SHORT TERM CAPITAL FLOWS AND PRESSURE ON THE EXCHANGE RATE IN KENYA

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Abstract

Using the Bayesian vector auto-regression methodology, we have empirically analyzed the causal relationship between the Kenya Shilling-USA Dollar exchange rate and net short term capital inflows. The impulse response results show, rather surprisingly, that a positive standard deviation shock to net short term capital inflows exerts an immediate statistically significant depreciating effect on the Shilling-USD Dollar exchange rate. The depreciating effect is followed by a gradual correction whereby the exchange rate appreciates relative to the initial depreciating effect. This result suggests that the Shilling-USA Dollar exchange rate movements, consequent to a shock in short term net capital inflows which is essentially a nominal shock, is consistent with the exchange rate overshooting phenomenon. We also find, based on the corresponding variance decomposition results, that net short term capital inflows play a limited direct role in explaining exchange rate movements. In contrast, a positive standard deviation shock to the risk adjusted interest rate differentials leads to an immediate and statistically significant appreciation effect, which is fully corrected for automatically within a year, on the Shilling-USA Dollar exchange rate. The corresponding variance decomposition results show that 71.4% of the one-period-ahead forecast error in the exchange rate are due to the risk adjusted interest rate differentials thereby suggesting that the risk adjusted interest rate differentials are the single most important factor exerting pressure, both directly and indirectly through net short term capital inflows, on the Shilling-USA Dollar exchange rate in Kenya.

JEL Classification: E44, F41, F42, G15

Key Words: Bayesian vector auto-regression methodology, net short term capital inflows, impulse response functions, variance decomposition, risk adjusted interest rate differentials.

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1. Introduction

There is no doubt that empirical analysis of the impact of capital flows on exchange rates continues to be an exciting and relevant theme considering the increased economic interdependence among countries. More recently, interest in researching on the implications of capital flows for currency exchange rates has been rekindled by observed and anticipated net capital flows between emerging and developing countries, and industrialized countries. Following the global financial and economic crises of 2007, whose epicenter was the USA, there was resurgent net capital flows from industrialized countries to emerging and developing countries. As the economic prospects of the industrialized countries improve, evidence of reversal in net capital flows is mounting amid appreciation of the affected emerging and developing countries’ currencies.

Concern about currency exchange rates derives from these asset prices’ economic implications. As a relative price of foreign exchange in terms of the domestic currency, the nominal exchange rate can significantly influence the volume of international trade and overall macroeconomic performance. As discussed in Edwards (1989), structural exchange rate misalignment is a price distortion which leads to resource misallocation in a country and across countries. As a relative price of a country’s bundle of imported goods and services in terms of bundles of the country’s exported goods and services, the real exchange rate is a critical element in determining the country’s international trade competitiveness. Moreover, excessive exchange rate volatility has been likened to an implicit tax on international business transactions it therefore has the potential to reduce the volume of international trade with adverse multiplier effects for sustainable economic and human development.

It is not surprising, therefore, that a competitive exchange rate is one of the most important policy objectives pursued by most open economies. So important is the objective of competitive exchange rates that without sufficient exchange rate policy coordination and surveillance among trading partner countries, the stability of the global financial system can be jeopardized should countries resort to competitive exchange rate devaluation (or depreciation) and/or imposition of foreign exchange and exchange controls. For the avoidance of such disruptive commercial policies, most countries are agreed on ensuring orderly foreign exchange rate adjustment under the auspices of the International Monetary Fund.

Orderly exchange rate adjustment however entails continuous assessment of the real value of the currency exchange rates as well as analyzing factors which influence exchange rate movements. While past research efforts have led to such important findings as the “Dutch Disease” and the trilemma of monetary policy management, the need for country-specific evidence regarding the causal relationship between capital flows and exchange rates is even greater now than ever before since, over the years, countries have opened up their capital accounts (in the balance of payments) thereby easing
restrictions on cross-border capital flows. Consequently, internationalization of international finance has assumed unprecedented volumes.

Available evidence on the impact of capital flows on major currency exchange rates show that purchases of a country’s equities lead to appreciation of the country’s currency. See, for instance, Brooks et al. (2001), Hau and Rey (2002), and Siourounis (2003). In contrast, purchases of bonds do not seem to affect the exchange rate as much. It has been explained that this is because cross-border flows associated with bond purchases are substantially hedged to the extent that their effect on currency exchange rates is equally substantially reduced. This is unlike equity capital flows which are hedged only up to 12% compared to over 90% for bond holdings (Hau and Rey, 2002).

According to Siourounis (2003), a positive standard deviation shock to net USA equity purchases leads to about 10% statistically significant appreciation of the USA Dollar for up to 13 months. Brooks et al. (2001) derive results which show that the current account deficit, which essentially reflects the volume of accommodating items in the capital and financial account, and capital flows significantly affect major currency exchange rates. They also find that bilateral interest rate differentials and relative stock returns, which are key underlying factors for capital flows, significantly influence major currencies’ exchange rates vis-à-vis the USA Dollar.

Due to the expected limited availability and relatively higher cost of financial instruments for hedging against currency risks in developing countries, we expect to find that cross-border equity and bond capital flows affect currency exchange rates differently in developing countries. This study attempts answering the question as to whether net capital inflows exerts pressure on developing countries currency exchange rates. We focus on short term net capital inflows in Kenya as the case study.

Kenya presents a suitable context within which to derive the comparative evidence because of a number of reasons. Kenya has a liberalized financial sector which has grown steadily over the last three decades. See Ndung’u and Ngugi, (1999) for a discussion of Kenya’s financial sector liberalization experience. For instance, Kenya’s capital account has remained open since the Foreign Exchange Control Act was repealed in 1995. As a member of the IMF, Kenya observes the provisions of the IMF’s Articles of Association including Article VIII which prohibits member countries from imposing unilateral restrictions on current account transactions (IMF, 2011). Kenya’s Nairobi Securities Exchange (NSE) is one of the most vibrant in sub-Saharan Africa. The NSE has an active foreign trading board through which Kenya enjoys receipt of foreign portfolio investment. Since adopting a flexible exchange regime in June 1995, Kenya has experienced episodes of elevated exchange rate volatility and misalignment and it will be informative knowing the role played by net short term capital inflows in exerting pressure on the Kenya Shilling exchange rate.
While available evidence, in for instance Ndung’u (2000) and O’Connell et al. (2010), suggest that net foreign capital inflows significantly influence the short run Shilling exchange rate movements, the evidence needed to be updated to support the Central Bank of Kenya’s policy decisions and actions regarding its participation in the domestic foreign exchange market. In the recent past, the Bank has had to take action to discipline market participants to desist from such engaging themselves in speculative activity amid protests from some players in the foreign exchange market.

In our quest to answer the general empirical question about whether or not net short term capital inflows affects developing countries’ currency exchange rates differently from the way it does for industrialized countries’ currency exchange rates, we are guided by the following two specific questions: Do changes in net short term capital inflows exert a statistically significant impact on the Kenya Shilling-USA Dollar exchange rate? What is the relative importance of net short term capital inflows in explaining the Kenya Shilling-USA Dollar nominal exchange rate fluctuations? Since these two questions are best addressed using the impulse response functions and variance decompositions, we have applied the Bayesian vector auto-regression methodology.

We have chosen the Shilling-USA Dollar nominal exchange rate as the basis of our empirical analysis mainly because the USA Dollar commands a substantial weight in Kenya’s official foreign exchange reserves. The USA Dollar is also used most in settlement of Kenya’s international financial obligations and commands the largest weight in the trade-weighted nominal and real effective Shilling exchange rates. The other consideration is that the USA Dollar is the intervention and intermediation currency in the domestic foreign exchange market.

Briefly, the impulse response results show, rather surprisingly, that a positive standard deviation shock to net short term capital inflows exerts an immediate statistically significant depreciating effect on the Shilling-US Dollar exchange rate. The variance decomposition results, however, show that net short term capital inflows play a limited direct role in explaining exchange rate movements. We also find that a positive standard deviation shock to the risk adjusted interest rate differentials has an immediate statistically significant increasing effect on net short term capital inflows. It also leads to an immediate and statistically significant appreciation effect, which is fully corrected for automatically within a year, on the Shilling-USA Dollar exchange rate. The corresponding variance decomposition results show that 71.4% of the one-period-ahead forecast error in the exchange rate is due to the risk adjusted interest rate differentials.

We have organized the remaining part of this study into 6 sections. Upon reviewing literature on exchange rate determination, we outline the Bayesian vector auto-regressive (BVAR) methodology in section 3. We then briefly explain how we take the BVAR model to Kenya’s quarterly data covering the period 2000Q1-2012Q4 in section 4. In particular, we explain the choice of variables that we have
used in the empirical analysis. We then present and discuss the empirical results in section 5 upon which we summarize the results and conclude the paper in section 6.

2. Literature Review

There are three dominant analytical frameworks to exchange rate determination: the asset price, the microstructure (or chartists), and the so called traditional economic fundamental approaches. We also have hybrids of these three. In application, these analytical frameworks can be set up either as single-equation, semi-structural or fully- fledged structural models. The choice of which set up to use will largely depend on the availability of data, the purpose for which the empirical analysis is being carried out and, above all, one’s ability to use the chosen set up.

The asset price view of exchange rate determination, which is essentially the modern view, is particularly illuminating as to how exchange rates are determined. Mussa (1984), for instance, provides an elegant illustration of this analytical framework in which the exchange rate is considered to be an asset price whose current value depends on current and expected future information about the exchange rate fundamentals. The author underlines the relative importance of expectations in exchange rate determination and therefore clarifies why the non-expectations augmented traditional exchange rate models were doomed to fail. Ideally, the asset price view of the exchange rate considers exchange rates as having two components: a current exchange rate component which essentially depends on the current values of selected exchange rate fundamentals, and a futuristic component which depends on the discounted future values of the exchange rate fundamentals. Effectively, this means that the asset price view of exchange rates is basically an extension of the traditional economic fundamentals based exchange rate models. In his illustration, Mussa (1984) invokes money market and balance of payments equilibrium to formulate an integrated monetary and portfolio balance models augmented with rational expectations.

Another important approach to exchange rate determination which became important as an alternative to the traditional exchange rate models is the microstructure approach, in which investor order flow is a critical factor in the determination of exchange rate movements. This approach has been applied successfully to explain number exchange rate movements. According to this approach, once information about investor order flows is revealed, participants in the foreign exchange market respond by buying or selling foreign exchange thereby exerting pressure on the exchange rate which has to assume a new value in light of the new information. More specifically, the microstructure approach to exchange rate determination predicts that net purchases of a country’s real assets, which are essentially accompanied with corresponding net capital inflows, induces an appreciation of the domestic currency. Just as the asset price view of exchange rate determination, extends the traditional
exchange rate models, there is a recent strand of literature, which is exemplified in Rime, Sarno and Sojli (2010), which aims to integrate microstructure and macroeconomic models.

In contrast, and to the extent that monetized net capital inflows, net short term capital inflows in particular, are essentially nominal shocks, the Dornbusch (1976) type of exchange rate overshooting model predict that net capital inflows will, on impact, cause the exchange rate to depreciate more than the exchange rate could depreciate when goods and factor prices are fully flexible in order to make up for sticky prices for the attainment of momentary equilibrium in both the financial and commodity markets during the short run. As goods prices increase gradually during the medium to long term in response to the positive nominal shock brought about by the monetized capital inflows, the exchange rate will equally gradually appreciate to eventually attain the initially overshot long run equilibrium value by which time commodity prices shall have increased proportionately to the size of the initial monetary shock. As to which between the two competing empirical outcomes best characterizes a given country, one cannot tell a priori.

During the first decade of the generalized float of the major currencies, many initiatives were taken to model exchange rate determination for a number of reasons. Chief among these reasons was the need for enhancing understanding of the factors which drove exchange rate movements so policy makers could choose appropriate measures to mitigate the adverse effects of exchange rate misalignment and/or excessive volatility. Edwards (1989) and Hinkle and Montiel (1999) provide recent discussions of the analytical and empirical models of exchange rate misalignment. Maturu (2002) provides an application to Kenya with specific reference to the period 1980-1998.

The exchange rate models of the 1970s, 1980s and the 1990s, which include the monetary model in its two variants of flexible and sticky prices, the portfolio balance model, the real interest rate differentials model and the real productivity differentials model, and which are generally referred to as traditional models of exchange rate determination were afflicted with a number of limitations. In particular, the models’ out-of-sample forecasting power was severely limited (Meese and Rogoff, 1983) to the extent that they were out-performed by the random walk representations of exchange rate dynamics. Chartists’ forecasts could also outperform exchange rate forecasts based on the traditional models. This result, that exchange rates were random walk processes, has been difficult to overturn except in isolated case such as in Koedijk and Schotman (1990) and, potentially, in Mussa (1984).

Among the reasons advanced to explain failure of the economic models of exchange rate determination is miss-specification of models whereby, for instance, linear relationships between the exchange rates selected economic fundamentals are assumed even when the true relationship is nonlinear. Lack of sufficiently long time spans of data on exchange rates and relevant economic fundamentals also severely limited efficient estimation of the traditional models when applying asymptotic estimators under classical econometrics. The success of Koedijk and Schotman (1990),
for instance, follows the authors’ adoption of two key innovations in model estimation. The authors expand the information space used to estimate the exchange rate models by exploiting the concept of cross-rates to apply panel regression analysis instead of applying ordinary regression model.

The experience of modeling exchange rates during the three decades following the generalized float identified “news”, which is the exchange rate prediction error, to be a critical factor in the determination of, especially short run, exchange rate movements. It was however a daunting task finding a pragmatic measure of the unobservable “news”. It is therefore reasonable to argue that one of the reasons why the traditional exchange rate models performed poorly in out-of-sample forecasting is misspecification of the models in terms of inadequate incorporation of expectations, if at all. This is reminiscent of the failure of large scale reduced form macroeconometric models of the 1970s (Lucas, 1976; and Lucas and Sargent, 1981). This specific limitation of the traditional economic models, in general, can be inferred from the better performance of the vintage dynamic stochastic general equilibrium (DSGE) models whose key feature is incorporation of rational expectations.

For instance, Thoenissen (2003) applies a calibrated DSGE model in which incomplete exchange rate pass-through is assumed, to find that the current account, which basically reflects capital and financial account flows, significantly impact the real exchange rate. Whether a change in the current account deficit leads to an appreciation or depreciation of the real exchange rate will depend on the home country’s initial net foreign assets position. We should emphasize that the most crucial contribution in bridging the gap between the traditional Keynesian approach to macroeconomics as encapsulated in the Mundell-Fleming model which is introduced in Mundell (1963) and Fleming (1962) and underpinned by the assumption of perfectly competitive markets, and the introduction of the new open economy macroeconomics in which markets feature friction as, for instance, shown by the Dornbusch’s exchange rate overshooting paper (Dornbusch, 1976), is the “Exchange Rate Dynamics Redux” paper of Obstfeld and Rogoff (1994). An accessible discussion of central points in the exchange rate dynamics redux paper is provided by Rogoff (2002). An important analytical result deriving from open economy DSGE models is uncovered interest parity (UIP) condition which is a critical element, if not a fundamental exchange rate model itself.

According to Evans and Lyons (2002), for instance, 60% of daily exchange rate movements are due to daily order flow between dealers. Rime (2001) also adduces evidence based on weekly order flows that is supportive of the microstructure approach and therefore collaborate the evidence in Evans and Lyons (2002). Froot and Ramadorai (2002) provides further insights regarding the role of investor order flows in driving exchange rates. It is shown that investor order flows are particularly important for short run exchange rate movements.
The microstructure approach is also used in Brooks et al., (2001) whereby an empirical analysis of the role of different types of net foreign capital inflows (as well as the role of factors that underlie capital flows) in driving selected major currency exchange rates. Based on the bivariate regression model results, that study shows that equity flows and long-run interest rate differentials significantly influenced movements in the Euro-US dollar and the Yen-US dollar bilateral exchange rates. A key limitation of the study is that simple bivariate regression models are applied in the analyses. With this kind of model, potentially useful information in the form of other factors is not controlled for in the estimated models. This raises issues of the omitted variable kind of model miss-specification. Siourounis (2003) shows how to overcome the limitation by, not only using the comprehensive VAR methodology, but also using a linear regression models in which, in addition to the equity flows, important factors known to drive exchange rates are incorporated.

Siourounis (2003) analyzes the causal relationship between capital flows and the bilateral nominal exchange rates of 5 OECD countries that cross-border equity flows predict exchange rate movements unlike cross-border bond flows which do not. It is also found that a shock to domestic equity return differentials induces short run appreciation of the domestic currency.

Most recently, Were, Kamau and Kisinguh (2013) carried out an empirical investigation of the role of the current account balance in the determination of the Kenya shilling exchange rate and find that an improvement in the current account [which reflects improvement in the net capital inflows, when accommodating flows surpass autonomous flows in the capital and financial account] is associated with an appreciation of the exchange rate. More specifically, it follows from the long run exchange rate model results that a 10 percentage point improvement in the current account balance, on average, leads to an appreciation of the shilling exchange rate by 5.9 percentage points. It can also be inferred from the study findings that an increase in real interest rate differentials [which induce improved net capital inflows] leads to an appreciation of the domestic currency.

These evidence from Were, Kamau and Kisinguh (2013) is consistent with recent developments in the shilling exchange rate. With the persistent and increasingly widening current account deficit, the shilling exchange rate has tended to depreciate in nominal terms. A study by the World Bank however predicts an appreciation of the real effective exchange rate in the last couple of years (World Bank, 2013).

The study finding in Were, Kamau and Kisinguh (2013) that real interest rate differentials play a consistent role in the determination of the shilling exchange rate is consistent with earlier evidence in Ndung’u (2000). In particular, Ndung’u (2000) finds that real interest rate differentials explain short run exchange rate movements.
The empirical results presented and discussed in O’Connell et al. (2010) show that real net foreign direct investment and portfolio flows were generally subdued during the most part of 1996-2008. And so were official development assistance flows and remittances. During the same period, short term external debt as a proportion of exports, and also as a proportion of total external debt were generally between 5-25%. Most importantly, deviations from uncovered interest parity are estimated to be largest in Kenya among comparative countries and the implication of this is that risk premium adjusted real interest rate differentials should be the better variable to apply when empirically analyzing the role of interest rate differentials (as the underlying factor for net capital inflows) in exchange rate movements.

Estimates of the foreign exchange market pressure in O’Connell et al. (2010) for the period 1996-2008 show that while the volatility in exchange rate pressure hardly exceeded 2 standard deviations, the pressure was relatively higher during national election periods. This suggests that political risks have adverse implications for exchange rate. It is explained that such political risks initially adversely impact the current account balance which in turn adversely affect the domestic foreign exchange market in terms of increased exchange rate volatility.

Applying a vector auto-regressive (VAR) model, O’Connell et al. (2010), obtain results which show that the consequent to a 1 standard deviation innovation in domestic nominal interest rates, the response of the exchange market pressure (EMP) is mixed. Moreover, a shock to the exchange market pressure (EMP) significantly and persistently increases domestic interest rates including the repo rate. This would suggest that whenever exchange market pressures mounted, the Central Bank took policy action to ease the pressure.

3. Methodology

3.1. Vector Autoregressive (VAR) Model

We assume that the economy is adequately represented by the structural model provided by (1) and which is reduced to obtain (2).

\[ Ay_t = B(L)y_{t-1} + \theta Z_t + \phi D_t + \epsilon_t; \quad \epsilon_t \sim iid(0, \Lambda) \]  
\[ y_t = C(L)y_{t-1} + \mu Z_t + \eta Q_t + u_t; \quad u_t \sim iid(0, \Sigma) \]

Whereby,

\[ C(L) = A^{-1} B(L); \]
\[ \mu = A^{-1}\theta; \]
\[ \eta = A^{-1}\phi; \quad \text{and} \]
\[ u_t = A^{-1}\epsilon_t, \quad \text{(3)} \]

The moving average representations of (1) and (2), which are provided correspondingly by (4) and (5) are useful in computing impulse responses. While (4) is the basis for generating the impulse responses of \( y_t \) with respect to shocks to components of the innovations vector, \( \epsilon_t \), (5) forms the basis for generating the impulse responses of \( y_t \) with respect to shocks to components of the regression residuals, \( u_t \). When evaluated in the current period, which is when \( s = 0 \) in (4) and (5), the impulse responses are, respectively, \( \xi_t \) and \( \phi_t \), \( \forall t = 0,1,2,... \text{steps} \) and \( \text{steps} < \infty \). Notice that in (4) and (5), \( \hat{y}_t \) is the \( nx1 \) vector of the steady state values of the endogenous variables. It is expected that \( \hat{y}_t \) is time-invariant, in spite of the attaching time index.

\[ y_t = \hat{y}_t + \sum_{s=0}^{\infty} \xi_{t-s}\epsilon_{t-s} \quad \text{(4)} \]

\[ y_t = \hat{y}_t + \sum_{s=0}^{\infty} \phi_{t-s}u_{t-s} \quad \text{(5)} \]

Ideally, the impulse responses of interest to us are \( \xi_{t-s} \), \( \forall t = 0,1,2,... \text{steps} \). However, because (1) is not directly estimable due to inadequate information, we cannot also directly estimate (4). By convention, the reduced form provided by (2) is estimated to obtain the covariance matrix, \( \Sigma \), and the vector of regression residuals, \( u_{t-s} \). These results are exploited to recover \( \xi_{t-s} \) from \( u_{t-s} \).

For any invertible matrix \( A \), (6) holds and as such we can re-write (5), using (6), to obtain (7).

\[ A^{-1}A = I \quad \text{(6)} \]

\[ y_t = \hat{y}_t + \sum_{s=0}^{\infty} \phi_{t-s}A^{-1}Au_{t-s} \quad \text{(7)} \]

Direct comparison of (4) with (7) suggests that if we were to translate (7) into (4), (8) must hold.

\[ \xi_{t-s} = \phi_{t-s}A^{-1} \quad \text{(8)} \]

\[ \epsilon_{t-s} = Au_{t-s} \quad \text{(9)} \]
When evaluated in the current period and hence at \( s = 0 \), (9) is basically the re-parameterization of the innovation vector to obtain the vector of regression residuals as provided by (3). We can therefore obtain (3) from (9) by inverting (9) and evaluating the resultant expression at \( s = 0 \). The implication of this analytical result is that the optimal choice of \( A \) in (7), in a bid to recover \( \xi_{t-s} \) as per (9) as well as recovering \( \tilde{\xi}_{t-s} \) as per (8), is contingent upon upholding the structural model provided by (1). In other words, \( A \) should be that matrix which can be used to decompose the potentially contemporaneously correlated vector of regression residuals, \( u_t \), into the contemporaneously uncorrelated innovation process vector, \( \epsilon_t \), in line with (3) or (9). In order therefore to recover \( \epsilon_t \) from \( u_t \), we need to know \( A \).

If we square both sides of (3) and then take expectations of both sides of the resultant expression, we will obtain (10) which is re-organized to obtain (11) and then solved to obtain (12).

\[
E_t(u_t u_t^T) = E_t \left( A^{-1} \epsilon_t \epsilon_t^T \left( A^{-1} \right)^T \right) 
\]

(10)

\[
E_t(u_t u_t^T) = A^{-1} E_t(\epsilon_t \epsilon_t^T) \left( A^{-1} \right)^T 
\]

(11)

\[
\Lambda = A^{-1} \Sigma \left( A^{-1} \right)^T 
\]

(12)

Whereby, \( \Lambda = E_t(u_t u_t^T) \) and \( \Sigma = E_t(\epsilon_t \epsilon_t^T) \)

By inverting (12), we obtain (13).

\[
\Sigma = A \Lambda A^T 
\]

(13)

For simplicity, it is conventional to assume that the diagonal covariance matrix \( \Lambda \) is an identity matrix. This is tantamount to assuming that the components of the structural shocks vector are identically and independently distributed with mean zero and unity variance. Using \( \Lambda = I_n \) in (13), therefore, we obtain (14) which is the fundamental system from which \( A \) is to be estimated. It follows from (14) that, the much needed estimate of \( A \) is essentially a factorization of the covariance matrix, \( \Sigma \), which is one of the outputs from estimating the reduced form representation of the structural model.

\[
\Sigma = AA^T 
\]

(14)

Due to the symmetrical nature of the covariance matrix, \( \Sigma \), however, the system represented in (14) is not solvable as it is because there is a fewer number of independent equations than the number of unknown elements in \( A \). A minimum number of values of the elements of \( A \) must therefore be
assigned a priori to pave way to estimation of the remainder from the restricted variant of (14). The required minimum number of restrictions equals the number of symmetrical elements of $A$ and which is $\left(\frac{n^2 - n}{2}\right)$. Any additional number of assigned values to the elements of $A$, which are over-identifying restrictions, can be tested for statistical significance using a likelihood ratio test statistic whose distribution is akin to the standard $\chi^2$ distribution in which the number of degrees of freedom is equal to the number of over-identifying restrictions.

In imposing the identifying restrictions, one would use either the Choleski or the structural identification approach. We have used the Choleski identification in this study in line with Sims 1980) and as applied in Maturu and Ndirang’u (2013) in Kenya’s context. Under the Choleski identification approach, one imposes a recursive ordering of the endogenous variables so that the resultant matrix $A$ is lower-triangular and the system will be just identified. Unlike the Choleski identification approach, restrictions under the structural identification approach are imposed according to theoretical predictions and/or according to available relevant empirical study findings just like when calibrating an economic model. The structural identification approach is attributed to Bernanke (1986) although other applications can be found in for instance Blanchard and Quah (1989).

Under the simplifying assumptions that $E_i \left( \epsilon_i, \epsilon_i^2 \right) = \Lambda$ and that $E_i \left( \epsilon_i, \epsilon_{i-s} \right) = 0 \forall s = 0$, meaning that the components of the regression residuals vector obtained upon estimation of the unrestricted reduced form VAR model are contemporaneously uncorrelated across the VAR equations and each one of the components is devoid of autocorrelation, the reduced form model provided by (2), can be estimated one equation at a time using ordinary least squares (OLS) to obtain consistent estimates of the VAR parameters and the VAR covariance matrix, $\Sigma$, applied in (14). When the VAR model involves many endogenous variables and a long optimal lag as it is the case in this study, estimation of the VAR using OLS results in parameter “over-fitting” whereby the estimated model’s in-sample prediction power is usually good amid very poor out-of-sample prediction power. To circumvent this problem of inadequate degrees of freedom, Bayesian estimation techniques are used.

### 3.2. Bayesian Vector Autoregressive (BVAR) Model

Our BVAR model is the VAR model in state-space representation and with priors assigned to the parameters. The idea is that the challenge of inadequate degrees of freedom and which leads to “over-fitting” of large dimensioned VAR models is overcome by augmenting observed data with prior information. The priors are the essentially the modeler’s expected VAR parameter values coupled with the modeler’s confidence that expected values are the true values for the parameters. As
exemplified in Litterman (1986) and Doan, Litterman and Sims (1984), priors are specified as a joint density function for the VAR model parameters.

By convention, the state-space representation of a linear system comprises a measurement and a transition equation and for our unrestricted VAR reduced form model provided by (2), the measurement and transition equations are provided by (15) and (16). For the ease of evaluation of our BVAR model, we have assumed that the measurement and transition equations’ variances are independent of each other so that a shock to any of the components of the vector of transition equations can only affect the vector of measurement equations indirectly through the shock’s initial effect on the state vector, $\beta_t$, and not directly through $u_t$.

$$ y_t = x_t \beta_t + u_t; \quad \text{Var}(u_t) = \eta_t $$  

(15)

$$ \beta_t = \beta_{t-1} + \nu_t; \quad \text{Var}(\nu_t) = M_t $$  

(16)

We have also assumed, for simplicity purposes, that $\eta_t$ and $M_t$ are constants: $\eta_t = \sigma_\eta = 1$ and $M_t = 0$. Under these simplifying assumptions, the BVAR’s parameters, which are elements of the state vector, $\beta_t$, are assumed to be constant during the estimation period. This may be a stringent assumption for a fast growing economy such as Kenya but if need be, the assumption can be relaxed. Sims (1992) provides an empirical study in which these assumptions have been relaxed thereby dealing with a BVAR time-varying parameters and obtaining improved results for the USA.

### 3.3. Estimation of the BVAR Model

BVAR models can be effectively estimated using a linear Kalman Filter which involves an iterative process. Firstly, one makes the one-period ahead prediction of the state vector and its variance-covariance matrix. The prediction is then used in computing the simulated values of all the endogenous variables for that period to provide the one-period-ahead forecast of the endogenous variables. The discrepancy between the forecasts and corresponding observations are computed and used as the basis for updating the initial prediction of the state vector. Under the assumption of a one-pass filter, the updated values of the state vector are used to compute the final simulated values of the endogenous variables for the one-period ahead. One is then ready to make the second iteration which aims to compute the final state vector and simulated values of the endogenous variables for the second period ahead.
Using the updated state vector for the first iteration as the presumed initial prediction, the initial forecast of the endogenous variables’ values for the second period ahead is done and once again, the discrepancy between the forecasted values and the observed values for the period are computed. Once again the “initial state vector” for the second period is updated to incorporate information about the prediction errors and then the updated final values of the endogenous variables computed based on the updated values of the state vector. This iterative process is executed for all subsequent periods for which we have observed data.

The Kalman Filter updating-equations are generally provided by (17), (18) and (19).

\[
\Sigma_{t-1} = \Sigma_{t-1} + M_t \quad (17)
\]

\[
\Sigma_t = \Sigma_{t-1} - \Sigma_{t-1} x^T_t \left( x_t \Sigma_{t-1} x^T_t + \eta_t \right)^{-1} x_t \Sigma_{t-1} \quad (18)
\]

\[
\beta_t = \beta_{t-1} - \Sigma_{t-1} x^T_t \left( x_t \Sigma_{t-1} x^T_t + \eta_t \right)^{-1} \left( y_t - x_t \Sigma_{t-1} \right) \quad (19)
\]

\[\forall \ t = 0,1,2,...,T\]

Whereby, the initial values of the state vector prior means, \(\beta_{t0}\), prior covariance matrix, \(\Sigma_{t0}\), measurement equation residuals’ variance, \(\eta_0\), and the transition equation residuals’ variance, \(M_{t0}\), are chosen and applied by setting \(\beta_{t-1} = \beta_{t0}, \Sigma_{t-1} = \Sigma_{t0}, \eta_t = \eta_0\) and \(M_t = M_{t0}\) in (17), (18) and (19) \(\forall \ t = 0,1,2,...,T\).

Once the Kalman Filter algorithm is fully executed, we shall have the posterior joint density function, which is basically the updated state vector values for the last period in our model estimation sample, and simulated time series for the endogenous variables for the sample period. The posterior joint density function whose elements are the posterior state vector means and the posterior covariance matrix is particularly important for our further empirical analysis.\(^2\) We denote the posterior state vector mean and covariance by \(\beta_t\) and \(\Sigma_t\), respectively.

Ideally, we apply the posterior means in the unrestricted VAR model provided by (2) to estimate the regression residuals vector, \(u_t\). We also factorize the posterior covariance matrix in line with (14) to obtain the factorization matrix \(A\). Using the factorization matrix, we factorize estimates of the

---

1 Detailed explanation of these equations with application to Kenya is provided in Maturu and Ndirang’u (2013).

2 The simulated time series will include those for unobserved variables incorporated into the analysis and this is when the Kalman Filter is useful in estimating unobserved components of a given model.
regression residuals, $u_t$, in line with (3) or (9) to obtain estimates of the much needed contemporaneously uncorrelated components of $u_t$, which we denote by $\hat{\varepsilon}_t$. The idea is to generate the orthogonal vector of the estimates of the underlying structural shocks, $\varepsilon_t$, which we use in (4) for $\varepsilon_{t-s}$ to compute the point estimates of the impulse responses as well as factorizing the one period ahead forecast errors to obtain the variance decomposition results.

### 3.4. Assigning Priors

We have assigned the prior means and prior variances to the state variables vector using the original Minnesota Prior introduced by Doan, Litterman and Sims (1984), and Litterman (1986). The original Minnesota prior joint probability density function is summarized in (20) and (21) whereby (20) is the basis for assigning prior means and (21) the basis for assigning prior variances. Accordingly, under the belief that endogenous variables were adequately represented as random walk processes, $\omega_{i,j} = 1, \forall i = j = 1$ and $k = 1$.

In (21), $\lambda$ is the overall “tightness” of the prior mean (i.e. the strength of our belief that the assigned prior mean is the true mean for the parameter under consideration. When $\lambda = 0$, there is very strong belief, in fact bordering on one being certain, that the prior mean and the true mean are identical and the parameter need not be estimated using the observed data but simply fixed. Otherwise when $\lambda = \infty$, one has no idea at all what the true value is and the parameter is estimated using observed data.\(^3\) As $\lambda \to 0$, the tighter the prior and as $\lambda \to \infty$ the flatter the prior becomes. For these intermediate situations, the observed data and prior information are combined in line with Bayes’ theorem to estimate the relevant parameters.

$$E[\beta_{k}^{(i,j)}] = \begin{cases} \omega_{i} & \forall i = j \text{ and } k = 1 \\ 0 & \forall i \neq j \text{ and } k \neq 1 \end{cases}$$

(20)

$$\text{Var}[\beta_{k}^{(i,j)}] = \lambda^2 \frac{1}{\ell^2} \frac{\sigma_{i}^2}{\sigma_{j}^2}; \forall \ell = 1,2,\ldots,p$$

(21)

\(^3\) In situations whereby we have $\lambda = 0$, we will have “very tight” priors otherwise for $\lambda = \infty$ we have “flat” or “non-informative” priors.
\[ p(\beta | y) = \frac{p(y | \beta)p(\beta)}{p(y)} \] (22)

Whereby,

- \( p(\beta) \) = Prior density function;
- \( p(y | \beta) \) = Log likelihood function;
- \( p(\beta | y) \) = Posterior density function; and
- \( p(y) \) = marginal likelihood of the observed data.

The alternatives to the original Minnesota Prior include the “sum of coefficients Prior” introduced by Sims (1992) and Sims and Zha (1998). In this case, it is assumed that \( B_1 + B_2 + \ldots + B_p = 1 \) (i.e. VAR coefficients for own lags in any VAR equation add up to unity). Otherwise, one may also use the “symmetric Minnesota Prior” (also called the natural conjugate prior) advanced by Robertson and Tallman (1999), Banbura et al. (2010) and Beauchemin and Zaman (2011).

### 3.5. Optimizing the Hyper-parameters

The original Minnesota prior tackles the problem of limited degrees of freedom in a two-pronged manner. It augments the observed data by assigning the prior joint probability density function and by so doing, reduces the number of unknowns from \( n[p(n+k)+d] \) to a much smaller and manageable number of unknowns, referred to as “hyperparameters”, to which the prior variances are indexed. In \( n[p(n+k)+d] \), \( n \) is the number of endogenous variables, \( p \) is the value of the optimal lag length used in the BVAR, \( k \) is the number of exogenous variables in the BVAR and \( d \) is the number of deterministic terms in the BVAR. The deterministic terms include a constant and a set of seasonal dummies if the data is not seasonally adjusted. We have assumed, in \( n[p(n+k)+d] \) that though, by their very nature, the exogenous variables are not assigned equations as part of the unrestricted BVAR, they can (and are, in our case) lagged to the extent that the endogenous variables are.

Choosing optimal values of the hyper-parameters, which are the parameters in (20) and (21), to which the prior means and the prior variances are indexed is an important part of the estimation of the BVAR model. One approach, and which we have used in our analysis, is to calibrate the hyperparameters on the basis of relevant past empirical results. The alternative is to estimate the hyperparameters using the maximum likelihood estimator conditional to the prior means and in which the
optimization loss function is defined in terms of minimization of the out-of-sample forecast errors. For instance, in Beauchemin and Zaman (2011), the optimization problem to be solved when estimating the hyper-parameters is provided by (23). Notice that in (23), \( p(y) \) is the marginal likelihood of the observed data which is integrated out of the posterior joint probability density function provided by (22). By optimizing only over \([\lambda^*, \sigma^*]\), the assumption is that the rest of the unknown hyper-parameters in (21) are calibrated.

\[
\left( \lambda^*, \sigma^* \right) = \arg\max_{[\lambda, \sigma] \in \Omega^*} \ell n\{p(y)\}
\]

(23)

\[
p(y) = \int p(y \mid \beta)p(\beta)d\beta
\]

(24)

4. **Empirical Analysis**

An important part of specification of our model is selection of the set of variables to be included in the model. In choosing the variables, we assume that Kenya is a small open economy which is largely influenced by foreign economic developments without significantly influencing economic developments in the rest of the world. This is unlike a semi-small open economy described by, for instance, Cuche-curiti, Dellas and Natal (2009) within the context of a dynamic stochastic general equilibrium modeling. Like Sims (1992), we include variables to ensure we can tell a consistent economic story based on the empirical results. In particular, we draw from past relevant studies to identify the range of variables to be included in the model.

The other consideration is choosing the optimal lag for the BVAR model. Inadequate degrees of freedom necessitate choosing a conservative lag length. This may, however, unduly constrain the dynamics of the model. When using Bayesian estimation techniques, which can overcome the problem of inadequate degrees of freedom, one should provide for at least a year’s worth of lag length. Otherwise models of varied lags can be put head-to-head and the one which optimizes the loss function carries the day.

4.1. **Choosing Model Variables**

4.1.1. **Endogenous Variables**

Since the objective of this study is to empirically analyze the role played by short term capital flows, \( CAPS \), on the Kenya Shilling US Dollar exchange rate, \( LSHS \), net short term capital inflows and the Kenya Shilling US Dollar exchange rate are mandatory inclusions in the set of data that we
use in the analysis. We follow Siouriounis (2003), which is a study that is pretty similar to ours, to include equity return differentials, $NSE_t$, and interest rate differentials, $IRD_t$, in the endogenous variables vector, $Y_t$, as shown in (25).

Inclusion of net equity flows and interest rate differential is justified further by the supportive empirical evidence in Brooks et al. (2001). Although equity return differentials are not supported by the evidence in Brooks et al. (2001), it is a factor worth considering in a study focusing on a developing country in which there is active trading of equities and bonds at the Nairobi Securities Exchange.

We notice that the risk premium variable is not incorporated in some of the past studies including Brooks et al. (2001) and Siouriounis (2003) and we therefore extend the endogenous variables vector to include the risk premium variable, $RISK_t$. In so doing, we effectively use the risk adjusted interest rate differential, $ADJIRD_t$, thereby realistically controlling for the country-specific risk.

We also assume that investors care about real magnitudes and do not suffer from money illusion. We therefore control for inflation differentials in our analysis by including the log of domestic consumer price index, $LP_t$, as part of the endogenous variables while the log of the foreign consumer price index, $LPF_t$, is included as part of the exogenous variables.

A shock to, say, the domestic interest rate such as could arise from a monetary policy shock, amid sticky goods prices, is predicted to induce a corresponding more than proportionate instantaneous change in the current value of the exchange rate to equilibrate financial markets. This kind of economic adjustment is well discussed in Dornbusch (1976). This result can be generalized economic agents’ optimization subject to an inter-temporal budget constraint for an open economy. Following a monetary policy shock amid sticky goods prices, there will be a change in the real interest rates which will induce changes in real output with implications for the country’s current account. As discussed in Obstfeld and Rogoff (1994), this welfare effect will have a lasting effect on the country’s exchange rate. The implication of this analytical result is that the current account has potential to impact the domestic currency exchange rate and this, for instance, justifies inclusion of the current account as an explanatory variable in the exchange rate determination model such as in the application by Were, Kamau and Kisinguh (2013).

In order therefore to control for the welfare effects transmitted through the current account, and this would be embodied in remittances and other current transfers, to the Shilling exchange rate, we include the current account balance, $ACAB_t$, as one of the endogenous variables in our BVAR model.
We complete writing the list of endogenous variables with the inclusion of a monetary conditions variable to proxy the potential role of monetary and fiscal policy in driving the Shilling exchange rate movements. We therefore include a monetary conditions variable, $LRM_t$, which is measured in terms of the log of base money (or reserve money). Within the Kenyan context, it would as well be that the policy shocks emanate from the Central Bank Rate, $CBR_t$, which is the policy rate used for monetary policy signaling.

O’Connell et al. (2010) shows that exchange market pressure is entirely absorbed in the exchange rate if there is no easing of the pressure through changes in the official net foreign assets on account of financing, $DNFA_t$. It is therefore useful controlling for $DNFA_t$.

$$Y_t = \begin{pmatrix} CACB_t \ LY_t \ LP_t \ LRM_t \ CBR_t \ DNFA_t \ IRD\_ADJ_t \ NSE_t \ CAPS_t \ LSHS_t \end{pmatrix} \quad (25)$$

where

$CACB_t =$ Current account balance expressed as a proportion of GDP;

$LY_t =$ Log of real output measured as GDP;

$LP_t =$ Log of the domestic consumer price index;

$LRM_t =$ Log nominal reserve money;

$CBR_t =$ Central Bank Rate;

$DNFA_t =$ Change in net foreign assets (financing);

$IRD\_ADJ_t =$ Risk adjusted nominal interest rate differentials measured in terms of the excess of Kenya’s 91-day Treasury bills nominal interest rate over the USA 90-day Treasury bills nominal interest rate;

$NSE_t =$ Equity return differentials measured as the excess of potential capital gain at the Nairobi Securities Exchange (NSE) Market over potential capital gain at the New York Stock Exchange Market;

$CAPS_t =$ Net short term net capital inflows; and

$LSHS_t =$ Log of the nominal bilateral exchange rate measured as the number of units of the Kenya Shilling that buy a US Dollar.
4.1.2. Exogenous Variables

We also control for the broader world economy developments with implications for Kenya’s economy. We therefore include in the list of exogenous variables, a measure of the world economy real economic performance estimated as the log of USA real gross domestic product, $LYF_t$. When weighed against the inclusion of the home country real GDP as an endogenous variable, we effectively shall have considered the implications of the real productivity differentials for the home country exchange rate.

Similarly, we have taken into account developments in world money markets by including money market interest rate differentials measured in terms of prevailing and past monetary policy stance differentials. While we have included the Central Bank Rate as an endogenous variable, we include the foreign policy rate, which we consider to be the USA Federal Reserve Rate, $FEDRATE_t$, as an exogenous variable.

We do also control for the world commodity market conditions by including the world oil prices, $LPRICE_t$, and the log of the foreign consumer price index, $LPF_t$. It is worth noting that Kenya’s import bill is not only a significant part of the overall import bill but world oil price shocks pose significant potential impact on Kenya’s economy and more specifically, the Shilling exchange rate which bears the pressure piled up by dealers, from time to time, seeking foreign exchange for the importation of oil.

In a nutshell, the exogenous variables vector is provided by (26).

$$ x_t = \begin{pmatrix} LYF_t & LPF_t & LPRICE_t & FEDRATE_t \end{pmatrix} $$ (26)

4.1.3. Deterministic Variables

The two usual suspect variables which we include as part of the deterministic terms are the constant and seasonal factors. We therefore have the vector of deterministic terms provided by (27).

$$ d_t = \begin{pmatrix} CONS & SEAS_{1t} & SEAS_{2t} & SEAS_{3t} \end{pmatrix} $$ (27)

4.2. Solving the Identification Problem

For simplicity purposes, we apply Sims’ (1980) approach which is essentially the Choleski factorization of the covariance matrix. Rather than ordering the endogenous variables arbitrarily, we
do the ordering based on a preliminary computation of the contemporaneous correlation coefficient matrix of the endogenous variables vector. The endogenous variables are then listed in their order of increasing contemporaneous correlation with each other so that most correlated variable is listed last.

Our estimable decomposition model is the just identified system provided by \((28)\).

\[
\begin{bmatrix}
\varepsilon_{t1}^1 \\
\varepsilon_{t2}^1 \\
\varepsilon_{t3}^1 \\
\vdots \\
\varepsilon_{tn}^1
\end{bmatrix} =
\begin{bmatrix}
a_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
a_{21} & a_{22} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
a_{31} & a_{32} & a_{33} & 0 & 0 & 0 & 0 & 0 & 0 \\
\vdots \\
a_{n1} & a_{n2} & a_{n3} & a_{n4} & \ldots & a_{n(n-1)} & a_{n(n-2)} & \ldots & a_{nn}
\end{bmatrix}
\begin{bmatrix}
u_{t1}^1 \\
u_{t2}^1 \\
u_{t3}^1 \\
\vdots \\
u_{tn}^1
\end{bmatrix}
\]  

(28)

Whereby, \(A = \)

\[
\begin{bmatrix}
a_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
a_{21} & a_{22} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
a_{31} & a_{32} & a_{33} & 0 & 0 & 0 & 0 & 0 & 0 \\
\vdots \\
a_{n1} & a_{n2} & a_{n3} & a_{n4} & \ldots & a_{n(n-1)} & a_{n(n-2)} & \ldots & a_{nn}
\end{bmatrix}
\]

Notice that the empirical problem involves estimating \(A\) as the factorization of the covariance matrix \(\Sigma\) in line with \((14)\) and then using the estimated \(A\) in \((28)\) to decompose estimates of \(u_t\) to recover its orthogonal components which are essentially estimates of the innovation process components, \(\varepsilon_t\).

Having estimated \(A\) and \(\varepsilon_t\), from \((14)\) and \((28)\), respectively, we are in a position to compute the impulse response functions from \((4)\) (or, equivalently, from \((7)\)). The impulse responses are then plotted as impulse response functions with superimposed confidence intervals to tell when point estimates of the impulse responses are statistically significant. The confidence intervals are derived from simulated impulse responses using the Monte Carlo Integration as in Maturu and Ndirangu (2013). We also obtain variance decomposition results which are useful in evaluating the relative importance of net short term capital inflows in explaining the Shilling exchange rate movements.
4.3. Preliminary Data Analysis

Figure 1 shows that during the period 2000Q1-2005Q1, net capital inflows were predominantly comprised of net short term flows, general limited and for a substantial part of the sub-period, declining. As one would expect, other factors remaining equal, the shilling USA dollar exchange rate was generally stable. As the exchange rate generally appreciated during the second sub-period of 2005Q2-2008Q2, net capital inflows generally picked up whereby short term capital inflows were still predominant. This apparently provides a consistent potential relationship between the net foreign flows and the exchange rate. However during the remaining sub-period of 2008Q3-2012Q4 the relationship between net capital inflows, net short term inflows in particular, and the exchange rate is rather paradoxical because as the net capital inflows picked up rather strongly relative to its historical past, the exchange rate was also depreciating rather remarkably. This could suggest that there must be other factors explaining the rather elevated depreciation of the exchange rate in spite of the increasing trend in net capital inflows. We suspect that one of these other factors is the inflation differentials.

Figure 1: Structure of Net Capital Inflows and the Exchange Rate
Figure 2: Interest Rate Differentials and the Exchange Rate

Figure 3: Current Account Balance and the Exchange Rate
5. Empirical Results

Using quarterly data for the period 2000Q1-2012Q4 from the Central Bank Database, we carried out preliminary analysis to determine the optimal lag for the unrestricted VAR model. Using the Theil U test statistics while allowing for sufficient dynamics in the system, we adopted 4 lags to be best suited for the empirical analysis. Variation of the lag to 3 or 5 does not lead to radically different empirical results. These other results are presented at the Appendix.

We present the preferred empirical results in sections 5.1 and 5.2. A brief discussion of the results is provided in section 5.3.

5.1. Impulse Responses

The impulse response results presented in Figure 4 which should be viewed as a 10x10 panel of impulse response functions. The impulse response function of immediate interest to us is Figure 4 Panel (10,9) which shows the dynamic response of Shilling-USA Dollar exchange rate consequent to a sudden 1 standard deviation increase in net short term capital inflows. Rather surprisingly, therefore, 1 standard deviation shock to net short term capital inflows leads to an immediate statistically significant depreciating effect on the Shilling-USA Dollar exchange rate. Though the depreciating
effect tends to increase initially for a couple of quarters, there is a correction to the depreciation whereby, relative to the peak depreciating effect, the exchange rate appreciates through the 4th quarter when the impact of the capital flows shock on the exchange rate dies off. The results are surprising because one would expect that, generally, net capital inflows add to the supply of foreign exchange in the domestic foreign exchange market so that, other factors such as demand for foreign exchange remaining unchanged amid the increase in supply, the Shilling USA Dollar exchange rate would have appreciated, instead. If however we interpret the shock to net short term capital inflows to be a nominal shock because the net capital inflows are monetized, then the dynamics of the exchange rate will fit the exchange rate “overshooting” phenomenon described by Dornbusch (1976).

The second important result to us is the impulse response function of net short term capital flows to a sudden change in the real interest rate differentials which is a crucial underlying factor for net capital inflows in general and net short term capital inflows in particular. According to the specific results in Figure 5.1.1 panel (10,7), a positive 1 standard deviation shock to the risk adjusted real interest rate differentials will lead to an immediate statistically significant appreciation of the Shilling USA Dollar exchange rate. The appreciation effect for about 5 quarters and as such the effect is fairly persistent.

The results in panel (9,7) show that the positive shock to the risk adjusted interest rate differentials has an immediate, albeit short-lived, statistically significant increasing effect on net short term capital inflows. The effect, however, switches to a reducing one within a year; beyond which, the reducing effect is statistically significant. These results suggest that short term capital flows seek quick real returns and that, therefore, short term capital flows are potentially subject to “sudden stops” and abrupt reversals. They also show that apart from its direct effect on the exchange rate, the risk-adjusted interest rate differentials influence the exchange rate indirectly through the net short term capital inflows.

Also found to be important for exchange rate movements is the current account balance whereby a positive shock to the current account balance, which represents an improvement in the current account balance, is shown to, on average, to lead to a statistically significant appreciation of the exchange rate. The significant effect is however short-lived as it lasts for about 3 quarters. See panel (10,1).

The impulse response results provided in panel (10,8) show that there is no clear role for returns at the Nairobi Securities Exchange in influencing the Shilling USA Dollar exchange rate. This suggests that equity net short term capital flows are relatively less important for the exchange rate dynamics compared to short term government debt instruments including the 91-Day and the 182-Day Treasury bills which constitute the bulky of short term paper in Kenya’s financial market.
5.2. Variance Decomposition

The variance decomposition results are presented in Table 1. The first column of the table provides the number of periods of out-of-sample forecast of the Shilling USA Dollar exchange rate. The exchange rate forecast error for each of the out-of-sample exchange rate forecast is provided in column 2. We notice that while the forecast errors, generally, tend to increase with the number of periods of out-of-sample exchange rate forecast, the increase in the exchange rate forecast errors is extremely gradual and this suggests that the exchange rate equation in the BVAR model fits the data very well.

Most importantly, the results in Table 1 show that, other than the exchange rate’s own shocks, the three most important variables that explain observed short run (i.e. up to 4 quarters) exchange rate fluctuations are, in their order of reducing importance, initial corresponding fluctuation in risk adjusted interest rate differentials (IRD_ADJ), the current account balance (CACB), and real output (LY). The contribution of the interest rate differentials to a one period-ahead Shilling USA Dollar exchange rate forecast error is estimated at 71.4% compared to the contributions of the current account balance and real output which are estimated at 15.7% and 4.5%, respectively.
While relative importance of the risk adjusted interest rate differentials, the current account balance and real output diminishes with the increasing number of out-of-sample forecasts, the relative importance of the Central Bank Rate (CBR) increases to the extent that it supplants real output as the third most important factor. For instance, the relative contributions of the interest rate differentials, the current account and the CBR to explaining the 4 quarters-ahead Shilling USA Dollar exchange rate forecast error are 54.2%, 17.4% and 12.8%, respectively.

Table 1: Preferred Variance Decomposition Results of the Exchange Rate (LSHS)

<table>
<thead>
<tr>
<th>Out-of-Sample Forecast Periods</th>
<th>Forecast Error in LSHS</th>
<th>Proportion of the Forecast Error explained by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CACB</td>
</tr>
<tr>
<td>1</td>
<td>0.022</td>
<td>15.7</td>
</tr>
<tr>
<td>2</td>
<td>0.029</td>
<td>18.3</td>
</tr>
<tr>
<td>3</td>
<td>0.033</td>
<td>17.9</td>
</tr>
<tr>
<td>4</td>
<td>0.035</td>
<td>17.4</td>
</tr>
<tr>
<td>5</td>
<td>0.036</td>
<td>17.1</td>
</tr>
<tr>
<td>6</td>
<td>0.037</td>
<td>16.6</td>
</tr>
<tr>
<td>7</td>
<td>0.038</td>
<td>16.1</td>
</tr>
<tr>
<td>8</td>
<td>0.039</td>
<td>15.6</td>
</tr>
<tr>
<td>9</td>
<td>0.010</td>
<td>15.2</td>
</tr>
<tr>
<td>10</td>
<td>0.040</td>
<td>14.8</td>
</tr>
</tbody>
</table>

These variance decomposition results simply validate the impulse response results whereby the risk adjusted interest rate differentials play the most important role in piling pressure on the Shilling USA Dollar exchange rate. These results clarify that while the net short term capital inflows exert statistically significant effect on the exchange rate, as per the impulse response results, the pressure is negligible going by the variance decomposition results.

Most interestingly, own exchange rate shocks account for between 5-6% of the fluctuations in the exchange rate during the short run period of up to a year. These results suggest that there have not been appreciable speculation bubbles during the estimation period.
5.3. Brief Discussion of the Results

Generally, the impulse response results which are consistent with corresponding variance decomposition results are largely similar to past study findings. For instance, Ndung’u (2000) finds that the real interest rate differentials drive short run Shilling exchange rate movements. In Ndung’u (2000), short run exchange rate movements are measured as deviations of the exchange rate from purchasing power parity (PPP).

In particular, we are unable through this study findings, to overthrow the fundamental empirical result that real interest rate differentials, being the key underlying factor for net capital inflows (see for instance Brooks et al., 2001, on the essence of underlying factors), is the most important factor explaining exchange rate movements. Our results, however, provide further improvement to those in Ndung’u (2000) in two important ways.

Firstly, we take into account the role played by the risk premium, as implied from the uncovered interest parity (UIP) condition and as also discussed in O’Connell et al. (2010). More specifically, we have used risk adjusted nominal interest rate differentials in our analysis. Since we have also controlled for inflation differentials by incorporating goods prices measured in terms of headline consumer price indices for Kenya and for the rest of the World, we have effectively incorporated the risk adjusted real interest rate differentials.

Notice also that our study employs an alternative methodology, Bayesian econometric techniques, to derive theoretically consistent and empirically coherent results about the role of net short term capital inflows (implicitly, though through the risk adjusted real interest rate differentials).

A question one may ask is whether or not our results would have been significantly different had we used either the medium term, long term net capital inflows or total net capital inflows instead of the net short term capital inflows. The results that we have presented in Figure 4 and Table 1 are robust to the type of net capital inflows. The alternative results however provide additional useful information in light of evidence adduced within the context of the industrialized countries and by extension for the major currencies including the Pound Sterling, USA dollar, Japanese Yen exchange rates.

Contrary to the finding in, for instance, Siourounis (2003) and the discussion in Brooks et al. (2001) to the effect that cross-border bond flows do not significantly influence exchange rates because such flows are amenable to and therefore substantially hedged in the industrialized countries in which forward financial markets are well established, we find that medium term and long term net capital inflows (which we assume to incorporate cross-border bond flows), exert largely similar pressure on the Shilling USA Dollar exchange rate. This finding suggests that perhaps the reason why cross-border bond flows have been important in driving the Shilling exchange rate is because of limited...
hedging financial products within the Kenyan context. The finding does not, however, diminish the need for carrying out disaggregated net capital inflow analyses such as the one that we have. Otherwise, we could not get to know that the structure of net capital inflows to Kenya matters for the Kenya Shilling exchange rate.

Another important point to note about our results is that since shocks to the current account balance significantly, and in a consistent manner, influence the Shilling exchange rate movements, we add to the stock of knowledge regarding the role the current account balance plays in driving the exchange rate. Our results regarding the role of the current account balance for exchange rate movements supports recent evidence obtained by Were, Kamau and Kisinguh (2013).

It is however surprising that own-exchange rate shocks play a very limited role in driving the Shilling exchange rate. Quite to the contrary, one would have expected that own shocks played a big role considering that in the recent past, the domestic interbank foreign exchange market is considered to have experienced episodes of speculative activity leading to too much exchange rate volatility. What these results show, apparently, is that such episodes were isolated cases that wash out when one considers the general domestic foreign exchange market trends. Again this should not in any way underrate the severe economic consequences of a financial crisis triggered by an exchange rate speculation bubble, however short-lived the bubble may be. Lessons learned from past financial crises show that the economic consequences of “sudden stops” and reversal of capital flows can be drastic and long lasting.

We note rather surprisingly, also, from the results that the estimation period, which is 2000Q1-2012Q4, is generally devoid of the exchange rate pass-through effects to domestic commodity prices. Neither could we find evidence of a J-effect whereby a positive shock to the real exchange rate is believed worsen the current before the current account could improve gradually as if the current account balance adjustment profile were tracing the letter J.

Furthermore, we note from the results that the Central Bank Rate, though largely used in fighting inflation, has potential to influence exchange rate movements. A positive 1 standard deviation shock to the CBR leads to an immediate significant appreciation of the exchange rate. The effect lasts 4 quarters. The CBR can also indirectly exert further pressure on the exchange rate through the risk adjusted real interest rate differentials. This is because, though it appears to respond (as a matter of policy) to shocks to the risk adjusted real interest rate differentials, unexpected changes to the CBR indices transitory but statistically significant increasing effect on the risk adjusted real interest rate differentials (which have been shown to have tremendous effect on exchange rate movements).

It is useful noting that although shocks to net short term capital inflows do not exert significant direct effect on the exchange rate, there is potential for shocks to net short term capital inflows to induce
significant indirect effect on the exchange rate through the liquidity effect. This is because a positive 1 standard deviation shock to the net short term capital inflows has a significant reducing effect on the risk adjusted interest rates differentials which in turn exerts significant impact on the exchange rate. See Figure 1 panels (7,9) and (4,9).

Finally, to the extent that net short term capital inflows induce a statistically significant liquidity effect, which manifests in reduced interest rate differentials and increased headline consumer price index inflation consequent to a positive 1 standard deviation in net short term capital inflows, is suggestive of the challenges that the Central Bank of Kenya must be confronting in its attempt to formulate and implement independent monetary policy amid freely flowing cross-border short term capital and the bank’s concern for a competitive exchange rate. This is because if the capital inflows are monetized, then there will be unplanned monetary expansion which should be checked if price stability is to be assured.

With deployment of the bank’s policy instruments including the central bank rate and open market operations which would see the repo rate increasing, too, the country would induce further net short term capital inflows thereby placing the central bank at the deep end of the trilemma problem. This vicious cycle of net short term capital inflows, sterilized monetary policy and a further round of net short term capital inflows can lead to spiraling inflation, term structure of interest rates with dire consequences for cost of domestic credit for both the private and the public sector. The vicious cycle can only be broken by introducing additional policy tools to manage short term capital flows. These would include reserve requirements on short term capital inflows and taxation of capital gains on capital flows of a defined duration, say, up to a year.

6. **Summary and Conclusions**

Using the Bayesian vector auto-regression methodology, we have empirically analyzed the causal relationship between the Kenya Shilling-USA Dollar exchange rate and net short term capital inflows. The impulse response results show that a positive standard deviation shock to net short term capital inflows exerts an immediate statistically significant depreciating effect on the Shilling-US Dollar exchange rate. The depreciating effect is followed by a gradual correction whereby the exchange rate appreciates relative to the initial depreciating effect. This result suggests that the Shilling-USA Dollar exchange rate movements, consequent to a shock in short term net capital inflows which is essentially a nominal shock, is reminiscent of the exchange rate overshooting phenomenon. We also find, based on the corresponding variance decomposition results, that net short term capital inflows play a limited direct role in explaining exchange rate movements.
In contrast, a positive standard deviation shock to the risk adjusted interest rate differentials has an immediate statistically significant increasing effect on net short term capital inflows. It also leads to an immediate and statistically significant appreciation effect, which is fully corrected for automatically within a year, on the Shilling-USA Dollar exchange rate. Most importantly, the corresponding variance decomposition results show that, apart from the exchange rate’s own past innovations, the risk adjusted real interest rate differentials, the current account balance and real output and the Central Bank Rate explain the bulky of observed exchange rate movements. The contribution of the interest rate differentials to one period ahead forecast error of the exchange is estimated at 71.4% when contributions of the current account balance and real output are estimated at 15.7% and 4.5%, respectively, while the relative contributions to explaining the 4 quarters ahead forecast error of the exchange rate by these same variables and in their maintained order are 54.2%, 17.4% and 12.8%.

Consistent with past evidence, we also obtain other important empirical results including the observed significant impact which the current account balance apparently had on exchange rate during the model estimation period 2000Q1-2012Q4. The fluctuations in the current account balance are estimated to explain, at its best, up to 18% of 1-period ahead forecast error in the exchange rate thereby being the second most important factor driving the exchange rate.

We also obtain two rather surprising results. One would have expected the exchange rate’s own past innovation to play a key role in driving the exchange rate but this is not the case. As such, in spite of the episodes of elevated exchange rate volatility which is considered to have been driven by excessive speculative activities, it appears that the exchange rate was largely driven by economic fundamentals. We however caution that exchange rate bubbles can be pretty devastating in their economic consequences for sudden reversals of short term capital flows are known to have triggered major financial crises elsewhere in the World.

The other surprising result is the apparent non-existence of the J-effect and the exchange rate pass-through effect to domestic commodity prices. In fact shocks to the exchange rate do not in any significant way impact the current account balance and this suggests that there is limited room for attaining sustained international trade competitiveness through the exchange rate. Perhaps this is because Kenya’s imports are predominantly price inelastic such that the Marshall-Lerner condition does not hold.

To the extent that the risk adjusted real interest rate differentials play such a significant and appreciable role in driving the Shilling exchange rate and yet it interacts with the Central Bank Rate, which is the policy rate, there is potential that even when the Central Bank Rate is changed as a matter of policy aimed to fight inflationary pressures, such changes inevitably result in the easing or built up of Shilling exchange rate pressures depending on whether the Central Bank Rate was increased or
reduced. It is therefore useful, as it is done, that changes to the policy rate be informed by not only current and future inflationary pressures but also by the implications of such changes on the Shilling exchange rate.

Overall, we tentatively conclude that net short term capital inflows have been exerting statistically significant and quantitatively appreciable pressure, indirectly though through the risk adjusted interest rate differentials, on the Shilling US Dollar bilateral nominal exchange rate during the period 2000Q1-2012Q4. If Kenya’s economic structure does not change drastically in the years ahead, short term net capital inflows would continue exerting immense pressure on the exchange rate and it is therefore imperative that additional tools be devised to manage short term capital flow. The tools would include reserve requirements on short term capital inflows and taxation of capital gains on capital flows of a defined duration, say, up to a year.

References


