

Central Bank Intervention in the Foreign Exchange Market and Interest Rate Policy in Jamaica: Signaling or Leaning Against the Wind

by
Dave Seerattan
&
Nicola Spagnolo

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Abstract

Direct intervention in the foreign exchange market and monetary policy, particularly interest rate policy, seems to be inextricably linked, even when direct interventions are fully and immediately sterilized. Looking at them separately in empirical studies may therefore give misleading results. Some research also suggests that direct intervention and monetary policy changes are more effective when coordinated, highlighting the need to look at the impact of intervention and interest rate policy on exchange rates in a joint framework. However, most studies looking at the impact of these policy instruments on exchange rate dynamics look at these policy instruments in isolation. This study seeks to close this gap by investigating in a multivariate GARCH framework whether direct intervention “signals” the future interest rate policy stance of the Central Bank or whether interest rate policy decisions induce interventions designed to “lean against the wind” of exchange rate trends in Jamaica. If the former relation dominates it would suggest that direct intervention is used to reinforce monetary policy initiatives but if the latter dominates it would suggest that direct interventions are used to resist exchange rate changes generated by fundamentals. In the latter case this may reflect a policy conflict between monetary policy and direct interventions generated by vulnerability to external shocks.

JEL Classification: E58; E43; F31

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1. Introduction

Most central bank operating flexible exchange rate regimes have intervened with direct intervention in the foreign exchange market. These interventions are usually executed together with offsetting operations in the domestic money market so that the money supply is

not affected. In this sense they are *sterilized* interventions and therefore cannot be thought of as monetary policy initiatives. Over time there has been a growing pessimism about the effectiveness of intervention, especially in developed market economies (Schwartz, 2000). The results of empirical studies on the effectiveness of intervention in the 1980s and 1990s, done almost exclusively on developed markets, indicate that there is mixed evidence that intervention can affect the level and variance of exchange rate returns (Edison, 1993 and Sarno and Taylor, 2001).

In the case of developing countries, there is less pessimism since in these markets the intervention volumes are larger relative to total turnover in the market. Additionally, a variety of regulations restricts the size of the market and helps to give the central bank leverage. The central bank also has an information advantage in the market due to reporting requirements. These advantages impact on the channels through which intervention is thought to affect exchange rates and may detract from or enhance the strength of a particular channel. These channels are not mutually exclusive and include the signaling, portfolio balance channel and market microstructure channels, all of which are based on their respective models of exchange rate determination. The portfolio balance channel works by generating rebalancing in terms of the currency composition of market participants' portfolios which generates changes in the exchange rate, the microstructure channel intervention works by emitting information to the market which modifies expectations and generates huge order flows which change exchange rate dynamics and the signaling channels works by indicating to agents what future monetary policy would be which cause them to alter current exchange rate dynamics. In spite of these supposed advantages of central banks in developing countries, a review of studies on the effectiveness of direct intervention in the foreign exchange markets in developing and transition economies by Disyatat and Galati (2007) showed that there is mixed evidence on the effectiveness of intervention in these countries.

Nevertheless, the effectiveness of intervention and tangential issues related to this policy instrument, such as the links between monetary policy and interventions remains a serious policy area in need of research in developing countries. This is particularly so since exchange rate stability is still a major policy objective given that the pass-through from exchange rate movements to inflation is higher in these markets compared to developed economies (Calvo and Reinhart, 2002). The exposure of financial assets denominated in local currency to significant capital loss and their vulnerability to external shocks also lead to a high premium being placed on exchange rate stability in

developing countries with flexible exchange rate regimes (Guimaraes and Karacadag, 2004).

Central banks intervention in the largest markets has declined (with the notable exception of Japan) but in many markets with flexible exchange rate regimes, especially developing markets, direct intervention have actually become rather common. Central banks must therefore have some policy objective in mind when they intervene in the foreign exchange market because they continue to do so in increasing numbers. In this study we are primarily interested in the relationship and feedback effects between monetary policy and direct intervention in developing countries especially since interventions are often not fully or immediately sterilized in these jurisdictions, leading to situations in which they may reinforce or counter monetary policy objectives. Direct interventions often run counter to monetary policy in developing economies because of their vulnerability to external shocks. For example, central banks in jurisdictions with high debt burdens may attempt to lower interest rates to spur growth but this can lead to capital outflows and depreciation which damages growth¹ and creates inflationary spirals², the so called “contractionary depreciations”. In this situation a central bank may intervene “leaning against the wind” by selling foreign currency to bolster the exchange rate in the short term rather than buying foreign exchange to signal its more accommodating monetary policy stance.

Since we are interested in the links between monetary policy and direct intervention, the signaling channel is a useful starting point to explore this issue. The empirical literature on the veracity of the signaling channel is mixed with most studies finding evidence supporting the signaling hypothesis with positive correlation between monetary policy variables and direct intervention, as well as evidence of “leaning against the wind”, that is, negative correlation between monetary policy and intervention (Kim, 2003, Lewis, 1995 and Kaminsky and Lewis, 1996). If the latter case predominates it implies that direct intervention does not drive or signal future monetary policy but instead is a response to economic conditions as reflected in monetary variables. In this case the central bank would be “leaning against the wind” in its intervention operations, that is trying to counter a short-term trend in the exchange rate driven by fundamental which include monetary policy.

¹ The empirical literature has generally found that depreciations tend to slow growth (Ahmed, 2003)

² See (Calvo and Reinhart 2002).

In this study, we examine the interrelation in Jamaica between direct intervention, interest rate policy and exchange rate dynamics jointly in a multivariate GARCH framework. One of the major advantages of using the multivariate GARCH framework include the ability to look at the impact of policy instruments on the mean and volatility of exchange rate returns. Previous studies looking at the links between direct intervention, monetary/interest rate policy and exchange rates (Lewis, 1995, Kim, 2003 and Kearns and Rigobon, 2005) have concentrated only on the first moment of exchange rate returns. Recent empirical studies have focused on the second moment as central banks increasingly intervened to reduce volatility rather than targeting a particular rate or band. This framework also allows one to look at how policy intervention affects the conditional covariance and correlation of important variable like interest and exchange rates over time. This can provide a clear picture of the inter-temporal dynamics of the way the correlation of important variables reacts to policy interventions and therefore shed some light on the likely costs associated with unsynchronized implementation of related policy instruments.

This can provide information on the extent of policy conflicts such as whether direct intervention is used to “lean against the wind” of exchange rate trends driven by the stance of interest rate policy (negative correlation). On the other hand, it could also provide insights on whether there is coordination amongst these instruments if direct intervention “signals” future interest rates (positive correlation). We also utilize daily data on intervention, policy interest rates and exchange rates rather than the monthly and weekly data used in previous studies (Lewis, 1995 and Kim, 2003). Daily data is more appropriate in today’s policy environment given the ample evidence that exchange rates reacts to new information and policy interventions very quickly, even on an intra-daily frequency.

The paper is structured as follows. Section 2 details very briefly the literature on the channels through which intervention may impact the exchange rate as well as a simple model of the signaling hypothesis. Section 3 outlines the empirical methodology. Section 4 evaluates whether the relationship between intervention, interest rate policy and exchange rate dynamics in Jamaica is best described as signaling or leaning against the wind in a multivariate GARCH framework and section 5 concludes.

2. Theory

Theoretically, *sterilized* interventions in the foreign exchange market can affect the exchange rate through a variety of channels that are

not mutually exclusive. These include the portfolio balance, market microstructure and signaling channels, all of which are based on their respective models of exchange rate determination³. In terms of the literature on intervention channels, the portfolio balance channel works by generating rebalancing in terms of the currency composition of market participants' portfolios which generates changes in the exchange rate. The key assumptions of this framework are that domestic and foreign-currency denominated financial assets are imperfect substitutes and that investors are risk-averse (Edison, 1993 and Dominguez and Frankel, 1993b). The microstructure approach to foreign exchange markets focus on order flow⁴, information asymmetries, trading mechanisms, liquidity and the price discovery process. Central bank intervention works in this framework by emitting information to the market which modifies expectations and generates huge order flows which change exchange rate dynamics (Evens and Lyons, 2002).

The signaling channel works by signaling to market participants the future stance of monetary policy, shifting their expectations about future monetary policy leading to a change in present exchange rate dynamics. This holds even if interventions are sterilized (Dominguez and Frankel, 1993a) and Kaminsky and Lewis, 1996). In this framework the exchange rate is treated as an asset price which is determined by the money supply. This channel can only work effectively if the central bank has policy credibility since the lack of credibility may increase the likelihood of speculative attacks against the currency where market participants speculate against the defensive (usually) interventions of the central bank (Sarno and Taylor 2001). The fact that this channel works by changing perceptions means that it can only be effective if it is well publicized to strengthen the central bank's policy signal.

In developing countries where central banks' credibility may be weak, this channel may not be as effective as in developed market economies where the central bank has a long history of prudent macroeconomic management. As such, the magnitude of the interventions by central banks in these jurisdictions may have to use relatively larger intervention amounts to have an impact, in other words they would have to "buy credibility" for their signal of future monetary policy stance to be as effective as in a developed market

³ See Mussa (1981), Taylor (1995) and Lyons (2001) for outlines of the signaling, portfolio balance and microstructure approaches to exchange rates respectively.

⁴ Order flow is transaction volumes that are *signed*. That is if you are the *active initiator* of a *sell* order this takes on a *negative sign* while the *active initiator* of a *buy* order takes on a *positive sign*. Markets with a negative sign and a positive sign indicate net selling and buying pressure respectively.

context (Mussa 1981). On the other hand, central banks in developing countries enjoy certain benefits relative to their developed market counterparts such as information advantages over the market and the ability to intervene with larger amounts relative to the market given the size of turnover in these markets (Canales-Kriljenko, Guimaraes and Karacadag 2003). These factors may therefore give central banks in some developing countries an advantage over even some of their developed market counterparts in the use of the signaling channel, particularly where the size of the intervention amount is relative to the overall market is large given the small size of the market.

The signaling hypothesis requires that intervention leads to future changes in monetary policy in line with the initial intervention. That is if the signaling channel is dominant future sales (purchases) of foreign exchange must be backed up by contractionary (expansionary) monetary policy. This is best explained by a simple model as outlined in Lewis (1995). Consider a standard asset pricing model

$$s_t = (1 - \theta) \sum_{j=0}^{\infty} \theta^j E_t f_{t+j} \quad (1)$$

Where s_t is the log exchange rate, f is the log of fundamentals and θ is a discount factor. Furthermore

$$f_t = (m_t - n_t^*) + v_t \quad (2)$$

Where m and n^* are the domestic and foreign monetary policy variables and v_t are fundamentals which are not controlled by central banks. Following Lewis (1995) we assume that n^* and v are exogenous and uncorrelated which means that the exchange rate solution is dependent on current expectations of future domestic monetary policy, as well as current expectations of foreign monetary policy and other fundamental out of central banks' control. We set the values of n^* and v to zero to focus on the role of domestic shocks so that $f_t = m_t$. This does not affect the inferences that can be drawn from this simple model regarding the impact of intervention and domestic monetary policy on exchange rates because by assumption future values of n^* and v are independent of m and direct intervention (I). Assuming that the process of fundamentals is autoregressive in 1st difference we have:

$$\Delta m_t = \rho_m \Delta m_{t-1} + \beta_{t-k} + \mu \quad (3)$$

Where Δ is the backward difference operator, ρ_m is the autoregressive coefficient of the first difference of fundamentals on their on lag, I_t is direct intervention at time t and β is a parameter relating intervention k periods in the past to a current change in the domestic monetary supply. If I is measured as sales of foreign currency and the central bank is effectively signaling with these interventions then β should be negative if m is a monetary aggregate. The logic behind this is that an intervention sale is contractionary since it takes domestic liquidity out of the system. Therefore, for an intervention sale to be consistent with the signaling hypothesis future changes in monetary policy must be contractionary, that is, it must be correlated with a fall in m in the future. If a policy interest rate was used as a proxy for monetary policy then an intervention sale would have to be correlated with a rise in the interest rates, that is β must be positive.

There are problems involved in determining the appropriate monetary policy variable to use in studies of this nature. The discussion on the monetary transmission mechanism helps inform this choice. In particular, when monetary aggregates contains elements which are positively correlated with interest rates then this is an inappropriate proxy for monetary policy based analysis based on a monetary model since monetary models are driven by liquidity effects which predicts that monetary aggregates would be *negatively* related to interest rates (Christiano and Eichenbaum, 1992). Also, Bernanke and Blinder (1992) argue that the federal funds rate is a better predictor of economic trends since it is truly exogenous because it is targeted by the Federal Reserve. Policy interest rates are therefore seen as a better proxy of monetary policy. Robinson and Robinson (1997) in a study of the monetary transmission mechanism in Jamaica also argue that the transmission of monetary policy begins with the repo rate and it is the main policy instrument.

The process for intervention is assumed to be autoregressive and is defined as:

$$I_t = \rho_I I_{t-1} + e_t \quad \text{where} \quad E(e_t | \mu) = 0 \quad (4)$$

For a given lag k then the exchange rate solution is:

$$s_t = m_{t-1} + \delta_m (\Delta m_t - \beta I_{t-k}) + \beta \delta_m \sum_{j=0}^{\infty} \rho^j E_t I_{t-k+j} \quad (5)$$

Where $\delta_m \equiv (1 - \theta_m)^{-1}$. Equation 5 therefore shows that in this framework the exchange rate depends on lagged money supply, the discounted present value of changes in the money supply adjusted by lagged intervention and the expected discounted present value of all future interventions. In sum current interventions affect the exchange rate by shifting the agents' expectations of future money supplies – that is signaling. When $\beta = 0$ interventions have no impact on the exchange rate but when $\beta > 0$ sales of foreign currency will signal future declines in money supplies and current and expected future interventions will lead to appreciation today.

If $k = 1$, that is, the lag between intervention and changes in the money supply is one period, the exchange rate solution is:

$$s_t = m_{t-1} + \delta_m \Delta m_t + \beta \delta_m \delta_I I_t \quad (6)$$

Where $\delta_I \equiv (1 - \theta_I)^{-1}$. From equation 6, once $\beta > 0$, current intervention will increase the expected money supply in the next period, changing the discount rate on money and therefore the exchange rate. The present value of the intervention effect on all future expected interventions and therefore money supplies is captured by $\delta_m \delta_I$, the product of the discount factor of money and the discount factor of intervention.

3. Empirical Methodology

The following mean equation was estimated for each series being considered:

$$X_{i,t} = \mu + \alpha X_{i,t-1} + \varepsilon_{it} \quad (7)$$

Where X_{it} is a vector of variables of interest (exchange rates, intervention and policy interest rates) at time t , μ is a long term drift coefficient and ε_{it} is the error term for variable i at time t .

This mean equation formulation can be more explicitly represented in this study by the following three equations which outlines the mean equation for the variables of interest, that is, exchange rate (ER), intervention (I) and the repo rate (RR):

$$ER_{i,t} = \alpha_1 + \alpha_{11} ER_{t-1} + \alpha_{12} I_{t-1} + \alpha_{13} RR_{t-1} + \varepsilon_{1,t} \quad (8)$$

$$I_{2,t} = \alpha_2 + \alpha_{21}ER_{t-1} + \alpha_{22}I_{t-1} + \alpha_{23}RR_{t-1} + \varepsilon_{2,t} \quad (9)$$

$$RR_{3,t} = \alpha_3 + \alpha_{31}ER_{t-1} + \alpha_{32}I_{t-1} + \alpha_{33}RR_{t-1} + \varepsilon_{3,t} \quad (10)$$

The two most popular parameterization for multivariate GARCH models are the VEC (Bollerslev, Engle and Wooldridge, 1988) and BEKK (Engle and Kroner, 1995) and parameterization. The VEC parameterization is characterized as:

$$\text{vech}(H_t) = A_0 + \sum_{j=1}^q B_j \text{vech}(H_{t-j}) + \sum_{j=1}^p A_j \text{vech}(\varepsilon_{t-j} \varepsilon'_{t-j}) \quad (11)$$

where $\varepsilon_t = H_t^{1/2} \eta_t$ $\eta_t \sim iid N(0,1)$. The notation $\text{vech}(\cdot)$ in equation 11 is a matrix operator which stacks the lower part of the symmetric matrix into a column vector and H_t is the conditional variance-covariance matrix. A_0 is a vector of constants capturing the unconditional variances and covariances while B_j and A_j are matrices of parameters representing the GARCH process. The major weaknesses of the VEC model include the number of parameters⁵ to be estimated and the fact that there is no guarantee that the covariance matrix will be positive semi-definite unless additional restrictions are imposed. The latter property is necessary for the estimated variance to be greater than or equal to zero. We therefore use the BEKK parameterization for the multivariate GARCH model estimated in this paper.

The general form of the BEKK model is:

$$H_{t+1} = C'C + A' \varepsilon_t \varepsilon_t' A + B' H_t B \quad (12)$$

The BEKK model is more tractable since it utilizes quadratic forms in such a way to ensure that matrix H_t will be positive semi-definite, without additional restrictions having to be imposed. This multivariate GARCH parameterization can significantly reduce the number of elements to be estimated in the variance equations. The BEKK model still involves some heavy computations because of the number of matrix inversions which is required. Also, because the BEKK parameterization uses a higher order polynomial representation which increases the non-linearity of the parameters, obtaining convergence may be difficult and time consuming. The individual

⁵ For example in a trivariate model the number of parameters to be estimated for the variance equation would be 78.

elements of matrices A , B and C in the case of a three-variable multivariate GARCH model are outlined below:

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \quad B = \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix} \quad C = \begin{bmatrix} c_{11} & 0 & 0 \\ c_{21} & c_{22} & 0 \\ c_{31} & c_{32} & c_{33} \end{bmatrix} \quad (13)$$

where C is a 3x3 lower triangular matrix of unconditional variances and covariance, A is a 3x3 square matrix of parameters that show the correlation of conditional variances with past squared errors and B is a 3x3 matrix of parameters that measure the impact of past levels on current levels of conditional variances. The parameters in A measure the impact of shocks in variables on the conditional variance of all variables while the parameters in B measure the volatility spillovers from variables under consideration.

The conditional variance equation for each variable⁶ which shows how shocks and volatility are transmitted over time sector can be expanded as follows:

$$h_{11t+1} = a_{11}^2 \varepsilon_{1t}^2 + 2a_{11} a_{12} \varepsilon_{1t} \varepsilon_{2t} + 2a_{11} a_{13} \varepsilon_{1t} \varepsilon_{3t} + a_{21}^2 \varepsilon_{2t}^2 + 2a_{21} a_{31} \varepsilon_{2t} \varepsilon_{3t} + a_{31}^2 \varepsilon_{3t}^2 - b_{11}^2 h_{11t} + 2b_{11} b_{12} h_{12t} + 2b_{11} b_{13} h_{13t} - b_{21}^2 h_{22t} + 2b_{21} b_{31} h_{23t} - b_{31}^2 h_{33t} \quad (14)$$

$$h_{22t+1} = a_{12}^2 \varepsilon_{1t}^2 + 2a_{12} a_{22} \varepsilon_{1t} \varepsilon_{2t} + 2a_{12} a_{32} \varepsilon_{1t} \varepsilon_{3t} + a_{22}^2 \varepsilon_{2t}^2 + 2a_{22} a_{32} \varepsilon_{2t} \varepsilon_{3t} + a_{32}^2 \varepsilon_{3t}^2 - b_{12}^2 h_{11t} + 2b_{12} b_{22} h_{12t} + 2b_{12} b_{32} h_{13t} - b_{22}^2 h_{22t} + 2b_{22} b_{32} h_{23t} - b_{32}^2 h_{33t} \quad (15)$$

$$h_{33t+1} = a_{13}^2 \varepsilon_{1t}^2 + 2a_{13} a_{23} \varepsilon_{1t} \varepsilon_{2t} + 2a_{13} a_{33} \varepsilon_{1t} \varepsilon_{3t} + a_{23}^2 \varepsilon_{2t}^2 + 2a_{23} a_{33} \varepsilon_{2t} \varepsilon_{3t} + a_{33}^2 \varepsilon_{3t}^2 - b_{13}^2 h_{11t} + 2b_{13} b_{23} h_{12t} + 2b_{13} b_{33} h_{13t} - b_{23}^2 h_{22t} + 2b_{23} b_{33} h_{23t} - b_{33}^2 h_{33t} \quad (16)$$

In this framework h_{11t} is the conditional variance for the first variable at time t and h_{12t} is the conditional covariance between the first and second variables. The error term ε_{it}^2 measures deviations from the mean due to some unanticipated event in variable

⁶ The constant terms are excluded.

i and cross error terms such as $\varepsilon_{1t}\varepsilon_{2t}$ measure the impact of unanticipated events in one sector on another.

Assuming that the errors are normally distributed the following likelihood function is maximized:

$$L(\theta) = -\frac{TN}{2} \ln(2\pi) - \frac{1}{2} \sum_{t=1}^T (\ln |H_t| + \varepsilon_t' H_t^{-1} \varepsilon_t) \quad (17)$$

where T is the number of observations, N is the number of variables in the model and θ is the vector of parameters to be estimated. The BFGS algorithm is used to obtain final estimates of the parameter with the variance covariance matrix and corresponding standard errors. The simplex method was used to obtain initial parameter for the BFGS algorithm.

4. The Links between Intervention, Monetary Policy and Exchange Rates

Data

The data set includes 1161 daily observations covering the period February 7, 2002 to September 28, 2006 after non-trading days are excluded. The exchange rate for Jamaica is defined as the midpoint between the weighted average bid and ask prices of the domestic currency per unit of the intervention currency. The intervention currency for Jamaica is the United States dollar. Intervention is defined as daily sales and purchases of foreign currency. The proxy used for monetary policy in Jamaica is the high rate on 30-day reverse repurchases (repo rate). Exchange rate returns and interest rate returns were used instead of the levels of these variables as they were not stationary at levels.

Empirical Results

The test by Engle (1982) indicated evidence of ARCH effects in the mean equations therefore a GARCH framework is appropriate. The preliminary estimation results for the multivariate GARCH model with BEKK parameterization for the variance equation for exchange rate returns are presented in Table 1.

Table 1: Trivariate GARCH Model Results

Variance Equation	Mean Equation
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Variable	$h_{1,t-1}$	Parameter	
$\varepsilon_{1,t}^2$	0.71 (7.20)	α_1	0.1 (3.47)
$\varepsilon_{1,t}\varepsilon_{2,t}$	0.08 (1.35)	α_{11}	-0.05 (-1.06)
$\varepsilon_{1,t}\varepsilon_{3,t}$	-1.13 (-3.52)	α_{12}	0.12 (1.69)
$\varepsilon_{2,t}^2$	-0.68 (-3.67)	α_{13}	-0.01 (-1.40)
$\varepsilon_{2,t}\varepsilon_{1,t}$	1.21 (2.44)	α_2	-0.02 (-6.9)
$\varepsilon_{2,t}\varepsilon_{3,t}$	1.14 (0.8)	α_{21}	-0.04 (-2.26)
$\varepsilon_{3,t}^2$	0.90 (32.17)	α_{22}	0.45 (11.87)
$\varepsilon_{3,t}\varepsilon_{1,t}$	0.01 (0.46)	α_{23}	-0.01 (-1.80)
$\varepsilon_{3,t}\varepsilon_{2,t}$	0.02 (1.94)	α_3	-0.05 (-1.70)
h_{11t}	0.68 (7.42)	α_{31}	1.50 (3.70)
h_{12t}	-0.01 (-1.64)	α_{32}	-1.53 (-1.97)
h_{13t}	0.23 (0.38)	α_{33}	-0.26 (-5.31)
h_{22t}	0.09 (0.82)		
h_{21t}	0.31 (1.67)		
h_{23t}	0.26 (1.93)		
h_{33t}	0.50 (4.46)		
h_{31t}	-0.01 (-0.79)		
h_{32t}	-0.005 (-1.52)		

Notes: t-statistics are in parenthesis

The results from the mean equation imply that intervention and the interest rate have little significant impact on the exchange rate. The signs are a priori correct but they are not statistically significant. This is in line with other studies looking at the impact of these variables in developing countries. The exchange rate, however, seem to drive both intervention and policy interest rate changes with the coefficients indicating that an increase in the exchange rate (depreciation) elicits increased intervention sales and increases in interest rates. This result supports the “leaning against the wind” school of thought. There also appears to be a negative but weakly statistically significant relationship between intervention sales (which

tightens domestic liquidity) and interest rates which imply that they generally act in concert in the sense that increased intervention sales is normally correlated with increases in interest rates. These policy instruments therefore appear to “lean against the wind” generally in a coordinated manner.

We are also interested in the impact of these policy instruments on volatility. The results indicate that in terms of the exchange rate volatility, shocks to exchange rate ($\epsilon_{1,t}^2$) increase volatility while shocks to interest rate tends to dampen exchange rate volatility ($\epsilon_{1,t}\epsilon_{3,t}$). In terms of interest rates, shocks to intervention ($\epsilon_{3,t}\epsilon_{2,t}$) and interest rate ($\epsilon_{3,t}^2$) tend to increase its volatility. In the case of intervention, shocks to exchange rate ($\epsilon_{2,t}\epsilon_{1,t}$) increase its volatility and there are positive volatility spillovers from interest rate volatility (h_{23t}). The results from the variance equations seem to also imply that exchange rate developments drive intervention and interest rate dynamics in the first and second moments of these variables which suggests that “leaning against the wind” behavior mostly characterizes the relationship between intervention, policy interest rate and exchange rates. The policy instruments also appear to act in tandem in this “leaning against the wind” behavior.

We are also interested in evolution of the correlation between these variables over time to see whether correlation fluctuates over time as policy changes. Figures 1, 2 and 3 show that there are considerable variations in the correlation of these variables over time, especially the correlation between the policy variables and the exchange rate. The spikes in the correlation are in most cases during period of high exchange rate volatility. This also suggest that the exchange rate drives the dynamics of the relationship between these variables.

Figure 1: Correlation of Exchange Rates and Interest Rates

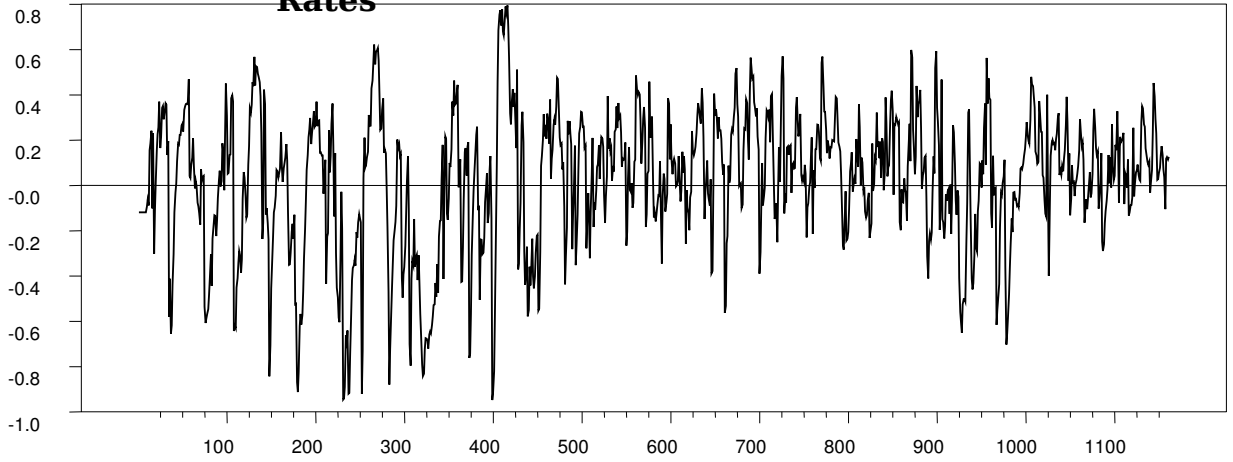


Figure 2: Correlation of Interest Rates and Intervention

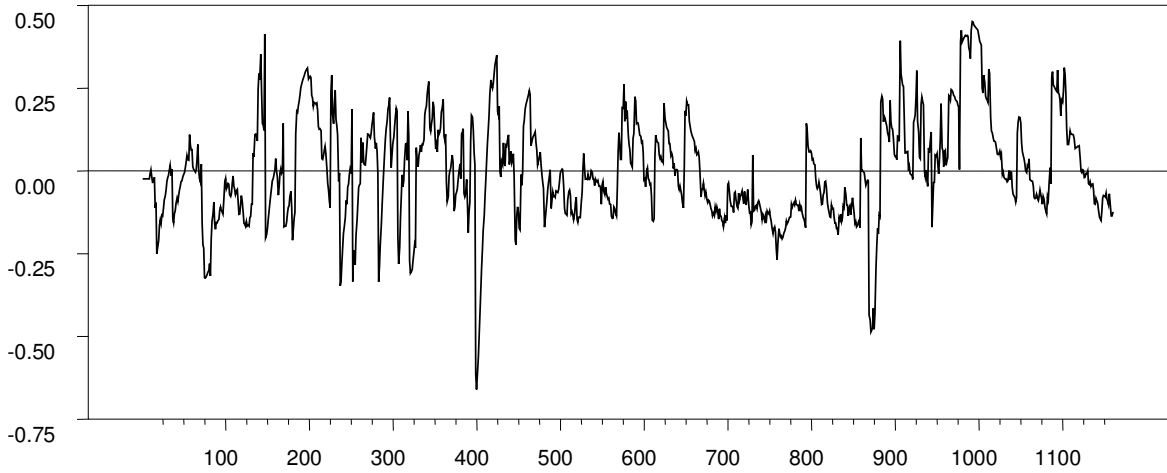
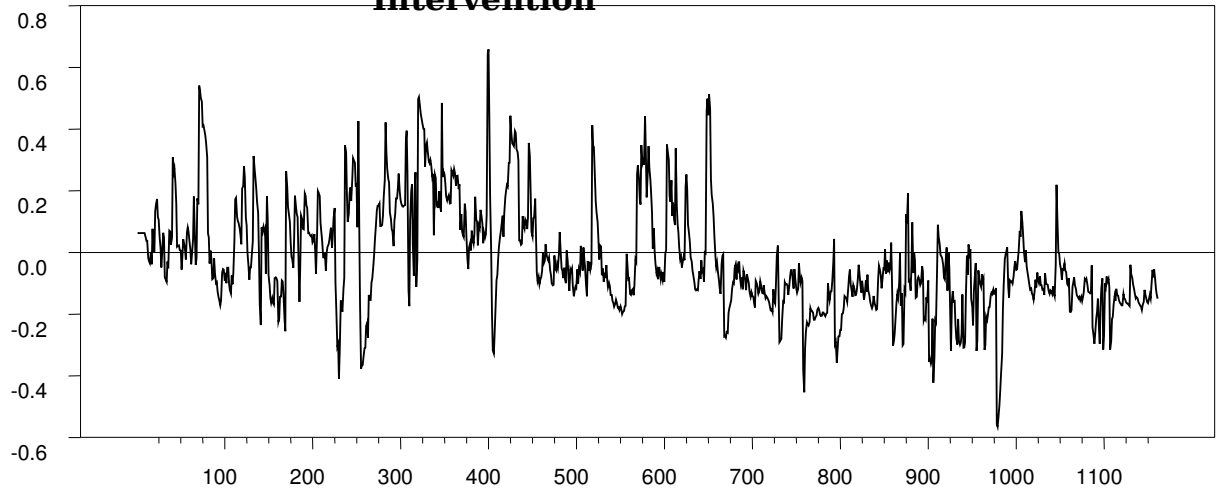


Figure 3: Correlation of Exchange Rates and Intervention



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