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Effects of Interest Rates on Foreign Exchange Rate in Kenya

[1]BERNARD KIPKEMOI, [2]GEORGE KOSIMBEI

[1,2] JOMO KENYATTA UNVERSITY OF AGRICULTURE AND TECHNOLOGY, NAIROBI, KENYA

Abstract: **This paper investigates how interest rates are likely to have influenced the exchange rate movements in Kenya. It set to establish if interest rates have a significant contribution to the level of exchange rate or vice versa. It has also set out to determine if the International Fisher's effect applies to Kenya with respect to the United States. Using a Vector Autoregressive model the paper estimated the relationship among the key variables i.e exchange rate and interest rates. The study made use of VAR regressions and multivariate Granger causality tests. From the VAR analysis using impulse responses, the research established that changes on the exchange rates are sensitive to all its past values upto the second lag but with varying degrees with the past one month value having the most significance. The change on exchange rate is also sensitive to the previous month's change on the foreign interest rate. In addition the changes to the local interest rate are sensitive to the change in exchange rate in the third lag and also changes on its own lagged values in the second and third months respectively. In concluding the VAR estimate analysis, changes on the foreign interest rate are not sensitive to changes on any of the other variables including its own lagged values. The multivariate granger causality diagnosed that, changes on the local interest rate do not cause changes on the exchange rate while changes on the foreign interest rates do not cause changes in the exchange rate. In addition, changes on both the local and foreign interest rates jointly do not cause changes on the exchange rate. However, changes on exchange rate cause changes in the local interest rate while changes on the foreign interest rates do not cause changes in the local interest rate. In addition, changes on both the exchange rate and foreign interest rate jointly do cause changes on the local interest rate. Finally changes on exchange rates do not cause changes in the foreign interest rate while changes on the local interest rates do not cause changes in the foreign interest rate. Further, changes on both the exchange rate and local interest rate jointly do not cause changes on the foreign interest rate. In conclusion, the research also established that the International Fishers effect does not apply to Kenya with respect to the United State.**

Keywords: **Vector Auto regression, Exchange rate, Interest rate parity and Fischers Effect.**

1. INTRODUCTION

Monetary policy affects the real economy through different channels. These channels have been identified as interest rate channel, expectations channel, credit channel, asset prices channel and the exchange rate channel. In his research paper (Cheng, 2006) points that the interest rate channel was weak in Kenya during the period 1997-2005 because of financial sector rigidities. This study examined the relationship amongst the local interest rate, foreign interest rate and the exchange rate in Kenya after this period. In the interest rate channel, an increase in the bank rate causes an increase in the lending rate causing a reduction in private investment and consumption expenditures therefore reducing output and pressure on prices (Ireland, 2010). Movements in the policy rate are therefore only effective to the extent that they influence the lending rates of banks and hence the economic activity of a country. Hence this channel will largely depend on the competitiveness of the banking sector. If banks do not reduce their lending rates when the policy rate is reduced, this undermines the effectiveness of this channel in providing countercyclical support to economic activity during a recession. Under this channel, a tight monetary policy increases the payments that firms and households have to make service their floating rate debt (Mwega, 2014). On the exchange rate channel, this channel becomes important in small open economies with a flexible exchange rate. An increase in the bank rate for example raises local interest rates relative

to foreign rates so that the local currency appreciates to equate the non-adjusted returns of the debt instruments denominated in domestic and foreign currencies (uncovered interest rate parity). Increased capital inflows and the appreciation of the exchange rate reduces net exports and therefore aggregate demand with negative Keynesian effects on output and reduced pressure on prices. An appreciation of the exchange rate also reduces domestic inflation by lowering the shilling import prices. These impacts are often amplified through inflationary expectations as the exchange rate is a highly visible macro price. In the absence of adequate information, economic agents may interpret the appreciation of the exchange rate as an early indicator of the monetary conditions and reduce inflationary pressures in the economy and vice-versa (Christensen 2010). Interest rates play a key role in two very important relationships in macroeconomics, i.e., the Fisher hypothesis (FH) and uncovered interest rate parity (UCIRP). The former links nominal rates to expected inflation, requiring full adjustment of these two variables in the long run and implying stationary I(0) of ex-ante interest rates (a crucial variable for understanding investment and saving decisions as well as asset price determination). In the absence of a one-to-one adjustment, permanent shocks to either inflation or nominal rates would have permanent effects on real rates as well, which would be inconsistent with standard models of inter-temporal asset pricing. (Mishkin,1990). In the United States federal interest rate announcement manipulates the markets around the world. Interest rate slash by Federal bank positively influence the United States exchange rate. Researchers have different opinions regarding the determination of exchange rates. There are few who believe exchange rate is determined by interest rate parity (Suthar, 2008), (Haque M.A, 2008). Does the interest rate differential actually help predict future currency movement? Available evidence is mixed as in the case of PPP theory. In the long-run, a relationship between interest rate differentials and subsequent changes in spot exchange rate seems to exist but with considerable deviations in the short run (Hill, 2004). The International Fisher Effect (IFE) explains the rate differentials of two countries and changes in their expected exchange rates (Utami & Inanga, 2009).The foreign currencies having high interest rate tend to depreciate because nominal interest rate reflects the expected rate of inflation. Too abrupt change in the value of its currency, it is feared, could imperil a nation's export industries (if the currency appreciates) or leads to higher rate of inflation (if the currency depreciates).

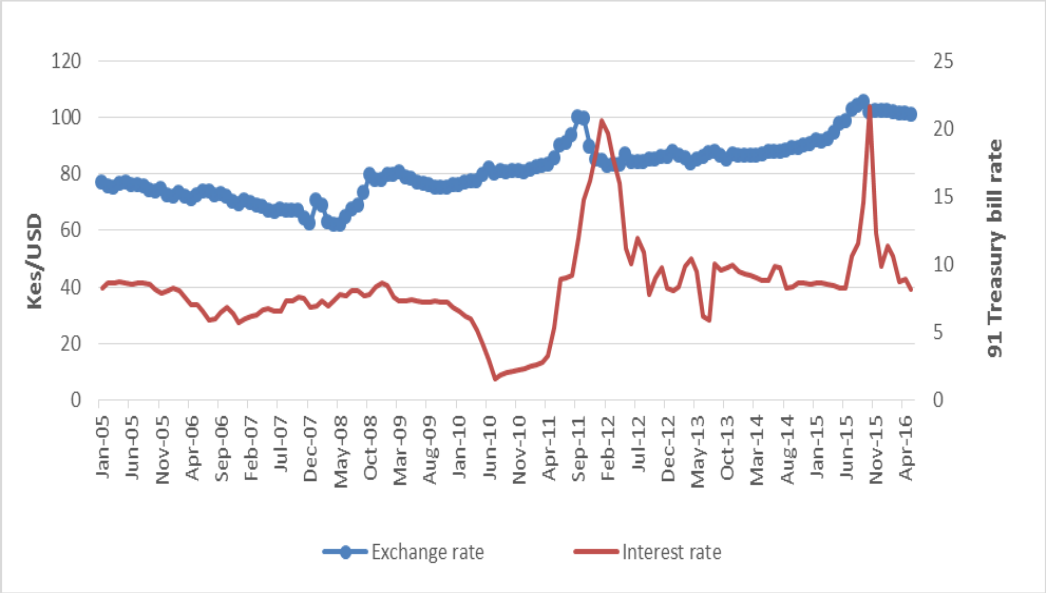


Figure 1: Trend in Local interest rate and Exchange rate in Kenya.

The data used in Figure 1 consists of monthly exchange rates on the Kenya Shilling against the US Dollar. The exchange rate was an average of buying and selling rates of commercial banks spot exchange rates. The shilling to the USA dollar nominal exchange rate is used as the basis of the empirical analysis mainly because the USA dollar commands the largest weight in Kenya's official reserves. It is also the currency used most by Kenya in settlement of her international financial obligations. (Maturu, 2014) Figure 1 shows that the trend in exchange rate seems to mirror that of local interest rate and vice versa. Hence, the question, what is the causal relationship between the variables? This study will set out to explore theories that link these macroeconomic variables and to empirically test one of the theories, that is the International Fisher's effect and estimate the relationship between these variables. The CBK's primary responsibility is formulating and implementing monetary policy to achieve stability in the general price level (Kenyan Parliament Act, 2009).This includes the exchange rate which is the price of the Kenya shilling expressed in other currencies. The CBK participates in the

foreign exchange market mainly to acquire foreign exchange to service official debt, finance government imports, build its foreign exchange reserves, and in times of volatility, buy or sell foreign exchange to stabilize the market also known as open market operations. In this case, foreign exchange reserves are also an indirect instrument of monetary policy and can be used for liquidity management. This is because buying or selling of foreign exchange injects or withdraws Kenya shillings from the market. In terms of the exchange rate regimes, the country has had two distinct periods i.e. 1966 to 1992 when the policy was under a fixed exchange rate regime and the subsequent period after 1993 when the CBK adopted the floating exchange rate regime. This study has focused on the latter period. In the year 2006, the CBK introduced the CBR rate as a policy tool to control inflationary pressures in the country.

In Kenya, the exchange rate as measured by the local currency against the dollar depreciated by 28 % year on year from March 2008 to March 2009, by 23% in September 2010 to September 2011 and again in the recent past by 18% September 2014 to September 2015 based on CBK data. The depreciating currency against an increase in interest rate brings to the fore the use of interest rate as a policy transmission instrument for the Central Bank. Do the interest rates determine the level of exchange rate or vice versa?Does the interest rate differential actually help predict future currency movement? Available evidence is mixed as in the case of PPP theory. In the long-run, a relationship between interest rate differentials and subsequent changes in spot exchange rate seems to exist but with considerable deviations in the short run (Hill, 2004).

Kenya adopted a floating exchange rate regime in 1993. It is assumed that under this form of exchange rate regime the exchange rate is determined by market forces of demand and supply. According to Ndungu (2000), the effect of maintaining foreign exchange within a certain level is at a cost of high interest rate (treasury bill). The exchange rate is stabilized in the short run but at the cost of high interest rates. On the other hand, domestic interest rates have been pushed by the presence of a large and growing domestic debt. In his research paper (Cheng, 2006) points that the interest rate channel was weak in Kenya during the period 1997-2005 because of financial sector rigidities. This research examined how changes in interest rates affects foreign exchange rate in Kenya using the latest available data in a floating exchange rate regime. The main objective is to evaluate the effects of both the local and foreign interest rates on exchange rate in Kenya.

According to the Vision 2030, Second Medium Term Plan (MTP), The Central Bank of Kenya (CBK) is expected to pursue a prudent monetary policy to ensure price stability with inflation projected to remain at about five per cent as a policy target. In addition, the CBK will build international reserves to six months import cover as agreed by all EAC Member States compared to four months during the First MTP period. This study will want to address the knowledge gap on monetary policy actions with regards to interest rate and its likely impact on the exchange rate in Kenya in the short run. The study will aim at offering an insight on the implication of interest rates fluctuations on the exchange rate and likewise the impact of exchange rate fluctuations on interest rates. The study intends to add to the body of empirical literature on interest rates and exchange rate in Kenya. It will also set out to establish the opportunities and challenges on the International Fishers effect with respect to Kenya and the United States. The study was conducted in Kenya during the period Jan 2005 and May 2016, although the exchange rate regime was liberalized in Jan 1993. This is due to data revisions on some of the variables used, introduction of the CBR in 2006 and also due to financial sector rigidities during the period 1997 to 2005. The focus remains to establish the effect of interest rates on foreign exchange rate. This study will help policy analysts have a deeper understanding in relation to nexus on interest rates and exchange rates.Financial sector rigidities prior to 2005 led to limitations in scope although the exchange rate regime was liberalized much earlier.

2. LITERATURE REVIEW

The exchange rate theories can be classified into three kinds: partial equilibrium models, general equilibrium models and disequilibrium or hybrid models. Partial equilibrium models include relative PPP and absolute PPP, which only consider the goods market; and covered interest rate parity (CIRP) and uncovered interest rate parity (UCIRP), which only considers the assets market, and the external equilibrium model, which states that the exchange rate is determined by the balance of payments. General exchange rate equilibrium models include the Mundell- Fleming model, which deals with the equilibrium of the goods market, money market and balance of payments, but lacks micro-foundations. To some extent; the Balassa-Samuelson model, which is built on the maximization of firms profit; the Redux model, which was developed by (Rogoff, 1996), and the PTM (Pricing to Market) model, created on the maximization of consumer's utility. A simple monetary model with price flexibility and the (Dornbusch, 1976) (or Mundell-FlemingDornbusch model), are actually obtained by combining the monetary equilibrium with the adjustment of price and the adjustment of output

toward their long run equilibrium, and can be called hybrids of monetary equilibrium with PPP or UCIRP (Kanamori& Zhao, 2006).

Depending on the hypothesis on price flexibility, monetarist models typically fall in the categories of flexible price model or sticky price monetary model (SPMM). The flexible price model assumes that PPP holds and prices are flexible and consistent with the equilibrium between the money demand and money supply. (Isard, 1995) and (J.D, 1989) U.S. federal interest rate announcement manipulates the markets around the world. Interest rate slash by U.S. Federal bank positively influence the U.S. exchange rate. Researchers have different opinions regarding the determination of exchange rates. There are few who believe exchange rate is determined by interest rate parity (Suthar, 2008), (Haque M.A, 2008).

According to studies done in Kenya the effect of maintaining foreign exchange within a certain level is at a cost of high interest rate. Exchange rate has been stabilized in the short run but at the cost of high interest rates. On the other hand, domestic interest rates have been pushed by the presence of a large and growing domestic debt (Ndungu, 2000).

The paper by Were et al.(2013) investigates exchange rate determination in Kenya using vector error correction model approach to uncover the long run relationships. The empirical results show that current account balance has a role to play in the determination of the exchange rate. Applied studies tend to adopt the SPMM approach by using the UCIRP specification. However, formulation for the exchange rate equation need not include money or domestic output based on the argument that these correlations are embodied in the price level adjustment mechanism (Rogoff, 1996), and (R.W, 1999). This leads to the specification of the form:

$$s_t = \beta_0 + \beta_1 (i_t - i^*_t) + \beta_2 (p_t - p^*_t) + u_t \qquad (a)$$

Where s = nominal exchange rate

$(i_t - i^*_t)$ =domestic and foreign rates of interest respectively

$(p_t - p^*_t)$ = domestic and foreign rates of inflation respectively.

A positive and a significant β_i will indicate that the exchange rate will appreciate with an increase in the value of the independent variables, while a negative β_i denotes that exchange depreciates with a decrease in value of the said independent variables. That is β_1 is < 0 which implies an appreciation under the assumption that prices are sticky and β_2 is > 0.

According to Blanchard, Amighini, & Giavazzi (2012), interest rate is determined by the equilibrium condition that the supply of money be equal to the demand for money. For a given supply of money, an increase in income leads to an increase in the demand for money and an increase in interest rate. An increase in supply of money leads to a decrease in the interest rate. Interest rates play a key role in two very important relationships in macroeconomics, i.e., the Fisher hypothesis (FH) and uncovered interest rate parity (UCIRP). The former links nominal rates to expected inflation, requiring full adjustment of these two variables in the long run and implying stationary I(0) of ex-ante interest rates (a crucial variable for understanding investment and saving decisions as well as asset price determination). In the absence of a one-to-one adjustment, permanent shocks to either inflation or nominal rates would have permanent effects on real rates as well, which would be inconsistent with standard models of inter-temporal asset pricing. (Mishkin,1990). More evidence is available in the case of Kenya, Musila (2002) applied co-integration methods to develop a macro model for forecasting purposes. Ndungu (2000) examined the relationship between exchange rates and interest rate differentials in Kenya using a time-varying parameters approach. Finally, in a more recent paper, Odhiambo (2009) investigated the impact of interest rate reforms on financial deepening and economic growth in Kenya. He found a positive relationship in both cases using standard (I(0)/I(1)) co-integration techniques

A number of hypotheses support the existence of a nexus between interest rates and exchange rates. These are mainly the classical economic parity theorems. The decision whether to invest abroad or at home depends on more than interest rates. It also depends on the expected movements in the exchange rate in the future (Blanchard et al.2012). Purchasing power parity (PPP) is a theory which states that exchange rates between currencies are in equilibrium when their purchasing power is the same in each of the two countries. This means that the exchange rate between two countries should equal the ratio of the two countries' price level of a fixed basket of goods and services. When a country's domestic price level is increasing (i.e., a country experiences inflation), that country's exchange rate must depreciate in order to return to PPP (Rogoff, K 1996)

The PPP condition is perhaps one of the most prominent and a key building block under the monetary models of exchange rate determination. PPP posits that goods market arbitrage will over time move the exchange rate so that prices in two countries are equalized. In essence, the fundamental value of the nominal exchange rate is based on relative consumer price indices. The PPP has been used both as a model of exchange rate in its own right and as a component in monetarist models of exchange rate determination. (M.Were, A.W.Kamau, & K.N.Kisinguh, 2013).The interest parity theory was developed by John Maynard Keynes in 1923 to link the exchange rate, interest rate and inflation. As early as the gold standard period, monetary policy makers found that exchange rates were influenced by changes in monetary policy. The rise of home interest rate is usually followed by an appreciation of the home currency, and a fall in the home interest rate is followed by a depreciation of the home currency implying that the price of assets plays a role in exchange rate variations (Kanamori& Zhao, 2006). The International Fisher Effect (IFE) explains the rate differentials of two countries and changes in their expected exchange rates (Utami & Inanga, 2009).The foreign currencies having high interest rate tend to depreciate because nominal interest rate reflects the expected rate of inflation. Too abrupt change in the value of its currency, it is feared, could imperil a nation's export industries (if the currency appreciates) or leads to higher rate of inflation (if the currency depreciates).Exchange rate uncertainty reduces economic efficiency by acting as a tax on trade and foreign investment. The International Fisher Effect (IFE) theory suggests that foreign currencies with relatively high interest rates will tend to depreciate because the high nominal interest rates reflect expected rate of inflation (Madura, 2010). The International Fisher effect is known not to be a good predictor of short run changes in spot exchange rates (Obstfeld, June 1981). Using quarterly and yearly data for the interest rates, inflation rate differentials, and changes in exchange rates over a five-year period, 2003-2008, (Utami & Inanga, 2009) applied a test of the IFE to four "foreign countries", namely, the USA, Japan, Singapore, and the UK. Indonesia was the "home country". Regression results showed that interest rate differentials had positive but no significant effect on changes in exchange rate for the USA, Singapore, and the UK relative to that of Indonesia. On the other hand, interest rate differentials had negative significant effect on changes in exchange rates for Japan. Once again, we see mixed results with evidence of IFE holding (though statistically not significant) for the USA, Singapore and UK pairing with Indonesia, while not holding for Japan pairing with Indonesia. This inconsistency may be explained by the fact that there is a whole host of factors that could cause exchange rates fluctuations. Thomas (1985) conducted a test of the IFE theory by examining results of purchasing future contracts of currencies with higher interest rate that contained discounts (relative to the spot rate) and selling futures on currencies with low interest rate that contained premiums. Contrary to the IFE theory the study found that 57 percent of the transactions created by this strategy were profitable. The average gain was higher than the average loss. If the IFE theory holds, the high interest rate currencies should depreciate while the low interest rate currencies should appreciate, therefore yielding insignificant profits by the transactions.

In a different but related study, Cheung, Hung-Gay, Kon, & Wai-Chung (1995) found more positive evidence for the support of the PPP hypothesis. Using reduced rank cointegration analysis, they found that the currency realignments of the European Monetary System (EMS) have been effective in maintaining PPP among its member countries. They attribute the difference in their findings to the statistical technique employed for the study. In view of the above, it is one of the objectives of this paper to examine the International Fisher Effect theory as relevant to Kenya.

Blanchard,et al.(2012) give the relation between the domestic nominal interest rate and the foreign nominal interest rate and the expected rate of appreciation of the domestic currency as long as the interest rates and the expected rate of depreciation are not too large – say below 20% per year.

Ndungu (2000) analyzed the relationship between movements in the real exchange rate and the real interest rate differential. The findings of the study indicate that the nominal exchange rate deviates from the expected long run equilibrium level. The deviations from the long run equilibrium level are governed by interest rate differential. Domestic and external shocks have an effect on real exchange rates and interest rate differential. Consequently, capital flows increase in the economy. The policy implication of the study is that attempts to close the gap in lowering the interest rates results in exchange rate depreciation. The researcher suggests non-intervention to the exchange rate markets. Gould & Kamin (1999) argue that during financial crises, changes in interest rates do not have a significant impact on exchange rates. This implies that adjusting interest rates to stabilize exchange rates during financial crises may not yield the desired results.

The conceptual framework is as outlined below indicating the inter-relationship amongst the local interest rate, foreign interest rate and the exchange rate in Kenya. The concept in the model is derived from the objectives of this research paper on the effects of interest rates on the exchange rate.

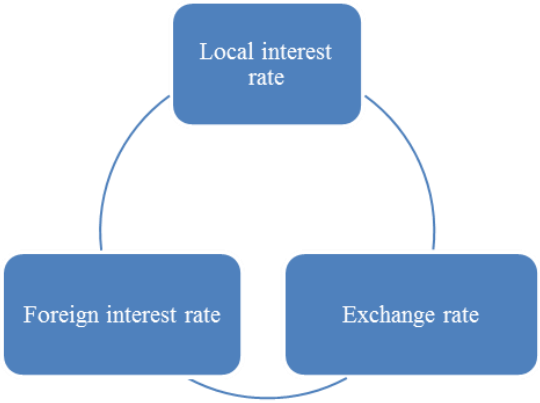


Figure 2: Conceptual Model

A non-directional cyclical model is used since the analysis will indicate where there is a significant impact of one variable to the other and as well explaining the direction of causality amongst the same variables.

This chapter is a collection of opinions of past researchers and thus details on how interest rates affect exchange rates. The literature reviewed in this section focuses on analysing the existence of a relationship between interest rates and exchange rates covering the classical parity theorems and more importantly on the International Fishers effect theory. This has resulted in the conceptual model as outlined in figure 2.

3. RESEARCH METHODOLOGY

The study will employ descriptive research design. According to (Cooper & Schindler, 2003) descriptive research, describes data and characteristics about the population or phenomenon being studied. It is concerned with how one variable affects or is responsible for changes in another variable. These variables are the local interest rate, foreign interest rate and exchange rate. Therefore, the study will focus on understanding, explaining, predicting and controlling relationships among the mentioned variables using a VAR approach.

Sims (1980) provided a new macro econometric framework that held great promise, vector auto regressions. A VAR is a n equation, n variable linear model in which each variable is in turn explained by its own lagged values plus current and past values of the remaining n-1 variables. This simple framework provides a systematic way to capture rich dynamics in multiple time series. VAR's held out the promise of providing a coherent and credible approach to data description, forecasting, structural inference and policy analysis.

The mathematical formulation of a VAR is :

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + Bx_t + \varepsilon_t$$

Where y_t is a vector of endogenous variables, x_t is a vector of exogenous variables, and $A_1 \ldots A_p$ and B are matrices of coefficients to be estimated, and ε_t is a vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values. A VAR will be applied to answer the first two objectives of this research by use of unit root tests, autocorrelation analysis, residual diagnostics tests and vector auto regression models to estimate this relationship. For the causality, the Granger Causality test will be applied. We will also empirically test the IFE model as is applicable to Kenya as the home country and the United States as the foreign country. The last objective will be addressed by applying tests of International Fisher Effect (IFE) between Kenya and the United States of America. Ordinary least squares regressions will be run on the historical exchange rates and the nominal interest rates of both the local and foreign interest rates.

Following (Madura, 2010), statistical tests of IFE among selected countries were conducted. Ordinary Least Squares regressions were run on historical exchange rates and nominal interest rates. The equations follow from the assumptions that the effective (exchange rate adjusted) return on a foreign bank deposit (or any money market security) is:

A. $r = (1 + i_f)(1 + e_f) - 1$ **(b)**

Where: i is the foreign interest rate, and

e_f is the percentage change in the value of the foreign currency denominating the security. The equation (b) states that the actual or effective return on a foreign money market security depends on foreign interest rate (i_f), as well as the percentage change in the value of foreign currency (e_f) denominating the security. Furthermore, the investors who invest in the money market at the home country is expected to receive the actual rate of return which is simply the interest rate offered on those securities. In accordance with the International Fishers Effect (IFE) the effective return on a home investment (i_h) should on average be equal to the effective return on a foreign investment (r), $r = i_h$

Substituting equation (b) for r, the equation becomes:

$(1 + i_f)(1 + e_f) - 1 = i_h$ **(c)**

Solving for $_f$: $e_f = [(1 + i_h)/(1 + i_f)] - 1$ **(d)**

When $i_h > i_f$, e_f will be positive. This means that the foreign currency will appreciate when the home interest rate is greater than the foreign interest rate. Conversely when $i_h < i_f$, e_f will be negative. That is, the home currency will appreciate when the home interest rate is smaller than the foreign interest rate. It should be recalled that the difference in the nominal interest rate between countries is due to differences in expected inflation rates assuming that the real rate of return is equal across countries (Shalishali, 2012).

It should also be recalled that the PPP theory suggests that the currency of a country with a higher inflation rate will depreciate by the amount of inflation differential. Therefore, the country with a higher interest rate will experience depreciation in the value of its currency by the amount of interest rate differential which will consequently negate any gains by investors who invested in the securities of those countries due to a higher interest rate. Eventually, the return on investment in respective countries will be similar. For detailed information on derivation of this equation, see (Madura, 2010).The model specification (e) below will be used. The model will be subjected to an Ordinary Least Square (OLS) linear regression. Before the regression, a test on the individual variables will be run to be able to establish their times series properties. This study has made use of time series data and will therefore conduct stationarity tests to indicate whether the variables have unit roots. This is a standard procedure conducted to ensure that the series has got constant mean and variance so that the regression results are not spurious.

To test for the International Fisher's Effect (IFE), the percentage change in currency is regressed against the nominal interest rate differential among the selected countries. That is, the home country verses the foreign country. Thus, the regression equation is as follows:

$e_f = a_0 + a_1 [[(1 + i_h)/(1 + i_f)] - 1] + \mu$ **……(e)**

Where, $_0$= constant , a_1= slope coefficient, and μ = error term

The hypothesized values of a_0 and $a_1$are 0 and 1, respectively, implying an equal offsetting average percentage change in the exchange rate for a given interest rate differential. Each coefficient is divided by its standard error. The level of significance is determined by the critical t-value from the table based on the number of observations and degrees of freedom (Gujarati & Potter, 2009)

SERIAL NO.	VARIABLE	DESCRIPTION AND MEASUREMENT	
1.	Exchange Rate	The exchange rate established on currency financial markets without adjustment for inflation. The Kenya shilling relative to the US dollar.	KES/USD
2.	Home or local interest rate	Domestic rates of interest. The official interest rate is the CBR rate but the 91 Treasury Bill rate will be used	91 Treasury Bill rate (%)
3.	Foreign interest rate	Foreign rates of interest. The short term London Inter-Bank Offer Rate (LIBOR) based on the US dollar.	LIBOR (%)

The study will rely exclusively on secondary data.(Atindehou & Gueyie, 2001) claim that there is little difference between nominal and real exchange rates because they are highly correlated. Thus, if the changes for nominal and real exchange rates were almost perfectly correlated, then the use of either one would have similar impact on exchange rates. Moreover, real exchange rate data are unavailable at a monthly frequency. So, the study will use nominal exchange rates, which were available on a monthly basis.

Econometric procedures will be fully employed due to the research design used. Specifically these statistics will include VAR and OLS regressions (capturing the relationship between the dependent and independent variables and subsequent significance). Presentation will be done mainly by use of tables and figures. The study will utilize E-views and MS-Excel in analyzing and sorting various data. E-views is employed due to its powerful analysis potential. MS-Excel will be vital in the preparation of graphs and manipulation of the raw data.

4. RESEARCH FINDINGS

This section outlines the data analysis process and also presents the research findings. It indicates tests for unit roots, lag order selection criterion, residual correlation analysis, VAR to estimate the short run equation in the individual variables and causality tests for causal relationships. The section will also describe residual diagnostics. Finally it will also indicate the test results on International Fisher's Effect.

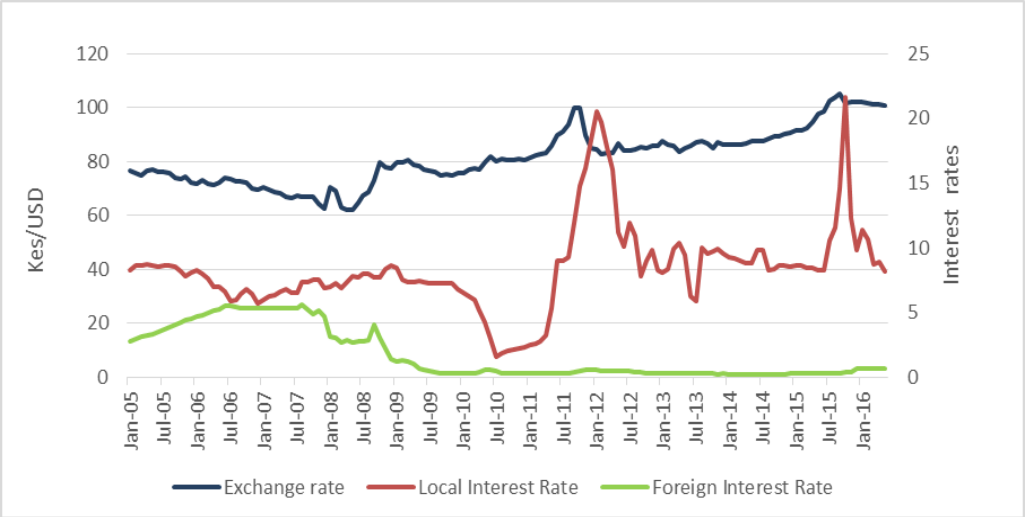


Figure 3: Trend of exchange rate and both local and foreign interest rates

From figure 3 the exchange rate and the local interest rate seem to have a general trend with one being a mirror of the other while the foreign interest rate seems relatively stable over the same period.

Most economic and financial time series exhibit trending behaviour in the mean. An important econometric procedure is to determine the most appropriate form of trend in the data and seeking ways to remove this trend so as to have meaningful results. The ADF test was employed in this study to sort out the time series data issue on stationarity. The test results show that exchange rate, local interest rates and foreign interest rates are non-stationary at level at 1%, 5% and 10% significance levels. However when these variables are tested at first difference the series becomes stationary using Augmented Dickey Fuller test as per table 4.2

Table 4.2 Results of the ADF test at first difference.

Level of Significance	***Exchange rate***	***Local interest rate***	***Foreign interest rate***
a) ADF Test	*-9.226945*	**-5.866791**	**-9.595935**
1% Critical Value	-2.582204	-2.582465	-2.582204
5% Critical Value	-1.943210	-1.943247	-1.943210
10% Critical Value	-1.615145	-1.615122	-1.615145
b) Level of Integration	***I (1)***	***c) I (1)***	***d) I (1)***

The exchange rate, local interest rate and foreign interest rate are therefore non stationary at level. However, these variables are stationary in first difference. Having concluded that the time series for these variables are non-stationary the

study proceeded to make the variables stationary before estimation of the results. Taking the first difference in the non-stationary variable makes all of them stationary as per the results in Table 4.2. Now, since all the variables are now stationary at first difference, it implies that estimation results will not be spurious.

This lag order selection criterion is arrived at by looking at the lag that has been identified by the Akaike information criterion as the optimal lag. Table 4.3 has outlined different criteria that have looked at the optimal lag in this system of equations.

Table 4.3 Results of the VAR Lag Order Selection Criteria

Lag	**LR	Final Predition Error	Akaike information criterion	Schwartz information criterion	Hannan-Quinn information criterion
0	NA	6.13e-09	-10.39682	-10.33031*	-10.36980*
1	20.04952	6.00e-09	-10.41768	-10.15165	-10.30959
2	11.65647	6.27e-09	-10.37369	-9.908139	-10.18453
3	22.73330*	5.96e-09*	-10.42519*	-9.760118	-10.15496
4	1.678896	6.76e-09	-10.30013	-9.435535	-9.948827
5	11.53446	7.03e-09	-10.26267	-9.198553	-9.830297
6	7.915549	7.55e-09	-10.19509	-8.931456	-9.681652
7	8.293321	8.06e-09	-10.13307	-8.669907	-9.538555

* indicates lag order selected by the criterion

** LR : sequential modified LR test statistic (each test at 5% level)

From the results in table 4.3 we estimate a VAR with a lag of three periods since the third lag returned the highest number of significant causal relationships based on the Akaike information criteria that had the least value. It was therefore considered as the optimal lag for this test. After getting the results on the optimal lag we then establish the estimates of the VAR system with three lags. The results for the estimates on these variables are shown on the table below Table 4.4

Table 4.4 Estimates of the VAR model

Lag Order	D(Exchange Rate)	D(Local Interest Rate)	D(Foreign Interest Rate)
D(Exchange Rate(-1))	0.299898	0.001032	6.46E-06
	(0.09043)	(0.00067)	(0.00012)
	[3.31650]	[1.53719]	[0.05508]
D(Exchange Rate(-2))	-0.195154	0.000156	-6.07E-05
	(0.09189)	(0.00068)	(0.00012)
	[-2.12372]	[0.22905]	[-0.50956]
D(Exchange Rate(-3))	0.156687	0.002186	-3.81E-05
	(0.08886)	(0.00066)	(0.00012)
	[1.76332]	[3.31501]	[-0.33053]
D(Local Interest Rate(-1))	-9.843358	0.138126	0.001125
	(11.4035)	(0.08463)	(0.01479)
	[-0.86319]	[1.63207]	[0.07608]
D(Local Interest Rate(-2))	-8.232133	-0.247002	0.008935
	(11.2370)	(0.08340)	(0.01457)
	[-0.73259]	[-2.96176]	[0.61310]
D(Local Interest Rate(-3))	8.211763	0.238761	0.001461
	(11.4340)	(0.08486)	(0.01483)
	[0.71819]	[2.81361]	[0.09855]
D(Foreign Interest Rate(-1))	144.4203	-0.045775	0.166737
	(70.8093)	(0.52552)	(0.09183)
	[2.03957]	[-0.08710]	[1.81565]
D(Foreign Interest Rate(-2))	44.18109	0.179460	0.032800
	(72.6661)	(0.53930)	(0.09424)
	[0.60800]	[0.33276]	[0.34805]
D(Foreign Interest Rate(-3))	-51.13865	0.173464	0.028498
	(71.4621)	(0.53037)	(0.09268)

	[-0.71561]	[0.32707]	[0.30749]
C	0.156935	-0.000675	-0.000131
	(0.16950)	(0.00126)	(0.00022)
	[0.92584]	[-0.53662]	[-0.59700]
R-squared	0.153626	0.188524	0.041172
Adj. R-squared	0.091696	0.129147	-0.028986
Sum sq. Resids	453.8151	0.024996	0.000763
S.E. equation	1.920821	0.014256	0.002491
F-statistic	2.480646	3.175063	0.586844
Log likelihood	-270.3370	381.8093	613.8165
Akaike AIC	4.215594	-5.591118	-9.079947
Schwarz SC	4.432913	-5.373798	-8.862628
Mean dependent	0.182173	-3.98E-05	-0.000190
S.D. dependent	2.015447	0.015276	0.002456
Determinant resid covariance (dof adj.)		4.38E-09	
Determinant resid covariance		3.47E-09	
Log likelihood		729.2927	
Akaike information criterion		-10.51568	
Schwarz criterion		-9.863721	

T-statistics in [ ] and standard errors in ( ).A t-statistic with an absolute value greater than two indicates that the variable is significant. From the table 4.4 we are able to establish the significant variables with a t-statistic whose absolute value is greater than two and noted the following; changes on the exchange rates are sensitive to all its past values upto the second lag but with varying degrees with the past one month value having the most significance followed by the past two months. The change on exchange rate is also sensitive to the first lag or previous month change on the foreign interest rate.

In addition the changes to the local interest rate are sensitive to the past exchange rate in the third lag, that is, the past three months, and also changes on its second and third lagged values with the both months having a significance level. In conclusion, changes on the foreign interest rate are not sensitive to changes on any of the other variables including its own lagged values. We then proceed to compute the VAR residual correlation LM test. This will test the null hypothesis that there is no residual serial correlation at lag order 3 as shown in Table 4.5 below. It will be able to indicate whether the VAR system upto the third lag is able to capture the dynamics in the changes in the variables. If that is the case, then the residuals in the VAR system should not be auto-correlated.

Table 4.5 Results of the tests on the VAR system residual serial correlation LM Tests.

Lags	LM-Stat	Prob
1	1.938560	0.9924
2	10.12761	0.3403
3	9.467592	0.3953
Probs from chi-square with 9 df.		

The first test informs us whether the first order auto correlation is significant ,also the second test tells us whether the second order auto correlation is significant and finally the third test tells us whether the third order auto correlation is significant. From the results above, since all tests have p-values greater than five percent, these show that there is no serial correlation in the residuals at all the three lags and implies that the VAR system of equations is sufficient to capture the dynamics of the regression. The stability of a VAR system is established by computing the complex roots of the characteristic polynomial. If all the roots of the system lie within the unit circle then we assume the VAR system is stable. Stability or stationarity of the VAR system ensures that standard errors for impulse response functions are valid and deductions on the impulse response functions would not be spurious.

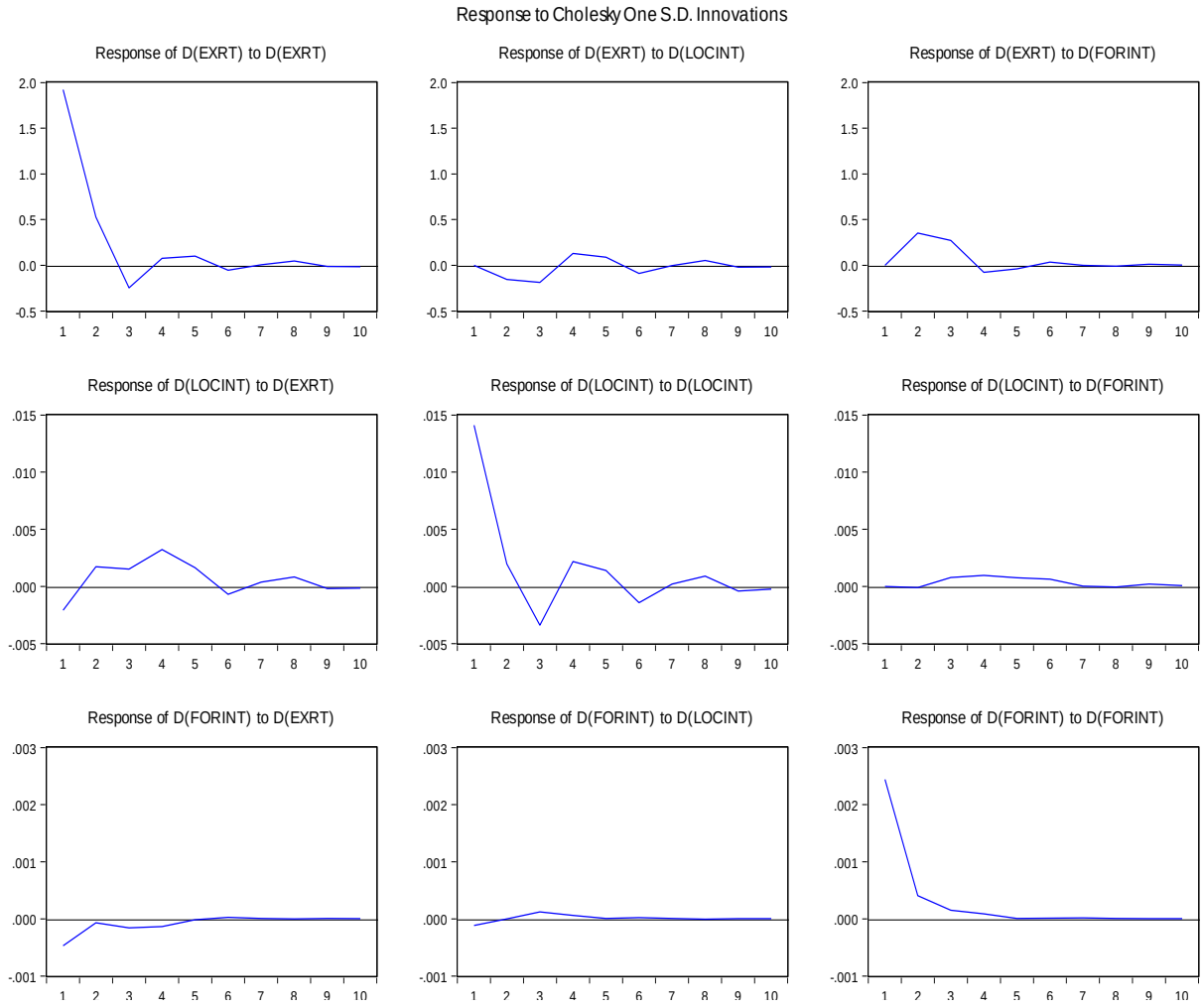
Table 4.6 Results on the stability of the VAR system.

Roots of Polynomial	Modulus
-0.226401 - 0.709160i	0.744423
-0.226401 + 0.709160i	0.744423
0.594005	0.594005
0.462728	0.462728
-0.140867 - 0.359210i	0.385843

-0.140867 + 0.359210i	0.385843
0.169373 - 0.321132i	0.363061
0.169373 + 0.321132i	0.363061
-0.056181	0.056181

We look at all the modulus of the roots of the system to establish if the VAR system is stable. If the absolute values of the complex roots are less than one or if they lie within the unit circle, then we conclude that the system is stable. From the results above since no root lies outside the unit circle, this assures us that the VAR system is stable. Therefore, using lag three there was no statistically significant evidence of auto correlation, heteroscedasticity, or non normality in the residuals from the model. After applying all the diagnostics on the VAR system we then proceed to interpret this system to come up with meaningful results.

Interpretation of the system is done by impulse response graphs based on the cholesky decomposition. Impulse responses trace out the response of current and future values of each of the variables to a unit increase in the current value of one of the VAR structural errors, assuming that this error returns to zero thereafter.



The cholesky decomposition above orders the variables in the system from the exchange rate first then to the local interest rate and finally to the foreign interest rate.

The first row shows the responses of the change in the exchange rate to first shocks in the change in exchange rate followed by shocks in the change to the local interest rate and finally to shocks of changes on the exchange rate to the changes in foreign interest rate. The second row shows the responses to changes in the local interest rate first to shocks to the exchange rate followed by the responses to shocks in the local interest rate and finally responses of shocks on the local rate to changes on the foreign interest rate. The third row shows the responses to shocks on the foreign interest rate first to changes in the exchange rate followed by the responses to shocks in the local interest rate and finally responses of changes on the exchange rate to the foreign interest rate.

From the impulse responses above, a one standard deviation change in the exchange rate produces a two hundred basis point positive change on itself in the next one month that gradually clears in the following two months with this effect completely clearing off after three months. This also has a corresponding effect on changes to the local interest rate with the most impact being felt after four months with a one standard deviation change on the exchange rate resulting in corresponding thirty basis points change on the local interest rate. This effect clears off after seven months. In the second row the results show one standard deviation changes on the responses of local interest rates to the other variables that are, exchange rate and the foreign interest rate and the changes on itself. A one standard deviation change on the local interest rate only has an impact on the changes on the exchange rate in the fourth month only to almost half a basis point which then clears off. The other shocks are not significant. The last row indicates a unique phenomenon in that, changes on the foreign interest rate has an impact only on its future values but has no significant impact on the other variables in this study, that is the exchange rate and the local interest rate. A one standard deviation change on the foreign interest rate has 0.3 percentage changes on the next month's foreign interest rate that clears off after the fifth month. The impulse responses are able to inform us of the likely impact of one standard deviation changes of one variable against the other variables and also on its own past values. The following table presents the results of the granger causality test. The VAR granger causality test was used at various lags. The third lag resulted in the highest number of significant causal relationships based on the Akaike Information criterion as per table 4.3 The variable was used at first difference to ensure that all variables are stationary.

Table 4.7 Results on Granger Causality test on the VAR model

Dependent Variable : D (Exchange Rate)			
Excluded	Chi-sq	Degrees of Freedom	Probability
D(Local Interest Rate)	2.131563	3	0.5456
D(Foreign Interest Rate)	5.409239	3	0.1442
All	8.035093	6	0.2355

Dependent Variable : D (Local Interest Rate)			
Excluded	Chi-sq	Degrees of Freedom	Probability
D(Exchange Rate)	14.00696	3	0.0029
D(Foreign Interest Rate)	0.267525	3	0.9660
All	14.58295	6	0.0238

Dependent Variable : D (Foreign Interest Rate)			
Excluded	Chi-sq	Degrees of Freedom	Probability
D(Exchange Rate)	0.500898	3	0.9187
D(Local Interest Rate)	0.415907	3	0.9369
All	0.933367	6	0.9880

The granger causality test looks at the null hypothesis, H_0: There is no causality between the dependent variable against the independent variable while the alternative hypothesis, H_1: There is causality between the independent variables and the dependent variable. In this case since all variables have lagged values, it would include all the lagged values of the variable all together. A p-value of less than five percent means that we reject the null hypothesis while a p-value of more than five percent means that we do not reject the null hypothesis.

The results shown above indicate that changes on the local interest rate do not granger cause changes on the changes on the exchange rate and also changes on the foreign interest rates do not granger cause changes in the exchange rate. In addition, changes on both the local and foreign interest rates jointly do not granger cause changes on the exchange rate. Subsequently, changes on exchange rate does granger cause changes in the local interest rate while changes on the foreign interest rates do not granger cause changes in the local interest rate. However, changes on both the exchange rate and foreign interest rate jointly do granger cause changes on the local interest rate. Finally changes on exchange rates do not granger cause changes in the foreign interest rate while changes on the local interest rates do not granger cause changes in the foreign interest rate. In addition, changes on both the exchange rate and local interest rate jointly does not granger cause changes on the foreign interest rate.

To test for the International Fisher's effect, the percentage change in currency is regressed against the nominal interest rate differential among the selected countries. That is, the home country verses the foreign country. Thus, the regression equation is as follows:

B. $e_f = a_0 + a_1 [[(1 + i_h)/(1 + i_f)] - 1] + \mu$ .....(f)

where,

a_0= constant

a_1= slope coefficient,

μ = error term

The hypothesized values of a_0 and $a_1$are 0 and 1, respectively, implying an equal offsetting average percentage change in the exchange rate for a given interest rate differential. Each coefficient is divided by its standard error. The level of significance is determined by the critical t-value from the table based on the number of observations and degrees of freedom (Gujarati & Potter, 2009).

In order to have results that are not spurious, unit root test were conducted on the respective variables, that is, the exchange rate and the IFE. The ADF was again used to ensure that the data used was stationary. The results are outlined in the table 4.4

Table 4.6 ADF Tests on IFE variables

a) Test Statistic	*Foreign Currency*	*IFE*
b) ADF Test	*c) -12.02291*	**-5.379041**
1% Critical Value	-2.602794	-2.602185
5% Critical Value	-1.946161	-1.946072
10% Critical Value	-1.613396	-1.613448
d) Level of Integration	***e) I (1)***	***f) I (1)***

Both variables were tested using the ADF test and both were non stationary at level. However, the variables were stationary at the first difference with the test results indicated on table 4.6 The resulting regression model on the International Fishers Effect is outlined below:

$e_f = 0.893 + 0.104 [[(1 + i_h)/(1 + i_f)] - 1] + \mu$

Since the results from the regression on the IFE have given different results from what had been hypothesised, where the co-efficient, a_0 =0.893 and a_1 = 0.104 then we are able to establish that the International Fishers effect does not apply to Kenya with respect to the United States.

5. SUMMARY AND CONCLUSION

From the VAR estimates analysis we are able to establish that changes on the exchange rates are sensitive to all its past values upto the second lag but with varying degrees with the past one month value having the most significance followed by the past two months. The change on exchange rate is also sensitive to the first lag or previous month change on the foreign interest rate. In addition the changes to the local interest rate are sensitive to the change in exchange rate in the third lag that is, the past three months and also changes on its own lagged values in the second and third month. In concluding the VAR estimates analysis, changes on the foreign interest rate are not sensitive to changes on any of the other variables including its own lagged values. In predicting the impact of changes on the variables an impulse response mechanism was applied. The research found out that, a standard deviation change in the exchange rate produces a two hundred basis point positive change on itself in the next one month that gradually clears in the following two months with this effect completely clearing off after three months. This also has a corresponding effect on changes to the local interest rate with the most impact being felt after four months with a one standard deviation change on the exchange rate resulting in corresponding forty basis points on the local interest rate. This effect clears off after a month. A one standard deviation change on the local interest rate only has an impact on the changes on the exchange rate in the fourth month only to almost half a basis point which then clears off. Changes on the foreign interest rate has an impact only on its future values but has no significant impact on the other variables in this study, that is the exchange rate and the local interest rate. A one standard deviation change on the foreign interest rate has changes on the next month's foreign interest rate that clears off

after the fifth month. We are also able to establish through the empirical analysis on granger causality that changes on the local interest rate do not granger cause changes on the changes on the exchange rate and also changes on the foreign interest rates do not granger cause changes in the exchange rate. In addition, changes on both the local and foreign interest rates jointly do not granger cause changes on the exchange rate. Subsequently, changes on exchange rate does granger cause changes in the local interest rate while changes on the foreign interest rates do not granger cause changes in the local interest rate. However, changes on both the exchange rate and foreign interest rate jointly do granger cause changes on the local interest rate. Finally changes on exchange rates do not granger cause changes in the foreign interest rate while changes on the local interest rates do not granger cause changes in the foreign interest rate. In addition, changes on both the exchange rate and local interest rate jointly does not granger cause changes on the foreign interest rate. The research has also been able to establish that the International Fishers effect does not apply to Kenya with respect to the United States. These findings are important in predicting the impact of changes amongst the variables in the short run. This study had set out to study the causal effect of an intervention in X on future instances of Y and has applied the use of vector auto regressions to look into the impact of exchange rates on both local interest rates and the foreign interest rates, impact of the local interest rates on the exchange rate and foreign interest rate and finally the impact of the foreign interest rates on the exchange rate and the local interest rate. It has also established the direction of causality and concluded that a change on the exchange rate does cause changes on the local interest rates and not that a change on the local interest rate causing changes on the exchange rate. In addition, there is a joint causality by both changes on the exchange rate and foreign interest rate in causing changes on the local interest rate. Results from the empirical analysis also provide evidence on the direction of causality amongst the variables. It is of interest to note that the direction of causality is uni-directional between the exchange rate and the local interest rate where the exchange rate only causes a change on the local interest rate and not vice versa. There is also a unidirectional effect on the local interest rates jointly by the exchange rate and foreign interest rate. Depending on the structure of an economy, policy analysts may want to target a given level of interest rate to encourage investments but they may also want to know the likely effect it may have on the exchange rate and thus the competitiveness of the same local economy to the external environment. However, this model only looks at the short-run effects while other models may be adopted to look at the long-run effects. In conclusion, this research paper concurs with other researcher papers that a relationship between interest rate differentials and subsequent changes in the exchange rate seem to exist.

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