African Development Review
Revue africaine de développement

African Development Review, Vol. 24, No. 2, 2012, 125–136

The Efficacy of Official Intervention in the Foreign Exchange Market in Malawi

Kisu Simwaka and Leslie Mkandawire*

***Abstract*:** This paper analyses the effectiveness of foreign exchange market interventions by the Reserve Bank of Malawi (RBM). We use a GARCH (1, 1) model to simultaneously estimate the effect of intervention on the mean and volatility of the Malawi kwacha. Results from the GARCH model indicate that net sales of US dollars by the RBM depreciate, rather than appreciate, the kwacha. Empirically, this implies the RBM 'leans against the wind', that is, the RBM intervenes to reduce, but not reverse, exchange rate depreciation. On the other hand, results for the GARCH model for the post-2003 period indicate the RBM intervention in the market stabilizes the kwacha. In general, results for the entire study period show that the RBM interventions have been associated with increased exchange rate volatility, with the only exception being the post-2003 period. The implication of this finding is that intervention can only have a temporary influence on the exchange rate.

1. Introduction

Most central banks, especially in developing countries, use foreign exchange market intervention[1] as a policy tool for macroeconomic stabilization. In Malawi, the exchange rate was floated in February 1994. Since then, the Reserve Bank of Malawi (RBM) has periodically intervened in the foreign exchange market. In line with the International Monetary Fund (IMF) conditions under the structural adjustment package, the RBM has also intervened to buy foreign exchange in order to build up reserves for the Government and moderate exchange rate fluctuations.

There has been a lot of debate in literature on the question of whether these interventions affect the value of the kwacha. Friedman (1953) provides the classic argument against central bank intervention in foreign exchange markets. Later, the introduction of models that allowed for imperfect information (Brainard, 1967; Poole, 1970) led to the conclusion that exchange rate policies could be used for stabilization purposes. Boyer's (1978) work on optimal foreign exchange market intervention helped to achieve an uneasy consensus in the theoretical literature. It was shown that optimal exchange rate policies lie between the theoretical extremes of complete exchange rate fixity and flexibility. Optimal policy responses were shown to be a function of the nature of the shocks to the economy as well as dependent on the degree of capital mobility in the economy (Doroodian and Caporale, 2001).

In contrast, empirical work on the actual impact of foreign exchange intervention has not yielded a consensus. Studies that regressed the exchange rate on intervention variable have often found coefficients with ambiguous signs (Doroodian and Caporale, 2001). For example, one might interpret a negative coefficient as evidence that official sales of foreign exchange depreciate the local currency (a perverse response) or that officials prevented a steeper depreciation from occurring, a 'leaning against the wind response' (Humpage, 1988; Dominguez and Frankel, 1992). Friedman (1953) suggests that a simple way to determine the desirability of intervention is to test if intervention is profitable. Taylor (1982) finds that official intervention is almost always unprofitable. These initial findings led to numerous studies on this topic, some of which find strong evidence of profitable intervention. Fatum and Hutchison (2003) find strong evidence that sterilized intervention systemically affects the exchange rate. Archer (2004) finds that intervening central banks within emerging market groups tend to rate their intervention quite successful. Leahy (1995) finds that official intervention by the Federal Reserve has consistently generated profits. On the other hand, using a GARCH methodology, Doroodian and Caporale (2001) find a statistically significant impact of intervention on spot rates for the USA.

These conflicting results have led many researchers to adopt different empirical methodologies to study the impact of intervention. However, these studies have done little to narrow the gap in opinion concerning intervention (Doroodian and

*Reserve Bank of Malawi, PO Box 30063, Lilongwe, Malawi. Corresponding author: K. Simwaka, Tel: +265 888 308080; e-mail: kisusimwaka@yahoo.co.uk

Table 1: RBM intervention: basic statistics for 1994–2009

Malawi kwacha/US dollar		
	Purchases	*Sales*
Mean	−6.144813	12.25119
Median	−1.900000	9.35000
Standard deviation	−9.927213	12.21028
Maximum	−84.690000	57.70000
Minimum	0.00000	0.00000
No. of observations	160	160

Source: Authors' calculation using RBM data. The figures are in millions of Malawi kwacha.

Caporale, 2001). Empirical literature concerning the appropriateness and effectiveness of official intervention range from Dominguez and Frankel's (1992) generally favourable view to Schwartz's (1996) contention that intervention is an 'exercise in futility' that at best can have only a very short-run effect on exchange values and at worse serve to introduce harmful amounts of uncertainty and volatility in foreign exchange markets.

The main objective of the study is to examine the effectiveness of the official intervention in the foreign exchange market. Specifically, the paper tries to answer the following questions: (1) floatation of the kwacha was intended to be market determined, but has it really been market determined?; (2) has intervention influenced the level of the Malawi kwacha/US dollar exchange rate? and (3) has intervention dampened and smoothened the volatility of the Malawi kwacha/US dollar exchange rate?

2. Exchange Rate Management in Malawi

2.1 Exchange Management in Malawi

The management of the exchange rate in Malawi has been pursued with three major policy objectives in mind. These are: (1) maintenance of a sustainable balance of payments position; (2) attainment of stable domestic prices; and (3) attainment of growth in real income.

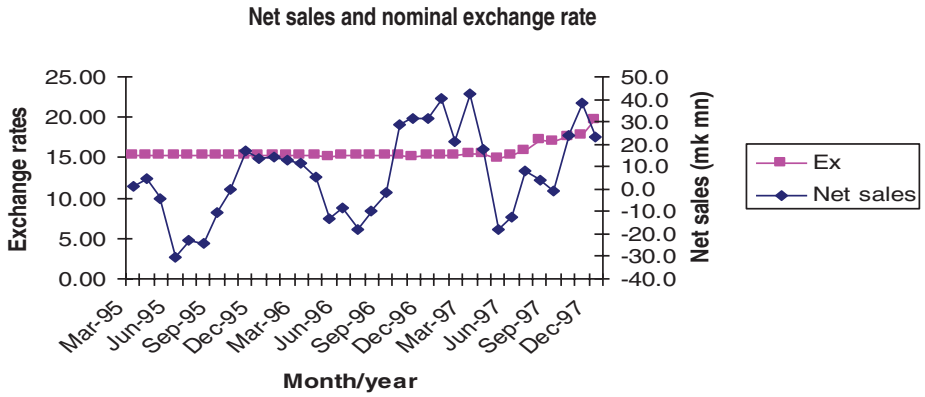
RBM Intervention in the Foreign Exchange Market

In February 1994 Malawi adopted a managed float exchange rate regime. This was aimed at resolving the foreign exchange crisis that had hit the country due to suspension of balance of payments support from donors, and the lagged effects of the 1992/93 drought. After the floatation, the Malawi kwacha/US dollar exchange rate depreciated from around K4.5 in February to over K17 in September 1994.

The RBM intervenes in the foreign exchange market primarily to smooth seasonal fluctuations related to the agricultural cycle and to build foreign exchange reserves. Due to the seasonal nature of the foreign exchange earnings related to agricultural activities, coupled with the fact that tobacco exports account for about 60 per cent of the foreign exchange earnings, the Malawi kwacha is normally expected to appreciate during the tobacco marketing season (April to August), reflecting increased supply of foreign exchange on the market, and depreciate during the off-season (September to March) reflecting increased demand for foreign exchange, as the economy imports farm inputs such as fertilizer. This seasonal pattern may vary if, during that time of the year, the country has received substantial donor inflows. A liberalized foreign exchange market environment implies that the RBM cannot dictate the value of the Malawi kwacha. However, the RBM can only influence the value of the kwacha by buying foreign exchange when there is an excess in the market and selling when there is a shortage (see Table 1 for basic statistics on RBM intervention).

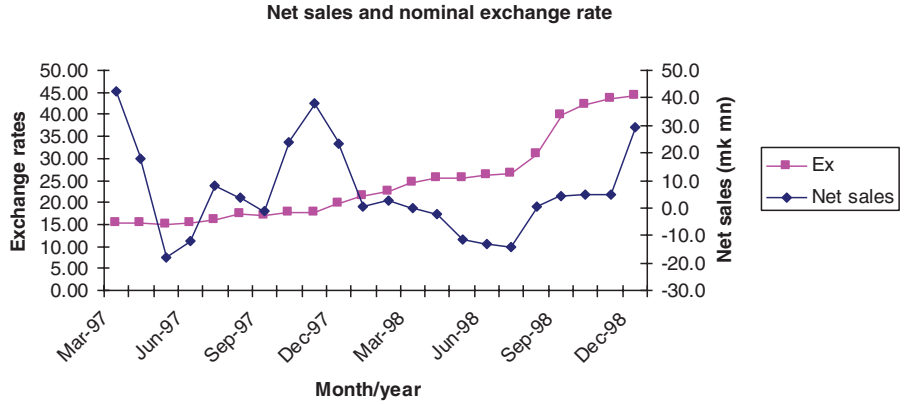
This means therefore that in theory, the RBM can maintain a stable exchange rate by intervening in the foreign exchange market. In practice however, the RBM has to consider the monetary implications as well as the implications of such interventions on the position of official foreign reserves. As the RBM buys foreign exchange from the market, the supply of Malawi kwacha in the economy increases and this has potential for inflationary pressures. For the RBM to sell foreign exchange to the market, it must have adequate foreign exchange reserves in the first place. And, as a source of its own foreign exchange reserves, the RBM also relies on whatever it is able to buy from the market, and/or, if there were any inflows of donor funds. Any constraints on

Figure 1: RBM intervention and nominal exchange rates (1995–1997)



Data source: Reserve Bank of Malawi.

Figure 2: RBM intervention and nominal exchange rate (1997–1998)



Data source: Reserve Bank of Malawi.

these two sources, means inadequate capacity for the RBM to support the market effectively, thereby affecting the surplus/demand balance in the market. Overall, the RBM has to do a lot of balancing in managing the exchange rate to ensure that the achievement of a stable exchange rate, which is good for the farmer, does not come at the expense of inflation and the depletion of foreign exchange reserves.

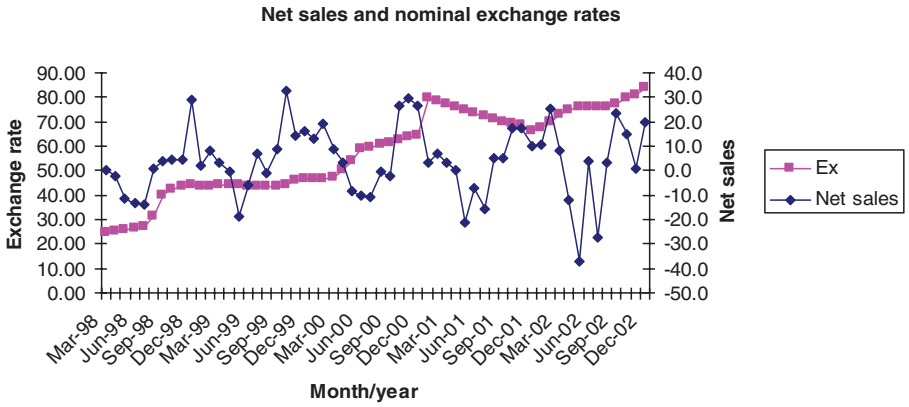
During the period 1995–97, the exchange rate fluctuated within a very narrow fixed band and accordingly, foreign reserves were used to support the exchange rate (Figure 1). The main objective of attaining low inflation rates was achieved towards the end of 1997 but at the expense of huge foreign exchange reserves and high interest rates, which were used to support the exchange rate. Consequently, the real exchange rate appreciated and had a negative impact on the current account balance. In other words the current account imbalance that emerged during the period of fixed exchange rates was being covered by a run down of reserves.

After achieving the inflation objective during 1997, the target of the monetary authorities was then to revive the lost competitiveness within a reasonable period of time. It soon became clear that the narrow band had to be abandoned in favour of an unannounced crawling peg. During this period the authorities were not committed to defend the currency thus the central parity rate was adjusted every time the maximum level (i.e. the upper limit of the band) was reached. Thus between 1997 and 1998 the exchange rate moved from around K15 to K38 to the US dollar (Figure 2).

This adjustment in the exchange rate brought back some competitiveness in the country's foreign trade. Consequently, the system was abandoned towards the end of 1998 and the exchange rate started operating in a more market fashion – that is, the free-floating system. This system saw Authorized Dealer Banks taking a more active role in determining the path for the kwacha. Unfortunately, during this period (1998–2002), the exchange rate was very unstable and not surprisingly, there was public outcry.

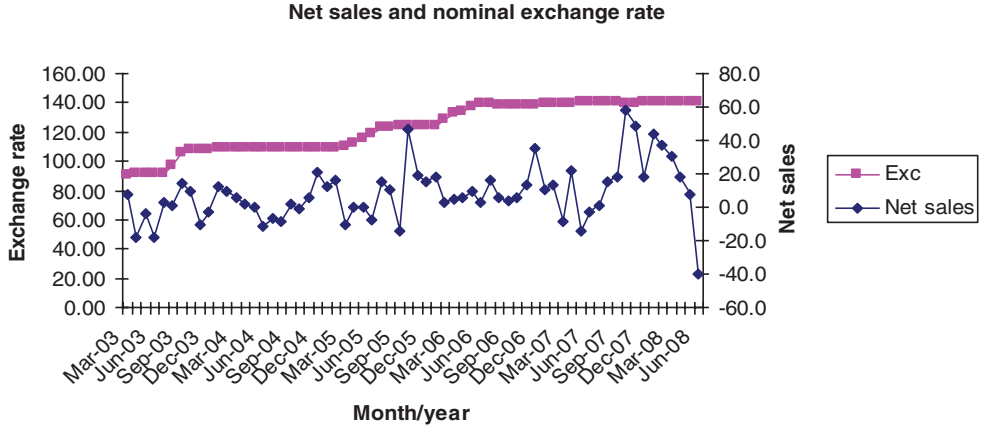
The free-float system, is perhaps remembered by the first ever appreciation of the kwacha in 2001 (see Figure 3). This appreciation came on the back of huge foreign reserves (see Figure 5). A short period of exchange rate instability followed until

Figure 3: RBM intervention and nominal exchange rate (1998–2002)



Data source: Reserve Bank of Malawi.

Figure 4: RBM intervention and nominal exchange rate (2003–2008)



Data source: Reserve Bank of Malawi.

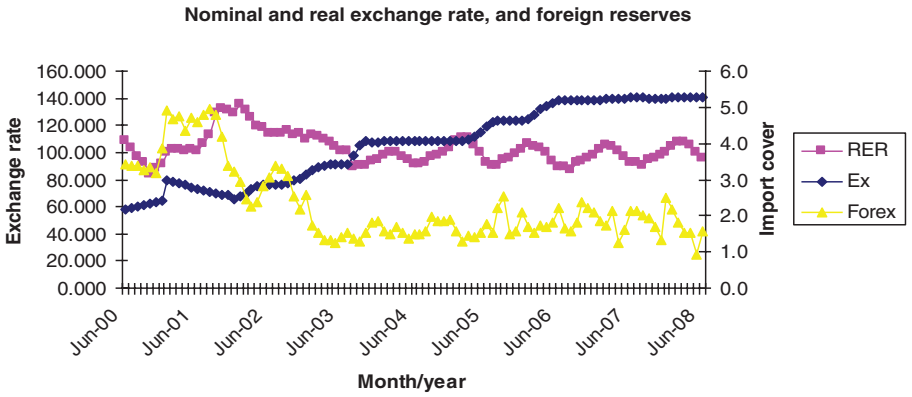
a policy decision was taken in August 2003 to stabilize the kwacha at a rate of K108 against the US dollar. The decision was in response to serious economic disequilibrium or instability following the suspension of the first IMF Poverty Reduction and Growth Facility and the resultant droughts in the early 2000s. The stability of the kwacha, however, only lasted until March 2005 when a series of adjustments saw the kwacha resting at K123 against the US dollar. The kwacha–US dollar exchange rate remained largely unchanged from August 2003 until mid-March 2005 when a series of adjustments saw the kwacha resting at K123 against the US dollar. The kwacha then stabilized at those levels until early 2006, when economic conditions necessitated a further review (Figure 4).

Nominal and Real Exchange Rate, and Foreign Reserves

Regarding the behaviour of the kwacha in real terms, the real exchange rate (RER), which had been appreciating since 2000,[2] with a rapid rise in official reserves, started depreciating in late 2001 as official reserves started declining. Since 2004, the real exchange rate has stabilized except for a few short-run fluctuations related to seasonal cycle of agricultural activities (Figure 5). During this period, rising aid and productivity have supported the real exchange rate, but declining terms of trade (TOT) have outweighed these factors, as indicated by slow reserve accumulation.

International reserves have been declining since late 2001 (see Figure 5); however, it is clear that from 2004 the kwacha has been largely stable and yet the levels of reserves have been too low and fluctuating. But the Malawi kwacha has been stable because the RBM is a dormant player in Malawi's foreign exchange market. Using its market power coupled with moral suasion, it is possible for the RBM to conduct its transactions with commercial banks at administrative exchange rates and consequently influence the commercial banks to maintain their rates at low levels.

Figure 5: Nominal and real exchange rate, and foreign reserves (2000–2008)



Data source: Reserve Bank of Malawi.

It is clear that an important element leading to the failure of Malawi's exchange rate policy relates to the inconsistency between exchange rate stability and other macroeconomic (particularly, fiscal) policies. Malawian authorities have preferred a stable exchange rate system. This preference is in line with empirical research and data analysis. Recent empirical research indicate that for a low-income country like Malawi with a good fiscal track record, stable exchange rates are the most appropriate in terms of achieving low inflation levels without sacrificing economic growth, whereas floating rates induce volatility that hurts economic growth (Harrigan, 2006). Furthermore, Munthali *et al*. (2010) find that the real effective exchange rate negatively affects economic growth. These research findings are supported by tallying Malawi's own growth experience with different exchange rate regimes the country has adopted and implemented in the past. Malawi achieved macroeconomic stability and economic growth during the 2004–2009 period, with output averaging 7.0 per cent (when the kwacha was stable) compared to 1.5 per cent during 1998–2003 (when the kwacha was flexible). Exports grew by 8.3 per cent between 2004 and 2009 compared to 0.9 per cent during the 1998–2003 period. Putting aside other factors, this shows that a stable exchange rate system seems appropriate for Malawi.

However, Malawi continues to have a severe shortage of foreign exchange. This is due to the fact that the high economic growth rates have been propelled by the non-tradable sector (non-foreign exchange generating sector), thus putting pressure on the foreign exchange that has been generated from the relatively small tradable sector and intermittent donor foreign exchange inflows. This has created over-valuation problems, for example a parallel foreign exchange market, extra finance charges on delayed payments, and delayed imports resulting in lost sales and bigger inventories. The loose monetary policies have significantly exacerbated the situation. In light of this, the International Monetary Fund has advised the RBM and the government to move towards more exchange rate flexibility.

3. Literature Review

3.1 Theory of Intervention[3]

Most studies in literature on the impact of intervention consider sterilized intervention. The papers do not focus on unsterilized intervention, which because it affects the monetary base, is generally assumed to have significant influence on the exchange rate. There is general agreement in literature that unsterilized sale of foreign exchange would be expected, other things being equal, to appreciate the exchange rate through contraction of the money supply and therefore interest rates. Sterilized intervention is where the authorities take deliberate action to offset foreign exchange market intervention with an equal change in the net domestic credit and this happens either simultaneously or with some short lag, while leaving interest rates unchanged. On the other hand, intervention is non-sterilized when it is conducted without any action taken to offset the impact of intervention.

Sterilized intervention[4] can affect the exchange rate through two channels. These are the portfolio balance channel and the signalling channel. The literature on effectiveness of intervention adopts the general view that exchange rates are determined in asset markets and they adjust to equilibrate global demands for stocks of national assets rather than demand for flows of national goods. In the class asset market models using the portfolio balance approach, domestic and foreign markets are deemed to be imperfect substitutes. In these models, asset holders allocate their portfolios to balance exchange rate risk against expected rates

of return, which are affected by relative supplies of assets. In the class of asset market models using the monetary approach, domestic and foreign assets are deemed to be perfect substitutes. This approach makes portfolio shares infinitely sensitive to changes in expected rates of return. In contrast to portfolio balance models, monetary models typically focus on demand for and supply of money, bond supplies being irrelevant when all bonds are perfect substitutes.

3.2 Empirical Findings

Studies in empirical literature use various approaches to evaluate the impact of central bank intervention. Problems arise in surveying studies of intervention. One of them is that literature is somewhat fragmented. Although there are often several articles on a particular topic, they tend not to build on one another or to broaden previous research. This self-imposed isolation makes it difficult to explain why results differ from study to study, a problem that is particular acute in the recent literature on the signalling and portfolio balance channels (Edison, 1993).

Doroodian and Caporale (2001) provide additional empirical evidence on the topic of effectiveness of the Federal Reserve intervention on the United States exchange rate. Using a daily measure of exchange rate intervention in the yen/dollar and mark/dollar exchange rate market for the period 1985–97, they find a statistically significant effect of intervention on spot rates. A generalized autoregressive conditional heteroscedasticity exchange rate equation is used to measure the impact of intervention on exchange rate uncertainty. The study finds that intervention is associated with a significant increase in the inter-day conditional variance (uncertainty) of both bilateral spot exchange rates. This supports the view of Friedman and Schwartz that exchange rate intervention serves to destabilize the foreign exchange market by introducing additional levels of exchange rate uncertainty. Simatele (2004) investigates the effect of central bank intervention on the Zambian kwacha. She uses a GARCH (1,1) model simultaneously estimating the effect of intervention on the mean and variance. She finds that central bank intervention in the foreign exchange market increases the mean but reduces the volatility of the Zambian kwacha. The explanation supports the 'speculative bandwagon' and a 'leaning against the wind' strategy. Although there is no attempt to distinguish through which channel intervention works, she argues that this is more likely to be a signalling effect rather than a portfolio balance.

Fatum and Hutchison (2003) investigate the effectiveness of intervention using Japanese official daily data and an event study methodology. Focusing on daily Japanese and US official intervention operations, they identify separate intervention episodes and analyse the subsequent effect on the exchange rate. Using the non-parametric sign test and matched-sample test, they find strong evidence that sterilized intervention systemically affects the exchange rate in the short run (less than one month). This result holds even when intervention is not associated with (simultaneous) interest rate changes, whether or not intervention is secret (in the sense of no official reports or rumours of intervention reported over the newswires), and against other robustness checks. Large-scale (amounts over $1 billion) intervention, coordinated with the Bank of Japan and the Federal Reserve working in unison, give the highest success rate.

Adebiyi (2007) investigates the impact of foreign exchange intervention in the Nigerian foreign exchange market using an Autoregressive Distributed Lag (ARDL) modelling approach. The overall finding is that foreign exchange intervention in Nigeria is sterilized because the cumulative aid, which constitutes part of the foreign exchange inflows, and net foreign assets variables, which are proxies for intervention, are not significant. The paper concludes by recommending that the use of stock of external reserves to support the exchange rate through increased funding of foreign exchange market should be encouraged.

Hisali (2007) analyses the efficacy of central bank intervention on the foreign exchange market in Uganda. The empirical results suggest that seasonal pressures are largely responsible for moving the short-term exchange rate process between the different state spaces. The findings also show that intervention reduces the probability of the exchange rate process staying in a regime characterized by sharp and disruptive tendencies. In conclusion, he observes that the results suggest that what matters is the message sent out by intervention, which favours the signalling channel of intervention.

Ghartey (2007) examines exchange rate pressures, sterilized intervention and monetary policy in Ghana. The empirical findings show that the country absorbs exchange rate pressure through depreciation and loss of net foreign assets (NFA) with the former bearing the brunt of the pressure. He observes that there is a growing need for the country to build up its NFA to enable the monetary authorities to employ sterilized interventions to arrest unidirectional depreciation of the cedi and revamp some of the foreign currency account policies to boost the public's confidence in the banking system.

In general, literature finds no significant impact of intervention through the portfolio balance channel. In contrast, most of the empirical evidence suggests that intervention can affect the exchange rate through the signalling channel. The implication from the studies is that intervention can only have a temporary influence on the exchange rate. The conclusion from the survey is that although we may be able to explain why a central bank intervenes in the foreign exchange market, it remains difficult to find empirical evidence showing that intervention has a long-lasting, quantitatively significantly effect.

4. Methodology

4.1 GARCH Model

We adopt the GARCH and equilibrium exchange rate methodologies. We will compare results from the GARCH model with those from the equilibrium exchange rate criterion. The first-order ($p = q = 1$) GARCH model, suggested by Taylor (1986), has since become the most popular ARCH model in practice. Compared to the Engel's basic ARCH model, the GARCH model is a useful improvement that allows a parsimonious specification. The GARCH (p, q) model on which the study is based takes the form:

$$h_t^2 = \alpha_0 + \sum_{i=1}^{q} \left(\alpha_i \varepsilon_{t-i}^2\right) + \sum_{i=1}^{p} \left(\beta_i h_{t-i}^2\right) \tag{1}$$

where $\alpha_0 > 0$, $\alpha_I \geq 0$ for $i = 1,2,\ldots, q$ and $b \geq 0$ for $i = 1,2,\ldots,p$. The GARCH (p, q) model successfully captures several characteristics of financial time series such as volatility.

The study estimates and tests ARCH models, that is, builds the ARCH into a GARCH (p, q) model using the Eviews. Initially we regress y on x by OLS and obtain the residuals $\{\varepsilon_t\}$; then we compute the OLS regression $\varepsilon^2{}_t = \alpha_0 + \alpha_1 \varepsilon^2{}_t + \cdots + \alpha_p \varepsilon^2{}_{t-p} +$ error; and test the joint significance of $\alpha_{\ldots} \alpha_1$. The hypothesis of interest is the extent to which changes in the conditional mean and conditional variance are associated with changes in the intervention variable. The general formulation of the model follows Edison and Liang (1999); but adjusted to suit the Malawi situation:

$$\Delta \ln ex_t = \sigma_0 + + \sigma 1 \ln NS_t + \sigma 2 \ln \mathrm{P}DTP_t + \sigma 3 \ln EP_t + \sigma_4 DMV + \varepsilon_{\mathrm{t}} \tag{2}$$

$$\varepsilon_t | I_{t-1}| \sim N(0, h_t) \tag{3}$$

$$h_t = \beta_0 + \beta_1 NS + \sigma \varepsilon_{t-1}^2 + \delta h_{t-1} \tag{4}$$

where $\Delta \ln ex_t$ = log change in Malawi kwacha/United States dollar (MK/US$), *NS* is net sales of foreign exchange (representing intervention), *PDTP* is the inflation differential between Malawi and its main trading partners,[5] *EP* is the parallel exchange rate premium (i.e. the spread between official and parallel market rates), *DMV* is the dummy variable for seasonal trends in exchange rates,[6] ε is a regression disturbance (forecast error), || is the absolute value operator, I_{t-1} is the information set through time $t-1$, h is the time-varying variance of ε.

Equation 2 measures the direct effect of net sales of foreign exchange (US dollars), price differential, exchange rate premium and seasonal factors on exchange rate changes. A positive coefficient on intervention variable indicates that net sales of the foreign currency (*NS*) depreciate the Malawi kwacha. Equation 3, ($\varepsilon_t | I_{t-1}| \sim N(0, h_t)$ states that the regression residuals will be modelled as a GARCH process. Equation 4 describes the conditional variance. The parameters of the model will be estimated using the quasi-maximum likelihood approach of Bollerslev and Wooldridge (1992), which yields standard errors that are robust to non-normality in the density function underlying the residuals. Parameters σ and δ in Equation 4 are for the ARCH and GARCH terms, respectively. The ARCH term ($\varepsilon^2{}_{t-1}$) measures volatility from the previous period measured as a lag of the squared residual from the mean equation. The GARCH term (h_{t-1}) measures the last period's forecast variance.

4.2 Data

We use monthly data series which includes the exchange rate (*EX*), net sales of foreign exchange as intervention variable (*NS*), the inflation differential between Malawi and its main trading partners (*PDTP*), the parallel exchange rate premium (*EP*) and the dummy variable for seasonality in exchange rate developments (*DMV*). We use the nominal bilateral exchange rate of the Malawi kwacha against the US dollar. The parallel exchange rate premium is the difference between the official exchange rate and the parallel exchange rate. All variables are expressed in logs except for net sales (see the Appendix for more description of the variables used).

Table 2: Conditional mean equation

Variable	Coefficient
C	0.01440
	(1.15587)
DMV	0.082142
	(1.36969)
lN*PDTP* (−1)	0.84078
	(3.93214)
Δ*EP*	0.000416
	(20.451010)
NS	0.651467
	(3.32534)
R-squared	0.414862
DW test	1.525484

Note: The values in brackets are *t*-statistics.

5. Estimation and Results

5.1 Time Series Properties of the Data

The second step is to test the variables in the GARCH and equilibrium exchange rate models for unit roots and conduct necessary cointegration tests (see Appendix). The results show that variables such as exchange rate (*Ex*), exchange rate premium (*EP*), and price differential between Malawi and its main trading partners (*PDTP*) are non-stationary (integrated of order one) and thus become stationary after first difference. On the other hand, net sales of foreign exchange (*NS*) is stationary (integrated of order zero).

The next step is to find out whether RBM intervention (net sales of foreign exchange) in the foreign exchange market in Malawi affects the kwacha. Seasonal dummies are introduced for seasonal trends in kwacha movements. We set off by running an OLS equation of the exchange rate deprecations on a constant, the net sales of foreign exchange, parallel exchange rate premium and inflation differential (to take care of balance of payments pressure) and seasonal dummy variable (to take care of seasonal trends in kwacha fluctuations). The results are indicated in Table 2.

The results find that net sales of foreign exchange by the RBM depreciate the kwacha. The results also indicate that price differentials between Malawi and its main trading partners affect the kwacha. As the price differentials widen, the kwacha tends to depreciate. It is also necessary to find out whether net sales of foreign exchange affect the volatility of the kwacha. We conduct ARCH tests on the residuals of the conditional mean equation to test for the presence of ARCH effects. The results are presented below:

ARCH test			
F-statistic	0.32545	probability	0.04408
Obs**R*-squared	0.376507	probability	0.03675

Results from the ARCH tests indicate that we reject the null hypothesis of no ARCH effects in the equation. Since there is presence of ARCH effects (i.e. presence of heteroskedasticity in the residuals), we then proceed to estimate a GARCH (1,1) model and simultaneously estimate the effect of net sales of foreign exchange on both the mean and volatility of the kwacha.

In this study, we use the GARCH method to model the heteroscedastic errors in our conditional mean equation. Compared to Engel's basic ARCH model, the GARCH model is a useful improvement that allows a parsimonious specification (it is robust to various types of misspecification). This approach is also beneficial because it allows us to simultaneously test the effect of intervention on both the mean and conditional volatility of kwacha. We run the GARCH model for two sample periods: *model 1* for the entire period 1995–2008 and *model 2* for the post-2003 period, when the nominal exchange rate was relatively stable. The GARCH equations allow the intervention terms to affect both the conditional mean and variance of the series. The conditional variance provides an excellent proxy for near-term exchange rate volatility. The results from both models are indicated in Table 3.

The positive sign on the intervention term (*NS*) in the mean equation of model 1 suggest that official sales of US dollars are associated with the depreciation of the Malawi kwacha. In other words, when the RBM sells foreign exchange with the intention of appreciating the kwacha, the kwacha depreciates instead.[7] This is not a surprising result for Malawi as sales of US dollars are

Table 3: GARCH estimation of exchange rate

	Conditional mean equation	
	Model 1	Model 2
Constant	0.03563	0.0421
	(1.17198)	(1.1840)
NS	0.61854	−0.01231
	(3.20342)	(1.1426)
ΔEP_{t-1}	0.08242	0.00506
	(1.35534)	(0.04711)
$PDTP_{t-1}$	0.85312	0.25783
	(3.96541)	(2.72062)
DMV	0.075449	0.06542
	(1.32336)	(1.26724)
	Conditional variance equation	
	Model 1	Model2
Constant	2.5240	1.6436
	(5.18543)	(4.0287)
NS	0.5649	−0.01384
	(3.1824)	(1.1265)
$ARCH(\varepsilon_{t-1}^2)$	0.422242	0.53509
	(2.42462)	(2.56213)
$GARCH(h_{t-1})$	0.505321	0.42059
	(2.48082)	(2.43812)

Note: The values in brackets are *t*-statistics.

normally conducted during the lean period of foreign reserves, so they coincide with a depreciating kwacha. The results suggest that the Bank intervenes in the market to reduce the rate of depreciation. In literature, this result is generally interpreted as 'leaning against the wind', that is, intervention prevents a steeper depreciation from occurring. In other words, the Bank intervenes to reduce, but not to reverse, around-trend-exchange rate depreciations. This finding is in line with Simatele (2004), Edison and Liang (1999) and Baillie and Osterberg (1997).

We also suspect that the results are reflecting speculation in the foreign exchange market. Typical of small economies, even after a Reserve Bank sale, the dollar tends to quickly dry out on the market due to small magnitudes of foreign exchange sales. What happens is that market speculators tend to buy as much foreign exchange as is possible after foreign exchange sales by the Reserve Bank and then withhold the foreign exchange till the exchange rate rises again and then they sell afterwards (see Simatele, 2004).

On the other hand, the negative sign on the intervention term on model 2 suggest that official sales of US dollars for the post-2003 period were associated with an appreciation of the kwacha. However, this interpretation might be misleading as the coefficient is both statistically insignificant and too small. Results from both models also indicate that price differentials between Malawi and its main trading partners affect the kwacha. As price differentials widen, the kwacha tends to depreciate. Similarly, higher exchange rate premium tend to depreciate the kwacha.

The positive coefficients on the intervention term in the conditional variance equation for model 1 reveal that official intervention leads to an increase in exchange rate volatility. This is in line with findings in other studies such as Doroodian and Caporale (2001). This means that the intervention operations of the RBM may have sent ambiguous signals (of both its intervention operations and future monetary policy) to the foreign exchange market and consequently added some uncertainty to the market. This outcome supports the view of Friedman (1953) and Schwartz (1996) that exchange rate intervention serves to destabilize the foreign exchange market by introducing additional levels of exchange rate uncertainty. However, the coefficient on the intervention variable in the conditional variance equation for model 2 reveals that official intervention during the post-2003 period tended to reduce volatility. This outcome is in line with Dominguez (1998)[8] and Simatele (2004). The ARCH (σ) and GARCH (δ) terms are both positive and statistically significant.

In general, the results from the GARCH model show that the RBM intervention has been associated with increased exchange rate volatility, with the only exception being the post-2003 period, particularly in 2004 and 2005. It must be noted, however, that the results in the opposite direction of what is expected could possibly be due to simultaneity bias in the estimated equations (see Neely, 2009).

6. Policy Implications and Conclusion

This paper analyses the effectiveness of foreign exchange market interventions carried out by the Reserve Bank of Malawi using a GARCH model. The paper uses monthly data of RBM intervention (net sales of foreign exchange), and exchange rate, among others, from January 1995 to June 2008. We start off by running a conditional mean equation using changes in exchange rate as a dependent variable. The results show the presence of ARCH effects. With the presence of ARCH effects, we then move on to run a GARCH (1, 1) model by quasi-maximum likelihood for the entire study period. In line with similar findings elsewhere in the literature, the paper finds that net sales of dollars by the RBM depreciate, rather than appreciate, the kwacha. Empirically, this implies that the RBM 'leans against the wind'. In other words, the RBM intervenes to reduce, but not to reverse, around-trend exchange rate depreciation. On the other hand, the negative sign on the intervention term on model 2 suggests that official sales of US dollars for the post-2003 period were associated with an appreciation of the kwacha. However, this interpretation might be misleading as the coefficient is both insignificant and too small.

In general, the results from the GARCH model show that the Reserve Bank of Malawi intervention has been associated with increased exchange rate volatility, with the only exception being the years 2004 and 2005. The policy implication of this finding is that intervention can only have a temporary influence on the exchange rate, as it is difficult to find empirical evidence showing that intervention has a long lasting, quantitatively significant effect. It must be noted, however, that the results in the opposite direction of what is expected could possibly be due to simultaneity bias in the estimated equations (see Neely, 2009).

Notes

1. Intervention refers to official sales or purchases of foreign exchange to influence exchange rate. In this paper, we have used net sales of foreign exchange as our intervention variable.
2. The huge reserves in 2001 also supported the first ever appreciation of the kwacha.
3. This section relies heavily on Simatele (2004).
4. The Reserve Bank of Malawi sterilizes its foreign exchange market intervention whenever it is perceived that intervention in the foreign exchange market will affect reserve money targets to the extent that the targets will be missed. Since money targets are usually tight, the Bank therefore often sterilizes its foreign exchange market intervention.
5. Malawi's main trading partners are the USA, France, Germany, Zambia, Australia, Belgium, the Netherlands, the UK, Japan and the RSA. We created a basket inflation for these countries using their trading weights with Malawi.
6. Movements in exchange rate follow seasonal patterns related to the agricultural cycle. We use dummy variables for the four seasons in Malawi.
7. This reflects an endogeneity problem. In other words, we are picking up influences from an RBM reaction function rather than isolating the impact of intervention. This suggests that RBM is choosing a positive value for *NS* whenever it thinks *EX* is going to be too big. What we are estimating is some combination of intervention parameter and reaction function parameter.
8. Dominguez finds that US intervention has tended to decrease exchange rate volatility except for the period 1985 to 1987, which increased volatility.

References

Adebiyi, M.A. (2007), *A Study of Foreign Exchange Intervention and Monetary Aggregates in the Nigerian Financial Sector*, Department of Economics, University of Lagos, Nigeria.

Archer, D. (2004), 'Foreign Exchange Market Intervention: Methods and Tactics', BIS Papers No. 24.

Ballie, R. and X. Osterberg (1997), 'Central Bank Intervention and Risk in the Forward Market', *Journal of International Economics*, Vol. 43, pp. 483–97.

Bollerslev, T. and J.M. Woodridge (1992), 'Quasi-maximum Likelihood Estimation and Inference in Dynamic Models with Time-varying Covariances', *Econometric Reviews*, Vol. 11, pp. 143–72.

Boyer, R. S. (1978), 'Optimal Foreign Exchange Market Intervention', *Journal of Political Economy*, Vol. 86, No. 6, pp. 1045–55.

Brainard, W.C. (1967), 'Uncertainty and the Effectiveness of Policy', Cowles Foundation Paper 257.

Dominguez, K.M. (1998), 'Central Bank Intervention and Exchange Rate Volatility', *Journal of International Money and Finance*, Vol. 17, pp. 161–90.

Dominguez, K. and J.A. Frankel (1992), 'Does Foreign Exchange Intervention Matter? The Portfolio Effect', *American Economic Review*, Vol. 83, No. 5, pp. 1356–89.

Doroodian, K. and T. Caporale (2001), 'Central Bank Intervention and Foreign Exchange Volatility', *International Advances in Economic Research*, Vol. 4, pp. 385–92.

Edison, H. (1993), 'The Effectiveness of Central Bank Intervention: A Survey of the Literature after 1982', Princeton University, Special Papers in International Economics, No. 18.

Edison, H.J. and H. Liang (1999), 'Foreign Exchange Intervention and the Australian Dollar: Has It Mattered?', IMF Working Paper.

Fatum, R. and M. Hutchison (2003), 'Effectiveness of Official Daily Foreign Exchange Market Intervention in Japan', NBER Working Paper No. 9648.

Friedman, M. (1953), 'The Case of Flexible Exchange Rates', in M. Friedman (ed.), *Essays in Positive Economics*, Chicago University Press, Chicago.

Ghartey, E. (2007), 'Exchange Rate Pressure, Sterilized Intervention and Monetary Policy in Ghana', University of West Indies, Department of Economics, Jamaica.

Harrigan, J. (2006), 'Time to Exchange the Exchange Rate Regime: Are Hard Pegs the Best Options for Low-income', *Development Policy* Review, Vol. 24, No. 2, pp. 205–23.

Hisali, E. (2007), *The Efficacy of Central Bank Intervention on the Foreign Exchange Market: Uganda's Experience*, Centre of the Study of African Economies, Oxford University.

Humpage, O. (1988), 'Intervention and the Dollar's Decline', *Economic Review*, Federal Reserve Bank of Cleveland, Quarter 2, pp. 2–16.

IMF (2004), Country Report No. 04/380, *Malawi*.

Leahy, M. (1995), 'The Profitability of U.S. Intervention in Foreign Exchange Markets', *Journal of International Money and Finance*, Vol. 4, pp. 823–44.

Munthali, T., K. Simwaka and M. Mwale (2010), 'The Real Exchange Rate and Growth in Malawi: Exploring the Transmission Route', *Journal of Development and Agricultural Economics* Vol. 2, No. 9, pp. 303–15.

Neely, C.J. (2009), 'Forecasting Foreign Exchange Volatility: Why Is Implied Volatility Biased and Inefficient? And Does it Matter?', *Journal of International Financial Markets, Institutions and Money*, Elsevier, Vol. 19, No. 1, pp. 188–205.

Poole, W. (1970), 'Optimal Choice of Monetary Policy Instruments in a Simple Stochastic Macro Model', *Journal of Political Economy*, Vol. 84, pp. 197–216.

Reserve Bank of Malawi (2002). *Monetary Policy and Exchange Rate Management*. RBM Report, Blantyre, Malawi.

Schwartz, A.J. (1996), 'U.S. Foreign Exchange Market Intervention since 1962', *Scottish Journal of Political Economy*, Vol. 43, pp. 379–97.

Simatele, M. (2004), 'Foreign Exchange Intervention and the Exchange Rate in Zambia', Economics Studies, Goteborg University.

Taylor, D. (1982), 'Official Intervention in the Foreign Exchange Market, or Bet against the Central Bank', *Journal of Political Economy*, Vol. 90, No. 2, pp. 356–68.

Taylor, D. (1986), 'Forecasting Volatility of Exchange Rates', *International Journal of Forecasting*, Vol. 3, No. 1, pp. 159–70.

Appendix: Variables Definitions

Variable name	*Variable description*
Ex_t	Malawi kwacha – United States dollar exchange rate
NS	Net sales of foreign exchange capturing Reserve Bank of Malawi interventions
DMV	Dummy variable for seasonal trends in exchange rates
EP	Parallel exchange rate premium
$PDTP$	Inflation differential between Malawi and its main trading partners
$\|\|$	The absolute value operator
I_t	The information set through time $t - 1$
ε_t	The disturbance term
$\varepsilon^2{}_{t-1}$	ARCH term
h_{t-1}	GARCH term
Δlpd	Logarithm of inflation differential computed as the difference between domestic inflation and inflation rate in major trading partners