Journal of Economics and International Finance Vol. 3(7), pp. 428-443, July 2011
Available online at http://www.academicjournals.org/JEIF
ISSN 2006-9812 ©2011 Academic Journals

Full Length Research Paper

Official intervention in the foreign exchange market in Malawi: Evidence from GARCH and equilibrium exchange rate methods

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Accepted 7 June, 2011

This paper analyses the effectiveness of foreign exchange market interventions by the Reserve Bank of Malawi (RBM). The study uses a GARCH (1,1) model to simultaneously estimate the effect of intervention on the mean and volatility of the Malawi Kwacha. The study also run an equilibrium exchange rate model and uses the equilibrium exchange rate criterion to compare results with those from GARCH model. Results from the GARCH model indicate that net sales of US dollars by the Reserve Bank of Malawi 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 from both GARCH and real equilibrium exchange rate criterion for the entire study period show that the Reserve Bank of Malawi 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.

Key words: Foreign exchange market, official intervention, GARCH, equilibrium exchange rate.

INTRODUCTION

Most central banks, especially in developing countries, use foreign exchange market intervention 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 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, 1993). Friedman (1953) suggests a simple way to determine the

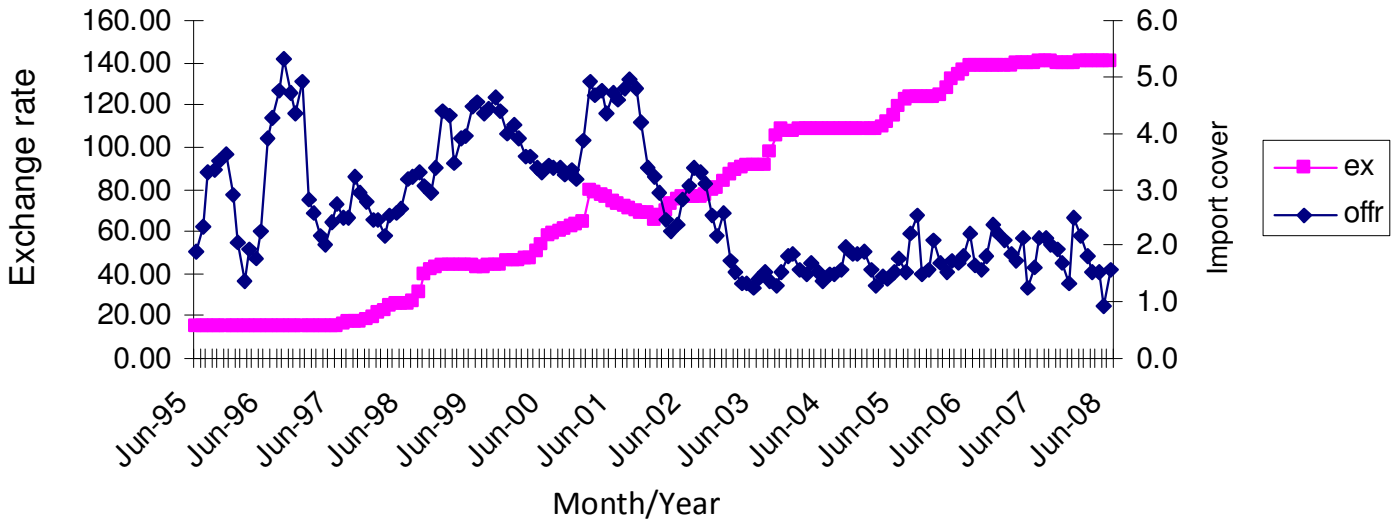

Figure 1. Evolution of nominal exchange rate and official foreign reserves (1995-2008).
Source: Reserve Bank of Malawi economic reviews (various copies).

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. Most recently, Leahy (1995) found that official intervention by the Federal Reserve has consistently generated profits.

On the other hand, using a GARCH methodology, Dorodian and Caporale (2001) found a statistically significant impact of intervention on spot rates for the United States of America. 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 Caporale, 2001). Recent academic work concerning the appropriateness and effectiveness of official intervention range from Dominguez and Frankel's (1993) generally favourable view to Schwartz' (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 efficacy of the official intervention in foreign exchange market. Specifically, the paper tries to answer the following questions:

i) Floatation of the Kwacha was intended to be market determined, but has it really been market determined?
ii) Has intervention influenced movements of the Kwacha? and
iii) Has intervention dampened and smoothened the volatility of the Malawi Kwacha?
In view of the conflicting results from empirical literature, there has been a rising need for researchers to adopt different methodologies to resolve conflicting findings. In this study, two methodologies were used to evaluate the impact of Reserve Bank of Malawi intervention in the foreign exchange market. The first will be a GARCH approach which is a recent development in econometric methodology for assessing the degree of volatility. Results from the GARCH methodology will be compared with results from another approach, the equilibrium exchange rate criterion.

Exchange rate management in Malawi

Exchange management in Malawi

The management of the exchange rate in Malawi has been pursued with three major policy objectives in mind. These are: i) maintenance of a sustainable balance of payment positions; ii) attainment of stable domestic prices; and iii) attainment of growth in real income.

The floatation of the Kwacha

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. It is clear from Figure 1 that nominal exchange rate has maintained a steady but depreciating long- run trend, while foreign reserves which were on the

Table 1. RBM Intervention: Basic Statistics for 1994-2008.

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: Author's calculation using Reserve Bank of Malawi data. The figures are in millions of Malawi Kwacha.

rise in the 1990s, have since dropped and have remained on the lower side. In the short- run, the Kwacha appears to have some level of stability.

RBM intervention in the foreign exchange market

The Reserve Bank of Malawi intervenes in the foreign exchange market primarily to smooth seasonal fluctuations related to agricultural cycle and 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% 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 Reserve Bank cannot dictate the value of the Malawi Kwacha. However, the Reserve Bank 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; Table 1 shows basic statistics on RBM intervention.

This means therefore that in theory, the Reserve Bank can maintain a stable exchange rate by intervening in the foreign exchange market. In practice however, the Reserve Bank has to consider the monetary implications as well as the implications of such interventions on the position of official foreign reserves. As the Reserve Bank buys foreign exchange from the market, the supply of Malawi Kwacha in the economy increases and this has potential for inflationary pressures. For the Reserve Bank 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 Reserve Bank 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 these two sources, means inadequate capacity for the Bank to support the market effectively, thereby affecting the surplus/demand balance in the market.

Overall, the Reserve Bank 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 to 1997, the exchange rate fluctuated within a very narrow fixed band and accordingly, foreign reserves were used to support the exchange rate (Figure 2). 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 (that is, 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 3).

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 to 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 (Figure 4). This appreciation came on the back of huge foreign reserves (Figure 6). A short period of

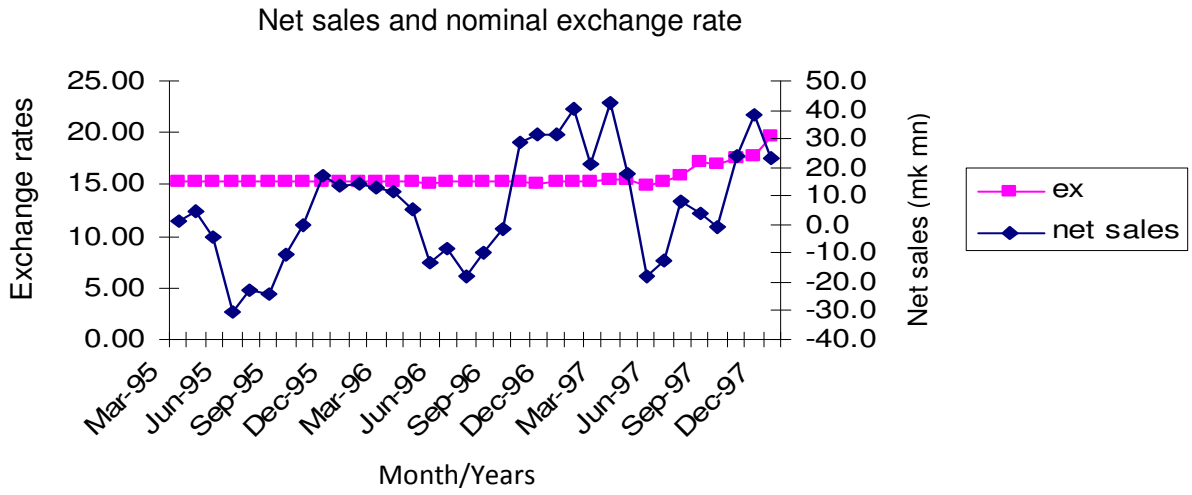

Figure 2. RBM intervention and nominal exchange rates (1995-1997). Data source: Reserve Bank of Malawi.

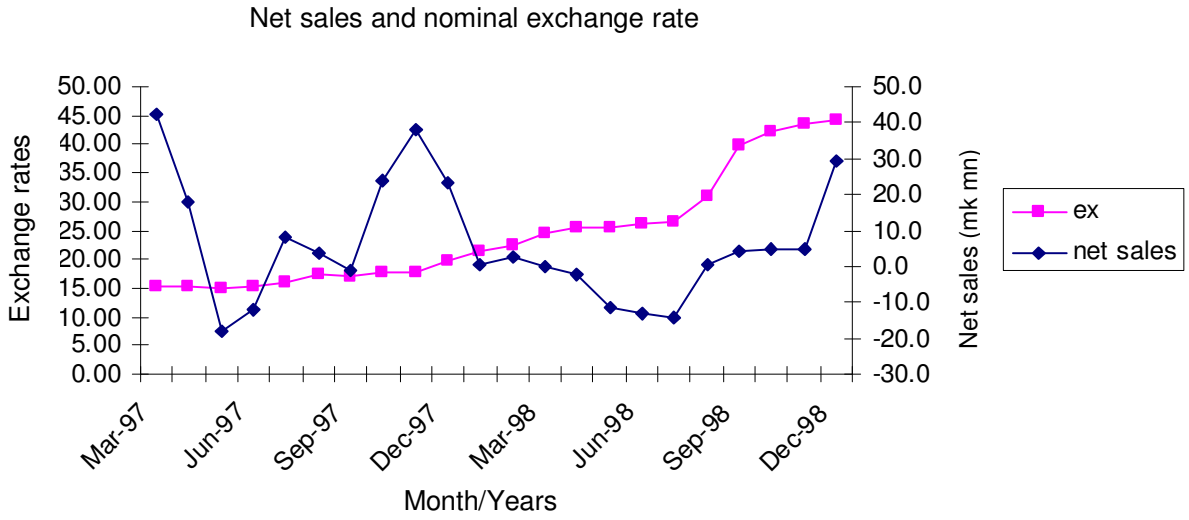

Figure 3. RBM intervention and nominal exchange rate (1997-1998). Data source: Reserve Bank of Malawi.

exchange rate instability followed until a policy decision was taken in August 2003 to stabilize the Kwacha at a rate of K108 against the United States dollar. The decision was in response to serious economic disequilibrium or instability following the suspension of the first IMF PRGF 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 United States 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 United States dollar. The Kwacha then stabilized at those levels until early 2006, when economic conditions necessitated a further review (Figure 5).

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, with a rapid rise in official reserves, started depreciating in late 2001 as official reserves started declining. Since 2004, the real exchange rate has stabilised except for a few short run fluctuations related to seasonal cycle of agricultural activities (Figure 6). 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 (Figure 6).

But it is clear that from 2004, the Kwacha has been

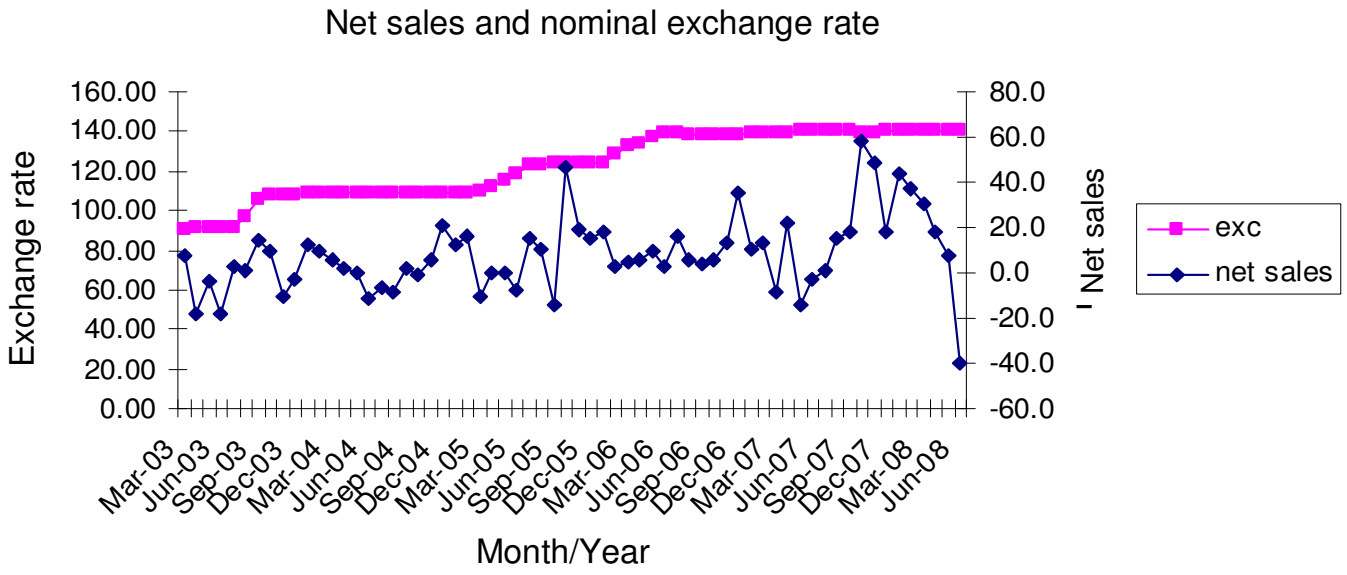

Figure 5. RBM intervention and nominal exchange rate (2003-2008). Data source: Reserve Bank of Malawi.

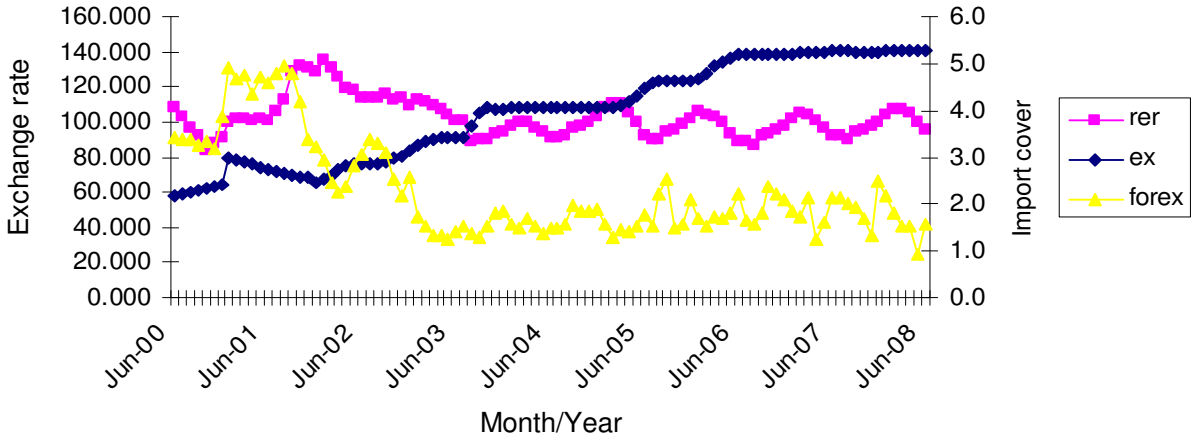

Figure 6. Nominal and real exchange rate, and foreign reserves (2000-2008). Data source: Reserve Bank of Malawi.

largely stable and yet the levels of reserves have been too low and fluctuating. But the Malawi Kwacha has been stable because the Reserve Bank 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.

The limited supply of foreign exchange on the market has resulted in the widening spreads that is the difference between rates offered by commercial banks and foreign exchange bureaus.

These spreads, also known as exchange rate premium, rose substantially in June 2007 and have remained wide (Figure 7).

LITERATURE REVIEW

Theory of intervention

Most studies in literature on impact of intervention consider sterilized intervention. The papers do not focus on unsterilized intervention, which because it affects monetary base, is generally assumed to have significant influence on 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 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

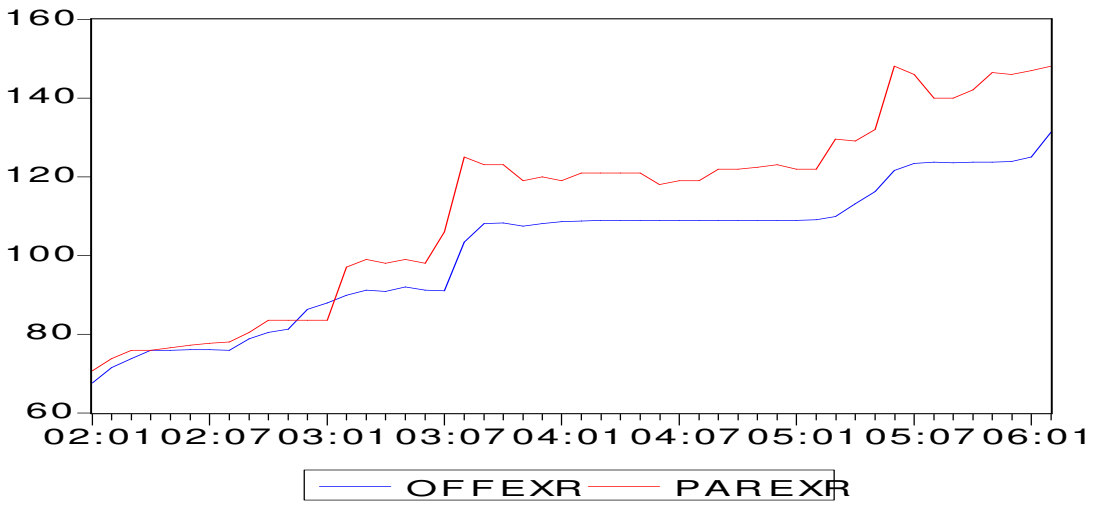

Figure 7. Official and parallel exchange rate trends. Data source: Reserve Bank of Malawi.

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.

Sterilised intervention can affect exchange rate through two channels. These are the portfolio balance channel and the signaling 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.

The portfolio balance channel

The portfolio approach is commonly used to assess the effectiveness of intervention because it identifies a direct channel through which intervention can influence exchange rate. This one states that sterilising intervention through typical open market operations will change the currency composition of government securities held by the public (Humpage, 2003). A sterilised purchase of foreign exchange, for example, increases the amount held, domestic bonds held by the public relative to foreign bonds, resulting in a depreciation of the local currency. Unfortunately, most empirical studies find the relationship to be statistically insignificant. The reason offered for the lack of a portfolio effect is that the typical intervention transaction is minor relative to the stock of outstanding assets. Dominguez (1998) is a notable exception to this conclusion.

Signalling channel

The second channel is the signalling or expectations channel. Mussa (1981) suggested that central banks might give indications regarding future, unanticipated changes in monetary policy through their sterilised interventions, with sales or purchases of foreign exchange implying, respectively, monetary tightening or ease. This would have direct implications for future fundamentals, and traders would immediately adjust spot exchange rate quotations. Mussa suggested that such signals could be particularly strong – more so than a mere announcement of monetary policy intentions – because interventions give monetary authorities open positions in foreign currencies that would result in losses if they failed to confirm their signal. Reeves (1997) has formalised Mussa's approach and has demonstrated that if the signal is not fully realistic, or if the market does not use all available information, then the response of the exchange rate intervention will be low. However, Edison (1993) argues that intervention is effective and occurs through both the portfolio balance and signalling channels.

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 particularly acute in the recent literature on the signalling and portfolio balance channels (Edison, 1993). Danker et al. (1987) estimate portfolio balance models and evaluate separate balance of separate bilateral equations for U.S. dollar exchange rates with Deutschemark, Yen, and the Canadian dollar. Their findings provide little evidence to support the portfolio balance model. Loopesko (1984) analyzes the impact of sterilized intervention using data on U.S exchange rate vis-à-vis the currencies of other G-7 countries.

She finds that in about half the cases, cumulated intervention is significant, which leads her to conclude that sterilized intervention may have an impact on the exchange rate through a portfolio balance channel. On the other hand, Dominguez and Frankel (1992) investigate both the signalling and portfolio balance channels. They use mean variance optimisation restrictions employed by many other portfolio balance studies, but differs from previous studies in finding that intervention works through both channels. They however fail to explain precisely how their findings contradict other research on the same subject. Mayer and Taguchi (1983) propose a number of criterions to evaluate intervention. All of the alternatives involve the calculation of the equilibrium exchange rate for use as the reference rate. Using monthly data, they find that German, Japanese and British intervention was primarily stabilising from January 1994 to June, 1982.

Dorodian 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 to 1997, they find a statistically significant effect of intervention on spot rates.

A generalized autoregressive conditional hetero-skedasticity 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. Dominguez (1992b) investigates whether intervention by U.S. and German authorities has influenced the variance of the exchange rate, using GARCH models. She finds that intervention has tended to decrease exchange rate volatility, the exception being U.S. intervention from 1985 to 1987, which increased volatility. Lewis (1991) develops and implements a target-zone model in which intervention is used to keep exchange rates near their target levels. She employs a multi-nominal model to estimate the probability of intervention by the G-3 central banks. She finds that intervention increases the exchange rates, as they deviate from their targets.

In general, literature finds no significant impact of intervention through 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 significant effect.

METHODOLOGY

Researchers have attempted to model foreign exchange market intervention using various methodologies and approaches.

The broad range of techniques present researchers with different types of problems about which anyone assessing their results needs to be careful.

Equilibrium exchange rate criterion and GARCH method

Equilibrium exchange rate criterion

This criterion is also known as the 'divergence from equilibrium' criterion, according to which intervention is considered to be stabilising (destabilising) when it tends to push the exchange rate (away) from its equilibrium path. The equilibrium exchange rate criterion is based on an assumption of a moving equilibrium level. The criterion allows for changes in the underlying fundamentals and therefore movements in the equilibrium levels of the exchange rate itself. This approach requires the computation of the equilibrium path of the exchange rate (Pessach and Razin, 1990). The equilibrium exchange rate approach evaluates intervention impact by establishing whether intervention at the point of time it occurred tended to push the market rate towards its then prevailing equilibrium level or away from it. Market fundamentals include such factors as money supply, and real income. A change in money supply or real income in either country will affect the exchange rate (Pessach and Razin, 1990).

In a system of flexible exchange rates, exchange rate volatility depends on the volatility of market fundamentals and expectations.

Hence, some analysts believe that if policy makers could reduce the volatility of market fundamentals, or the volatility of expectations, exchange rate volatility might also decline. Realignments become likely when exchange rate diverge from market fundamentals. This method has one technical drawback: it lacks the stabilising effect of intervention in the same way whether the intervention occurs when the exchange rate is very close to equilibrium (but not at) its equilibrium path or whether it occurs when the exchange rate is out of the line. This may not be very satisfactory since it could be argued that there is no need for intervention as long as the exchange rate was in any event very close to what could be considered its equilibrium level. Again, since at any point in time, equilibrium level cannot be defined with certainty and exactitude, there will be a serious danger of misidentification.

The GARCH/ARCH models: ARCH volatility in asset returns and exchange rates tend to gather around their marginal distributions. Modelling such time varying volatility was initiated by Robert Engel through autoregressive conditional heteroskedasticity (ARCH). In order to go around this problem, Bollerslev (1986) proposed a generalised ARCH or GARCH (p, q) model. This is the model we adopted in this study; it is particularly favoured to take account of variance correlations typically found in financial data. The generalised autoregressive conditional heteroskedastic (GARCH) model is robust to various types of misspecification, can simultaneously model conditional mean and conditional (Edison, 1999). Researchers in finance and economics have argued that a GARCH framework provides an efficient parametric way of modelling uncertainty in high frequency econometric time series (Doroodian and Caporale, 2001).

Econometric models (GARCH model)

The study adopts the GARCH and equilibrium exchange rate methodologies. It 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:

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

where $\alpha_0>0$, $\alpha_i \geq 0$ for i=1,2, …., q and b≥0 for i=1,2,….,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 GARCH (p, q) model using the Eviews. Initially, the study regress y on x by OLS and obtain the residuals $\{\varepsilon_t\}$; then we compute the OLS regression $\varepsilon^2_t=\alpha_0+\alpha_1\varepsilon^2_t+\ldots+\alpha_p\varepsilon^2_{t-p}$+error; and test the joint significance of $\alpha_{...}\alpha_1$. 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:

$$\Delta lnex_t = \sigma_0 + + \sigma 1 lnNS_t + \sigma 2 lnPDTP_t + \sigma 3 lnEP_t + \sigma_4 DMV + \varepsilon_t \quad (2)$$

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

$$h_t = \beta_o + \beta_1 NS + \sigma \varepsilon^2_{t-1} + \delta\, h_{t-1} \qquad (4)$$

Where $\Delta lnex_t$ = log change in Malawi Kwacha/United States dollar (MK/US$), *NS* is net sales of foreign exchange (representing intervention), *PDPTD* is inflation differential between Malawi and its main trading partners, *EP* is parallel exchange rate premium (that is, the spread between official and parallel market rates), *DMV* is dummy variable for seasonal trends in exchange rates, ε is a regression disturbance (forecast error), $|\,|$ is absolute value operator, I_{t-1} is 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, $(\varepsilon_t \mid I_{t-1} \mid \sim N(0, ht)$ states that the regression residuals will be modeled 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 (ε^2_{t-1}) measures volatility from 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.

The empirical model equilibrium exchange rate

The study employs the use of nominal and real exchange rate models (Appendix 4c and d for the models and Appendix 4a and b for model results). The models are used to compute nominal and real equilibrium exchange rate respectively. For the nominal exchange rate, we use a model that combines features of both the monetary and the portfolio models for nominal exchange rate model. The empirical variant of SPMM is based on a specification form introduced by Frankel (1979). He argued that in the short run, as in the SPMM model, prices are sticky and thus PPP does not hold continuously.

As for the real exchange rate, we use Edward's (1989) dynamic model for a real exchange rate model.

Although Edward's model was developed to describe nominal misalignment in fixed exchange rate regimes, it is well suited to identify fundamental variables that determine the Malawian real equilibrium exchange rate. First Malawi is a low income country, where pubic expenditure accounts for almost one-third of GDP, driven partly by large flows of external assistance. It is also relatively open with exports and imports exceeding 50% of GDP, and dependent on tobacco exports. Malawi is very dependent on imported goods, both for consumption and investment. Finally, although the Malawi Kwacha was floated in the mid-1990s, it has undergone periods of remarkable stability vis-à-vis the US dollar (Mathisen, 2003).

Data

The study use monthly data series which includes exchange rate (*EX*), net sales of foreign exchange as intervention variable *(NS)*, inflation differential between Malawi and its main trading partners (*PDTP),* parallel exchange rate premium *(EP)* and dummy variable for seasonality in exchange rate developments *(DMV).* The study uses nominal bilateral exchange rate of the Malawi Kwacha against the US dollar. Parallel exchange rate premium is the difference between official exchange rate and parallel exchange rate. All variables are expressed in logs except for net sales (Appendix 1a for more description of the variables used).

ESTIMATION AND RESULTS

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 (Appendixes 1b, 2 and 3). 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 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 Reserve Bank of Malawi 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 as presented in Table 4.

ARCH Test

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 (that is, presence of heteroskedasticity in the residuals), the study 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, the study use GARCH method to model the heteroscedastic errors in the conditional mean equation. Compared to the 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 GARCH model for two sample periods: *model 1* for the entire period 1995 to 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. This is not a surprising result for Malawi as sales of US dollars are 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 et al. (1999) and Baillie and Osterberg (1997). The study also suspects 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.

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 Dorodian 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.

Table 2. Conditional mean equation.

Variable	Coefficient
C	0.01440 (1.15587)
DMV	0.082142 (1.36969)
ΔLNPDTP (-1)	0.84078 (3.93214)
ΔEP	0.000416 (20.451010)
NS	0.651467 (3.32534)
R-squared D_W test	0.414862 1.525484

Table 3. GARCH estimation of exchange rate.

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

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 (1992b) and Simatele (2004). The ARCH (σ) and GARCH (δ) terms are both positive and statistically significant. The conflicting outcomes from the two GARCH models on the impact of intervention on exchange rate volatility lead us to employ another approach: the equilibrium exchange rate criterion. The study proceeds to model equilibrium exchange rate for the entire period. This helps us to compute equilibrium exchange rates. The task is to evaluate the bank's intervention in the foreign exchange market using equilibrium exchange rate criterion. The study will evaluate the impact of official intervention by establishing whether intervention at the point of time it occurred tended to push the market rate towards its prevailing equilibrium level or away from it. As can be seen from Figure 8, since the exchange rate was floated in 1994, the nominal exchange rate had been mostly undervalued for most of the period (1994 to 2003). But for most of post-2003 period, the nominal exchange rate remained overvalued.

Table 4. ARCH test.

F-statistic	0.32545	Probability	0.04408
Obs*R-squared	0.376507	Probability	0.03675

On the other hand, the real effective exchange rate (REER) has assumed the opposite behavior to that of the nominal exchange rate – appreciating as the nominal depreciated. This could be reflecting inflation differentials which seem to have been adversely affecting Malawi's competitiveness for most of the 1990s and the period 2003 to 2006. From 2007 onwards, the REER regained its competitiveness (depreciating) as inflation levels kept on declining. It is also clear from Figure 8 that almost the entire study period is characterized by wide oscillations, capturing exchange rate misalignments. This implies that both the nominal and real exchange rates were frequently drifting away from their equilibrium rates. This implies that the RBM interventions failed to push the nominal exchange rate toward its equilibrium level – instead, the market exchange rate was pushed away from its equilibrium path. So interventions during this period were destabilizing and increased volatility.

This outcome is in line with findings from GARCH methodology (model 1) which indicates that RBM interventions during the entire study period served to destabilize the foreign exchange market by introducing additional levels of exchange rate uncertainty. The only exception is the post-2003, particularly in 2004 and 2005, when the interventions were stabilizing as the market exchange rates were pushed closer to the equilibrium path. This exception seems to agree with findings from GARCH model 2 that official intervention during the post-2003 period reduced exchange rate volatility. In general,

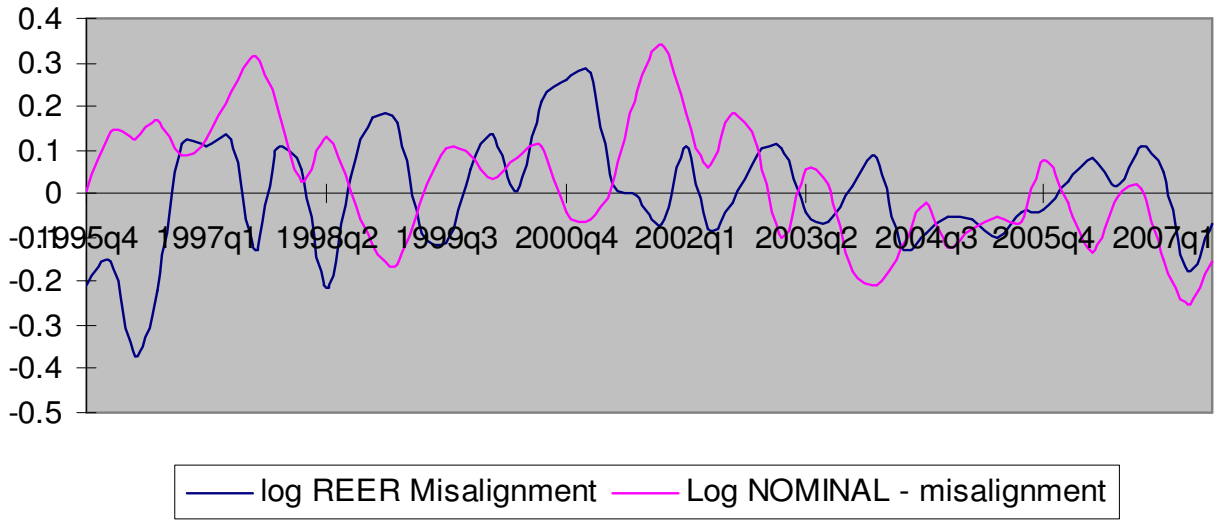

Figure 8. Nominal and real exchange rate misalignment (1995-2008). Data source: Reserve Bank of Malawi.

the results from both GARCH and equilibrium exchange rate criterion show that the Reserve Bank of Malawi intervention has been associated with increased exchange rate volatility, with the only exception being the post-2003 period, particularly in 2004 and 2005.

POLICY IMPLICATIONS AND CONCLUSION

This paper analyses the effectiveness of foreign exchange market interventions carried out by the Reserve Bank of Malawi using GARCH model and equilibrium exchange rate criterion. The paper uses monthly data of Reserve Bank of Malawi 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, the study 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 Reserve Bank of Malawi depreciate, rather than appreciate, the Kwacha.

Empirically, this implies the Reserve Bank of Malawi '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 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 insignificant and too small. Results from the equilibrium exchange rate criterion show that RBM interventions failed to push the exchange rate towards its equilibrium levels – instead, the market rate was pushed away from its equilibrium level. So intervention during the study period increased volatility. This outcome is in line with findings from GARCH methodology (model 1) which indicates that RBM interventions during the entire study period served to destabilize the foreign exchange market by introducing additional levels of exchange rate uncertainty.

The only exception is the post-2003 period, particularly in 2004 and 2005, as market exchange rates were close to their equilibrium path. This exception seems to agree with findings from GARCH model 2 that official intervention during the post-2003 period reduced exchange rate volatility. In general, the results from both GARCH and equilibrium exchange rate criterion 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 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.

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Appendix 1a. 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
ε^2_{t-1}	ARCH term
h_{t-1}	GARCH term
$govgdp$	Logarithm of government consumption as a share of GDP
$wsgdp$	Government spending on wages and salaries as a share of $invgdp$ investment as a share of GDP ($invgdp$), terms of trade of tot terms of trade goods (tot)
tp	Technological progress
mp	Monetary policy proxy
$fagdp$	Fiscal policies proxy
lid	Logarithm of interest rate differential, computed using the short –term (91-day) London Inter-bank offer rate (LIBOR) and the 91-day Treasury bill rate
lpd	Logarithm of inflation differential computed as the difference between domestic inflation and inflation rate in major trading partners.
ca_gdp	Current account balance as a proportion of nominal (quarterly) GDP
$lm2$	Log of money supply

Appendix 2. Unit root tests for variables in the models.

Variable	ADF test stat	PP test stat.	Order of Int.
lne	-1.754718	-1.107811	
Δ lne	-4.164111	-3.900384	I(1)
Ns	-4.7890	-6.29374	I(0)
pdtp	1.32462	1.524334	
$\Delta pdtp$	-4.6509	5.623109	I(1)
lnrer	-2.56436	-2.11342	
Δ lnrer	-5.27519	-5.33015	I(1)
$\ln govcngdp$	-2.75410	-2.00509	
lnird	-1.51355	-0.925450	
Δ lnird	-5.529812	-5.69811	I(1)
lnm2	-0.518479	-0.319449	
Δ lnm2	-7.522544	-11.79298	I(1)
nfa_gdp	-2.581926	-4.454167	
Δ nfa_gdp	-7.378059		I(1)
lnf_gdp	-3.523250	-4.454167	I(0)
lnmp	-2.45329	-3.54376	
$\Delta \ln mp$	-5.67840	0.89064	I(1)
lnpdtp	-4.161990	-3.490758	I(0)

Critical values are -3.5066 and –3.5045 are critical values at 5 % significance level.

Appendix 3a. Cointegration test for the nominal exchange rate model variables.

Date: 10/25/08 **Time:** 07:39
Sample(adjusted): 1997:1 2007:4
Included observations: 44 after adjusting endpoints
Trend assumption: Quadratic deterministic trend
Series: LNEX LIRD LM2 TB_GDP
Lags interval (in first differences): 1 to 4

Unrestricted cointegration rank test				
Hypothesized		**Trace**	**5%**	**1%**
No. of CE(s)	**Eigen value**	**Statistic**	**Critical value**	**Critical value**
None *	0.509457	57.35575	54.64	61.24
At most 1	0.367646	26.01712	34.55	40.49
At most 2	0.124200	5.851667	18.17	23.46
At most 3	0.000375	0.016482	3.74	6.40

*(**) denotes rejection of the hypothesis at the 5%(1%) level. Trace test indicates 1 cointegrating equation(s) at the 5% level. Trace test indicates no cointegration at the 1% level.

Appendix 3b. Johansen cointegration test for the real exchange rate Model 1.

Hypothesized no. of cointegrating vectors	**Eigen value**	**Trace stat**	**5% critical value**	**1% critical value**
None*	0.4352698	62.36948	56.37	68.57
At most 1	0.3225672	28.36436	38.04	46.20
At most 2	0.2236942	6.416240	20.78	29.66
At most 3	0.0822310	0.012631	4.22	7.95

*(**) indicates rejection of the hypothesis at 5% (1%) level. The trace statistic indicates I cointegrating equation(s) at 5% level of significance. Trace statistic indicates no cointegration at 1% level.

Appendix 4a. Long run nominal exchange rate equation.

Dependent Variable: LNEX
Method: Least squares
Date: 10/24/08 **Time:** 01:41
Sample: 1995:4 2007:4
Included observations: 49

Variable	**Coefficient**	**Standard error**	**t-statistic**	**Probablilty**
LM2	0.864234	0.023943	36.09581	0.0000
LIRD	0.335255	0.038412	8.727815	0.0000
TB_GDP	1.165300	0.687668	1.694567	0.0972
DUM	-0.005179	0.017538	-0.295323	0.7691
C	-4.940967	0.282342	-17.49992	0.0000
R-squared	0.971821	Mean dependent variable		4.079290
Adjusted R-squared	0.969259	S.D. dependent variable		0.776660
S.E. of regression	0.136172	Akaike info criterion		-1.053340
Sum squared residuals	0.815888	Schwarz criterion		-0.860297
Log likelihood	30.80682	F-statistic		379.3601

Appendix 4b. Results from the error correction model of real exchange rate[1].Dependent (real exchange rate).

	Model 1	
	Coefficient	**t-stat**
Constant	-0.0564	-0.5523
$\Delta \ln e_{t-1}$	0.0847	0.6652
$\ln govcngdp_{t-2}$	-0.1325	-1.9216
$\Delta \ln nwsgdp_{t-1}$	0.0245	0.2134
$\Delta \ln nwsgdp_{t-2}$	0.0525	0.4213
$\Delta \ln tp_{t-1}$	-0.8617	-0.6285
$\Delta \ln tp_{t-2}$	-0.7465	-0.5442
$\Delta \ln tot_{t-1}$	0.0342	0.1863
$\Delta \ln tot_{t-2}$	-0.1526	-1.9847
$\Delta \ln invgdp_{t-1}$	-0.0365	-0.3572
$\Delta \ln invgdp_{t-2}$	0.0984	0.7453
Δnfa_{t-1}	-0.0219	-0.3252
Δnfa_{t-2}	0.0042	0.1375
$\Delta \ln mp_{t-1}$	0.0434	0.3823
$\Delta \ln mp_{t-2}$	-0.0534	-0. 4841
coint. equat	-0.1357	180960
R^2	0.5253	
Adjusted R^2	0.1874	
S.E. equation	0.1251	
F-statistic	1.5250	
Log likelihood	83.204	
Akaike IC	-1.6419	
Schwarz SC	-1.3437	

[1] Model 1 shows results using data for the entire period. Model 2 has results from data for the period 2003-2006 when the exchange rate was relatively stable.

Appendix 4c. The empirical model for nominal exchange rate.

We use a model that combines features of both the monetary and the portfolio models. The empirical variant of SPMM is based on a specification form introduced by Frankel (1979). He argued that in the short run, as in the SPMM model, prices are sticky and thus PPP does not hold continuously. Frankel modified the basic assumptions of the original Dornbusch model to allow for differences in secular rates of inflation.

Based on Meese and Rogoff's (1983a, b) interpretation that the cumulative trade and current account balance terms are variables that allow for changes in the long-run exchange rate, and by incorporating stochastic elements in the model, we obtain the estimable version as:

$$e_t = \beta_0 + \beta_1(p_t - p_t^*) + \beta_2(i_t - i_t^*) + \beta_3(\rho_t - \rho_t^*) + \beta_4(CA) + \mu_t \quad (1)$$

Where: $(p_t - p_t^*)$ = inflation differential, $(i_t - i_t^*)$ = interest rate differential, $(\rho_t - \rho_t^*)$ = expected inflation differential, λ = coefficient of adjustment, $(\rho - \rho^*)$ = expected inflation differential.

Using et = $e_t = \ln ex$, $p_t - p_t^* = lpd$ and $i_t - i_t^* =$ lird, Equation 1 is re-written as an autoregressive distributed lag (ADL) model with n lags:

$$lex = \sum_{i=1}^{n}\beta_{1i} lird_{t-1} + \sum_{i=0}^{n}\beta_{2i} lpd_{t-1} + \sum_{i=0}^{n}\beta_{3i} ca\_gdp_{t-1} + \sum_{i=0}^{n}\beta_{4i} lm2_{t-1} + \sum_{i=0}^{n} nef_{t-1} + \sum_{i=0}^{n} lex_{t-i} + \mu \quad (2)$$

Where lex = logarithm of nominal exchange rate, lid = Logarithm of interest rate differential, computed using the short –term (91-day) London Inter-bank offer rate (LIBOR) and the 91-day Treasury bill rate, lpd = logarithm of inflation differential computed as the difference between domestic inflation and inflation rate in major trading partners, ca_gdp =current account balance as a proportion of nominal (quarterly) GDP, $lm2$ = log of money supply, $lNef$ = net donor inflows.

Given the nature of time series data, Equation 2 contains non-stationary variables, which on being differenced become stationary. However, that would imply that the long-run properties of the theoretical model are lost. To recover the long-run information, parameters for Equation 2 need to be reset into an error correction model (ECM), assuming that the non-stationary variables are integrated of the first order. Therefore, Equation 2 parameters are reset into Equation 3 with the error correction term in brackets.

$$\Delta lex = \sum_{i=1}^{n-1}\beta_{1i}\Delta lird_{t-1} + \sum_{i=0}^{n-1}\beta_{2i}\Delta lpd_{t-1} + \sum_{i=0}^{n-1}\beta_{3i} ca\_gdp_{t-1} + \sum_{i=0}^{n-1}\beta_{4i}\Delta lm2_{t-1} + \sum_{i=0}^{n-1}\beta_{5i} nef_{t-1} + \sum_{i=0}^{n-1}\beta_{6i}\Delta lex_{t-i} + \beta_7[lex - \alpha lird - lpd - lm2]$$

Appendix 4d. Equilibrium real exchange rate.

Edward's theoretical model identifies the following fundamental variables as the most important ones in determining equilibrium real exchange rate: the level and composition of government expenditure, external terms of trade, investment and capital flows. In addition, a variable has been added to capture the Balassa-Samuelson effect (MacDonald and Ricci, 2001 and 2002), and two variables have been added to capture the temporary misalignment induced by inconsistent macroeconomic policies. Hence the empirical model for equilibrium real exchange rate is:

$$\ln ex_t^* = \alpha_0 + \alpha_1 \ln govcngdp_t + \alpha_2 \ln wsgdp_t + \alpha_3 \ln invgdp_t + \alpha_4 tot_t + \alpha_5 \ln tp_t + \alpha_6 \Delta nfagdp_t + \alpha_7 \ln mp_t + \alpha_8 \ln fp_t + \varepsilon_t \quad (5)$$

Where the logarithm of real exchange rate (ex_t^*) is a function of logarithm of government consumption as a share of GDP ($govgdp$), government spending on wages and salaries as a share of GDP ($wsgdp$), investment as a share of GDP ($invgdp$), terms of trade of goods (tot), technological progress (tp), that is, real per capita growth, capital flows ($fagdp$), monetary policies(mp), that is, money supply as share of GDP, and fiscal policies (fp),that is, bank credit to government as a share of GDP, and error term (ε).

This analysis concentrates on permanent changes in the explanatory variables that bring about changes in the long run RER. The equilibrium real exchange rate (ERER) is associated with fundamental variables in their steady state levels. Deviations of these variables from their respective steady states results in deviations in ERER. This approach prevents the bias introduced by using the observed values to estimate the long run cointegrating relationship between the real exchange rate and the fundamentals, as a temporary shock would have a permanent impact on ERER (Mathisen, 2003).