**Original Research Article**

# Exchange rate pass-through dynamics: VAR evidence for Kenya

## Abstract

A VAR framework with exogenous variable is considered to analyse the exchange rate pass-through dynamics in Kenya. Monthly time series data from January 2006 to December 2022 is used. Six endogenous variables namely; US dollar exchange rate, broad money supply, total import, 20 Nairobi stock exchange share index, consumer price index and 91 days treasury bond rate sourced from the central bank of Kenya were considered. Global food price index and oil prices per barrel sourced from statista and Murban Adnoc respectively are the exogenous variables. Unit root test is first performed to test for stationary in line with VAR assumptions. Oil price and total import are the only stationary variables, while the other variables are of integrated order 1. Secondly, a VARX (2,0) is estimated, which is statistically significant at 5% level. Thirdly, Granger causality test is performed, that provide evidence of causality for 20 Nairobi stock exchange share index, consumer price index and broad money supply with respect to other endogenous variables. In addition, VARX(2,0) is converted to MA(2) to develop US dollars impulse response function. There exist high level of volatility for all variables. Finally, a forecast error variance decomposition following Cholesky decomposition shows significant proportion of variance explained by other variables respectively. Kenya's policy makers need to build strong framework for monetary policy and exchange rate control measures in safeguarding the performance of macroeconomic indicators.

## Keywords and phrases

*CPI, VAR, ERPT, fluctuation, Pass-through, inflation*

## 1 Introduction

Exchange rate pass-through is a measure of how local or international prices respond to change in nominal currency exchange rate. It's usually expressed as a percentage change in prices for a unit percentage change in exchange rate. In economic theories, fluctuation in exchange rate tends to affect inflation behavior, economic activities among other macro-economic indicators. According to Hüfner et al. [1] exchange rate pass-through effect on domestic prices is either direct or indirect. The effect is directly felt where exchange rate fluctuations increase production cost, import cost of finished goods and imported input cost. This leads to an aggregate domestic prices increase. The indirect effect is felt in relation to foreign market competitiveness on domestic goods. Depreciation of local currency result to cheaper commodities in foreign market, which in turn to increase in exports. Increase in export induce aggregate demand resulting to increase in domestic prices. The overall effect is decreased production as result of increase in price levels and production cost. This article investigates the dynamics of US dollar exchange rate pass-through in Kenya by considering a VAR system consisting of six endogenous variables and two exogenous variables.

There exist several empirical research on ERPT (exchange rate pass-through) both at local economies and regional blocks. Ndung'u [2] investigated foreign prices levels, exchange rate, domestic prices and other macro-economic variable interaction in Kenya using cointegration. The study observed inflation rate and exchange rate drives each other. In addition, domestic credit, exchange rate and foreign exchange reserve drive each other. There is no reverse effect for a casual relationship between domestic credit and inflation rate. Inflation rate and exchange rate are dominant in their dynamic movements with little aide of other variable shocks

Durevall et al. [3] analyzed inflation dynamics in Kenya from 1974 to 1996 where they established a long-run effect of exchange rate, foreign prices and terms of trade on inflation. On the other side, money supply and interest rate have a short-run effect on inflation. The study established a significant effect of food supply constraints on inflation. Leigh et al. [4] used a recursive VAR model to determine effect of ERPT on prices in Turkey. They established that exchange rate fluctuations effect on prices is mostly felt within the first four months but effect is over after an year. The study provided evidence of pass-through to consumer prices is low as compared to wholesale prices. Turkey has a larger pass-through as compared to key emerging economies and it's complete in a shorter time. Gagnon et al. [5] developed a theoretical model to analyze the changes in the rate of pass-through by considering central bank inflation stabilization measures for 20 industrial countries. There exist a significant link, which is robust, between rates of pass-through and inflation variability. Declining rate of pass-through is attributed to monetary policy behavior. Ihrig et al. [6] examined ERPT to consumer prices and import prices and the decline in G-7 countries. There exists a significant decline in import prices response to exchange rate fluctuations. A 1 % depreciation in local currency induce 0.4 % increase in import prices in 15 years. Consumer price response to exchange rate fluctuations declined for every country, though statistically significant in 2 countries only. Ca'Zorzi [7] established ERPT effect on consumer price and import is usually high in emerging economies as compared to developed economies. There is evidence of a positive relationship between inflation and the degree of ERPT as the Taylor's hypothesis. The study showed a weak empirical evidence of a link between import openness and EPRT. Babecká-Kucharèuková [8] explore exchange rate shock transmission in Czech republic consumer prices by considering impulse response estimate of 11 specifications. A VAR estimation strategy was first applied followed by ECM (Error Correction Model)framework. A high exchange rate shock transmission to all prices was observed with an ERPT value bound 25-30%.

Ocran [9] used an unrestricted VAR framework consisting of impulse response and variance decomposition to evaluate ERPT to import, producer and consumer prices in South Africa. The study established that 1 % shock in nominal exchange rate induced 0.125 % increase in CPI which is equivalent to a pass-through elasticity of 13 %. Pass-through elasticity of producer prices changes after 24 months which implies that producer price inflation has a significant moderating effect on CPI inflation. Sanusi [10] developed a structured VAR model to establish pass-through effect to consumer prices by accommodating Ghana's dependence on foreign aid and commodity exports. He established a large incomplete pass-through that implies exchange rate depreciation is a source of inflation. Monetary expansion in Ghana is more important in explaining inflationary process as opposed to exchange rate depreciation. Sansone et al. [11] performed a study to determine the level of ERPT to local prices and its evolution over time in Chile. Nominal ERPT to headline inflation is 14 % while core CPI pass-through ranges between 4 % and 12 %. It takes three to four quarters for the effect of exchange rate movements to be fully pass- through to prices. Establishment of inflation targeting measures resulted in a decline in ERPT while monetary policy measures did not affect pass-through as it remained fairly stable. Comunale et al. [12] used Bayesian VAR with zero and sign combination restrictions identification to study ERPT in four European countries. The study established that pass-through is not constant over time but at times depends on economic shocks composition for the exchange rate. Exchange rate movement that is triggered by exchange rate shocks and monetary policy results in strong pass through. ERPT measure is high in four countries but violates pass - through to import prices. Ghartey [13] established that depreciation in six non-carribean currency countries are as a result of price increase. Appreciation results to decrease in prices. Implementation of monetary policy principles tends to ineffective in all countries. Foreign prices drive prices in Jamaica, Guyana and Belize. 91-days treasury bill rate have insignificant effect in all countries a situation that call for controlling prices using exchange rates measures. Bonadio et al. [14] analysed pass-through effect on import prices as a result of Swiss national bank 2015 action to discontinue minimum exchange rate policy. The study provided evidence of an immediate and complete pass-through for goods invoiced in euros. For goods invoiced in Swiss francs, there is a partial and exceptionally fast pass-through. Ha et al. [15] used a structural factor - augmented VAR model by accommodating the nature of shock causing fluctuations in a currency and specific country characteristics for 47 countries. There exists a wide different pass-through ratios that is associated with global and different domestic shocks. Country individual characteristics in terms of policy framework for monetary policy regime and structural features for currency fluctuation matters. A country that has combined credible inflation targets and flexible exchange rate regime has a low pass- through ratio . Its noted that independence of central bank facilitate in stabilizing inflation. Revelli [16] examined the how consumer price index is affected by exchange rate pass-through in Kenya and Cameroon from the period 1991 to 2013. The degree of exchange rate in Kenya varied between 0.18 and 0.58 over in year. The impulse response function supported the degree of pass-through though lower at 0.3125. The study concluded that exchange rate fluctuations are source of inflation in Kenya and Cameroon.

# 2 Methodology

## 2.1 Data

In this study, monthly time series data for eight variables from 2006 to 2022 is used. For a VAR framework, variables are either endogenous or exogenous. Endogenous are defined as variable who's change is determined by relationship with other variables in a system while exogenous variables are the one that tend to behave as independent variable of a VAR system . Five variables are considered as endogenous variables, namely; 91 days treasury bond rate - TBR, 20 NSE (Nairobi stock exchange) share index - SI, consumer price index - CPI, broad money supply - M3 (in Ksh. Billions ), US dollar exchange rate- USDR and total imports - TI (in Ksh. Millions). All the endogenous variables were sourced form CBK (central bank OF Kenya). Global food prices index -GFPI and Oil price per barrel - OP (in US dollars) sourced from Statista and Murban Adnoc respectively are considered as exogenous variable. McCarthy [17] and Ito et al. [18] exchange rate pass-through mechanism is applied which follows the following pattern.

$$Oil \Rightarrow GAP \Rightarrow NERT \Rightarrow INT \Rightarrow M3 \Rightarrow IMP \Rightarrow PPI \Rightarrow CPI$$

where Oil -oil prices, NERT- nominal exchange rate, IMP- import prices, GAP - output gap, INT- interest rate, PPI - producer price index and CPI - consumer price index

## 2.2 Model

### 2.2.1 Unit root test

Testing for stationarity using unit root test is done follow the model:

$$\Delta X_t = \delta_0 + \delta_1 t + \delta_2 X_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta X_{t-1} + \gamma_t \quad (1)$$

where $\Delta X_t$- first variable difference; $\delta_0 + \delta_1 t$ - linear trend component, and $\gamma_t$ - error term.

Phillips-Perron test statistic is used, with the testing hypothesis as:
$H_0 : \delta_2 = 0$, versus $H_1 : \delta_2 < 0$.

At a 5% level of significance, total imports and Oil prices are stationary while 91 days treasury bind rate, 20 share index, customer price index, broad money

Table 1: Unit root test results

| P-P test | | | | |
|---|---|---|---|---|
| Variable | Statistic (in level) | p value | Statistic (1st Δ) | p value |
| TBR | -17.49 | 0.1182 | -143.29 | 0.01 |
| SI | -7.35 | 0.6949 | -194.86 | 0.01 |
| CPI | -4.08 | 0.8811 | -99.16 | 0.01 |
| M3 | -0.29 | 0.99 | -206.55 | 0.01 |
| OP | -44.92 | 0.01 | | |
| GFPI | -10.96 | 0.49 | -76.89 | 0.01 |
| USDR | -18.81 | 0.08 | -118.99 | 0.01 |
| TI | -52.40 | 0.01 | | |

supply, global food price index and US dollar exchange rate are stationary at first difference as shown in table 1. Variables that are stationary after the first difference are considered for analysis.

### 2.2.2 VAR estimation

Consider two univariate Auto-regressive (AR) process $y_1$ and $y_2$, with each variable being dependent on itself lagged, the other variable current and lagged values.

$$y_{1(t)} = v_{10} + v_{12}y_{2(t)} + \alpha_{11}y_{1(t-1)} + \alpha_{12}y_{2(t-1)} + \xi_{1(t)} \tag{2}$$

$$y_{2(t)} = v_{20} + v_{21}y_{1(t)} + \alpha_{21}y_{1(t-1)} + \alpha_{22}y_{2(t-2)} + \xi_{2(t)} \tag{3}$$

Equation(2) and (3) forms a structural VAR that is denoted in matrix form as

$$\begin{bmatrix} y_{1(t)} \\ y_{2(t)} \end{bmatrix} = \begin{bmatrix} v_{10} \\ v_{20} \end{bmatrix} + \begin{bmatrix} 0 & v_{12} \\ v_{21} & 0 \end{bmatrix} \begin{bmatrix} y_{1(t)} \\ y_{2(t)} \end{bmatrix} + \begin{bmatrix} \alpha 11 & \alpha 12 \\ \alpha 21 & \alpha 22 \end{bmatrix} \begin{bmatrix} y_{1(t)} \\ y_{2(t)} \end{bmatrix} + \begin{bmatrix} \xi_{1(t)} \\ \xi_{2(t)} \end{bmatrix} \tag{4}$$

Equation (4) in matrix notation for m variables and p lags is represented as

$$y_t = v + A_0 y_t + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + \xi_t \tag{5}$$

where $y_t$, $v$ and $\xi_t$ are $m \times 1$ column vectors and $A_0, A_1, A_2, \ldots, A_p$ are $m \times m$ coefficient matrices and vector $\xi_t$ is an m-element vector of white noise disturbances. Subtracting $A_0 y_t$ on both sides of equation (5), it reduces to;

$$(I - A_0)y_t = v + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + \xi_t \tag{6}$$

Diving through with $(I - A_0)$, equation (6) reduce to

$$y_t = (I - A_0)^{-1} v + (I - A_0)^{-1} A_1 y_{t-1} + (I - A_0)^{-1} A_2 y_{t-2} + \cdots + \\ (I - A_0)^{-1} A_p y_{t-p} + (I - A_0)^{-1} \xi_t \tag{7}$$

Contracting the constants, equation (7) reduces to general VAR(p)

$$y_t = c + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \cdots + \beta_p y_{t-p} + \mu_t \tag{8}$$

In term of lag operator

$$y_t = c + B(L) y_{t-1} + \mu_t \tag{9}$$

where $y_t$ is a vector of endogenous variables. In case of exogenous variable, variables that are independent of the system, equation (9) turns to be VARX (p,s) model as shown below

$$y_t = c + B(L) y_{t-1} + \Phi(L) x_t + \mu_t \tag{10}$$

Table 2: Information Criteria results

| AIC(n) | HQ(n) | SC(n) | FPE(n) |
|---|---|---|---|
| 2 | 2 | 2 | 2 |

The number of lag to be considered is 2 as shown in table 2, thus the order of equation(10) is VARX(2,0) given as

$$\begin{pmatrix} USDR_t \\ TBR_t \\ M3_t \\ CPI_t \\ SI_t \end{pmatrix} = \begin{pmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \\ c_5 \end{pmatrix} + \begin{bmatrix} \beta_{11}{}^1 & \beta_{12}{}^1 & \beta_{13}{}^1 & \beta_{14}{}^1 & \beta_{15}{}^1 \\ \beta_{21}{}^1 & \beta_{22}{}^1 & \beta_{23}{}^1 & \beta_{24}{}^1 & \beta_{25}{}^1 \\ \beta_{31}{}^1 & \beta_{32}{}^1 & \beta_{33}{}^1 & \beta_{34}{}^1 & \beta_{35}{}^1 \\ \beta_{41}{}^1 & \beta_{42}{}^1 & \beta_{43}{}^1 & \beta_{44}{}^1 & \beta_{45}{}^1 \\ \beta_{51}{}^1 & \beta_{52}{}^1 & \beta_{53}{}^1 & \beta_{54}{}^1 & \beta_{55}{}^1 \end{bmatrix} \begin{pmatrix} USDR_{t-1} \\ TBR_{t-1} \\ M3_{t-1} \\ CPI_{t-1} \\ SI_{t-1} \end{pmatrix}$$
$$+ \begin{bmatrix} \beta_{11}{}^2 & \beta_{12}{}^2 & \beta_{13}{}^2 & \beta_{14}{}^2 & \beta_{15}{}^2 \\ \beta_{21}{}^2 & \beta_{22}{}^2 & \beta_{23}{}^2 & \beta_{24}{}^2 & \beta_{25}{}^2 \\ \beta_{31}{}^2 & \beta_{32}{}^2 & \beta_{33}{}^2 & \beta_{34}{}^2 & \beta_{35}{}^2 \\ \beta_{41}{}^2 & \beta_{42}{}^2 & \beta_{43}{}^2 & \beta_{44}{}^2 & \beta_{45}{}^2 \\ \beta_{51}{}^2 & \beta_{52}{}^2 & \beta_{53}{}^2 & \beta_{54}{}^2 & \beta_{55}{}^2 \end{bmatrix} \begin{pmatrix} USDR_{t-2} \\ TBR_{t-2} \\ M3_{t-2} \\ CPI_{t-2} \\ SI_{t-2} \end{pmatrix} + \begin{pmatrix} \phi_1 \\ \phi_2 \\ \phi_3 \\ \phi_4 \\ \phi_5 \end{pmatrix} GFPI_t + \mu_t \quad (11)$$

The estimate of equation (11) is given as:

$$\begin{pmatrix} USDR_t \\ TBR_t \\ M3_t \\ CPI_t \\ SI_t \end{pmatrix} = \begin{pmatrix} 0.1888 \\ -1.9618 \\ -0.0273 \\ 0.1031 \\ -0.1035 \end{pmatrix} + \begin{bmatrix} 1.2100 & -0.0101 & 0.2196 & -0.0928 & -0.0609 \\ 0.6290 & 1.1440 & -1.2793 & 4.0354 & 0.1046 \\ -0.0834 & -0.0020 & 0.9292 & 0.0303 & -0.0035 \\ -0.0332 & 0.0081 & 0.0233 & 1.4230 & -0.0054 \\ -0.4274 & -0.0106 & 0.3166 & -0.4300 & 0.9602 \end{bmatrix}$$
$$\begin{pmatrix} USDR_{t-1} \\ TBR_{t-1} \\ M3_{t-1} \\ CPI_{t-1} \\ SI_{t-1} \end{pmatrix} + \begin{bmatrix} -0.3049 & 0.0036 & -0.2433 & 0.1846 & 0.0679 \\ -0.2566 & -0.2436 & 0.8529 & -3.3583 & -0.0005 \\ 0.0688 & -0.0006 & 0.0257 & 0.0535 & 0.0125 \\ 0.0257 & -0.0076 & 0.0208 & -0.5037 & -0.0004 \\ 0.4877 & 0.0219 & -0.2722 & 0.2958 & 0.0095 \end{bmatrix} \begin{pmatrix} USDR_{t-2} \\ TBR_{t-2} \\ M3_{t-2} \\ CPI_{t-2} \\ SI_{t-2} \end{pmatrix} +$$
$$\begin{pmatrix} -0.0045 \\ -0.0126 \\ 0.0036 \\ -0.0013 \\ 0.0630 \end{pmatrix} GFPI_t + \mu_t \quad (12)$$

with

$$\Sigma_\mu = \begin{bmatrix} 2.714\times10^{-4} & 0.00011 & 3.139\times10^{-5} & 7.949\times10^{-6} & -1.897\times10^{-4} \\ 1.062\times10^{-4} & 0.0150196 & -1.494\times10^{-4} & -2.960\times10^{-5} & -3.432\times10^{-4} \\ 3.139\times10^{-5} & -0.00015 & 1.391\times10^{-4} & 9.243\times10^{-6} & 4.939\times10^{-5} \\ 7.949\times10^{-6} & -0.00003 & 9.243\times10^{-6} & 3.393\times10^{5} & -5.621\times10^{-5} \\ -1.897\times10^{-4} & -0.00034 & 4.939\times10^{-5} & -5.621\times10^{-5} & 3.214\times10^{-3} \end{bmatrix}$$

Performing likelihood ratio test, gives a chi-squared value of 2262.72 with 75 degree of freedom and p-value $= 0.001$. VARX(2,0) model is statistically significant at 5 % level.

#### 2.2.3 Granger Causality

Granger Causality developed by Granger [19], is stated as an observed series $Y_t$ is causing observed series $X_t$ represented as $Y_t \Rightarrow X_t$ i.e

$$\sigma^2(X|U) < \sigma^2(X|\overline{U-Y})$$

Hamilton [20] developed Granger causality model for autoregressive lag length (p) as

$$X_t = c_t + \kappa(L)X_{t-1} + \eta(L)Y_{t-1} + \upsilon_t \tag{13}$$

The test statistic is

$$\frac{(RRS_0 - RSS_1)/p}{RSS_1/(T-2p-1)} \sim F(p, T-2p-1)$$

with $RRS_0$ is the sum of squared residual for $x_t$ which is a univariate autorgerssion under the null hypoyhesis and $RRS_1$ is the sum of squared residuals from equation (13). The null hypothesis is $\eta_i = 0$ for all i versus an alternative of at least one $\eta_i \neq 0$ . The null hypothesis model is given as

$$X_t = c_0 + \gamma(L)X_{t-1} + \tau_t \tag{14}$$

US dollar exchange rate at 5% level does granger-cause 91 days treasury bond rate, 20 NSE share index, consumer price index and broad money supply as shown in table 3. Similarly, 91 days treasury bond rate and consumer price index at 5% level do not granger-cause the other endogenous variables. However, it's noted that broad money supply and 20 NSE share index granger-cause the other endogenous variables at a 5% level.

Table 3: Granger causality result

| Granger-cause | F-Test | df1 | df2 | p value |
|---|---|---|---|---|
| USDR | 1.548 | 8 | 880 | 0.1368 |
| TBR | 1.293 | 8 | 880 | 0.2433 |
| SI | 2.548 | 8 | 880 | 0.0095 |
| CPI | 1.935 | 8 | 880 | 0.0518 |
| M3 | 2.858 | 8 | 880 | 0.004 |

### 2.2.4 Impluse Response Function

A VAR(p) equation (8) in vector MA($\infty$) is written as

$$X_t = \kappa_0 + \varepsilon_t + \phi(L)\varepsilon_{t-1} \tag{15}$$

where $\phi_s$ is interpreted as

$$\phi_s = \frac{\partial X_{t+s}}{\partial \varepsilon_t{}'} \tag{16}$$

The elements of matrix $\phi_s$ in the $i^{th}$ row and $j^{th}$ column, is a representation of the effect for a unit positive change in the $j^{th}$ variable innovation at a particular date t($\varepsilon_{jt}$) for $i^{th}$ variable value at time $t+s(y_{i,t+s})$, while holding all other variables constant for all other dates. Assuming all the elements of $\varepsilon_t$ are simultaneously changed by respective $\delta_i$, then the combined effects on the values of $X_{t+s}$ is given as

$$\Delta X_{t+s} = \frac{\partial X_{t+s}}{\partial \varepsilon_{1t}}\delta_1 + \frac{\partial X_{t+s}}{\partial \varepsilon_{2t}}\delta_2 + \cdots + \frac{\partial X_{t+s}}{\partial \varepsilon_{nt}}\delta_n = \phi_s \delta \tag{17}$$

where $\delta = (\delta_1, \delta_2, \ldots, \delta_n)'$ The impulse response function is a plot of the $i^{th}$ row, $j^{th}$ column element of $\phi_s$

$$\frac{\partial X_{i,t+s}}{\partial \varepsilon_{jt}} \tag{18}$$

By definition, impulse response function describes the response of $X_{i,t+s}$ to a one-time shock in $X_{it}$ while holding all other variables constant or dated t.

For one standard deviation in US dollar exchange rate, causes the exchange rate to respond positively for 7 months as shown in figure 1. A stable condition is attained after 18 months. There is high volatility between the $7^{th}$ month to the $20^{th}$ month. 91 days treasury bond responds positively for one standard deviation in US dollar exchange rate as shown in figure 2. The effect is highly felt

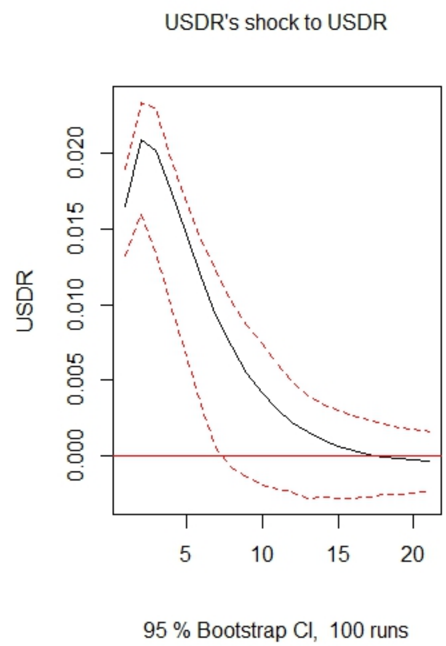


Figure 1: Impulse response function plot (on USDR)

within the first 10 months, as it then approaches zero. There is high volatility for the first 20 months period. The impulse in US dollar exchange rate has an effect on CPI volatility as shown in figure 4. CPI fluctuate around zero for one standard deviation in US dollar exchange rate. Similarly, US dollar has an effect on broad money supply volatility as shown in figure 3. 20 NSE share index respond negatively for first 12 months to one standard deviation in US dollar exchange rate, figure 5. There exist a notable high volatility between the $4^{th}$ month to $20^{th}$ month.

#### 2.2.5 Error Variance decomposition

Cholesky decomposition is a matrix factorization method for a positive define matrix given as

$$\Omega = PP' \tag{19}$$

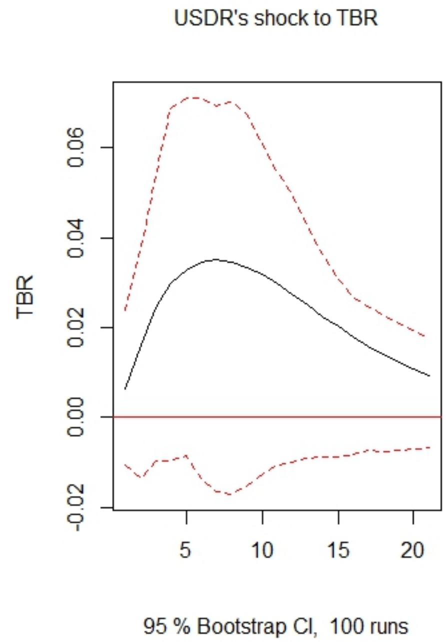


Figure 2: Impulse response function plot (on TBR)

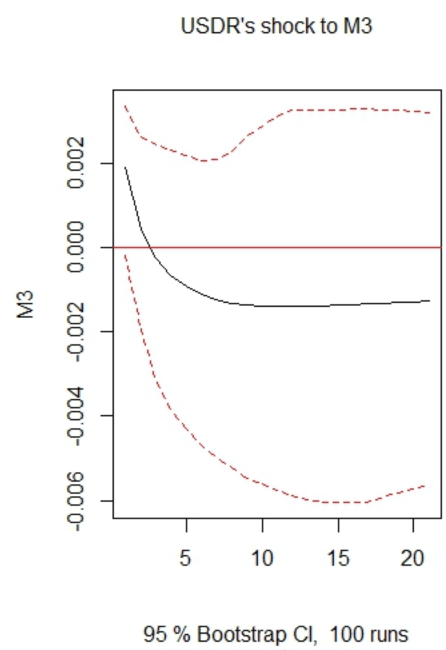




Figure 3: Impulse response function plot(on M3)

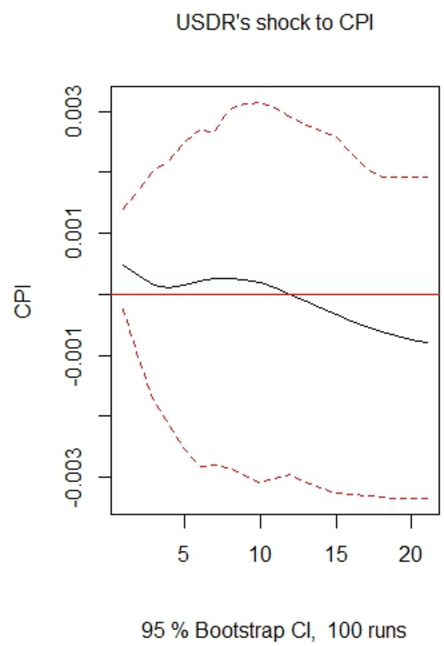


Figure 4: Impulse response function plot (on CPI)

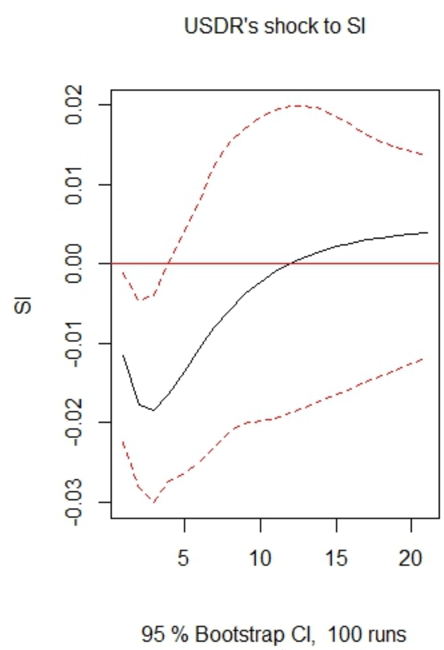




Figure 5: Impulse response function plot (on SI)

where P is Choleski factor which is lower triangular matrix.

$$\Omega = E(\mu_t \mu_t{}') = SE(\varepsilon_t \varepsilon_t{}')S' = SS' \tag{20}$$

for $E(\varepsilon_t \varepsilon_t{}') = I$ assuming orthonormal structural disturbances . S is lower triangular matrix which is equivalent to Choleski factor P.

Large proportion of the variance in forecasting US dollar exchange rate is by it's autoregressive direction as shown in figure 6. 91 days treasury bond rate has increasing order influence after three forecasts while 20 NSE share index and broad money supply by order of influence remains fairly constant. Consumer price index has its proportion as after $6^{th}$ forecast. The variance in forecasting 91 days treasury bond has large proportion attributed to it's direction as 7. Consumer price index and US dollar exchange rate in order of size respectively increase with time. Broad money supply and 20 NSE share index are small and constant. Autoregressive direction of the 20 NSE share index accounts for large proportion of it's variance, figure 8. US dollar proportion decrease with time while 91 days treasury bond increase with time. 20 NSE share index and consumer price proportion is significant after fifth forecast. Consumer price index autoregresive direction explains large proportion of it's forecast variance, figure 9. Broad money supply proportion increase with time, with 91 days treasury bond rate fairy constant. 20 NSE share index proportion starts as from the fourth forecast increasing with time while US dollar diminishes within the first two forecast. Figure 10 shows that 20 NSE share index variance is dependent on it's direction. US dollar exchange rate proportion increase for the first five forecast, thereafter decreases with time. Consumer price index and broad money supply in order of size, remains fairly constant with time. 91 days treasury bond rate has not significant influence.

# 3 Discussion and conclusion

The study sort to establish a VAR system for six endogenous variables and two exogenous variables. It also sort to establish the causality that may exist and the response of variables to US dollar exchange rate impulse. Among the endogenous variable, total import is stationary in level. Oil price index is also stationary. A VARX (2,0) is the most appropriate model for regression, with it being statistically significant at 5% level. The study provide evidenced of existence of Granger causality for 20 NSE share index, consumer price index and broad money supply with respect to other endogenous variables. US dollar exchange rate fluctuation

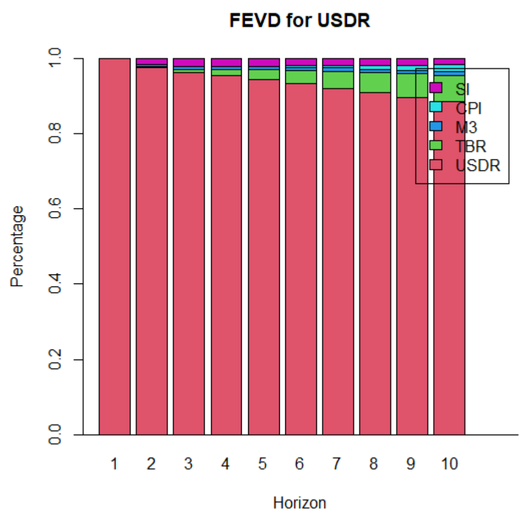


Figure 6: US dollar exchange rate fevd plot

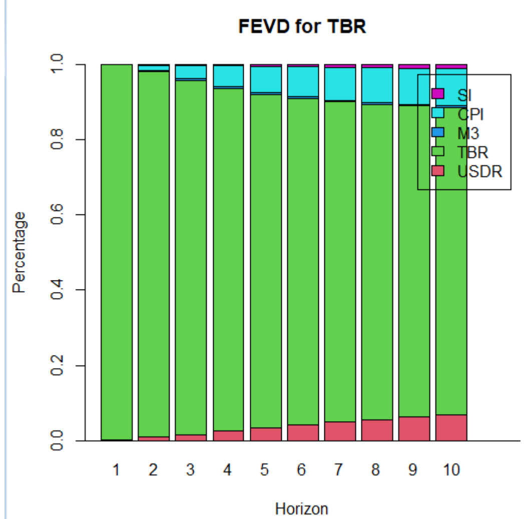


Figure 7: 91 days treasury bond rate fevd plot

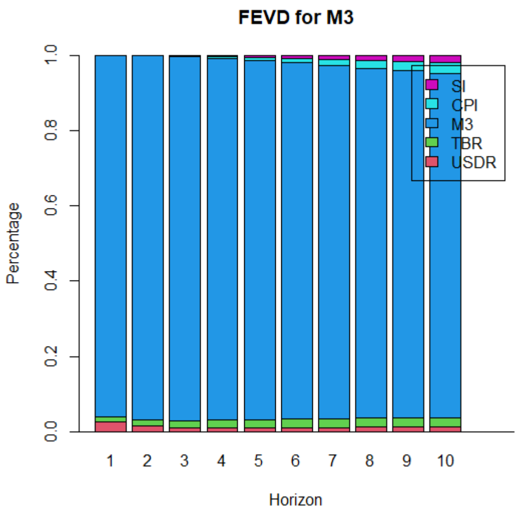


Figure 8: Broad money supply fevd plot

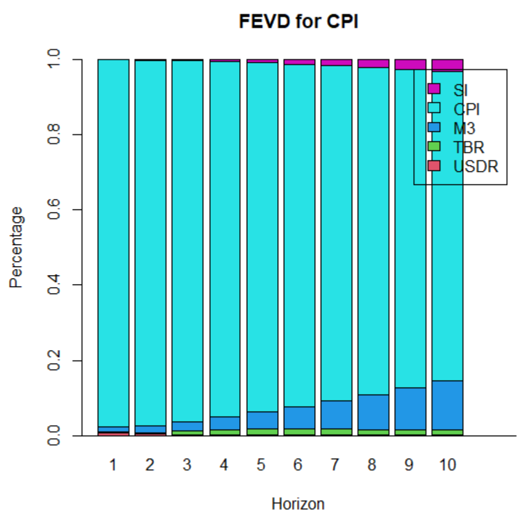


Figure 9: Consumer price index fevd plot

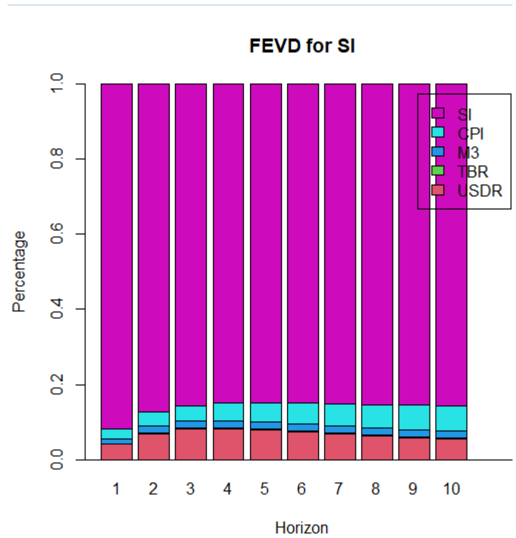


Figure 10: 20 NSE share index fevd plot

cause high volatility among endogenous variables in short term. There exist significant proportion of error forecast variance explained by other variables for each endogenous variable.

In conclusion, Kenya policy makers should employ exchange rate control measures to control for macroeconomic variables volatility. In addition, employing policy framework on monetary policy regime will help reduce the causality effect within Kenya financial system.

# References

[1] Hüfner FP, Schröder M. Exchange rate pass-through to consumer prices: A European perspective. 2002.

[2] Ndung'u NS. Price and exchange rate dynamics in Kenya: an empirical investigation (1970-1993). Research paper/African Economic Research Consortium; 58. 1997.

[3] Durevall D, Ndung'u NS. A dynamic model of inflation of Kenya, 1974-96. Journal of African Economies. 2001; 10(1): 92-125.

[4] Leigh D, Rossi M. Exchange rate pass-through in Turkey. 2002.

[5] Gagnon JE, Ihrig J. Monetary policy and exchange rate pass-through. International Journal of Finance & Economics. 2004;9(4): 315-338.

[6] Ihrig JE, Marazzi M, Rothenberg AD. Exchange-rate pass-through in the G-7 countries. FRB International Finance Discussion Paper. 2006: (851).

[7] Ca'Zorzi M, Hahn E, Sánchez M. Exchange rate pass-through in emerging markets. 2007.

[8] Babecká-Kucharèuková O. Transmission of exchange rate shocks into domestic inflation: the case of the Czech Republic. Czech Journal of Economics and Finance (Finance a uver). 2009;59(2): 137-152.

[9] Ocran MK. Exchange rate pass-through to domestic prices: The case of South Africa. Prague Economic Papers. 2010; 4: 291-306.

[10] Sanusi AR. Exchange rate pass-through to consumer prices in Ghana: Evidence from structural vector auto-regression. West African Journal of Monetary and Economic Integration. 2010; 10(1).

[11] Sansone A, Justel S. Exchange rate pass-through to prices: VAR evidence for Chile. Economía chilena. 2016; 19(1).

[12] Comunale M, Kunovac D. Exchange rate pass-through in the euro area. 2017.

[13] Ghartey EE. Asymmetries in exchange rate pass-through and monetary policy principle: Some Caribbean empirical evidence. The North American Journal of Economics and Finance. 2019; 47: 325-335.

[14] Bonadio B, Fischer AM, Sauré P. The speed of exchange rate pass-through. Journal of the European Economic Association. 2020; 18(1): 506-538.

[15] Ha J, Stocker MM, Yilmazkuday H. Inflation and exchange rate pass-through. Journal of International Money and Finance. 2020; 105: 102187.

[16] Revelli DNP. The Exchange Rate Pass-Through to Inflation and its Implications for Monetary Policy in Cameroon and Kenya. 2020.

[17] McCarthy J. Pass-through of exchange rates and import prices to domestic inflation in some industrialized economies. Eastern Economic Journal. 2007; 33(4): 511-537.

[18] Ito T, Sato K. Exchange rate changes and inflation in post-crisis Asian Economies: Vector Autoregression Analysis of the exchange rate pass-through. Journal of Money, Credit and Banking. 2008; 40(7): 1407-1438.

[19] Granger CW. Investigating causal relations by econometric models and cross-spectral methods. Econometrica: journal of the Econometric Society. 1969: 424-438.

[20] Hamilton H. Time Series Analysis. Princeton, New Jersey: Princeton University Press. 1994.