2010) that finds a low/absence of ERPT in the long-run. The most intriguing finding is the abnormally high effect of foreign price level on domestic prices. A 1% increase in inflation in the US causes a rise of about 4.76% in the domestic price level. This represents a very huge impact, which is also not consistent with the findings of (Frimpong & Adam, 2010) which reported a negative effect of US price shocks in the long-run.

| Source: Field survey, Azibah (2016) |

| Table 4: Estimates of long run coefficients |

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Standard error</th>
<th>Test statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchange rate</td>
<td>-0.247134</td>
<td>(0.07941)</td>
</tr>
<tr>
<td>Treasury bill rate</td>
<td>-0.025090</td>
<td>(0.04210)</td>
</tr>
<tr>
<td>US Prices</td>
<td>-4.757233</td>
<td>(0.40950)</td>
</tr>
<tr>
<td>Intercept</td>
<td>17.52612</td>
<td></td>
</tr>
<tr>
<td>Error correction term</td>
<td>-0.026012</td>
<td>(0.01364)</td>
</tr>
</tbody>
</table>

Source: Field survey, Azibah (2016)

4.5 Analysis of Short-Run Relationships

4.5.1 Speed of adjustment

In order to determine the speed of adjustment, the long-run model uses the lagged error correction term, ECM(-1). From the results, the ECM(-1) is negative and statistically significant. This estimate gives further evidence to support the presence of a long-run relationship or co-integration among the variables under thought. The significant ECM(-1) coefficient means that all things being equal, whenever the actual value of inflation deviates from its long-run equilibrium relationship, significant changes in the independent variables help restore the long term equilibrium or steady state. Considering the size of the error correction term, adjustment of deviations to equilibrium (whenever there is an imbalance) is 2.8% every month. This gives a aggregate adjustment of 33.6% every year.

4.5.2 VAR Granger Causality/Block exogeneity Wald tests

Also, although the interest rate variable does not appear very influential in the movement of exchange rate and prices, it reacts to shocks from those variables. This test is done to determine which set of variables have a significantly affect every dependent variable by placing zero restrictions on the lags of the independent variables (Brooks, 2008). From the results, table 5, it could be argued that nominal exchange rate and foreign prices Granger cause domestic prices but the interest rate does not. This test decides if changes in one variable may cause changes in another in view of the significant effect of the first variable to the other variable. The hypothesis various variables combined does not influence the domestic price is rejected at the 5% level.

| Table 5: VAR Granger Causality/Block Exogeneity Wald Tests |

| Source: Field survey, Azibah (2016) |

<table>
<thead>
<tr>
<th>Dependent variable: Domestic Prices</th>
<th>Dependent variable: Interest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excluded: Che</td>
<td>df</td>
</tr>
<tr>
<td>NER</td>
<td>9.903</td>
</tr>
<tr>
<td>TBR</td>
<td>6.061</td>
</tr>
<tr>
<td>USIP</td>
<td>9.881</td>
</tr>
<tr>
<td>All</td>
<td>22.971</td>
</tr>
</tbody>
</table>

Source: Field survey, Azibah (2016)

4.6 Impulse Response Functions

Shock on the exchange rate causes the exchange rate to increase by 6.3% within 1 month but begins to decline and continues until it reaches its minimum of 1.3% in 24 months. A one standard deviation
innovation in domestic prices causes the exchange rate to increase by 0.9% in 3 months. As indicated by the profiles, an exchange rate shock causes an immediate rise in domestic prices, which becomes significant after 3 months. The impulse response functions indicate that a 1% increase (depreciation) at an exchange rate causes an increase in prices of about 0.8% in the short run. A positive exchange rate shock (an exchange rate depreciation), results in an increase in inflation after a 3 months lag and peaks after 25 months. Also, one standard deviation innovation in the interest rate leads to a significant increase in prices, which dies out immediately. Although the price level continues to increase to a peak of 1.1% in 5 years, the significance of the shock goes off after 5 months. From figure 3, a 1% increase in interest rate causes the exchange rate to rise by 0.3% in one month. This increases further and becomes significant after 3 months with an increase of 0.9%. It increased to 2% within 12 months and continued to increase until reaching a peak of 2.9% in 54 months. A 1% increase in interest rate causes the price level to increase by 0.2% within one month of the shock. This continues to increase gradually and attains a peak in 25 months. After the 3 months, the effect continues to be significant and increases to attain a peak of 1.4% in the 12 months. The peak level is maintained until its significant impact subsides in 50 months. The reaction of household prices to generalized one standard deviation advancement is introduced in Figure 2. This significant peak effect is maintained throughout the 60 months.

**Figure 2: Response of domestic prices to Generalized One S.D. Innovations ± 2 S.E.**

![Figure 2: Response of domestic prices to Generalized One S.D. Innovations ± 2 S.E.](http://onlinejournal.org.uk/index.php/cajast/index)

**Figure 3: Response of exchange rates to Generalized One S.D. Innovations ± 2 S.E.**

![Figure 3: Response of exchange rates to Generalized One S.D. Innovations ± 2 S.E.](http://onlinejournal.org.uk/index.php/cajast/index)

4.7 Variance Decomposition

To be able to determine this, forecast error variance decomposition is used to decompose the exchange rate and domestic prices to movements due to own shocks and those from other variables. In this case, variance-decomposition shows the significance of shocks within the consumer prices themselves versus shocks from the exchange rate and other variables in the system. The variance-decomposition also shows the significance of shocks within the domestic prices themselves versus shocks from the exchange rate and import prices. The contribution due to own shock reduces further to 76% in 36 months, where exchange rates explained 20% and the interest rate also explains 6% of the movement in prices. Over 80% of deviations in the exchange rate are explained by exchange rate shocks within 12 months, whereas 7.6% and 10.5% can be explained by domestic price and interest rate shocks respectively. The contribution by exchange rate shocks persistently decline as the contribution from the inflation and interest rate continues to increase. The evidence based on the variance-decomposition indicates that, increases in domestic prices are mainly attributed to its own variations and exchange rate in the long run. This suggests that the inflation procedure in Ghana has noteworthy inertia (Frimpong and Adam, 2010). In two years, the commitment by the exchange rate achieves 61% and that of the domestic prices increments to 14%. More than two years, price shocks contribute 83% and exchange rates contribute 15%, while interest rates contribute 2% over a similar period. The breakdown of the exchange rate in Table 5 suggests that movement in the exchange rate are predominantly influenced by its own shocks. The
dynamics continued until the 60 months and price inertia accounted for 66% of its own movements, with 20% explained by exchange rates, and 14% by interest rates.

The Bank of Ghana is seriously challenged because, even when it takes interest rate decisions, it becomes difficult for households and firms to take off the memories of high inflation rates. Similar to most other forecast error variance decompositions, the contribution of own shock declines as the number of periods increases as the contribution of the other variables increase.

The interest rate variable also increased its contribution and reached 24% in 24 months, 40% in 48 months, and 44% in 60 months. More specifically, it highlights the percentage of the movements in the exogenous variable that are a result of their own shocks, versus shocks from other variables (Stock & Watson, 2012).

5. DISCUSSION, CONCLUSION

The suggestion that prices react positively to positive interest rate shocks (contractionary fiscal policy) implies that fiscal policy in terms of interest rates does not have the intended effect on prices (price reduction), a noteworthy price puzzle in Ghana. The interest rate as a policy tool in price stabilization is ineffective and that monetary regulators should not rely on this as the primary tool in controlling inflation inter-connectivity in Ghana.

The models further advocate that the Bank of Ghana has in the past not been able to properly identify exogenous changes in interest rates such that innovations in the policy rate from econometric models partly reflect a systematic response to inflationary shocks that are not truly exogenous. The indication of this is that a fiscal policy tool that directly controls the money supply is likely to be more effective in controlling inflation than a policy that directly controls the interest rate, given the weak transmission mechanism between the policy rate and inflation.

The fluctuations in the exchange rate either affect inflation through direct changes in import prices or through aggregate demand, which is issued as a feature of changes in the relative price between foreign and domestic commodities. From the analysis, even if the interest rate was increased, the models suggest that there wasn’t enough increased to properly extinguish the inflationary pressures, implying the need for a forward looking or Pre-emptive way to deal with monetary arrangement in Ghana.

The findings make it necessary for the Bank of Ghana to remain vigilant in assessing the potential impact of fiscal policy on the dynamics of inflation and exchange rate 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.

In terms of direction, the long-run relationship indicated that exchange rate, interest rate, and foreign prices exerts positive influence on domestic prices. The interest rate channel may not be effective 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.

### Table 6: Decomposition of exchange rate

<table>
<thead>
<tr>
<th>Period</th>
<th>S.E.</th>
<th>GHP</th>
<th>NER</th>
<th>TBR</th>
<th>USP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.014</td>
<td>0.414</td>
<td>99.585</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>2</td>
<td>0.019</td>
<td>0.775</td>
<td>99.041</td>
<td>0.177</td>
<td>0.007</td>
</tr>
<tr>
<td>3</td>
<td>0.023</td>
<td>1.243</td>
<td>98.153</td>
<td>0.582</td>
<td>0.022</td>
</tr>
<tr>
<td>4</td>
<td>0.026</td>
<td>1.805</td>
<td>96.948</td>
<td>1.201</td>
<td>0.044</td>
</tr>
<tr>
<td>5</td>
<td>0.030</td>
<td>2.443</td>
<td>95.471</td>
<td>2.012</td>
<td>0.074</td>
</tr>
<tr>
<td>6</td>
<td>0.033</td>
<td>3.137</td>
<td>93.770</td>
<td>2.985</td>
<td>0.108</td>
</tr>
<tr>
<td>7</td>
<td>0.047</td>
<td>7.584</td>
<td>81.512</td>
<td>10.548</td>
<td>0.356</td>
</tr>
<tr>
<td>8</td>
<td>0.057</td>
<td>11.239</td>
<td>70.051</td>
<td>18.138</td>
<td>0.570</td>
</tr>
<tr>
<td>9</td>
<td>0.067</td>
<td>13.804</td>
<td>61.050</td>
<td>24.427</td>
<td>0.718</td>
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<tr>
<td>10</td>
<td>0.076</td>
<td>15.541</td>
<td>54.164</td>
<td>29.482</td>
<td>0.813</td>
</tr>
<tr>
<td>11</td>
<td>0.084</td>
<td>16.710</td>
<td>48.334</td>
<td>33.585</td>
<td>0.871</td>
</tr>
<tr>
<td>12</td>
<td>0.092</td>
<td>17.496</td>
<td>44.623</td>
<td>36.976</td>
<td>0.905</td>
</tr>
<tr>
<td>13</td>
<td>0.099</td>
<td>18.018</td>
<td>41.232</td>
<td>39.828</td>
<td>0.922</td>
</tr>
<tr>
<td>14</td>
<td>0.106</td>
<td>18.357</td>
<td>38.452</td>
<td>42.262</td>
<td>0.928</td>
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<tr>
<td>15</td>
<td>0.113</td>
<td>18.568</td>
<td>36.139</td>
<td>44.365</td>
<td>0.926</td>
</tr>
</tbody>
</table>

Source: Field survey, Azibah (2016)

### Table 7: Decomposition of Prices

<table>
<thead>
<tr>
<th>Period</th>
<th>S.E.</th>
<th>GHP</th>
<th>NER</th>
<th>TBR</th>
<th>USP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.063</td>
<td>100.004</td>
<td>0.000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>2</td>
<td>0.083</td>
<td>99.656</td>
<td>0.339</td>
<td>0.0009</td>
<td>0.0024</td>
</tr>
<tr>
<td>3</td>
<td>0.095</td>
<td>99.004</td>
<td>0.987</td>
<td>0.0012</td>
<td>0.0072</td>
</tr>
<tr>
<td>4</td>
<td>0.103</td>
<td>98.163</td>
<td>1.822</td>
<td>0.0009</td>
<td>0.0137</td>
</tr>
<tr>
<td>5</td>
<td>0.109</td>
<td>97.219</td>
<td>2.758</td>
<td>0.0015</td>
<td>0.0212</td>
</tr>
<tr>
<td>6</td>
<td>0.115</td>
<td>96.229</td>
<td>3.736</td>
<td>0.0051</td>
<td>0.0294</td>
</tr>
<tr>
<td>7</td>
<td>0.119</td>
<td>95.232</td>
<td>4.715</td>
<td>0.0140</td>
<td>0.0380</td>
</tr>
<tr>
<td>8</td>
<td>0.123</td>
<td>94.249</td>
<td>5.673</td>
<td>0.0305</td>
<td>0.0468</td>
</tr>
<tr>
<td>9</td>
<td>0.126</td>
<td>93.295</td>
<td>6.592</td>
<td>0.0564</td>
<td>0.0557</td>
</tr>
<tr>
<td>10</td>
<td>0.129</td>
<td>92.376</td>
<td>7.466</td>
<td>0.0935</td>
<td>0.0646</td>
</tr>
<tr>
<td>11</td>
<td>0.133</td>
<td>91.494</td>
<td>8.288</td>
<td>0.1432</td>
<td>0.0735</td>
</tr>
<tr>
<td>12</td>
<td>0.136</td>
<td>90.650</td>
<td>9.061</td>
<td>0.2063</td>
<td>0.0823</td>
</tr>
<tr>
<td>13</td>
<td>0.168</td>
<td>82.595</td>
<td>15.140</td>
<td>2.0848</td>
<td>0.1805</td>
</tr>
<tr>
<td>14</td>
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<td>79.311</td>
<td>16.786</td>
<td>3.6751</td>
<td>0.2271</td>
</tr>
<tr>
<td>15</td>
<td>0.198</td>
<td>76.248</td>
<td>17.944</td>
<td>5.5339</td>
<td>0.2735</td>
</tr>
<tr>
<td>16</td>
<td>0.212</td>
<td>73.359</td>
<td>18.773</td>
<td>7.5468</td>
<td>0.3203</td>
</tr>
<tr>
<td>17</td>
<td>0.226</td>
<td>70.633</td>
<td>19.375</td>
<td>9.6237</td>
<td>0.3681</td>
</tr>
<tr>
<td>18</td>
<td>0.239</td>
<td>68.074</td>
<td>19.811</td>
<td>11.697</td>
<td>0.4169</td>
</tr>
<tr>
<td>19</td>
<td>0.253</td>
<td>65.685</td>
<td>20.126</td>
<td>13.722</td>
<td>0.4673</td>
</tr>
</tbody>
</table>

Source: Field survey, Azibah (2016)

Note: GHP = Price in Ghana, NER = Nominal Exchange Rate, TBR = Treasury Bill Rate

USP = Price in US
The findings reflect the undesirable effect of increased interest rate or tighter fiscal policy pursued by the central bank over the period. Specifically, the effectiveness of the exchange rate as a policy tool in attempting for import reduction or export promotion depends on the degree of pass-through to import and consumer prices, regardless of several other factors. It can be argued that fiscal policy in Ghana has in the past not been raising the interest rate in response to inflationary expectations.

Another possible reason for this might be that, the financial institutions and commercial banks do not react directly to the central bank’s policy on interest rate indicating the prevalence of a weak link between the interest rate set by the central bank and the lending and borrowing rates charged by financial institutions and commercial.

Using the impulse response function to determine the response of the variables to shocks from the extra variables, it was established that domestic prices rise in response to interest rate shocks.

Using the Johansen co-integration tests, the null hypothesis that there is no co-integration between domestic prices, exchange rate, interest rate, and foreign prices was rejected.

Among the variables incorporated in our model, consumer price inflation responds significantly to shocks in external price, interest rate, and shock to price itself.

As a consequence of 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.

From the breakdown of the exchange rate, it was confirmed that both domestic prices and interest rates contribute to variations in the exchange rate. Concerning fiscal policy the outcomes recommend that the exchange rate is part of the main transmission channels of fiscal policy.

However, the low ERPT to consumer prices suggests that inflation is most likely affected by other factors than the exchange rate. It ought to be noted in any case, that regardless of the low level of the pass-through, the results suggest that the impact of exchange rate movements is still significant for domestic prices. Contingent upon the outcomes, a higher rate of interest rate does not only cause prices to increase, but also causes the domestic currency to depreciate.

This recommends that a shock on the interest rate does not have a long-run impact on domestic prices. Another interesting finding is that an increment in the interest rate causes an increment in domestic prices in the short-run in spite of in the long-run it is not statistically significant.

Regarding exchange rate policies, the pass-through connection between exchange rate changes and prices of imported and consumer goods determines the level of current account adjustment and international competitiveness accomplished from variations in the exchange rate.

The results stated that, whereas exchange rate is relevant for domestic prices, the pass-through impact is not complete. It was determined that increases in domestic prices are mainly attributed to own shocks and exchange rate shocks.

About 20% of the variations is attributed to exchange rate movements in domestic prices.

The contribution of interest rate to exchange rate movements increased from about 11% in 12 months and reached 24% in 24 months, 40% in 48 months, and 44% in 60 months.

ACKNOWLEDGEMENTS

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