

Short Term Capital Flows and Pressure on the Exchange Rate in Kenya

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Abstract Using Bayesian vector auto-regression methodology, we empirically analyze the dynamic responses of the exchange rate to sudden changes in net short term capital inflows, among other economic factors, in Kenya. Based on impulse response results, we find, rather surprisingly, that a sudden increase in net short term capital inflows immediately induces a depreciating effect which increases during the first two quarters upon which a correction ensues whereby the exchange rate appreciates for 4 quarters after which the effect dies off. We believe that the sudden net short term capital inflows are initially monetized thereby becoming a domestic nominal shock which causes a Dornbusch-like exchange rate overshooting. We also find that a sudden increase in interest rate differentials immediately causes an appreciating effect which dies off within a year. Furthermore, a sudden increase in interest rate differentials immediately attracts net short term capital inflows followed by persistent capital reversals within 2 quarters. The variance decomposition results show that, 71.4% of the one quarter-ahead and 54.2% of the four quarters-ahead exchange rate forecast errors are accounted for by the interest rate differentials. Net short term capital inflows' share in the one quarter ahead exchange rate forecast error is a mere 0.1%. At its best, it accounts for only 6.8% of the seven-to-eight quarters ahead exchange rate forecast errors. These results suggest that net short term capital inflows play a relatively limited role compared to interest rate differentials in determination of exchange rates dynamics in Kenya.

Keywords Bayesian Vector Auto-Regression Model, Net Short Term Capital Inflows, Exchange Rate, Exchange Rate Overshooting, Impulse Response, Variance Decomposition, Interest Rate Differentials

1. Introduction

1.1. Objectives

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 carrying out research 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 2008-2009, whose epicenter was the USA, there was resurgent net capital flows from industrialized countries to emerging and developing countries. As the economic prospects of industrialized countries have continued to improve, evidence of reversal in net capital flows from emerging and developing countries to industrialized countries is mounting amid appreciation of the affected emerging and developing countries' currencies.

Concern about currency exchange rates derives from the exchange rates' economic implications. For instance, the nominal exchange rate can significantly influence the volume of international trade and overall macroeconomic performance due to its translation effects. Secondly, structural exchange rate misalignment, which is a price distortion, leads to resource misallocation within a country and across countries. This is well articulated in [1]. Thirdly, the real exchange rate, being the relative price domestic tradable goods, contributes to a country's international trade competitiveness. Most importantly, also, excessive exchange rate volatility is an implicit tax on international business transactions and it has the potential of reducing the volume of international trade with adverse multiplier effects on 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 will be jeopardized should countries resort to competitive exchange rate devaluation, and/ or imposition of foreign exchange and exchange controls. For the avoidance of such disruptive commercial and exchange rate 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 currencies in exchange with others 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 effect of capital flows on exchange rates is even greater now than ever before because, over the years, countries have opened 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, [2, 3] and [4]. 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 substantially reduced. This is unlike equity capital flows which are hedged only up to 12% compared to over 90% for bond holdings [3].

According to [4], 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. [2] 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 to answer the question as to whether net capital inflows significantly influence currency exchange rates in developing countries with specific application to short term net capital inflows and the exchange rate in Kenya.

Kenya presents a suitable case study because of several reasons. Kenya has a liberalized financial sector which has grown steadily over the last three decades. See [5] 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 International Monetary Fund (IMF), Kenya observes the provisions of the IMF

Articles of Association including Article VIII which prohibits member countries from imposing unilateral restrictions on current account transactions [6]. Kenya's Securities Exchange (NSE) market 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, see for instance, [7], and it will be informative knowing the role net short term capital inflows play in determination of the Kenya Shilling exchange rate.

While available evidence, in for instance [8] and [9], suggest that net foreign capital inflows significantly influence short run Shilling exchange rate movements, the evidence need 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 taken action to discipline market participants to desist from engaging themselves in excessive speculative activity amid protests from traders in the domestic interbank foreign exchange market.

In our quest to answer the general empirical question about whether net short term capital inflows affect developing countries' currency exchange rates differently from 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 decomposition results, we have applied the Bayesian vector auto-regression methodology which circumvents the problem of inadequate degrees of freedom which arise in large vector auto-regression models.

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 of the times 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. The positive standard deviation shock to the risk adjusted interest rate differentials 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 as follows. Upon reviewing literature on exchange rate determination, we outline the Bayesian vector auto-regressive (BVAR) methodology in section 2. We present the descriptive and BVAR model based empirical results in section 3. Upon discussing the results in section 4, we conclude in section 5.

1.2. Review of the Literature

The asset market price view of exchange rate determination, which is essentially the modern view, is particularly illuminating as to how exchange rates are determined. [10], for instance, provides an elegant illustration of this analytical framework in which the exchange rate is an asset price whose current value depends on current and expected future information about the exchange rate economic 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 in adequately accounting for the rather volatile exchange rates. Ideally, the asset market 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 exchange rate economic fundamentals, and a futuristic component which depends on the discounted future values of the exchange rate economic fundamentals. Effectively, this means that the asset market price view of determination of exchange rates is basically an extension of the traditional economic fundamentals based exchange rate models. In his illustration, [10] invokes money market and balance of payments equilibrium conditions to formulate an integrated monetary and portfolio balance model which is augmented with rational expectations implemented as model-consistent 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. 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 market price view of exchange rate determination extends the traditional exchange rate models, there is a recent strand of literature, which is exemplified in [11], which aims to integrate microstructure and macroeconomic models.

In contrast, and to the extent that net capital inflows are monetized, net capital inflows are essentially nominal shocks. Dornbusch's exchange rate overshooting model, see [12], predicts that net capital inflows will, on impact, cause the exchange rate to depreciate relative more than the exchange rate could depreciate when goods and factor prices are fully flexible to make-up for sticky commodity prices so that momentary equilibrium obtains in both the financial and commodity market. As commodity prices gradually increase during the medium to long term in response to the positive nominal shock brought about by monetized capital inflows, the exchange rate will gradually appreciate. Eventually, the exchange rate attains its long run equilibrium value when commodity prices shall have increased proportionately to the size of the 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 several reasons. Chief among these reasons was the need for enhancing understanding of the factors which drove exchange rates to inform policy makers' choice of appropriate measures to check exchange rate misalignment and/ or excessive volatility. [1] and [13] provide recent discussions of the analytical and empirical models of exchange rate misalignment. [7] 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 several limitations. In particular, the models' out-of-sample forecasting power were severely limited [14] to the extent that they were out-performed by the random walk representations of exchange rates. 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 [15] and, potentially, in [10].

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 exchange rates and selected economic fundamentals are imposed 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 model estimation techniques. The success of [15], for instance, follows the authors' adoption of two key innovations in model estimation. The authors expand the information used for model estimation by exploiting the concept of cross exchange rates to pave way to application of panel regression analysis instead of applying the standard ordinary regression analysis.

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 "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 macroeconomic models of the 1970s [16] and [17]. 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 which incorporate the role of rational expectations.

For instance, [18] applies a calibrated DSGE model in which incomplete exchange rate pass-through is assumed, to find that the current account balance, which basically reflects capital and financial account flows, significantly impacts 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 [19] and [20] 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 [12], is the "Exchange Rate Dynamics Redux" paper of [21]. An See, also, [22]. 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 [23], for instance, 60% of daily exchange rate movements are due to daily order flow between dealers. [24] 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 [2] 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, the 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 relevant and important factors is not explicitly incorporated in the analysis. This raises issues of the omitted variable kind of model miss-specification. [4] shows how to overcome the limitation by, not only using the comprehensive VAR methodology, but also using linear regression models in which, in addition to the equity flows, important factors known to drive exchange rates are incorporated. [4] analyzes the causal relationship between capital flows and the bilateral nominal exchanges 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, [25] carried out an empirical investigation of the role of the current account balance in the determination of the Kenya shilling exchange rate. The empirical results from the study show 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 presented in the study 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.

This evidence from [25] 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 [26].

The study finding in [25] that real interest rate differentials play a consistent role in the determination of the Shilling exchange rate is consistent with earlier evidence in [8]. In particular, [8] finds that real interest rate differentials explained short run exchange rate movements in the study period.

The empirical results presented and discussed in [9] 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 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 factor predicting net capital inflows) in exchange rate movements.

Estimates of the foreign exchange market pressure in [9] for the period 1996-2008 show that while the volatility in the Shilling 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 the exchange rate. It is explained that such political risks initially adversely impact the current account balance which then, in turn, adversely affects the domestic foreign exchange market in terms of increased exchange rate volatility.

Applying a vector auto-regressive (VAR) model, [9], obtain results which show that consequent to a 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 suggests that whenever exchange market pressures mounted, the Central Bank took policy action to ease the pressure.

2. Methodology

2.1. Vector Autoregressive (VAR) Model

Towards formulating the model, we assume that the structure and operations of the economy are adequately represented by the structural model provided by (1) and whose reduced form is provided by (2) under the specified reparameterization leading to (3), too.

$$Ay_t = B(L)y_{t-1} + \theta z_t + \phi d_t + \varepsilon_t; \quad \varepsilon_t \sim iid(0, \Lambda) \quad (1)$$

$$y_t = C(L)y_{t-1} + \mu z_t + \eta d_t + u_t; \quad u_t \sim iid(0, \Sigma) \quad (2)$$

Whereby,

$$\begin{aligned} C(L) &= A^{-1}B(L); \\ \mu &= A^{-1}\theta; \\ \eta &= A^{-1}\phi; \text{ and} \\ u_t &= A^{-1}\varepsilon_t \end{aligned} \quad (3)$$

In (1) and (2), y_t is a vector of endogenous variables, z_t is a vector of exogenous variables, and d_t is a vector

of deterministic terms.

The moving average representations of (1) and (2), which are correspondingly provided 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 emanating from the components of the innovations vector, ε_t , (5) forms the basis for generating the impulse responses of y_t with respect to shocks emanating from 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, ξ_t and φ_t , $\forall t = 0, 1, 2, \dots, steps$ whereby $steps < \infty$. Notice that in (4) and (5), \hat{y}_t is the $n \times 1$ vector of the steady state values of the endogenous variables. It is expected that \hat{y}_t is time-invariant, despite the attaching time index.

$$y_t = \hat{y}_t + \sum_{s=0}^{\infty} \xi_{t-s} \varepsilon_{t-s} \quad (4)$$

$$y_t = \hat{y}_t + \sum_{s=0}^{\infty} \varphi_{t-s} u_{t-s} \quad (5)$$

Ideally, the impulse responses of interest to us are ξ_{t-s} , $\forall t = 0, 1, 2, \dots, steps$. 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, Σ of the fitted residuals, and the vector of regression residuals, u_{t-1} . These results are exploited to recover ξ_{t-s} from u_{t-1} , whereby the latter is estimated from (5).

Towards that end, we note that for any invertible matrix A , (6) holds and as such we can re-write (5), using (6), to obtain (7).

$$A^{-1}A = I \quad (6)$$

$$y_t = \hat{y}_t + \sum_{s=0}^{\infty} \varphi_{t-s} A^{-1} A u_{t-s} \quad (7)$$

Direct comparison of (4) with (7) suggests that if we were to translate (7) into (4), (8) and (9) must hold.

$$\xi_{t-s} = \varphi_{t-s} A^{-1} \quad (8)$$

$$\varepsilon_{t-s} = A u_{t-s} \quad (9)$$

When evaluated in the current period and hence at $s = 0$, (9) is basically the re-parameterization of the innovations vector to obtain the vector of regression residuals 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 ε_{t-s} as per (9) as well as recovering ξ_{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, ε_t , in line with (3) or (9). To recover ε_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).

$$E_t(u_t u_t^T) = E_t(A^{-1} \varepsilon_t \varepsilon_t^T (A^{-1})^T) \tag{10}$$

$$E_t(u_t u_t^T) = A^{-1} E_t(\varepsilon_t \varepsilon_t^T) (A^{-1})^T \tag{11}$$

$$\Lambda = A^{-1} \Sigma (A^{-1})^T \tag{12}$$

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

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

$$\Sigma = \Lambda \Lambda^{-1} \tag{13}$$

To simplify the analysis, it is conventional to assume that the diagonal covariance matrix Λ 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 variances. Using $\Lambda = I_n$ in (13), therefore, we obtain (14) which is the fundamental system from which A is estimated. It follows from (14) that, the much-needed estimate of A is essentially a factorization of the covariance matrix, Σ , which is one of the outputs from estimating the reduced form representation of the structural model provided by (1).

$$\Sigma = \Lambda \Lambda^T \tag{14}$$

Due to the symmetrical nature of the covariance matrix, Σ , 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 values and therefore restricted to pave way to estimation of the remaining unknown elements from the restricted variant of (14). The required minimum number of restrictions must be equal to the number of symmetrical

elements of A and which must be equal to $\left(\frac{n^2 - n}{2}\right)$.

Any additional number of assigned values to the elements of A to the minimum number required for (14) to be estimable

i.e. $\left(\frac{n^2 - n}{2}\right)$, are over-identifying restrictions which

should be tested for statistical significance using a likelihood ratio test statistic whose distribution is approximated by the standard χ^2 distribution in which the number of degrees of freedom is equal to the number of the over-identifying restrictions.

In imposing the identifying restrictions, one would use either the Choleski or the structural identification method. We have used the Choleski identification method in this study in line with [27] and as applied in [28] 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 restricted variant of the system provided by (14) will be just identified as it will feature the minimum number of identifying restrictions required.

Unlike the Choleski identification, restrictions under the structural identification must be informed by theoretical predictions and /or available relevant empirical study findings as if one were calibrating an economic model. See for instance variants of the structural identification approach by [29], [30] and [31].

Under the simplifying assumptions that $E_t(\varepsilon_t (\varepsilon_t)^T) = \Lambda$ and that $E_t(\varepsilon_t \varepsilon_{t-s}^T) = 0 \forall s = 0$, 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, Σ , which is 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 excellent and the out-of-sample prediction power very poor. To circumvent this problem of inadequate degrees of freedom, we use Bayesian estimation techniques.

2.2. The BVAR Model

Our estimable BVAR model is a restricted variant of the reduced form VAR model provided by (2) expressed in state-space representation as provided by (15) and (16) whereby the assigned prior joint density function to the state vector β_t imposes the required restrictions.

$$y_t = x_t \beta_t + u_t; \quad Var(u_t) = \eta_t \tag{15}$$

$$\beta_t = \beta_{t-1} + v_t; \quad Var(v_t) = M_t \tag{16}$$

To simplify the analysis, we have assumed that the measurement equation (15) and transition equation (16) variances, which are $Var(u_t) = \eta_t$ and $Var(v_t) = M_t$, are not only independent of each other but also constant. That the variances are independent of each other ensures that a shock to any of the components of the vector of transition equations does not contemporaneously affect the vector of measurement equations directly through u_t but indirectly through the shock's initial effect on the state vector, β_t . This way, the unique impulse responses of the endogenous variables to a shock of interest can be delineated.

To the extent that the variances are constants, and in fact for convenience specified as $\eta_t = \sigma_\eta = 1$ and $M_t = 0$, the elements of the state vector, which are the BVAR model parameters are effectively assumed to be time-invariant during the model estimation sample period. It the economy was experiencing major structural economic transformation in the period, this will be too stringent an assumption to make and one will need to relax the assumption following, for instance, [36].

2.3. Estimation of the BVAR Model

BVAR models are usually effectively and efficiently estimated using the Kalman Filter whose updating equations are provided by (17), (18) and (19).¹

$$\Sigma_{t|t-1} = \Sigma_{t-1} + M_t \quad (17)$$

$$\Sigma_t = \Sigma_{t|t-1} - \Sigma_{t|t-1} x_t^T (x_t \Sigma_{t|t-1} x_t^T + \eta_t)^{-1} x_t \Sigma_{t|t-1} \quad (18)$$

$$\beta_t = \beta_{t|t-1} - \Sigma_{t|t-1} x_t^T (x_t \Sigma_{t|t-1} x_t^T + \eta_t)^{-1} (y_t - x_t \Sigma_{t|t-1}) \quad (19)$$

$$\forall t = 0, 1, 2, \dots, T$$

To initialize the Kalman Filter iterative process, the prior joint density function whose elements are the prior means, $\beta_{0|0}$, prior covariance matrix, $\Sigma_{0|0}$, prior measurement equation residuals variance, η_0 , and the prior transition equation residuals variance, $M_{0|0}$, are chosen and applied to initialize the Kalman Filter by setting $\beta_{t|t-1} = \beta_{0|0}$, $\Sigma_{t-1} = \Sigma_{0|0}$, $\eta_t = \eta_0$ and $M_t = M_{0|0}$ in (17), (18) and (19) $\forall t = 0, 1, 2, \dots, T$. Once the Kalman Filter algorithm is completed working through the sample period, the Metropolis-Hastings sampler makes a random draw of the state vector to initiate another Kalman Filter iterative process through the sample. As many such Kalman Filter processes as the modeler will choose – usually very many of them such as 10,000 in our case, are executed upon which the posterior joint density function is computed and the results

stored for the modeler's retrieval, interpretation, and reporting. The posterior state vector means β_T and the posterior covariance matrix Σ_T are particularly important for our further empirical analysis.²

Based on the posterior state vector mean, the simulated values of the endogenous variables for the sample period, which are akin to the fitted values under standard regression analysis, are computed and stored for the modeler's consideration. Combined with the observed values of the endogenous variables' the values, simulated residuals akin to the fitted regression residuals are computed and stored for use by the modeler as estimates the regression residuals vector, u_t , in (2). 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 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, ε_t , which we use in (4) for ε_{t-s} to compute the point estimates of the impulse responses as well as factorizing the one-period-ahead forecast errors based on the BVAR model so as to obtain the variance decomposition results.

2.4. Assigning Priors

We have assigned the prior means and prior variances to the state variables vector using the original Minnesota Prior introduced by [34], and [33]. The alternatives to the original Minnesota Prior include the "sum of coefficients Prior" introduced by [35] and [36]. In this case, it is assumed that $B_1 + B_2 + \dots + B_p = 1$ (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 [37, 38], and [39].

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. For detailed discussion on assigning the priors, consult with [33] and [34].

$$E[\beta_\ell^{(i,j)}] = \begin{cases} \varpi_i & \forall i = j \text{ and } \ell = 1 \\ 0 & \forall i \neq j \text{ and } \ell \neq 1 \end{cases} \quad (20)$$

$$Var[\beta_\ell^{(i,j)}] = \lambda^2 \frac{1}{\ell^2} \frac{\sigma_i^2}{\sigma_j^2}; \forall \ell = 1, 2, \dots, L \quad (21)$$

¹ Detailed explanation of these equations with application to Kenya is provided in [28] following [35].

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.

One of the assumptions made in assigning the Minnesota Prior is that endogenous variables are adequately represented by random walk processes. It is then assumed that the applicable persistence parameter in the random walk process for each endogenous variable's random walk process is unity. Thus, the prior mean of own one period lagged term in each of the unrestricted VAR model equations is unity, $E[\beta_\ell^{(i,j)}] = \varpi_{i-1} = 1, \forall i = j = 1$ and $\ell = 1$ whereby k denotes the k^{th} lag of the j^{th} endogenous variable in the i^{th} unrestricted VAR equation. The prior means of all other elements of the state vector are zero. Thus, $E[\beta_k^{(i,j)}] = \varpi_{i-1} = 0, \forall i \neq j \neq 1$ and $k \neq 1$.

The practical question about the assigned state vector mean priors is: how sure can we be about the prior means being representative of the true underlying population means? Assigning prior variance-covariance matrix in line with (21) answers to the question.

In (21), therefore, λ is the unknown 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. For the element of the state vector corresponding to the own one period lagged term, the prior variance is provided by $Var[\beta_L^{(i,j)}] = \lambda^2 \frac{1}{\ell^2} \frac{\sigma_i^2}{\sigma_j^2}, \forall \ell = 1$ whereby $\frac{\sigma_i^2}{\sigma_j^2}$ is the ratio of the standard errors of the i^{th} and j^{th} endogenous variables applied here to optimize the scale of the estimate of the prior variance. Thus, in the special case of $i = j = \ell = 1, Var[\beta_\ell^{(i,j)}] = \lambda^2$.

If, upon applying (21), the outcome is that $\lambda = 0$, then we have the conviction, in fact bordering on one being certain, that the prior mean and the true mean coincide. Otherwise if we end up $\lambda = \infty$ upon applying (21), then we have no idea whatsoever about what the true value of the parameter under consideration should be and as such the parameter should be estimated using observed data instead of fooling ourselves in attempting to assign the parameter a prior mean.³

Generally, $\lim_{\lambda \rightarrow 0}$, the tighter the prior becomes and $\lim_{\lambda \rightarrow \infty}$, the flatter or more diffuse the prior becomes. For intermediate cases, where $0 < \lambda < \infty$, meaning that the modeler has some idea as to what the true mean of the relevant element of state vector is and therefore proceeds to assign the prior mean, the observed data and prior mean is combined using Bayes' theorem to compute the posterior mean. More generally, joint prior density function $p(\beta)$ is combined with the observed data in form of the log

likelihood function of the data $p(y|\beta)$ to obtain the posterior joint density function in line with Bayes' theorem as provided by (22).

$$p(\beta|y) = \frac{p(y|\beta)p(\beta)}{p(y)} \tag{22}$$

In (22), $p(y)$, which is provided by (23), is the marginal likelihood of the observed data which is integrated out of the posterior joint probability density function provided by (22).

$$p(y) = \int p(y|\beta)p(\beta)d\beta \tag{23}$$

For the ease of reference,

$p(\beta)$ = Prior density function;

$p(y|\beta)$ = Log likelihood function;

$p(\beta_T|y)$ = Posterior density function; and

$p(y)$ = marginal likelihood of the observed data.

2.5. Optimizing the Hyper-parameters

Under the assigned Minnesota prior joint density function, we have 2 unknowns to which all other prior means and prior variances are benchmarked. These are the prior mean and the prior variance of the own one period lagged term elements of the state vector, which are ϖ_i and λ^2 , obtaining from $E[\beta_\ell^{(i,j)}] = \varpi_i, \forall i = j = \ell = 1$ and $Var[\beta_\ell^{(i,j)}] = \lambda^2, \forall i = j = \ell = 1$ and which are referred to as "hyperparameters".

Choosing the optimal values of the hyper-parameters to which prior means and prior variances of other elements in the state vector are indexed is an important part of estimating the BVAR model. One approach, and which we have used in our analysis, is to calibrate the hyper-parameters based on the assumption that endogenous variables are adequately represented as random walks empirical results thereby setting $\varpi_1 = 1$ so that $E[\beta_1^{(1,1)}] = \varpi_1$. We assume that the prior variance of $E[\beta_1^{(1,1)}] = \varpi_1$ is $Var[\beta_\ell^{(i,j)}] = \lambda^2 = 1, \forall i = j = \ell = 1$ while the covariance of each of the other elements of the state vector is $Var[\beta_\ell^{(i,j)}] = \lambda^2 = 0, \forall i \neq j \neq \ell \neq 1$.

The alternative is to estimate the hyper-parameters 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 [39], the optimization problem to be solved when estimating the hyper-parameters is provided by (24).

$$(\lambda^*, \varpi^*) = \underset{(\lambda, \varpi)}{Max} \ell n\{p(y)\} \tag{24}$$

Where, from (22), $p(y) = \int p(y|\beta)p(\beta)d\beta$ and an

3 In situations where $\lambda = 0$, we will have "very tight" priors otherwise for $\lambda = \infty$ we have "flat" or "non-informative" priors.

asterisk attaching to a hyperparameter such as it is the case for λ^* denotes the optimized value of the hyperparameter.

2.6. Empirical Implementation

In choosing the variables, we assume that Kenya is a small open economy which is largely influenced by economic developments in the rest of the world (RoW) with no control of over economic developments in the RoW. This is unlike a semi-small open economy described by, for instance, [40] within the context of dynamic stochastic general equilibrium modeling. Like [36], 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 variables to consider.

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 most carries the day.

2.6.1. Choosing Model Variables

2.6.1.1. 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 used in the analysis. We follow [4], which is a study that is pretty like ours, to include equity return differentials, *NSE_t*, and interest rate differentials, *IRD*, in the endogenous variables vector, Y_t' .

Inclusion of net equity flows and interest rate differential is justified based on the supportive empirical evidence in [2]. Although inclusion of equity return differentials is not supported based on the evidence in [2], it is a factor worth considering in a study focusing on a developing country in which there is active trading in equities and bonds at the Nairobi Securities Exchange market.

We notice that the risk premium variable is not incorporated in some of the past studies including [2] and [4] and we therefore extend the endogenous variables vector to include the risk premium variable, *RISK*. In so doing, we effectively use the risk adjusted interest rate differential *IRD_ADJ*, thereby realistically controlling for the country-specific risk.

We also assume that investors care about real magnitudes

as they do not suffer from money illusion. We therefore control for inflation differentials in our analysis by including the log of the domestic consumer price index, *LP*, as part of the endogenous variables while the log of the foreign consumer price index, *LPF*, is included as part of the exogenous variables.

A shock to, say, the domestic interest rate such as could arise from unexpected monetary policy action, amid sticky commodity prices, is predicted to induce a corresponding more than proportionate instantaneous change in the current value of the exchange rate to equilibrate financial and good markets. See, for instance, also [12, 22]. This result can be generalized to economic agents' optimization subject to an inter-temporal budget constraint for an open economy. Following a monetary policy shock amid sticky good 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 [21], 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 balance has potential to impact the domestic currency exchange rate and this, for instance, justifies inclusion of the current account balance as an explanatory variable in the exchange rate determination model such as in the application by [25]. [10] provided an analytical framework in which the current account balance plays a critical role, among other factors, in determination of the real exchange rate.

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, *CACB_t*, as one of the endogenous variables in our BVAR model.

We complete writing the list of endogenous variables with the inclusion of a domestic monetary conditions variable to proxy the potential role of monetary and fiscal policy in driving the Shilling exchange rate. 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.

[9] 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, *DNFA_t*. It is therefore useful controlling for *DNFA_t*. Virtually all these variables are considered in the integrated exchange rate model introduced by [10].

$$Y_t' = (CACB_t \quad LY_t \quad LP_t \quad LRM_t \quad CBR_t \quad DNFA_t \quad IRD_ADJ_t \quad NSE_t \quad CAPS_t \quad LSHS_t) \quad (25)$$

Whereby,

$CACB_t$ = 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 of nominal reserve money;

CBR_t = Central Bank Rate;

$DNFA_t$ = Change in net foreign assets;

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 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.

2.6.1.2. Exogenous Variables

We also control for the broader RoW economic developments with implications for Kenya's economy. We therefore include in the list of exogenous variables, a measure of the RoW 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 real productivity differentials for the home country exchange rate.

Similarly, we have considered 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 a "policy" endogenous variable to set up a policy reaction function, 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.

The exogenous variables vector is provided by (26).

$$x'_t = (LYF_t \quad LPF_t \quad LPRICE_t \quad FEDRATE_t) \quad (26)$$

2.6.1.3. 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).

$$d'_t = (CONS \quad SEAS_{1t} \quad SEAS_{2t} \quad SEAS_{3t}) \quad (27)$$

2.6.1.4. Descriptive Analysis

We have plotted selected data in Figure 1 through Figure 4 to visualize comparative trends during the period 2000Q1-2012Q4. Figure 1 shows that though net short term capital inflows were predominant in generally limited and declining in total net capital inflows for a substantial part of the sub-period. As one would expect, other factors remaining equal, the Shilling USA Dollar exchange rate was generally stable amid subdued short term net capital inflows during the period.

As the exchange rate generally appreciated during the second sub-period of 2005Q2-2008Q2, net capital inflows had picked up with short term capital inflows being predominant. This apparently provides a consistent potential relationship between net foreign capital inflows and the exchange rate.

During the remaining sub-period of 2008Q3-2012Q4, however, the relationship between net capital inflows, more particularly net short term inflows, and the exchange rate was rather paradoxical because as the net capital inflows picked up strongly by historical standards, the exchange rate was depreciating rather remarkably. This suggests that other factors other than capital flows must have been in play in driving the exchange rate movements.

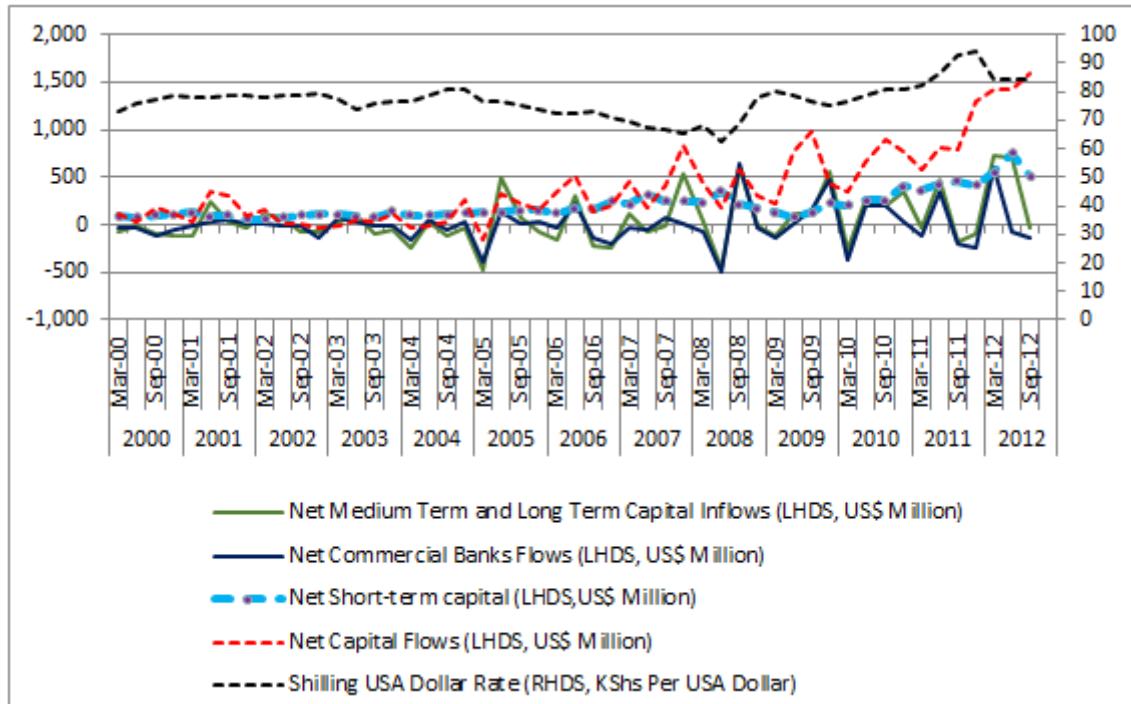


Figure 1. Structure of Net Capital Inflows and the Exchange Rate

We suspected that one of these other factors was the domestic country-RoW interest rate differentials IRD which tracked the exchange rate very well. The comparative trends between these 3 variables and the exchange rate KESRATE are shown in Figure 2. We have included in the country risk RISK and the risk adjusted interest rate differentials IRD_ADJ in the Figure.

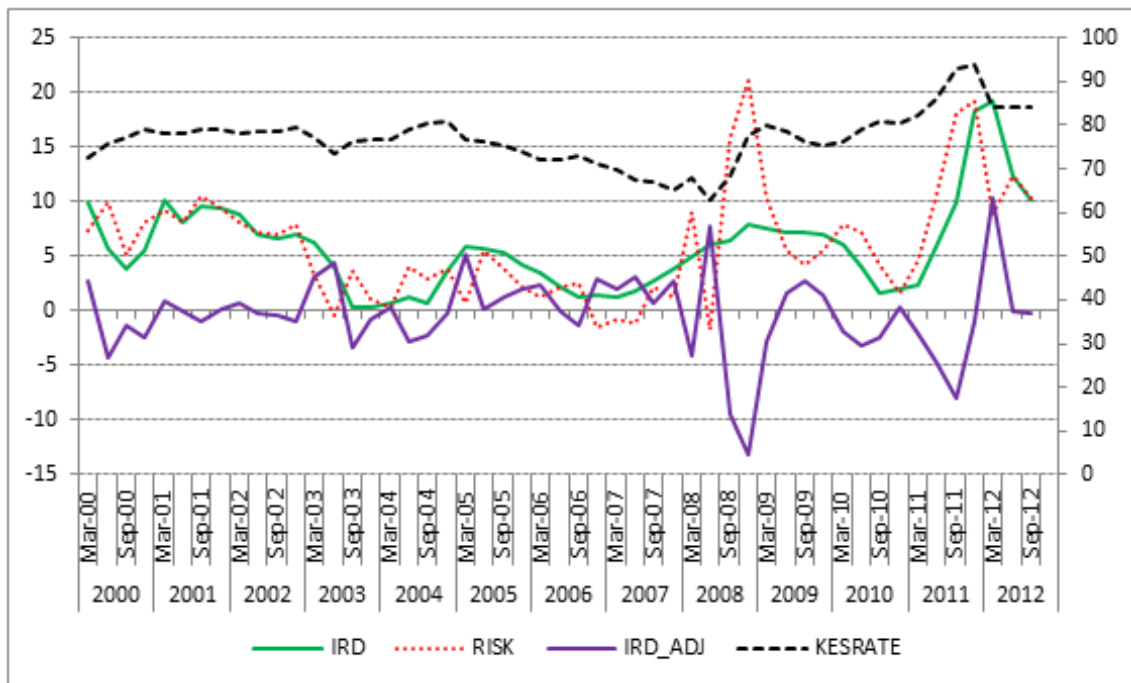


Figure 2. Interest Rate Differentials and the Exchange Rate

There is also a remarkable co-movement of the current account balance and the exchange rate from the beginning of the sample period through the beginning of 2010 when trends in the 2 variables diverge through the end of the sample period.

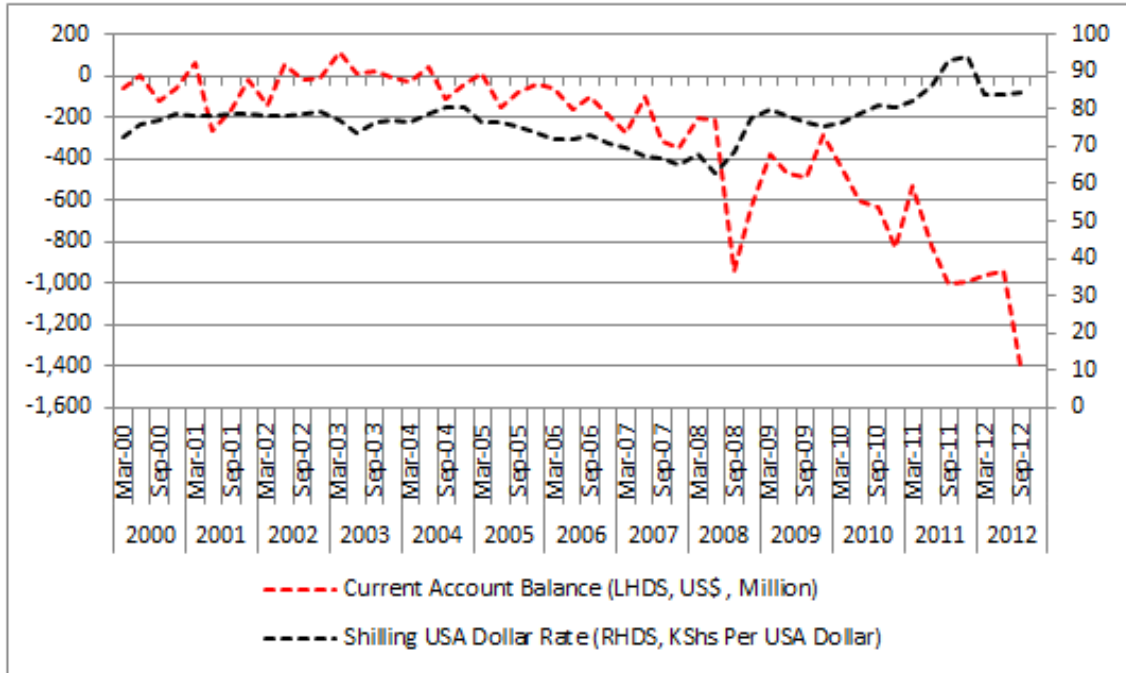


Figure 3. Current Account Balance and the Exchange Rate

Net commercial bank capital flows were generally stable and marginal during the most part of the sample period: 2000-2007. The remaining part of the sample period was characterized with elevated volatility in the commercial bank flows. This is perhaps due to the aftermaths of the post-election violence that occurred at the beginning of 2008 coupled with the contagion effects of the global financial and economic crisis of 2008-2009.

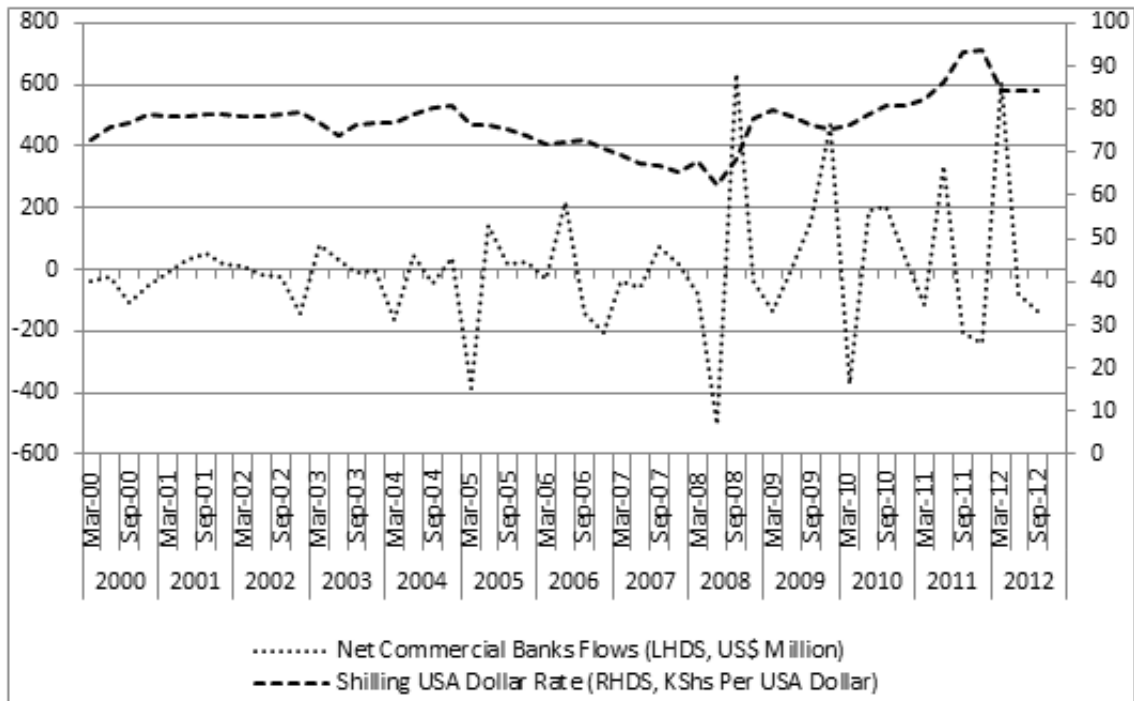


Figure 4. Net Commercial Bank Flows and the Exchange Rate

3. Empirical Results

3.1. The Joint Density Function and the Optimal Lag

We follow [28] in choosing the prior joint density function. 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. The Theil U test statistic whose value is basically 2.0 does not clearly discriminate among the suitability of lags 1 to 5.

The BVAR model based on 3 lags is suited for the analysis because it is the one, among the 5 alternative model specifications based on lag length, in which short term capital flows provide the largest contribution of 7.16% to explaining observed fluctuations in the exchange rate. It however limits the dynamics in the BVAR model.

Allowing for sufficient dynamics in the VAR model, meaning that we choose the longest lag possible subject to the importance of short term capital flows in the exchange rate equation, we are left to choose between the BVAR model based on 4 and that which is based on 5 lags. Because

the short-term capital flows play a relatively more important role in the exchange rate equation based on the BVAR model with 4 lags than the BVAR model with 5 lags, we choose the BVAR model with 4 lags for our further empirical analysis.

3.2. Impulse Response Function Results

The impulse response results based on the BVAR model with 4 lags are presented in Figure 5, which, for the ease of interpretation of the results, should be viewed as a 10x10 row-column panel of impulse response functions. These results are robust to variations in the optimal lag from 4 to 3 and to 5 lags. They are also robust to variations in the net capital inflows measure.

The results based on BVAR models with 3 and 5 lags are presented in the *Appendix: Robustness Test Results* as Figures A1 and A2 while those which are based on BVAR models with 4 lags and either the medium term-cum-long term net capital inflows or the net total capital inflows are presented in Figures A3 and A4.

Table 1. Theil U Statistics

VAR Lag	BVAR System		Exchange Rate Forecast Error Explained by (%)		
	4 Quarters Ahead Forecast Error	Theil U	IRD_ADJ	CACB	CAPS
1	0.104	1.884	66.80	7.35	5.38
2	0.100	1.951	68.12	4.98	6.46
3	0.076	1.89	69.14	6.46	7.16
4	0.077	2.14	54.16	17.45	5.40
5	0.028	2.01	56.91	17.02	3.72

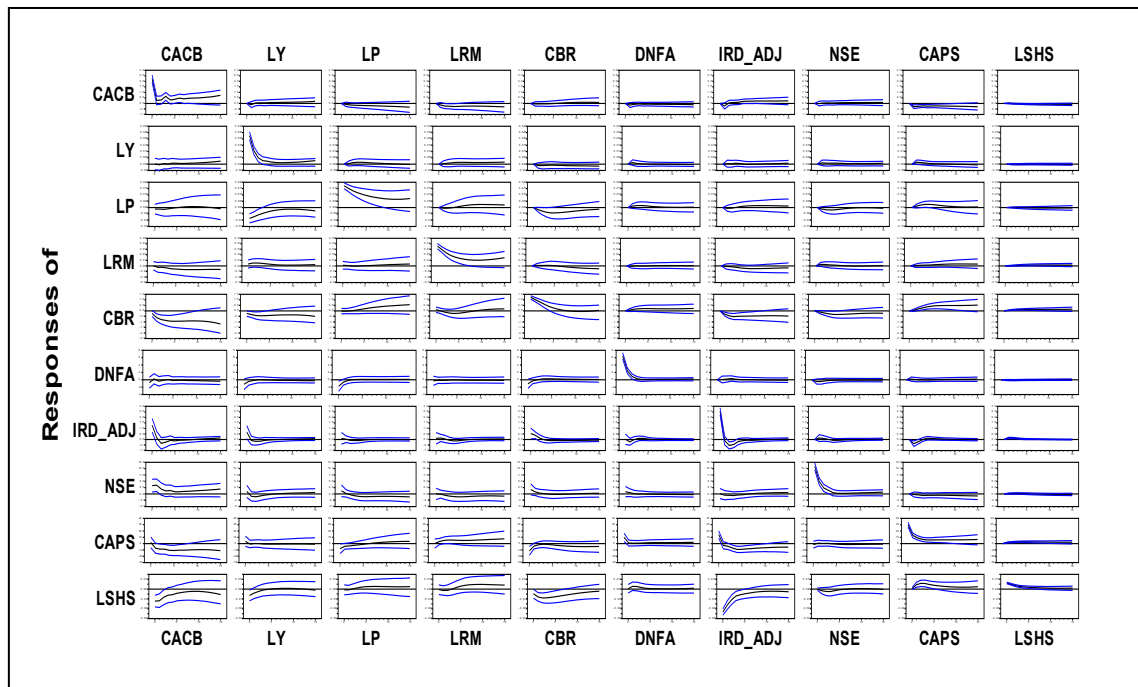


Figure 5. Impulse Response Functions

The impulse response function of immediate interest to us is the one which captures the dynamic response of the exchange rate LSHS consequent to a sudden increase in net short term capital inflows CAPS. This is in Panel (10, 9) of Figure 5 and it shows, rather surprisingly, that a positive 1 standard deviation shock to net short term capital inflows leads to a near-immediate statistically significant depreciating effect on the Shilling-USA Dollar exchange rate. Though the depreciating effect increases steadily for a couple of quarters, a correction follows upon attaining a peak depreciation whereby the exchange rate appreciates through the 4th quarter when the impact of the shock to the net short term capital flows on the exchange rate dies off.

The second important result is the impulse response function of net short term capital flows to a sudden increase in domestic country-RoW real interest rate differentials. This is because the interest rate differentials predict net capital inflows which eventually impact the exchange rate. The results in Panel (9, 7), show that consistent with expectations, a sudden increase in the risk adjusted real interest rate differentials IRD_ADJ significantly increases net short term capital inflows on impact for about 2 quarters with significant net short term capital reversal in the 3rd through the 10th quarters during which period, apparently, the “hot money” investors repatriate their capital gain.

It is possible that any incipient exchange rate volatility due to net short term capital reversal is dealt a death blow by central bank exchange rate stabilization using its policy rate CBR. As shown in Panel (10, 5), once the CBR suddenly increases, it exerts a persistent significant appreciating effect on the exchange rate. Stabilization of the exchange rate through central bank participation in the domestic interbank foreign exchange market is generally inconsequential to economic developments including the exchange rate. See the results in Panel (10, 6).

3.3. Variance Decomposition Results

We have presented the variance decomposition results in Table 2. The first column of the table provides the number of

periods out-of-sample. The exchange rate forecast error for each of the out-of-sample exchange rate forecasts is provided in column 2. We notice that exchange rate forecast errors are generally small as to be considered negligible and that they remain stable with the increasing number of periods of out-of-sample exchange rate forecasts. That suggests that the exchange rate equation in the BVAR model is fits the data very well and the results form a good basis for analyzing the relative importance of net short term capital flows in explaining historical exchange rate fluctuations.

The results in Table 2 show that 71.4% of the one period of out-of-sample exchange rate forecast error is accounted for by the risk adjusted real interest rate differentials IRD_ADJ while the current account balance CACB accounts for 15.7%. The importance of IRD_ADJ and CACB in accounting for observed exchange rate fluctuations up to 4 quarters is still unmatched by other determinants of the exchange rate. We note that IRD_ADJ accounts for 54.2% and CACB accounts for 17.4% of the 4 quarters out-of-sample exchange rate forecast error. Net short term capital inflows account for only 5.1%.

We also note that as the relative importance of IRD_ADJ and CACB in accounting for out-of-sample exchange rate forecast errors declines with the out-of-sample forecast period, the importance of the central bank policy rate increases, for instance, from 12.8% at 4 quarters to 20.8 at 10 quarters out-of-sample.

Most importantly, net short term capital inflows’ share in the one quarter ahead exchange rate forecast error is a mere 0.1%. At its best, it accounts for only 6.8% of the seven-eight quarters ahead exchange rate forecast errors.

Unlike the impulse response function results which show that net short term capital inflows exert significant and prolonged effect on the exchange rate, the variance decomposition results show that the most important factor driving the Shilling-US Dollar exchange rate is the risk adjusted real interest rate differentials which account for the bulky of observed exchange rate fluctuations.

Table 2. Exchange Rate (LSHS): Variance Decomposition Results

Out-of-Sample Forecast Periods	Forecast Error of LSHS Equation	Proportion of the Forecast Error Explained by:									
		CACB	LY	LP	LRM	CBR	DNFA	IRD_ADJ	NSE	CAPS	LSHS
1	0.022	15.7	4.5	0.1	0.0	2.7	0.0	71.4	0.0	0.1	5.6
2	0.029	18.3	3.8	0.1	0.2	6.2	0.6	63.5	0.2	1.8	5.4
3	0.033	17.9	3.3	0.1	0.2	9.8	1.0	58.1	0.6	3.9	5.2
4	0.035	17.4	3.0	0.1	0.2	12.8	1.0	54.2	0.8	5.4	5.1
5	0.036	17.1	2.7	0.3	0.3	15.1	0.9	51.4	0.9	6.2	4.9
6	0.037	16.6	2.6	0.6	0.8	16.9	0.9	49.4	0.8	6.6	4.8
7	0.038	16.1	2.5	0.8	1.4	18.2	0.8	47.8	0.8	6.8	4.7
8	0.039	15.6	2.4	1.1	2.2	19.2	0.8	46.4	0.8	6.8	4.6
9	0.010	15.2	2.4	1.3	3.1	19.9	0.8	45.2	0.8	6.8	4.6
10	0.040	14.8	2.4	1.4	3.9	20.4	0.8	44.2	0.8	6.8	4.5

4. Discussion

Our key impulse response function results showing that a positive 1 standard deviation shock to net short term capital inflows leads to a near-immediate statistically significant depreciating effect on the Shilling-USA Dollar exchange rate are rather surprising because we expected an appreciation, instead. One would have expected that, a sudden increase in the net short term capital inflows increase the net supply flow of foreign exchange in the domestic foreign exchange market thereby, *other factors such as the net demand flow of foreign exchange in the market remaining unchanged*, bidding down the price of foreign exchange that the Shilling-USA Dollar exchange rate is and as such causing an appreciation of the exchange rate.

It is possible, however, that when short-term net capital inflows are monetized thereby effectively becoming a domestic nominal shock which unleashes a Dornbusch-like exchange rate “overshooting” effect whereby the exchange rate initially overshoots its long run equilibrium consequent to a positive nominal shock to make-up for sticky commodity prices thereby momentarily equilibrating the domestic financial and commodity markets. The correction for the exchange rate overshooting occurs subsequently in tandem with the gradual adjustment in the sticky commodity prices.

Past studies, for instance, [8] also find that the real interest rate differentials drive short run Shilling exchange rate movements. In [8], short run exchange rate movements are measured as deviations of the exchange rate from purchasing power parity (PPP).

We are unable through our study findings, to overthrow the fundamental empirical result that real interest rate differentials, being the key underlying factor predicting net capital inflows, see for instance [2] on the essence of underlying factors to net capital flows, is the most important factor explaining exchange rate movements. Our results, however, provide further improvement to those in [8] in two important ways. Firstly, we consider the role played by the risk premium, as suggested by a failed uncovered interest parity (UIP) condition, and as also discussed in [9]. Since we have also controlled for inflation differentials by incorporating the price of goods measured in terms of the headline consumer price index for Kenya and for the RoW, we have effectively used the risk adjusted real interest rate differentials in the analysis. 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 in exchange rate dynamics in Kenya.

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 5 and Table 1 are robust to the type of net capital inflows. See the alternative results in Figure A1, Figure A2, Figure A3 and

Figure A4 in the *Appendix: Robustness Test Results*.

Contrary to the finding in, for instance, [4] and the discussion in [2] 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 in Kenyan. 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 matters for the Kenya Shilling – US Dollar 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 – US Dollar exchange rate movements, we add to the stock of knowledge regarding the role the current account balance plays in driving the exchange rate within the Kenyan context whereby our results collaborate those presented in [25].

It is however surprising that own-exchange rate shocks play a very limited role in driving the exchange rate. Quite to the contrary, one would have expected that own shocks play an appreciable role considering that in the recent past, the domestic interbank foreign exchange market is considered to have experienced episodes of speculative activity leading to excessive exchange rate volatility thereby warranting admonishment of market players by the central bank. What these results suggest is that such episodes of excessive exchange rate volatility must have been isolated cases that wash out when one considers general foreign exchange market trends. This should not in any way underrate the severe economic consequences of a financial crisis triggered by busting exchange rate speculation bubbles, 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.

5. Conclusions

Using the Bayesian vector auto-regression methodology, we have empirically analyzed the dynamic response of the Kenya Shilling-USA Dollar exchange rate to sudden changes in 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. In contrast to the impulse response results, variance decomposition results show that net short term capital inflows play a limited role in explaining observed exchange rate fluctuations.

Among the other important results is that, a positive standard deviation shock to the risk adjusted real interest rate differentials has an immediate statistically significant increasing effect on net short term capital inflows. A positive standard deviation shock to the risk adjusted real interest rate differentials 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 variance decomposition results show further that, apart from the exchange rate's the risk adjusted real interest rate differentials and the current account balance explain the bulky of observed exchange rate movements from one to 4 quarters. The contribution of the interest rate differentials to the one period ahead exchange rate forecast error 71.4% when the contribution of the current account balance is 15.7%. The contributions to explaining the 4 quarters ahead exchange rate forecast error by these variables, in their order, are 54.2% and 17.4%. The policy rate is particularly important in influencing the exchange over the medium to long term. Its importance increase from explaining 12.8% of the 4 quarters out-of-sample exchange rate forecast error to 20.4% of the 10 quarters out-of-sample exchange rate forecast error.

To the extent that the risk adjusted real interest rate differentials play such a significant and appreciable role in driving the Shilling-US Dollar 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 easing or building up of Shilling exchange rate pressures depending on whether the policy rate is increased or reduced. It is therefore useful, as it is the practice of the Monetary Policy Committee of the Central Bank of Kenya, 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 exchange rate.

Overall, we tentatively conclude that net short term capital inflows exerted statistically significant effect on Kenya's exchange rate during the sample period 2000Q1-2012Q4. The magnitude of effect of the net short term capital inflows on the exchange rate is however limited. The qualitative effect of the net short term capital inflows on the exchange rate is Donrbusch-like where the exchange rate initially overshoots its long run equilibrium and gradually corrects for the overshooting in tandem with the gradual adjustment in sticky output prices. Apart from the net short term capital inflows, the risk adjusted real interest rate differentials were by far the most important factor driving the Shilling-US Dollar bilateral nominal exchange rate during the period 2000Q1-2012Q4. Barring major economic transformation in Kenya's economy, the empirical results remain valid past the study sample period of 2000Q1-2012Q4.

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Appendix: Robustness Test Results

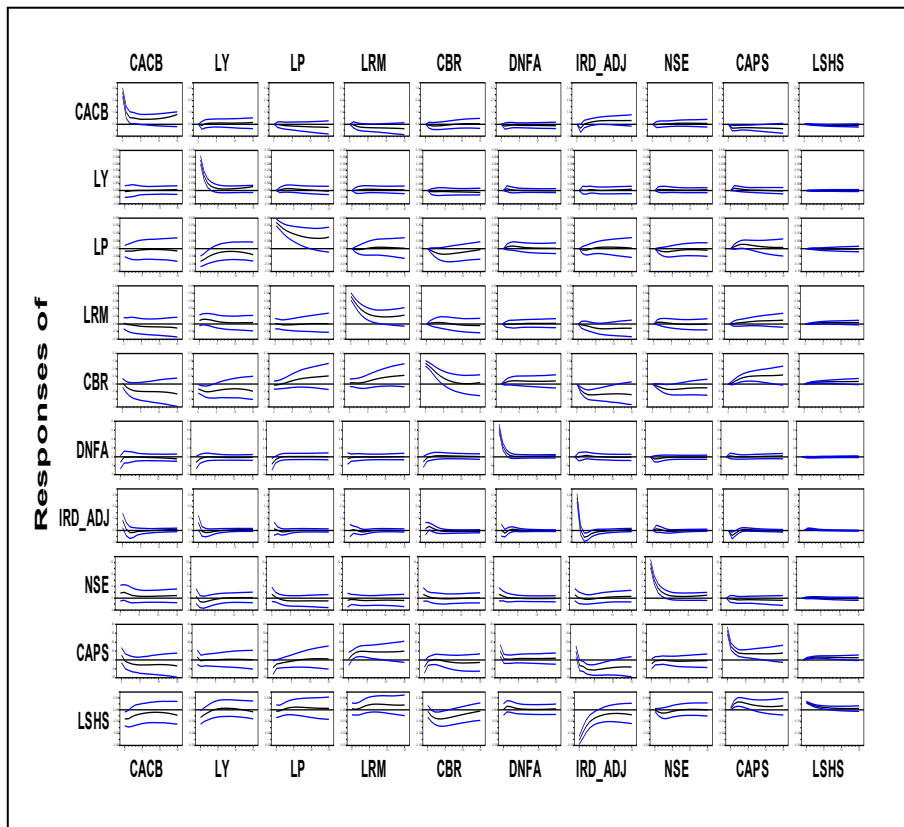


Figure A1. Model with 3 Lags

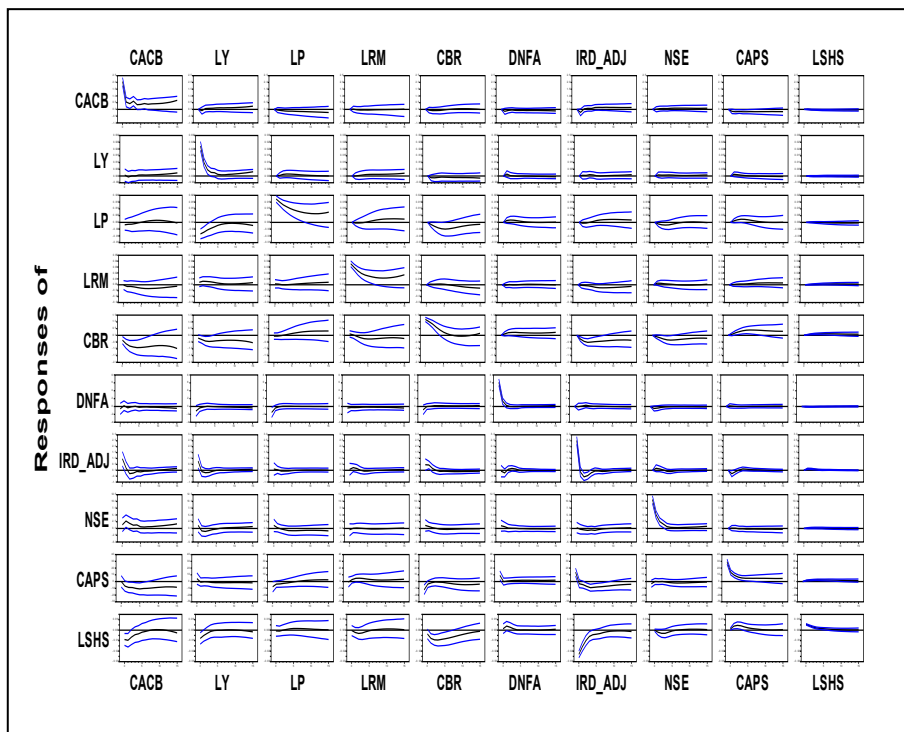


Figure A2. Model with 5 Lags

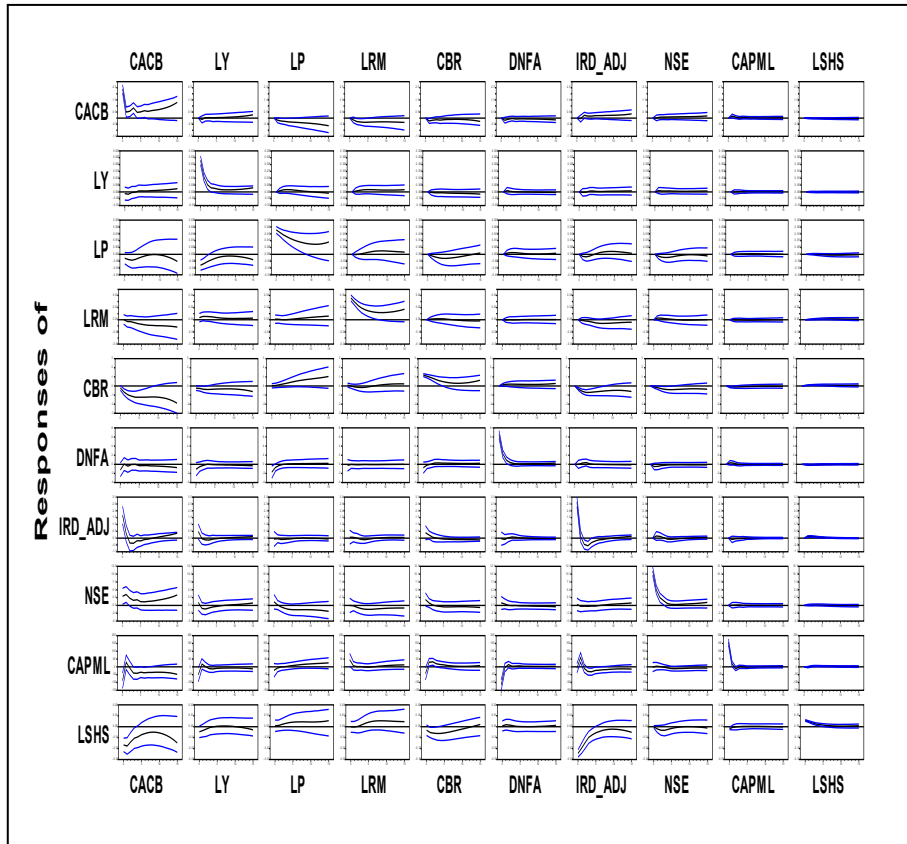


Figure A3. Model with Medium- and Long-term Capital Inflows

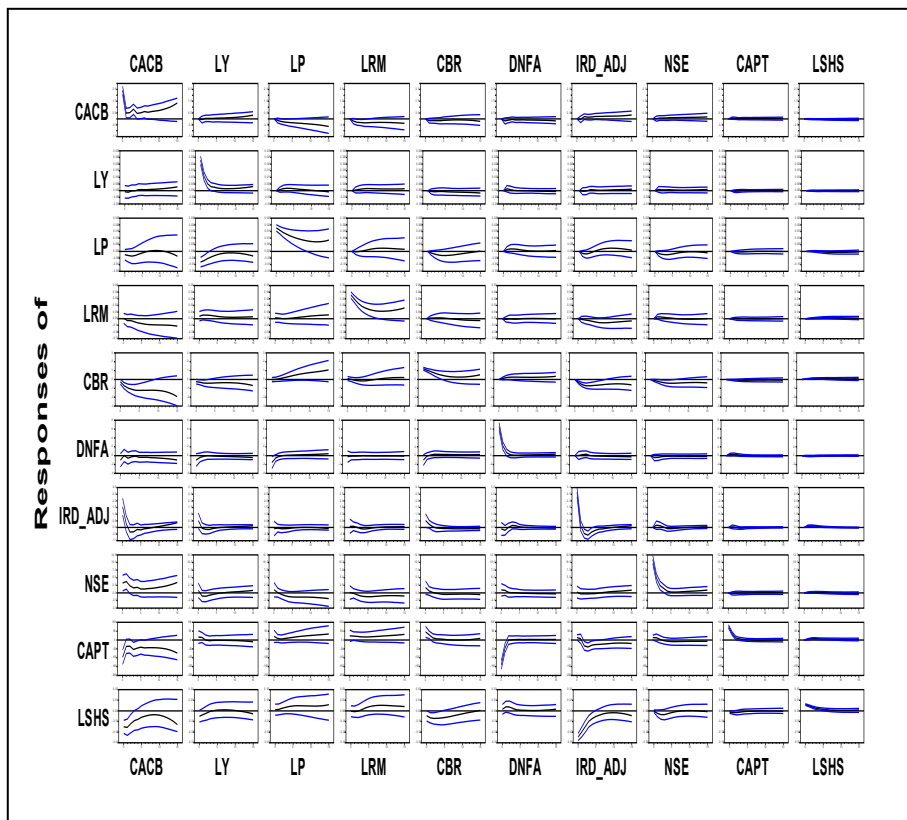


Figure A4. Model with Net Total Capital Inflows

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