Central Bank Intervention and Exchange Rate Volatility in Zambia

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Abstract

The study analyses the impact of central bank intervention on the volatility of the exchange rate in Zambia over the period 1996-2010. The empirical findings reveal a statistically weak negative impact of intervention on exchange rate volatility. Further, there is little empirical support for a central bank decision to intervene in the foreign exchange market on account of volatility in the exchange rate. The results seem to suggest that the Bank of Zambia should not rely entirely on intervention to dampen volatility in the exchange rate; domestic policy changes are required to reinforce intervention. Triggers for intervention should also be re-examined within the context of the exchange rate policy objective.

Keywords: Exchange Rate Volatility, Intervention

JEL classification: F30, F31
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1. Introduction

Foreign exchange intervention is widely used by many central banks to achieve a particular objective. Countering market disorderliness, correcting exchange rate misalignment away from fundamental values, offsetting volatility in the (nominal) exchange rate, resisting short-term trends in exchange rates, accumulating official reserves, limiting exchange rate pass-through to prices and defending an exchange rate target are cited as some motivating factors for intervention (see Bonser-Neal, 1996; Baillie and Osterberg, 1997; Dominguez, 1998; Neely, 2000; Schwartz, 2000).

It is against this background that central banks all over the world strive to stabilize the exchange rate in order to mitigate the adjustment and uncertainty costs that a volatile exchange rate imposes on the economy. A volatile exchange rate causes undesirable changes in aggregate and sectoral output, the price level, volume of international trade and foreign investment (Chipili, 2010).

Many empirical tests regarding central bank intervention have been conducted on the deutschmark/US dollar and yen/US dollar exchange rates with very little work done on other currencies (Aguilar and Nydahl, 1998). The reason why these three currencies have been widely studied is because the authorities want to establish the effectiveness of intervention in achieving the intended policy objective. For example, the G-5 countries decided to use intervention to achieve an orderly depreciation of the US dollar against the deutschmark and yen during the Plaza period (1985-1987), and stabilize these currencies around their current levels during the Louvre period (1987-1989).

By and large, empirical evidence shows that, the effect of intervention on the level and volatility of the exchange rate is mixed, with overwhelming support for the leaning-against-the-wind proposition (Schwartz, 2000; Neil and Fillion, 1999). Comprehensive empirical evidence on the effectiveness of official intervention is provided by Dominguez (1998) and Edison (1993).

Available empirical work done in Zambia on the exchange rate has concentrated on analysing its factor determinants (Chipili, 1998; Mwenda, 1996; Mungule, 2004). The effect of the Bank of Zambia (BoZ) intervention as a policy instrument has received little empirical investigation. This study attempts to bridge this gap.

Thus, this study analyses the impact of the BoZ intervention on the volatility of the exchange rate and also assesses whether intervention is driven by volatility in the exchange rate. The study results reveal a weak negative impact of intervention on exchange rate volatility and that intervention is not necessarily driven by volatility in the exchange rate.

The rest of the paper is organised as follows. Section 2 outlines the objectives of the study. Section 3 briefly reviews Zambia’s exchange rate policy. Section 4 presents
the BoZ’s intervention strategy. The theoretical framework relating to intervention and exchange rate behaviour is given in Section 5, while Section 6 reviews the empirical literature on the impact of intervention on the exchange rate. The estimation procedure and empirical results, including data sources, are contained in Section 7. Section 8 concludes and provides policy implications of the study results.
2. Objectives of the study

This study attempts to test the hypothesis that intervention by the BoZ in the foreign exchange market stabilises the exchange rate. In particular, the study endeavours to establish:

1. The impact of the BoZ intervention on the volatility of the kwacha/US dollar exchange rate over the period April 1996 – December 2010; and
2. Whether volatility in the exchange rate influences the BoZ’s decision to intervene in the foreign exchange market.
3. Exchange rate policy in Zambia

Increased exchange rate volatility, misalignment of the exchange rate from equilibrium levels for long periods, prolonged current account imbalances and the rise in capital mobility prompted most central banks, such as the Bank of Japan, Bank of England and most emerging economies in Latin America and Asia to manage exchange rates as opposed to having a freely floating exchange rate arrangement.

Likewise, Zambia adopted a managed float exchange rate system in 1994, when the kwacha was made fully convertible. Prior to that, the exchange rate was fixed from the time of independence, in 1964. The kwacha was first pegged to the British pound sterling and subsequently alternated between the US dollar, Special Drawing Rights and a basket of currencies of major trading partners. However, between 1985 and 1987, the exchange rate was allowed to float, during which the Dutch auction system was used to allocate foreign exchange. Nevertheless, the Dutch auction system was abandoned in May 1987, due to excessive depreciation of the exchange rate, a reflection of the misalignment of the exchange rate, and inflationary pressures that arose from a depreciated exchange rate. Thereafter, the kwacha was fixed to the US dollar again and the Foreign Exchange Management Committee (FEMAC) undertook the allocation of foreign exchange. Between 1990 and 1991, a dual exchange rate system managed by FEMAC was adopted. The system included a retail window for importers, an open general licence (OGL) system and an official window with a lower rate. Later in 1991, the OGL and official exchange rates were unified. For most of 1992, the exchange rate was fixed, with the unified market rate determined as the weighted average of commercial bank and bureau de change market rates until 1994.

Consistent with the International Monetary Fund (IMF) classification of Zambia’s post-1994 exchange rate system as initially independently floating and later as a managed float, the BoZ does not target the exchange rate and instead allows the exchange rate to be determined by market conditions. Thus, the exchange rate policy in Zambia is aimed at achieving a stable and competitive exchange rate consistent with macroeconomic conditions (Bank of Zambia Annual Reports, 1996-2010).

In terms of exchange rate behaviour, it is observed that the post-float period is distinguished by wide fluctuations in the exchange rate, with the kwacha exhibiting a rising trend with some volatility (Figure 1), similar to experiences of most countries that switch from fixed to floating exchange rate regimes.
Figure 1: Weekly kwacha/US dollar exchange rate
4. Intervention strategy

Consistent with the exchange rate policy, the BoZ interventions in the foreign exchange market are undertaken to smooth out short-term fluctuations in the exchange rate without influencing the underlying trend. This intervention strategy is in line with the independently floating and managed float exchange rate system classification by the IMF, which stipulates that interventions in the foreign exchange market by the central bank should be aimed at moderating the rate of change and preventing undue fluctuations in the exchange rate rather than establishing a level for it.

The BoZ interventions in the spot foreign exchange market involve direct purchases and sales of foreign currency, mainly US dollars, the intervention currency. The BoZ also indirectly intervenes in the foreign exchange market by influencing money market liquidity conditions through instruments such as open market operations, reserve requirements and moral suasion (Bank of Zambia Annual Reports, 1996-2010).

The main sources of BoZ intervention funds include foreign exchange purchases from the market (i.e., export earnings) and donor inflows (balance of payments support). In terms of donor inflows, the government receives the local currency value of the balance of payments while the BoZ retains the foreign exchange. This transaction inevitably leads to an expansion in reserve money and, consequently, broad money. Given the monetary framework adopted by the BoZ, where monetary aggregates are used as the nominal anchor for monetary policy, the central bank seeks to sterilize liquidity arising from foreign exchange transactions whenever reserve money expansion exceeds the set target (Bank of Zambia Annual Reports, 1996-2010).

In terms of the actual BoZ intervention activities in the foreign exchange market, it is observed that the floating of the kwacha was accompanied by a rise in the frequency and scale of interventions by the BoZ. The bulk of the intervention by BoZ prior to April 1996 was mere onward re-sale of the surrendered foreign exchange proceeds by exporters, particularly Zambia Consolidated Copper Mines (ZCCM).2 The BoZ interventions were intense between April 1995 and May 1996, when the BoZ used to intervene daily in the foreign exchange market. Prior to that (December 1993 to March 1995), the BoZ intervened three times a week and the volume of sales and purchases were lower compared with the April 1995 to May 1996 period.3 Increased interventions by the BoZ during that period were aimed at developing the inter-bank market, besides stabilising the exchange rate following the liberalization of the foreign exchange market. However, the presence of the BoZ in the foreign exchange market reduced drastically after April 1996, following the abolition of the ZCCM retention scheme and subsequent establishment of the interbank foreign exchange market (IFEM) system in July 2003.
Interventions in the foreign exchange market by the BoZ became limited and occasional, aimed at smoothing out short-term fluctuations in the exchange rate.

Table 1 and Figure 2 show the annual rate of change of the kwacha/US dollar and the volume of intervention in millions of US dollars (in absolute terms) between April 1996 and December 2010.

<table>
<thead>
<tr>
<th>Period</th>
<th>% change in K/US dollar exchange rate</th>
<th>Intervention (million US dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>April-Dec 1996</td>
<td>4.2</td>
<td>55.9</td>
</tr>
<tr>
<td>1997</td>
<td>8.7</td>
<td>36.9</td>
</tr>
<tr>
<td>1998</td>
<td>63.7</td>
<td>30.8</td>
</tr>
<tr>
<td>1999</td>
<td>13.7</td>
<td>30.3</td>
</tr>
<tr>
<td>2000</td>
<td>58.4</td>
<td>52.8</td>
</tr>
<tr>
<td>2001</td>
<td>-3.1</td>
<td>89.0</td>
</tr>
<tr>
<td>2002</td>
<td>24.1</td>
<td>81.4</td>
</tr>
<tr>
<td>2003</td>
<td>-3.4</td>
<td>146.3</td>
</tr>
<tr>
<td>2004</td>
<td>1.6</td>
<td>96.7</td>
</tr>
<tr>
<td>2005</td>
<td>-26.6</td>
<td>123.3</td>
</tr>
<tr>
<td>2006</td>
<td>20.8</td>
<td>291.6</td>
</tr>
<tr>
<td>2007</td>
<td>-7.1</td>
<td>221.9</td>
</tr>
<tr>
<td>2008</td>
<td>27.3</td>
<td>314.5</td>
</tr>
<tr>
<td>2009</td>
<td>-4.4</td>
<td>435.0</td>
</tr>
<tr>
<td>2010</td>
<td>1.5</td>
<td>292.4</td>
</tr>
</tbody>
</table>

Source: Computed from BoZ Annual Reports and the Bank of Zambia Statistics Fortnightly Bulletins
Note: A positive % change in the exchange rate implies a depreciation while a negative % change in the exchange rate implies an appreciation

Figure 2: BoZ intervention and exchange rate movement
A casual inspection of the data in Table 1 and Figure 2 reveals that the relationship between intervention and exchange rate movement is not systematic over the sample period. Further, although not apparently clear in Figure 2, there are periods when large changes in the exchange rate are followed by large changes, and small changes followed by small changes. This is an indication of volatility clustering, implying the presence of autoregressive or generalized conditional heteroscedasticity (ARCH/GARCH). Section 7 aims to confirm the conclusion drawn about the effect of the BoZ intervention based on Table 1 and Figure 2 through a formal investigation.
5. Theoretical framework

The exchange rate is affected by both fundamental and transitory reversible factors. The effect of intervention on exchange rate volatility depends on the extent to which the former influences the causes underlying the latter. Volatility in the exchange rate is caused by volatility in market fundamentals such as money supply, income and interest rates as well as changes in expectations due to new information and speculative bandwagons (Bonsear-Neal, 1996).

Dominguez (1998) argues that, it is standard to model the exchange as a forward-looking process that is expectationally efficient with respect to public information. In this regard, the current spot exchange rate can be represented as:

\[ s_t = (1 - \delta) \sum_{k=0}^{\infty} \delta^k E_t(z_{t+k} | \Omega_t) \]  

(1)

where \( s_t \) is the logarithm of the current exchange rate; \( \delta \) is the discount factor such that \( \delta = \beta / (1 + \beta) \) where \( \beta \) is the interest semi-elasticity of money demand in the monetary model; \( z_{t+k} \) is a vector of exogenous driving variables; \( E_t \) is the expectations operator; and \( \Omega_t \) is the information set in period \( t \).

According to Equation 1, intervention operations denoted as \( I_t \) provide relevant information to the market, and, as such, enlarge the market’s information set \( \Omega_t \) and, consequently, influence the spot exchange rate as \( \Omega_t = \Omega_t + I_t \).

Intervention is narrowly defined as any official sale or purchase of foreign assets against domestic assets in the foreign exchange market (Dominguez, 1998). In general, foreign exchange market intervention is any transaction or announcement by an official agent of government intended to influence the value of the exchange rate. Foreign exchange intervention can either be sterilized or unsterilized. Sterilized intervention involves an offsetting domestic asset transaction that leaves the monetary base unchanged, whereas unsterilized interventions alter the monetary base. Sterilized intervention does not affect prices or interest rates directly. On the other hand, unsterilized intervention changes the interest rate differentials and, consequently, the exchange rate. According to the monetary model of the exchange rate determination, unsterilized intervention affects the exchange rate in proportion to the change in the relative supplies of domestic and foreign money.
Neil and Fillion (1999) argue that, there are at least four mechanisms by which sterilized intervention might affect the exchange rate. These are signalling, portfolio-balance, noise-trading and liquidity approaches. The asset market model, abstracted from Aguilar and Nydahl (1998), is used to explain how intervention affects the exchange rate through these various channels. In this model, the exchange rate is specified as

\[ s_t = f_t + \alpha \left[ E_t \left( s_{t+1} \mid \Omega_t \right) - s_t \right] \]  

(2)

where \( f_t \) is current period fundamentals; and, \( s_t, E_t \) and \( \Omega_t \) are as earlier defined.

According to Equation 2, the exchange rate at time \( t \) is determined by the current period fundamental factors and the expected capital gain \( E_t \left( s_{t+1} \mid \Omega_t \right) - s_t \) of holding the currency until the next period. Equation 2 can be simplified further to obtain the following expression

\[ s_t = \frac{1}{1 + \alpha} \sum_{j=0}^{\infty} \left( 1 + \frac{1}{1 + \alpha} \right)^j \left[ E \left( f_{t+j} \mid \Omega_t \right) + \frac{1}{1 + \alpha} E \left( b_{t+1+j} \mid \Omega_t \right) \right] \]  

(3)

Everything else is as defined in above except \( b_{t+1} \) which represents a rational bubble. According to Equation 3, the exchange rate is expressed as the expected present value of future fundamentals \( \left( \frac{1}{1 + \alpha} \sum_{j=0}^{\infty} \left( 1 + \frac{1}{1 + \alpha} \right)^j E \left( f_{t+j} \mid \Omega_t \right) \right) \) and a bubble \( \left( \frac{1}{1 + \alpha} E \left( b_{t+1} \mid \Omega_t \right) \right) \). Using this model, intervention affects the exchange rate through various channels as follows.

**Signalling approach**

The signalling approach works on the assumption of information asymmetry where the central bank has an information advantage over market agents with regard to future monetary policy or the long-run equilibrium value of the exchange rate. By intervening in the foreign exchange market, the central bank changes market agents’ expectations of future fundamentals by providing information about future monetary policy. When the central bank buys domestic currency, a contractionary future monetary policy is signalled to the market: this induces agents to revise their expectations of the future exchange rate, given that the exchange rate is forward-looking as shown in Equation 3, resulting in an appreciation. The signalling theory predicts that the exchange rate will depreciate following a sterilized purchase of a foreign currency by the central bank, if the purchase is assumed to signal a more expansionary domestic monetary policy. A depreciation of the exchange rate occurs because the central bank does not alter the domestic monetary base to avoid the agents misconstruing it as a change in the monetary policy stance.
Intervention in this context is effective if and only if the signal about future monetary policy arising from intervention is credible.

**Portfolio-balance approach**

Through the portfolio-balance channel, investors diversify their holdings among domestic and foreign assets as a function of both expected returns and the variance of returns. Intervention, therefore, affects the level of the exchange rate through the portfolio-balance channel by altering the relative supply of foreign and domestic securities, compensating investors by a risk premium for holding foreign securities, provided that these securities are imperfect substitutes. This creates disequilibrium in the investors’ portfolio. Equilibrium is restored through a change in the risk premium, which causes a change in asset returns imbedded in capital gains in Equation 2, thereby producing changes in the spot exchange rate. In an event that intervention increases the supply of domestic — relative to foreign — assets held by the market, a higher expected return on domestic assets will be demanded on domestic assets for the market to willingly hold them, resulting in the depreciation of the domestic currency. However, if these securities are perceived to be perfect substitutes, intervention is predicted to have no effect on the exchange rate.

**Noise-trading approach**

In this approach, the exchange rate is allowed to move away from its fundamental value due to a rational bubble, which reflects the behaviour of “noise traders”.

Noise traders can, therefore, move asset prices away from their fundamental equilibrium when induced by the central bank through intervention to either buy or sell currency. This affects the noise traders’ perception of the trend in the exchange rate changes. Intervention in this case either increases or reduces exchange rate volatility by leaning with or against the wind, respectively, when noise traders move the exchange rate away or towards its fundamental value. Theory is ambiguous on the effects of central bank intervention on exchange rate volatility. Central bank intervention can reduce exchange rate volatility if it helps resolve market uncertainty about future fundamentals and policies, or if it reduces the likelihood of speculative attacks on the currency and vice versa.

**Liquidity approach**

This approach presupposes that intervention might have a direct impact on the exchange rate volatility, but not its level. Intervention is expected to have a short-term, flow-driven impact on the exchange rate if the size of intervention is large relative to the market turnover within a brief period of time. The size of the intervention influences fundamentals, which, in turn, affect the current exchange rate. In addition, intervention reduces the risk of market making through the provision of more liquidity on the market, which induces dealers to provide additional liquidity, thereby affecting fundamentals and, ultimately, the exchange rate.
6. Empirical literature review

The literature on the effect of central bank intervention on exchange rate volatility is extensive and the results of empirical research are mixed. The variation in empirical results is explained by intervention strategies used by central banks (sterilized or unsterilized), type of currencies studied, sample period investigated, models used and the amount of intervention involved.

During the 1980s and early 1990s, efforts by researchers concentrated on analysing the effect of sterilized intervention on the level of the exchange rate and the channels through which it works. Over the past few years, focus has shifted to analysing the effect of intervention on exchange rate volatility.

Intervention has been found to be effective through both signalling and portfolio-balance channels (Neely, 2000). However, Rogoff (1984), Humpage (1988), Obstfeld (1989), Klein and Rosengren (1991) and Ghosh (1992) have generally found little empirical support for the liquidity approach due to the fact that the size of the intervention by central banks is relatively smaller than the total market liquidity. Conversely, Dominguez and Frankel (1993) found empirical support for the portfolio-balance approach. Due to diverse empirical results regarding these two channels, Galati and Melick (1999) conclude that, there is a general consensus in the literature that intervention does not affect exchange rates through the portfolio channel in favour of the signalling approach despite the view that signals from intervention are not always clear and credible with respect to future monetary policy.

Dominguez and Frankel (1993) provide leading evidence of intervention (both coordinated and non-coordinated) having a significant impact on the level of exchange rate. Later studies that confirm Dominguez and Frankel’s finding include Catte et al. (1994) for the yen/US dollar and DM/US dollar exchange rates. However, intervention is found to be ineffective in influencing the level of the exchange rate (see Aguilar and Nydahl, 1998). Similarly, Aguilar and Nydahl (1998), in examining the impact of Riksbank’s intervention on the krona/US dollar and DM/US dollar exchange rates over 1993-1996 period, find weak evidence of intervention affecting the level of the exchange rates over the whole study period, although in some sub-periods, a significant relationship is observed.

Several measures of volatility have been employed in analysing the impact of intervention on the volatility of the exchange rate. The commonly used measures of volatility are GARCH and implied volatility methods. Baillie and Humpage (1992) find a positive relationship between the Federal Reserve, Bank of Japan and Bundesbank intervention and the conditional volatility of the DM/US dollar and yen/US dollar

The empirical evidence on the effect of intervention on implied volatility of the exchange rate is also mixed. Bonser-Neal (1996) and Bonser-Neal and Tanner (1996) establish varied effects of the Federal Reserve, Bundesbank and Bank of Japan intervention on the volatility of the exchange rate across time. Intervention had no significant effect on the volatility of the exchange rate during the Plaza period, but increased it during the Louvre period, with some evidence of a reduction in volatility of the DM/US dollar exchange rate but no effect on the yen/US dollar exchange rate during the post-Louvre period.

Although intervention has been found to generally increase volatility in the exchange rate, Domínguez (1993) argues that the impact of intervention on exchange rate volatility depends on how central banks conduct them. Officially announced interventions reduce volatility while undetected interventions by the market increase volatility. Galati and Melick (1999) find perceived intervention insignificant in influencing the exchange rate level and the skewedness of the probability density functions while it increases traders’ uncertainty about future exchange rate movements.

Triggers for intervention by central banks have also been examined empirically. Baillie and Osterberg (1997) find intervention to be granger caused by high volatility of the changes in the nominal exchange rate while weak support for intervention granger causing the conditional variance of the changes in the nominal exchange rate is reported. In addition, the authors find little evidence of granger causality running from implied volatility to intervention; a similar conclusion arrived at by Domínguez (1993; 1998). Evidence of central banks basing intervention decisions on volatility in the exchange rate is found (see Chaboud and LeBaron, 1999). Domínguez (1998) find that intervention is correlated with volatility although causation runs from intervention to volatility. The Federal Reserve intervened when it was observed that an intervention would be successful given the market conditions that existed over the September 1993 and April 1996 period (Galati and Melick, 1999). On the other hand, the Bank of Japan is seen to intervene in response to deviations of the exchange rate from its implicit target level.

Generally, doubt has been cast on the efficacy of intervention. Intervention does not appear to affect fundamental economic determinants of the exchange rate. It also has weak long-run effects on the exchange rate (see Chaboud and LeBaron, 1999; Edison, 1993; Klein and Rosengren, 1991). In the short-term, central bank intervention is often associated with sharp price movements in currency markets. It is argued that intervention would only have lasting effects if it was accompanied by domestic policy changes (Schwartz, 2000).
7. Estimation procedure and empirical results

Model specification

Similar to Simatele (2004), GARCH (1,1) model is used to determine the impact of the weekly BoZ intervention on the volatility of the nominal spot kwacha/US dollar over the period April 1996-December 2010 as follows:

\[
\Delta s_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \Delta s_{t-i} + \phi NIV_t + \varepsilon \\
\]

\[
h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta h_{t-1} + \phi NIV_t + \nu_t \\
\]

\[
\varepsilon_t \mid I_{t-1} \sim (0, h_t) \\
\]

where \(s_t\) is the logarithm of the kwacha/US dollar exchange rate such that \(\Delta s_t\) is returns in the kwacha/US dollar exchange rate; \(NIV_t\) is net intervention sales by the BoZ to the market; \(\varepsilon_t\) is residuals used to compute \(h_t\); \(h_t\) is conditional variance (volatility) of \(s_t\) derived from the GARCH (1,1) model; \(\nu_t\) is standardised residuals; \(I_{t-1}\) is the information set at time \(t-1\); and \(q\) is the lag length.

To ensure that the GARCH model is well-specified, \(\alpha_0 > 0, \alpha_1 > 0\) and \(\beta \geq 0\) must hold. The degree of volatility persistence is captured by \(\alpha_1 + \beta\) such that the closer the sum is to 1, the more persistent the shocks are on volatility.

A GARCH(1,1) model specification as opposed to higher order GARCH specifications is chosen as it is parsimonious and, thus, avoids over-fitting the model and violation of non-negativity constraint. In addition, it sufficiently characterises the behaviour of the exchange rate, i.e., leptokurtic, asymmetry and volatility clustering (see Brooks, 2006). Further, the study models volatility of the kwacha/US dollar exchange rate using a GARCH (1,1) process based on the evidence of volatility clustering deduced from the descriptive statistics presented in Figure 2 and Table 2. Moreover, econometric models such as ARCH-type introduced by Engel (1982) and Bollerslev (1986) have been empirically useful in modelling temporal evolution of volatility.

The underlying theory suggests that, intervention in Equation 4 will reduce volatility if
the sign on is negative and increase volatility if the sign on is positive. This model does not distinguish between sterilized and unsterilized interventions similar to the approach taken by Aguilar and Nydahl (1998) and Baillie and Osterberg (1997). Further, the study does not explicitly test the channel through which intervention works, but simply if intervention affects the exchange rate.

Further, the probit test is conducted to determine whether the BoZ interventions are driven by volatility in the kwacha/US dollar. Ramana and Samiei (2000) argue that probit models provide a useful econometric technique for identifying triggers for intervention. Accordingly, intervention defined as $D_t$ is a dummy variable that takes the value of one when intervention occurs and zero otherwise. $D_t$ is said to respond linearly to variables such as the extent of the absolute change in the exchange rate during a specified period as below

$$D_t = \theta' x_t + u_t$$

(5)

where $x_t$ is the set of exogenous variables that influence the response variable, $u_t$ is an error term, and $\theta$ is the parameter to be estimated. In this study, $D_t$ (denoted as IDUMMY) is created by modifying the intervention data series, such that $D_t$ is assigned the value of one in weeks when intervention occurred and zero otherwise. A one lagged period value of $D_t$ is included in the model as an explanatory variable to capture intervention clustering, i.e., whether intervention in one period is necessarily followed by another intervention in the following period.

### Data sources

The intervention data series used in the empirical test are defined as net sales (sales less purchases) in millions of US dollars. Similar to Kamil (2008), actual values of intervention in US$ million are used in this study despite the series being discontinuous. Since foreign exchange interventions are carried out in US dollars, the exchange rate studied is the nominal weekly average spot BoZ-mid kwacha/US dollar (K/US$). Both the exchange rate and intervention data are obtained from the Bank of Zambia Statistics Fortnightly Bulletin (1996-2010).

### Statistical properties of variables

Before empirical tests of equations 4 and 5 are conducted, various descriptive statistics for the exchange rate and intervention data series are examined, which provide insights into the characteristics of the data series under investigation. Table 2 reflects these descriptive statistics.

The presence of skewedness and kurtosis in the exchange rate and intervention data series are detected. Further, the Jarque-bera statistic confirms at 1% significance level that the two data series are not normally distributed. The kurtosis statistic reveals
the presence of leptokurtosis in the weekly change in the kwacha/US dollar exchange rate and intervention data series. Thus, evidence of leptokurtosis in the exchange rate suggests that there exists temporal clustering in the variance of the exchange rate where large changes are followed by large changes and small changes are followed by small changes and therefore warrant the use of a GARCH model. In addition, the presence of kurtosis in the data series indicates the likelihood that the market attributes to very large exchange rate movements in either direction in the near future. Finally, the BoZ was a net seller of foreign exchange over the sample period with an average intervention size of about US$2.0 million per week.

Table 2: Weekly exchange rate and intervention statistics (1996-2010)

<table>
<thead>
<tr>
<th>Statistic/Variable</th>
<th>$S_t$</th>
<th>$\Delta S_t$</th>
<th>$FXP_t$</th>
<th>$FXS_t$</th>
<th>$NI_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3575.7</td>
<td>0.002</td>
<td>1.49</td>
<td>1.99</td>
<td>0.50</td>
</tr>
<tr>
<td>Maximum</td>
<td>5704.5</td>
<td>0.014</td>
<td>55.0</td>
<td>56.0</td>
<td>56.0</td>
</tr>
<tr>
<td>Minimum</td>
<td>1230.3</td>
<td>-0.167</td>
<td>0.00</td>
<td>0.00</td>
<td>-55.0</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>1242.6</td>
<td>0.021</td>
<td>4.64</td>
<td>5.07</td>
<td>7.13</td>
</tr>
<tr>
<td>Skewedness</td>
<td>-0.59</td>
<td>-1.48</td>
<td>5.94</td>
<td>4.96</td>
<td>0.10</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.13</td>
<td>17.04</td>
<td>49.66</td>
<td>38.48</td>
<td>22.12</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>69.3</td>
<td>6999.9</td>
<td>74288.2</td>
<td>43477.5</td>
<td>11713.2</td>
</tr>
<tr>
<td>Probability</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Sum</td>
<td>1149.6</td>
<td>1535.0</td>
<td>385.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Authors’ Computations

Note:
- $S_t$ = weekly average spot BoZ-mid kwacha/US dollar exchange rate (raw series)
- $\Delta S_t$ = change in natural logarithm of weekly average spot BoZ-mid kwacha/US dollar exchange rate
- $FXP_t$ = weekly BoZ purchase intervention
- $FXS_t$ = weekly BoZ sales intervention
- $NI_t$ = weekly BoZ net intervention ( - )

Empirical results

The results of the estimated Equation 4 are reported below:

$$
\Delta S_t = 0.0004 + 0.285 \Delta S_{t-1} - 0.0000434 NI_t
$$

(5.83)*** (9.71)*** (-1.91)*

$$
h_t = 1.26e-06 + 0.295 + 0.645 h_{t-1} + 6.00e-06 NI_t
$$

(2.45)** (6.81)*** (20.38)*** (-0.48)

$$
u_t Q = 7.3160[0.397]; \quad = 1.2434[0.990]; \quad J-B = 19914.64[0.000]; \quad ARCH LM = 0.0007[0.9796]; \quad Log L = 2345.5; \quad AIC = -6.087; \quad SBC = -6.039
$$

The lag length for $v_t Q$ and $v_t^2 Q$ is at 7 according to Tsay (2002), i.e., $k = \ln(T)$, where $k$ is lag length and $T$ is the number of observations. Bollerslev-Wooldridge robust standard errors and variance are used to take care of the non-normality property of the
data series and ensure consistent coefficient estimates are derived; z-statistics are reported in parenthesis, p-values in square brackets. ***,**,,* refer to statistical significance at 1%, 5% and 10%, respectively.

The model is well-specified according to the diagnostic tests. The empirical results indicate persistence of volatility in the exchange rate series evidenced by the significance of the coefficient on the lagged value of the volatility term. While the results suggest that BoZ interventions tend to reduce volatility in the kwacha/US dollar exchange rate, its impact is, however, small and the coefficient is statistically insignificant. On the other hand, net sales of foreign exchange in the market tend to appreciate the kwacha/US dollar exchange rate, even though the statistical significance at 10% level indicates a relatively weak relationship. One possible explanation for the weak relationship could be attributed to the small average size of intervention of about US$2.0 million relative to average market turnover of about US$20.0 million over the sample period. A low correlation of 0.127 between the BoZ intervention and volatility in the kwacha/US dollar exchange rate further supports the weak impact of intervention on volatility.

The weak impact of intervention on the volatility of the exchange rate established in this study is not unique but in line with Chaboud and LeBaron (1999), Edison (1993), and Klein and Rosengren (1991). Bonsear-Neal (1996) argues that the effect of intervention on the volatility of the exchange rate depends on the extent to which it influences the fundamental causes of the latter, a possible argument in the Zambian case.

Finally, the probit test result reported below reinforces a weak relationship between volatility in the kwacha/US dollar exchange rate and the BoZ decision to intervene in the foreign exchange market.

\[ IDUMMY_t = -0.493 + 0.917\ IDUMMY_{t-1} + 11.622 \ h_t \]
\[ (-7.23)*** (9.75)*** (0.47) \]

Log likelihood=-482.8.

z-statistics are in parenthesis.

Contrary to our results, Ramana and Samiei (2000) established that the decision by the Japanese authorities to intervene in the foreign exchange market was influenced by excessive movements in the yen/US dollar exchange rate consistent with the official pronouncement. The significance of the coefficient on the lagged value of the intervention dummy variable at 1% level confirms that intervention by the BoZ in the foreign exchange market in one period is likely to be followed by another intervention in the following period (i.e., interventions occur in clusters).
8. Conclusion and policy implications

The study analysed the impact of the BoZ foreign exchange intervention on the volatility of the kwacha/US dollar exchange rate over the period 1996-2010 using weekly data. The GARCH framework was employed in assessing the impact of intervention on the volatility of kwacha/US dollar exchange rate while the probit model analysed the extent to which volatility in the exchange rate is a factor in the intervention decision by the BoZ.

The empirical results reveal persistence of volatility in the exchange rate series and that, although interventions tend to reduce volatility in the exchange rate, its impact is weak. Further, evidence of BoZ’s decision to intervene in the foreign exchange market on account of volatility in the kwacha/US dollar exchange rate appears weak.

Some important policy conclusions can be drawn from the empirical results obtained in this study. The empirical results reveal weak influence of intervention on the volatility of exchange rate. This could suggest that if the objective of the central bank is to reduce volatility of the exchange rate, intervention should not be taken as the sole policy instrument to achieve the desired results. Instead, the central bank would have to supplement intervention with other policy instruments. The choice of the instruments to use should be made in the context of their effectiveness to deal with volatility in the exchange rate. This, therefore, requires the central bank to identify the fundamental factors underlying volatility of the exchange rate so that appropriate instruments can be employed. This is an area for future research identified in this study. Moreover, Schwartz (2000) argues that domestic policy changes are required to re-enforce intervention in order to obtain desired results. Finally, a comprehensive re-examination of the foreign exchange intervention drivers is required.
Notes

1. The kwacha is the Zambian currency.

2. The foreign exchange in Zambia has traditionally been supplied by the copper mining sector (mostly by the now privatized ZCCM), which accounted for about 90% of total foreign exchange earnings. Up to 1984, all Zambian exporters surrendered foreign exchange earnings to the BoZ, which, in turn, allocated them to the market through an administrative arrangement. In 1984, non-copper exporters (i.e., non-traditional) were allowed to retain 50% of their export earnings. In 1992, non-traditional exporters were allowed 100% foreign exchange earnings retention. In April 1996, the ZCCM foreign exchange retention scheme was abolished. This meant that ZCCM could now trade foreign exchange directly in the inter-bank foreign exchange market. The retention scheme refers to the requirement by law at that time for ZCCM to surrender some of the total foreign exchange earnings to the BoZ and retain the rest for its own operational use.

3. All interventions undertaken by BoZ were pre-announced to the market and the market was informed of the change in the frequency of BoZ intervention.

4. Noise traders (chartists) are those traders whose demand for currencies or other assets is influenced by beliefs or sentiments that are not fully consistent with economic fundamentals. They base their expectations of future changes in the exchange rates on the behaviour of past values of the exchange rates.

5. Data gaps make the distribution of intervention to be concentrated around zero ("zero-inflated process") such that the relationship between intervention and its determinants is non-linear and the distribution of errors from regressions that include absolute intervention data may not be normal as per OLS assumption, especially in small samples.
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