The Efficacy of Central Bank Intervention on the Foreign Exchange Market: Uganda's Experience

By

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Abstract

This paper seeks to contribute to understanding of the efficacy of central bank intervention on the foreign exchange market by explicitly modelling the fact that intervention actions usually do not target the exchange rate itself but rather its orderly movement. Conditional probabilities generated from a homogenous two-state Markov chain are employed to obtain maximum likelihood estimates of possible factors that may govern a shift from one exchange rate state space to another. This enables us to find answers to some pertinent questions such as: what are the possible factors that may govern the shift from one state space to another in the short term? Is it possible that central bank intervention is one of these factors, that is to say, is central bank intervention effective? In other words, if for some reason it happens that large and disruptive movements arise in the spot exchange rate process, what is the likelihood that central bank intervention will succeed in returning it to a more tranquil regime? What would happen on the other hand, if for any reason the bank intervened when the exchange rate was in a tranquil regime?

The empirical results suggest that seasonal pressures are largely responsible for moving the short term exchange rate process between the different state spaces. Intervention reduces the probability of the exchange rate process staying in a regime characterized by sharp and disruptive tendencies. This is an interesting result especially if seen in light of the fact that interventions are small in relation to the overall size of the daily market turnover. The results appear to suggest that what matters is the message sent out by the interventions, which favours the signaling channel of intervention.

1 Introduction

Intervention typically entails buying and selling of a foreign currency against the domestic currency based on market conditions. Intervention operations usually seek to ensure stability of the foreign exchange rate market (Rankin, 1998). Highly variable exchange rates increase exchange rate risk and are likely to impede long term planning and investment (Arize, Osang and Slottje, 2004). Evidence on the effectiveness of intervention is generally mixed (Sarno and Taylor, 2001) but clearly, unsuccessful intervention is costly. The existing literature seems to pay proportionately less attention to possibility of an endogeneity bias and nonlinearity in the effects of intervention and this perhaps explains the failure to resolve the debate on the efficacy of intervention.

The approach developed in Baillie and Osterberg (1997a, 1997b, 2000b) and Dominguez (1998) works under assumptions of policy exogeneity of intervention and linearity in the effects of interventions and abstracts from the fact that interventions represent a highly irregular activity with prolonged intervals of inaction. These are strong assumptions. The probability that the bank will decide to participate in the market and the probability that the exchange rate will respond in the desired manner are both endogenous functions of existing market conditions. Also, actual interventions are in practice undertaken irregularly with some intervals of inaction, possibly because intervention within a small neighborhood of equilibrium may result in a greater probability of instability (Taylor, 2004). In addition, in floating exchange rate arrangements banks do not seek to target the level of the exchange rate itself but rather to mitigate the effects of short term disruptions and return the exchange rate process to an orderly path. In other words central banks seek

to move the exchange rate process to an orderly path without necessarily targeting the level of the exchange rate itself.

This paper seeks to analyse the efficacy of central bank intervention on the foreign exchange market. It employs conditional probabilities generated from a homogenous two-state Markov chain to obtain maximum likelihood estimates of possible factors that may govern a shift from one exchange rate state space to another. This enables us to find answers to some pertinent questions such as: what are the possible factors that may govern the shift from one state space to another? Is it possible that central bank intervention is one of these factors, that is to say, is central bank intervention effective? In other words, if for some reason it happens that large and disruptive movements arise in the spot exchange rate process, what is the likelihood that central bank intervention will succeed in returning it to a more tranquil regime? What would happen on the other hand, if for any reason the bank intervened when the exchange rate was in a tranquil regime?

The approaches employed by Taylor (2004) and Beine, Laurent and Lecourt (2001) use regime switching specifications to take account of nonlinearity and policy endogeneity of intervention and to generate transition probabilities. An implicit assumption of their frameworks is that determinants of the exchange rate are clearly known to the analyst. This is a questionable assumption especially when seen in light of the controversy surrounding the predictive ability of structural models of exchange rate determination. On the other hand, specifications based on duration dependence (such as Taylor, 2004) assume that markets clearly understand the different regimes and models governing the

exchange rate process. The transition probabilities employed in this paper are initially assumed to be generated by a homogenous Markov chain process. Subsequently then, possible factors that may influence switching of the process from one state space to another are explored. This approach therefore avoids the controversies surrounding specification of the exchange rate models as functions of fundamentals or even duration dependence in the process of generating the transition probabilities. This approach seems plausible since most central banks do not target the exchange rate itself but rather seek to mitigate the effects of short term disruptions and return the exchange rate process to an orderly path.

An important innovation of this paper therefore is to explicitly take into consideration the fact that intervention actions usually do not target the exchange rate itself but rather its orderly movement in assessing the efficacy of intervention. This should provide a better way to understand the effects of intervention. At the same time though, we make recognition of the possibility that since banks can not a priori be sure of what the effect of its actions will be, it can only intervene on a probabilistic basis; that its actions will have the desired impact[1].

The empirical results suggest that seasonal pressures are largely responsible for moving the short term exchange rate process between the different state spaces. Central bank intervention actions reduce the probability of staying in the regime characterized by sharp and disruptive tendencies. This is an interesting result especially if seen in light of the

[1] This emanates from the fact the influences that cause the disruptions are exogenous and outside of what the bank can control and also the fact that there is a lot of controversy surrounding the efficacy of intervention.

fact that interventions are small in relation to the overall size of the daily market turnover. The results appear to suggest that what matters is the message sent out by the interventions, which favours the signaling channel of intervention. We lend empirical support to the intervention actions of the bank of Uganda. In face of the numerous disruptions to the short term exchange rate process, failure to intervene may cause rational panic and given the nature of investor behavior, this may quickly spread and even cause further disruptions. It is important for the central bank has to send signals that these disruptions are temporary.

After the introduction, the rest of the paper is organized as follows. Section 2 gives a description of monetary policy conduct and central bank intervention. This is followed by an overview of the literature in section 3. A framework for analyzing central bank intervention is presented in section 4 followed by the estimation technique and choice of variables in section 5. Results of the study are given in section 6. The paper ends with a summary and conclusions in section 7.

2 Monetary Policy Conduct and Central Bank Foreign Exchange Market Intervention

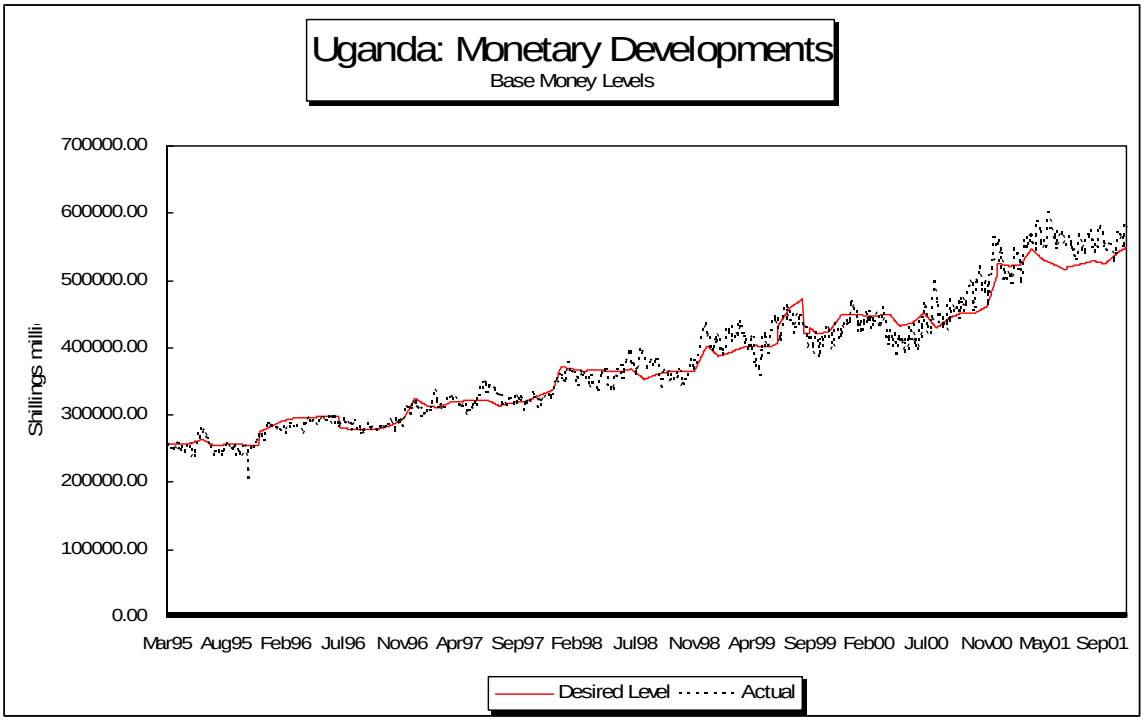
2.1 The Conduct of Monetary Policy

Central banks employ tools of monetary policy to attain and maintain macroeconomic stability in order to facilitate long term growth and high levels of employment. As part of its programme with the International Monetary Fund (IMF) the Bank of Uganda (BoU) has since 1993 been employing a monetary targeting approach to monetary policy within

the framework of the Reserve Money Programme (RMP). The Reserve Money Programme is basically a framework for determining the desired and appropriate level of growth in monetary aggregates that can enable the economy to attain a set of predetermined targets of key variables such as high growth rates of the gross domestic product, a favorable international reserves position and low levels of inflation. The standard stable money multiplier relationship is assumed to provide a link between the monetary base and the broad monetary aggregates.

Under the Reserve Money Programme, the Bank of Uganda monitors developments in the base money and weekly indicators of inflation and Treasury bill rates and the actual developments ultimately dictate the monetary policy stance adopted by the Bank (Katarikawe and Sebudde, 2000). Figure 1 shows that in many of the instances, there have been deviations of the actual outturns and desired targets mainly on account of the ever bourgeoning deficits arising from government fiscal operations (Brownbridge, 2004).

Figure 1: Monetary Developments in Uganda



Source: Bank of Uganda

The fiscal deficits minus grants as a percentage of GDP have increased from about 2% of GDP in 1991 to about 13% of GDP in 2004. Partly in response to the fiscal gap and partly due to successful[2] implementation of Uganda's programmes with the IMF and the World Bank, donors have responded by making even more resources available[3,4]. A recent development that has contributed to domestic liquidity expansion has been the debt forgiveness under the auspices of the highly indebted poor country (HIPC) initiative.

[2] The reforms have resulted in impressive growth rates and low inflation over the programme period.
[3] Inflows from non official sources have also increased drastically in the recent past, in response to relative stability in the political regime and increasing confidence in the country as an investment destination within a liberalized current and capital account framework. (Kasekende, 2000).
[4] Liquidity created by programmed fiscal operations increased from 68 billion in 1998/99 to 664 billion in 2001/02.

Whereas these increased inflows have been welcomed and even encouraged in some circles to help increase the pace at which some social targets can be attained, others have strongly argued that they complicate short run macroeconomic management and may generally not be sustainable in the long run[5] (Brownbridge, 2004). The strong inflows can have many adverse consequences including putting pressure on the domestic price level and domestic currency appreciation. These in turn can hurt export competitiveness and stifle the role of the private sector in economic activity and thus require carefully planned policy response.

Owing to the underdeveloped nature of the financial market, though, only a limited range of instruments are available to the central bank in Uganda (Ating, 2000). The main instruments that have been employed both for general monetary policy purposes and more specifically as response to the increased inflows are the open market operations through the sale and purchase of treasury bills[6] and foreign exchange market operations. The increased sales (having gone up from 36 billion in 1998/99 to 268 billion in 2001/02, for instance) depict the ever increasing importance of the treasury bill instrument as a liquidity management tool. The outstanding stock of treasury bills held outside the Bank increased from 148 billion at the end of 1998/99 to 717 billion at the end of 2001/02 (Annual Report, Bank of Uganda, 2004). It should be noted however, that the Treasury bill market remains thin and is dominated by commercial banks that hold about 90

[5] The most fierce debate in this area in Uganda has been largely between the Ministry of Finance and the Bank of Uganda on the one hand who have continued to point out that the present trend is not sustainable, and spending Ministries that do not seem to understand why spending should not even increase further so as to tap the seemingly readily available donor resources, on the other (Brownbridge, 2004).
[6] In 1992, the government surrendered the Treasury bills instrument to the Bank of Uganda and since then it has been entirely a monetary policy instrument.

percent of the outstanding stock. There has also been a remarkable increase in the foreign exchange operations with the net sales "…rising from 5 million dollars in 1998/99 to the programmed level of almost 254 million dollars in 2001/02" (Bank of Uganda, 2003, pg 12). There have been in some cases divergences between the programmed and actual sales arising from fears that this could build appreciation pressures. Other instruments have been employed include reserve requirements, bank rate, the rediscount rate and the Bank of Uganda bill and repurchase agreements.

The Bank provides a periodic review and assessment of its monetary policy actions to inform the expectations formation process. The monetary targeting framework implicitly allows for variable interest rates though there have been a few instances when the bank has intervened in the inter-bank money market to smooth interest rate fluctuations.

2.2 Macroeconomic Implications of Sterilization

The use of treasury bills and foreign exchange operations to realize the targeted levels of money growth has been to large extent successful. Partly as a result of these actions and partly due to fact that government no longer borrows from the domestic banking system, inflation has declined from the peak of about 250 percent per annum in 1987 to present day single digit levels[7] .

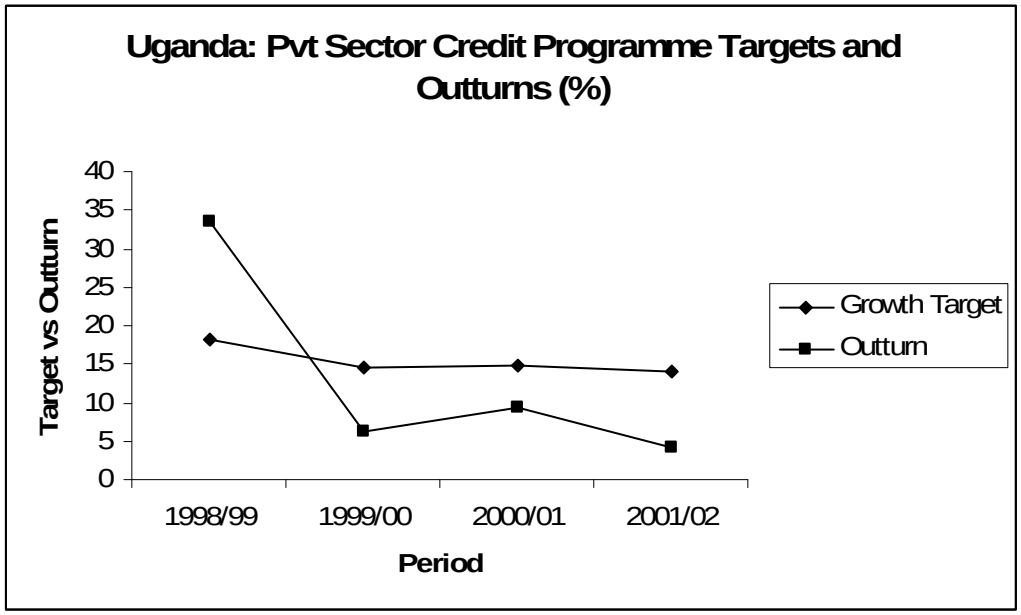
The successful use of the treasury bills and foreign exchange operations in the process of liquidity management has not, however, come without costs and there have been some

[7] This suggests existence of a strong link between money creation and inflation in Uganda.

unpleasant implications for other important macroeconomic aggregates (Kasami, 2002). These effects have been particularly manifested in the high level and volatility of domestic interest rates and the crowding out of private sector credit resulting in less than desired private sector performance for the most part. There have also been consequences for the exchange rate, export competitiveness and the sustainability of the external debt. Other effects can be manifested in the international reserve position and interestingly even in money growth itself.

Increased reliance on net treasury bills transactions has not only resulted in high levels of interest rates but also increased their volatility. Whereas there is a paucity of empirical evidence in Uganda on the link between lending rates and demand for loans by the private sector, the most widely held view is that there has been an inverse relationship (see for instance Brownbridge, 2004). Also, for some reasons, commercial banks in Uganda hold about 90 percent of all the outstanding stock of treasury bills. By providing a risk free, yet high yield investment opportunity to commercial banks, increased use of treasury bills reduces resources available for private sector borrowing. Regardless of the specific mechanism, private sector lending is likely to decline. Figure 4.2 indeed shows that in most cases the actual credit to the private sector has fallen below the programme targets.

Figure 2: Targets and Outcomes of Private Sector Credit in Uganda



Source: Bank of Uganda.

The ratio of private sector credit to GDP has averaged only a dismal 5.715 percent over the 1991/92 to 2002/03 period (Bank of Uganda, 2003). This becomes a matter of great concern to policy makers especially given the fact that the policy thrust has been to promote an increased role of the private sector participation in the economy.

Another cost associated with the Treasury bill instrument is that of huge interest repayment bills imposed on government. High Treasury bill rates have also started to attract portfolio inflows. A problem with this class of inflows is that they are normally associated with temporary domestic currency appreciation. In addition, they are potentially volatile and disruptive.

By increasing the supply of foreign exchange, net sales of the intervention currency alter the market equilibrium and spur a nominal appreciation of the exchange rate. This may

according to standard economic theory render the exports of the domestic economy to become less competitive. This can be even made worse if an appreciation coincides with a decline in the terms of trade as has partly been the case in Uganda. It is partly for this reason that actual sales have tended to fall below the programmed levels, possibly to allow for some depreciation. This provides an important example of non linearity in the central bank reaction function. Exchange rate appreciation tendencies have also emanated from the nature of government spending that has largely fallen on the non tradables such as construction contracts, increasing their relative price and thus shifting incentives from the tradable goods sector.

The bank of Uganda usually targets a certain level of net international reserves and this implies a specific level of net sales of foreign exchange to the domestic market. This, coupled with the fact that foreign aid is a major source of foreign reserves implies that delays in aid disbursement may constrain the central bank's intervention even in the face of notable disruptions (Kasekende, 1998). In fact one wonders what would happen if, for some reason, the current strong donor inflows were halted. Anyhow, such is the complexity and intricacy of liquidity management options available to the Bank of Uganda!

2.3 Intervention Operations and Mechanics

In addition to foreign exchange market operations aimed at liquidity management, net bank of Uganda intervention seeks to ensure stability of the exchange rate and conditions in the money market (Mutebile, 2001). Highly variable exchange rates increase exchange

rate risk and are likely to impede long term planning and investment (Arize, Osang and Slottje, 2004). The arguments contained in this hypothesis seem to be particularly pertinent in the context of underdeveloped markets with hardly any sort of hedge instruments. The common instability pressures appear to be closely related to the seasonal nature of foreign exchange receipts from coffee exports and remittances by Ugandan's living abroad. There are also seasonal patterns that seem to be associated with episodes of strong corporate demand for purposes of paying for imports and dividend payments. Other sources of disruptive tendencies have been observed to be related to portfolio movements and periods of high speculation (Bank of Uganda, 2003).

The intervention operations in Uganda do not seek to neither target the exchange rate nor to make profits and the Bank does not appear in the market when fundamentals change. Theoretical arguments in the policy trilema (Bernanke, 2005; Fischer, 2004) imply that this would instead to a large degree result in loss of monetary control. Intervention operations in Uganda therefore appear to be in line with the standard leaning against the wind and the fear of floating[8] hypotheses. Owing to the potentially disruptive consequences on monetary targets, foreign exchange intervention operations by the Bank are usually followed by other actions, most notably net Treasury bills issuance. From the discussion in this section, it appears reasonable to think of the probability of bank of Uganda's appearance in the market along the intervention modality as a function of prevailing market conditions, actual and projected inflows, international reserve position and possibly experiences with past intervention episodes.

[8] The basic idea of the fear of floating concept is that governments and central banks, without setting any particular exchange rate target use monetary policy and interventions to try and mitigate the adverse effects of volatility on their economies.

The decision making framework for central bank participation in the market is taken at two levels. The Monetary and Credit Policy Committee sets the broad policy guidelines relating to the external policy developments, monetary aggregate trends and flows and projected flows whereas the tactical and day to day monitoring of market developments is the responsibility of the Intervention Committee. The dealing room at the Bank's department of External Operations monitors developments and renders advice on the appropriate timing of interventions and also has the responsibility of implementing the decisions of the Intervention Committee (Bank of Uganda, 2004). The intervention currency is the dollar and almost all intervention is done in the spot inter bank foreign exchange market. The intervention is not coordinated and it is entirely the domain of the central bank.

Early episodes of the Bank's participation in the market relied on a telephone network and the actual mechanics of the system involved calling up the authorized dealers, indicating the amounts available for sale or purchase. A best quote system was used until the entire amount was exhausted. However, in addition to being slow, the first banks to be contacted were apparently advantaged. It is partly a result of these difficulties with the telephone system that prompted a shift to the Reuters 3000 system in 2001 (Bank of Uganda, 2002). Under the present system, a message indicating the Bank's presence in the market is flashed on the screen and all dealers are able to get the information instantly. The best quote system is still employed. All the banks know each others offer and express their desires following developments in the market. The Central Bank deals

only with authorized dealers and other customers may only place their orders through the authorized dealers. In the present system, the amount is not disclosed.

In April 2002, Bank changed the modalities of its presence in the foreign exchange market by making a distinction between sterilization and intervention operations. Sterilization aims entirely to control the effects of inflows on liquidity whereas intervention aims to mitigate excess movements in the exchange rate. Under the sterilization strategy, BOU sells a daily amount of foreign exchange in a stable but discrete manner to the IFEM to mop up excess liquidity associated with poverty-reducing fiscal expenditures whereas intervention takes place through net purchases of the US dollar against the Uganda shilling (Quarterly Economic Report, September, 2004). Sterilizations are secret whereas interventions are posted on the investment screen but without indicating the amounts. It is hoped that announcing the Bank's presence should maximize the effects of intervention through the announcement effect. Interventions are sterilized to avoid the unwanted effects on the monetary base.

3 An Overview of the Literature on Central Bank Intervention

Intervention primarily entails purchase (or sell) of a foreign currency against a local currency. Interventions may be undertaken by individual central banks or may be coordinated. Owing to the fact that interventions affect the domestic money market conditions, most of the interventions are sterilized (Dominguez and Frankel, 1993a, Edison, 1993, Kim et al., 2000) and are carried out secretly (Neely, 2001, Hung, 1997).

King (2003) outlines the rationale for the secrecy[9] though Sarno and Taylor (2001) recommend that interventions should be public if they are to have the desired effect. King (2003) outlines a number of considerations that may motivate central bank presence in the foreign exchange market and calls attention to the fact that these considerations may change over time. By far, the most commonly professed considerations that motivate intervention are the desire to dampen the effect of sharp movements in the nominal exchange rate and also to 'target' the exchange rate towards some level. A central bank that intervenes with these objectives can get to impact on the exchange rate through two channels; the portfolio balance channel and the signaling channel.

The portfolio balance channel is based on the portfolio balance channel of exchange rate determination (Sarno and Taylor, 2001) and is predicated on the assumption that domestic and foreign assets are imperfect substitutes and hence intervention works by inducing a readjustment in the relative holdings of domestic and foreign assets (Taylor, 1995). Most of the early analyses of the effectiveness of intervention through this channel suggested relatively weak relationships. Edison (1993) outlines some of the evidence from the studies undertaken in the 1980s. Support in favor of the portfolio balance channel is provided by the work by Dominguez and Frankel, 1993b.

The key idea of the signaling channel on the other hand is that by intervening in the market, the central bank signals the likely future course of the fundamentals and therefore induces a change in expectations by providing new information (Musa, 1981). There is

[9]The possible explanations for secrecy include the need to beat market expectations and help build credibility, among others.

no consensus regarding the effectiveness of intervention (Sarno and Taylor, 2001), an outcome that King (2003) suggests may, in part, emanate from the apparent failure to match specific objectives and outcomes, on the one hand and failure to recognize that objectives may be time varying, on the other. That most banks continue to intervene in view of such mixed evidence is construed imply that "either the models and theory used to study foreign exchange intervention are mis-specified, or intervention is conducted for non-economic purposes", King (2003) pg. 250. Sarno and Taylor (2001) on their part suggest that the failure by 'early' studies to establish effectiveness of intervention can possibly be explained by lack of access to actual intervention data by these studies and argue that more recent studies, most of which support effectiveness of intervention, should be more reliable.

The traditional approach developed by Friedman (1953) seeks to assess effectiveness by analyzing whether central banks make a positive profit on intervention activity. If this approach is true, a positive profit can be interpreted as an indicator of effectiveness of intervention activity. Studies based on this approach have not been able to come up with a unanimous conclusion; some (Baumol, 1957 and Dominguez and Frankel, 1993a) suggest that profitability may not necessarily imply that intervention is working to stabilize the market whereas Andrew and Broadbent (1994) offer some support in favor of the view that profitability of central bank intervention implies that it is stabilizing.

The approach developed in Baillie and Osterberg (1997a, 1997b, 2000) and Dominguez (1998), Beine, Benassy-Quere and Lecourt (2002) basically employ the ARCH

techniques to assess the effectiveness of intervention. They work under the possibility of policy exogeneity of intervention and they implicitly assume linearity in the effects of interventions on the mean and variance of the time series and abstract from the fact that interventions represent a highly irregular activity with prolonged intervals of inaction. Other studies seek to directly assess the responses to intervention of the level of exchange rate. Most studies in this category suggest that intervention did not have a statistically permanent impact on exchange rate (Aguilar and Nydahi 1998, Almekinders and Eijffinger 1994, Edison 1993, Neely 2001). Studies that find some evidence in favor of effectiveness in this context are Dominguez and Frankel (1993 a, b). Another line of research has sought to assess the ability of intervention to curb volatility. Evidence in support comes from Murray et al. (1996); Beattie and Fillion (1999) whereas Rogers and Siklos (2001) suggest no effect and Dominguez (1998) suggests that intervention increases volatility. A general presentation of the literature on intervention can be found in Sarno and Taylor (2001).

4 A Framework for Analyzing the Practice of Central Bank Intervention

This sub-section presents a simple model to illustrate how the practice of central bank intervention can affect the exchange rate and also the endogeneity of the central bank participation decision. There are two sources of the endogeneity bias; the participation decision and the change in exchange rate once the participation decision has been made.

Consider the uncovered interest parity variant of a standard pricing framework in which an assets price in the spot market is influenced by macroeconomic aggregates and the expected future price of an asset. This relationship can be represented as

$$y_t = E\{y_{t+1} \mid \Omega_t\} + i_t - i_t^* + \eta_t, \qquad (1)$$

where y_t is log of the current spot exchange rate (domestic currency per unit of foreign currency), $i_t - i_t^*$ is the expected depreciation and the information set Ω_t is defined to include the determinants of the asset price including news and intervention variables. η_t denotes any possible departure from the uncovered interest parity condition. Since it is unlikely that there can be any significant relationship between key macroeconomic aggregates and observed exchange rates over relatively short time horizons, we can rewrite the above spot market relationship as

$$y_t = E\{(i_{t+1} - i_{t+1}^* + \eta_{t+1})\}. \qquad (2)$$

This gives the optimal forecast of the next period value of the spot rate. If the central bank decides to intervene, the one period ahead forecast will be a function of contemporaneous levels of central bank participation (I_t) in the foreign exchange market,

$$y_t = E\{(i_{t+1} - i_{t+1}^* + \eta_{t+1}) \mid I_t\}. \qquad (3)$$

Equation (3) can be used to illustrate the mechanisms through which intervention can affect the spot market rate. In the portfolio balance channel, intervention affects the relative demand and supply conditions and is thus expected to result in a change in the relative holdings of domestic and foreign assets as a result of changes in relative risk. This term is captured by $E(i_{t+1}) \mid I_t$.

On the other hand, according to the signaling channel, previously unknown information about the likely future path of the fundamentals is provided to the market which in turn induces a change in expectations, $E(\eta_{t+1}) \mid I_t$. In any case, the contemporaneous exchange rate will be a function of intervention, $y_t(I_t)$.

King (2003) outlines a number of considerations that may motivate central bank presence in the foreign exchange market and calls attention to the fact that these considerations may change over time. Intervention operations by the bank of Uganda are motivated by the desire to dampen the effect of sharp movements in the nominal exchange rate and also to return the exchange rate towards a representative moving average (See Abuka and Ssajjabi, 1999, BrownBridge, 2004). Following Almekinders and Eijffinger (1996), desired intervention I^* is defined as the level that would minimize the squared deviation of the exchange rate $L = (y_t(I_t^*) - \bar{y}_t)^2$ away from its moving average level, $\bar{y}_t = \frac{1}{m}\sum_{i=0}^{m-1} y_{t-i}$, where m is the length of the moving average.

In practice, actual interventions are undertaken irregularly with some intervals of inaction, possibly because intervention within a small neighborhood of equilibrium may result in a greater probability of instability (Taylor, 2004). It follows then that the central bank has to have a framework that guides its actual intervention. In what follows, it is assumed that the nominal exchange rate evolves according to a two state Markov chain, with one regime characterized by tranquility (and short term trend stationarity) and the other regime characterized by volatility (and trend non stationarity). The process of

switching between the two regimes is itself also assumed to be latent and stochastic. Let the probability that the central bank will intervene be α^I and that it will not intervene be $1-\alpha^I$. The probability that the bank will intervene is postulated to be an increasing function of deviations from a 'representative' moving average (mvav) and seasonal pressures (s)[10]. This can be represented as:

$$\alpha^I = \alpha^I(mvav, s). \quad (4)$$

Since banks cannot be sure that intervention will affect the exchange rate in the way that it wants it to[11], intervention takes place on a probabilistic basis, that it will affect the exchange rates in the desired way. Let the probability that the exchange rate will change be α and that it will not change be $1-\alpha$. The probability that the exchange rate will respond to an intervention is postulated to be a function of market conditions such as the extent of deviation from the trend and again seasonal pressures (s),

$$\alpha = \alpha(mvav, s). \quad (5)$$

In other words, both the intervention probability and the probability that the exchange rate will respond are, to an extent, not independent of each other:

$$\alpha^I = \alpha^I(\alpha), \quad (6)$$

$$\alpha = \alpha(\alpha^I). \quad (7)$$

But once the decision to intervene has been taken, the probability of intervention for a day strongly increases if the bank was present in the market the day before,

$$\alpha^I = \alpha^I(I_{t-1}). \quad (8)$$

[10] In addition, intervention probability may be influenced other shocks such as non economic market sentiments. These are difficult to capture quantitatively.
[11] This arises from the controversy surrounding the effectiveness of central bank intervention.

5 Estimation Technique and Choice of Variables

5.1 Estimation Technique

Given that observed nominal exchange rate data may follow different regimes over time, a complete description of the data generating process should involve understanding the different regimes and factors that may lead to a shift from one regime to another. The analysis in this paper assumed a two state Markov chain; if $s_t = 1$ the process is in state 1 and if $s_t = 2$ the process is in regime 2.

Subsequently, the estimation strategy employed in this paper followed three steps. First, the probabilities that the exchange rate was in a given state at each single date in the sample, $\Pr\{s_t = i / y_1, y_2, ...y_T; \theta\}$, were obtained. In the second step, the conditional probabilities ($\Pr\{s_t = 2 \mid s_{t-1} = 1\}$ and $\Pr\{s_t = 1 \mid s_{t-1} = 2\}$) that a particular state was followed by another for the entire sample were computed. In the third step, maximum likelihood estimates based on a logistic[12] specification were fitted to the following sets of equations,

$$\Pr\{s_t = 2 \mid s_{t-1} = 1\} = \frac{e^{\mu_1 + \eta_1 I_{t-1} + \gamma_1 s + \psi_1 dev}}{1 + e^{\mu_1 + \eta_1 I_{t-1} + \gamma_1 s + \psi_1 dev}} \tag{9}$$

$$\Pr\{s_t = 1 \mid s_{t-1} = 2\} = \frac{e^{\mu_2 + \eta_2 I_{t-1} + \gamma_2 s + \psi_2 dev}}{1 + e^{\mu_2 + \eta_2 I_{t-1} + \gamma_2 s + \psi_2 dev}} \tag{10}$$

[12] One other option would have been to employ a probit specification. The canonical link function for the Probit model is based on an inverse normal distribution. In as much as this assumption that may not be very appealing in our setting, the results are quite similar to those obtained from a logistic specification (See Appendix). The logit specification is ruled out since we would be loosing the advantages of a more robust specification based on the maximum likelihood estimation method.

There are strong reasons for choosing to analyse the efficacy of intervention on the basis of the assumption that the central bank intervenes only on a probabilistic basis. The controversy surrounding the effectiveness of central bank intervention makes very plausible the conjecture that banks cannot be sure if intervention will affect the exchange rate in the desired way. In addition, there are usually many short-term disruptions and shocks to the exchange rate process that are purely exogenous to the central bank and which may neutralize the effects of intervention.

5.2 Choice of Variables

5.2.1 Trend Deviation

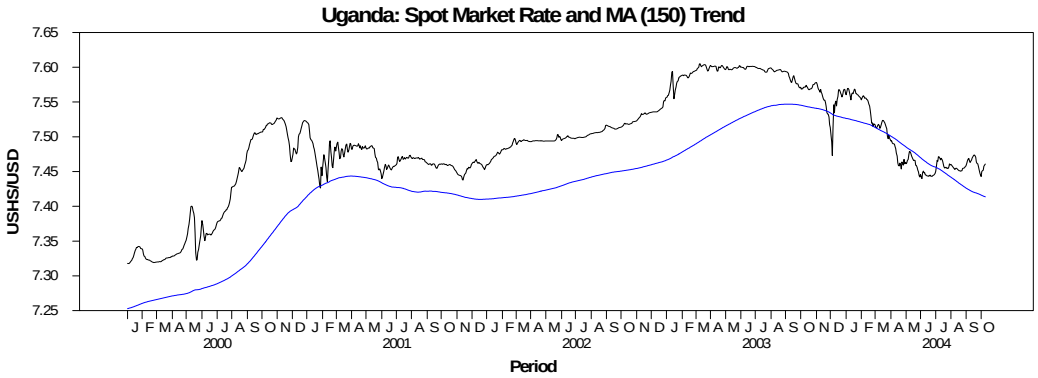
A value of the exchange rate that is far from its moving average may be interpreted to mean a disconnection of the exchange rate from its 'representative' path this may push the exchange rate into an unstable state space. The most commonly used technique to obtain a representative path of a financial time series is its moving average. The moving average is the average closing price over some period,

$$MA(T) = \frac{1}{T}\sum_{t=0}^{T-1} s_{t-i} \ . \qquad (11)$$

Figures 3 and 4 present graphs of deviation of the spot rate from its moving average based on the MA (150) rule. The figures suggest that a considerable part of the sample was characterised by negative off trend deviations.

Figure 3: MA (150) Exchange Rate Trend Deviations

Figure 4: Spot Market Rate and MA (150) Trend



5.2.2 Seasonal Patterns

In the context of the currency market in Uganda, there appear to be noticeable seasonal patterns that seem to influence short term exchange rate movements. These emanate from various sources such as the seasonal nature of Uganda's agricultural exports and remittances from Ugandans living abroad that tend to coincide with the festive calendar seasons of Easter and Christmas and the beginning of school terms (Ating-Ego and Egesa, 2003). Seasonal patterns in exchange rate movement have also been noted at those times of the year when profit and dividend payments to parent companies from their Ugandan subsidiaries are being made. These may create short term disruptions in the exchange rate process and that is why the seasonal index was chosen as one of the

variables. Presence of seasonal patterns in the series was investigated using the Holt-Winters exponential smoothing method.

5.2.3 Intervention

The study employed daily data on interventions from the Bank of Uganda covering the period 3rd January 2000 to 31st December 2004. A summary of the intervention data is presented in Table 1.

Table 1: Intervention Descriptive Statistics

Number of interventions	
Sales	653
Purchases	10
Total number of days	663
Average intervention ($ US Millions)	
Sales	1.270
Purchase	1.658
Absolute value	1.274
Maximum ($US Millions)	
Sale	10.62
Purchase	3.23
Minimum ($ US Millions)	
Sale	0.1
Purchase	1.0

Source: Computed

On average, the bank appeared in the market on about half the time covered by the study. The statistics also show some strong clustering of intervention episodes. The average intervention size of about 1.3 million US dollars are small relative to the overall market turnover. The intervention variables were lagged to ensure that they are predetermined.

6 Results of the Study

Table 2 presents the maximum likelihood estimates of factors that may shift the regime from a regime characterized by sharp depreciations to the relatively calm state. The results are first presented in terms of the more conventional coefficients and then in terms of odds ratios.

Table 2: Maximum Likelihood Estimates of the Logistic Regression

Variable	Coefficient	Std. Err.	P>|z|
Cons	-5.089925	.5407258	0.000
Intv{-1}	-.2008063	.1025555	0.050
Season	416.7638	109.9245	0.000
Trend Deviation	-3.293237	7.100418	0.643
LR $\chi^2(3)$ = 13.33[0.0040]			

Dependent Variable: $\Pr\{s_t = 2 \mid s_{t-1} = 1\}$

Log Likelihood = -70.074144

The log likelihood increased from -76.739344 in the initial iteration to -70.074144 in the final iteration. The final iteration log likelihood value is significant to two decimal places. Table 3 presents the same estimation but now in terms of odds ratios.

Table 3: Odds Ratios of the Logistic Regression

Variable	Odds Ratio	Std. Err.	z
Intv{-1}	0.8180709	0.0838977	-1.96
Season	1.0e+181	1.1e+183	3.79
Trend Deviation	0.0371335	0.2636631	-0.46
LR $\chi^2(3)$ = 13.33[0.0040]			

Dependent Variable: $\Pr\{s_t = 2 \mid s_{t-1} = 1\}$

The likelihood ratio statistic suggests that the specified model fits the data significantly better than the "know nothing" model. The coefficients for the variables intervention and seasonal pattern have an estimate significantly different than zero, as judged by the probability values which give the upper bound of making a type I error. The negative sign on the intervention coefficient means that intervention reduces the likelihood of staying in the regime associated with large and disruptive depreciations. The odds ratio of 0.82

suggests that the odds of intervention moving the exchange rate out of an unstable regime are 0.82 times higher than not moving it. This result is quite interesting especially if seen in light of the fact that actual interventions by the bank of Uganda are quite small in proportion to foreign exchange market turnover. This possibly suggests that what matters is the message sent out by intervening, and not the actual amounts themselves. It therefore appears that intervention works through the signaling channel and this perhaps explains why interventions are no longer secret. Seasonal pressures on the other hand reduce the chances of moving to a stable regime. The odds ratio suggests that the odds of seasonal pressures keeping the exchange rate in the unstable regime are 1.0e+181 times higher than moving it out of such a regime.

We also investigated factors that may govern the probability of moving from a regime characterized by small appreciations to the one characterized by large and sharp depreciations. The estimation results are given in Tables 4 and 5.

Table 4: Logistic Regression Results

Variable	Coefficient	Std. Err.	P>|z|
Cons	-8.217963	1.360637	0.000
Intv{-1}	-.0481268	.1762612	0.785
Season	-1163.294	209.7298	0.000
Trend Deviation	-15.59463	10.94573	0.154

Dependent Variable: $\Pr\{s_t = 1 \mid s_{t-1} = 2\}$

LR $\chi^2(3) = 73.07[0.0000]$

The log likelihood increased from -58.194721 in the initial iteration to -21.65956 in the final iteration. The final iteration log likelihood value is significant to all decimal places.

Table 5: Estimated Maximum Likelihood Odds Ratios

Variable	Odds Ratio	Std. Err.	z
Intv{-1}	0.9530129	0.1679792	-0.27
Season	0	0	0.000
Trend Deviation	1.69e-07	1.85e-06	-1.42

Dependent Variable: $\Pr\{s_t = 1 \mid s_{t-1} = 2\}$
LR $\chi^2(3) = 73.07[0.0000]$
Log Likelihood = -58.194721

The log likelihood increased from -58.194721 in the initial iteration to -21.65956 in the final iteration. The log likelihood is significant at all decimal places.

The specified model fits the data significantly better than the intercept only model. The coefficient for the variable seasonal pressures has a negative sign and is significant. Loosely speaking therefore, seasonal pressures reduce the chances of staying in the stable regime. Overall then it seems that the disruptions in the short term exchange rate movements closely reflect seasonal pressures. The policy options in this case are rather difficult to pinpoint owing to the exogenous nature of the factors driving the disruptions but intervention can help pass on signals to agents that these disruptions are only temporary. But attempts to intervene in a stable regime would at best be futile and at worst be a waste of scarce resources.

7 Summary and Conclusions

This paper contributes to the understanding of the effects of intervention by explicitly making recognition of the fact that the effects of intervention are nonlinear and that they are endogenously functions of existing market conditions. Our approach also makes recognition of the fact that central bank in most cases will not seek to target the exchange

rate itself but will rather seek to mitigate the effects of short term disruptions and return the exchange rate process to an orderly path. A logistic specification based on maximum likelihood estimation was employed to analyse the probability of intervention being able to move the exchange rate process from one regime to another. Intervention reduces the probability of the exchange rate process staying in an unstable regime. This result is quite interesting especially if seen in light of the fact that actual interventions by the bank of Uganda are quite small in proportion to foreign exchange market turnover. This possibly suggests that what matters is the message sent out by intervening, and not the actual amounts themselves. It therefore appears that intervention works through the signaling channel and this perhaps explains why interventions are no longer secret. Failure to intervene may cause rational panic and given the nature of investor behavior it may spread so fast. The bank has to send signals that the disruptions are short-term and temporary.

References

Abdalla Y.A., Abuka C.A. and Wandera A. (2000), "Indirect Monetary Policy and the Monetary Authority's Reaction Function", *Bank of Uganda Staff Papers*, 2(1); 108-147.

Abuka, C.A. and M.D. Sajjabi, (1996), "The Importance of Domestic and External Factors in the Appreciation of the Real Exchange Rate in Uganda", *Final Report* Presented at the AERC workshop, Nairobi.

Aguilar, J. and S. Nydahl, (1998), "Central Bank Intervention and Exchange Rates: The Case of Sweden", Sveriges Riksbank Working Paper No. 54.

Almekinders, Geert J. and Sylvester C. W. Eijffinger (1996), "A Friction Model of Daily Bundesbank and Federal Reserve Intervention", *Journal of Banking and Finance*, 20 (8), 1365-80.

Almekinders, Geert J. and Sylvester C. W. Eijffinger (1994), "The Ineffectiveness of Central Bank Intervention", *Center for Economic Research Working Paper No. 94101*, Tilberg, University Holland.

Andrew R. and J. Broadbent, (1994), "Reserve Bank Operations in the Foreign exchange Market: Effectiveness and Profitability", *Research Discussion Paper 9406*, Reserve Bank of Australia.

Arize, A.C., Osang, T. and Slottje, (2004), "Exchange Rate Volatility in Latin America and its Impact on Foreign Trade", *Mimeo*, Texas A&M University.

Atingi-Ego, M. (2000), "Inflation Targeting: Considerations in Uganda's Case", *Bank of Uganda staff Papers*, Vol 2(1).

Atingi-Ego, M. and K.A. Egesa, (2003), "Compiling Trade in Services in a Fully Liberalised Country: the Case of Uganda", *Mimeo* Bank of Uganda.

Atingi-Ego M. and K.R. Sebudde (2000), "Uganda's Equilibrium Real Exchange Rate and its Implications for Export Performance" *Bank of Uganda Staff Papers*, Vol 2(1).

Baillie, R., O. Humpage and W. Osterberg (2000a), "Intervention from an Information Perspective", *Journal of International Financial Markets, Institutions and Money*, 10: 407-421.

Baillie, R. and W. Osterberg, (2000b), "Deviations from Daily Uncovered Interest Rate Parity and the Role of Interventions", *Journal of International Financial Markets, Institutions and Money*, 10:363-379.

Baillie, Richard T. and William P. Osterberg (1997a), "Central Bank Intervention and Risk in the Forward Market", *Journal of International Economics*, 43:483-497.

Baillie, Richard T. and William P. Osterberg (1997b), "Why do Central Banks Intervene?", *Journal of International Money and Finance*, 16 (6): 909-919.

Baillie, R.T. and T. Bollerslev (1989a), "Common Stochastic Trends in a System of Real Exchange Rates", *Journal of Finance* 44(1):167-181.

Baillie, R.T. and T. Bollerslev (1989b), "The Message in Daily Exchange Rates: A Conditional Variance Tale", *Journal of Business and Economic Statistics*, 7:297-305.

Bank of Uganda (2004), *Quarterly Economic Report*, September.

Bank of Uganda (2004), *Annual Report*.

Bank of Uganda, (2003), "Policy Applications of Balance of Payments and IIP Statistics" *A Paper Prepared for the Sixteenth Meeting of the IMF Committee on Balance of Payments Statistics, Washington D.C., December 1st-5th*.

Bank of Uganda (2003), *Annual Report*.

Bank of Uganda (2002), *Annual Report.*

Baumol, W.J. (1957), "Speculation, Profitability, and Stability", *Review of Economic Statistics*, 39:263-271.

Beattie, N. and J. Fillion (1999), "An Intraday Analysis of the Effectiveness of Foreign Exchange Intervention", *Bank of Canada Working Paper No. 99-4*.

Beine, M., S. Laurent and C. Lecourt (2001), "Official Central Bank Interventions and Exchange Rate Volatility: Evidence from a Regime Switching Analysis" Forthcoming in *European Economic Review*.

Beine, M., A. Benassy-Quere, and C. Lecourt (2002), "Central Bank Intervention and Foreign Exchange Rates: New Evidence from FIGARCH Estimations", *Journal of International Money and Finance*, 21:115-114.

Bernanke B.S. (2005), "Monetary Policy in a World of Mobile Capital", *Cato Journal*, 25(1):1-12.

BrownBridge, M. (2004), "Macroeconomic Effects of Aid Funded Deficits in Uganda", *Occasional Paper No. 20*, Ministry of Finance, Planning and Economic Development.

Diebold, F.X., J.H. Lee and G. Weinbach (1994), "Regime Switching with Time-Varying Transition Probabilities" in Hargreaves C.P. (ed.), *Non-Stationary Time Series Analysis and Cointegration*, Oxford University Press.

Dominguez, Kathryn M. (1998), "Central Bank Intervention and Exchange Rate Volatility", *Journal of International Money and Finance*, 17:161-190.

Dominguez, K and J. Frankel, (1993a), "Does Foreign Exchange Intervention Work?" *Institute for International Economics*, Washington, D.C.

Dominguez, K and J. Frankel, (1993b), "Does Foreign Exchange Intervention Matter? The Portfolio Effect", *American Economic Review*, 83(5):1356-69.

Edison, Hali (1993), "The Effectiveness of Central Bank Intervention: A Survey of the Post 1982 Literature", *Special Papers in Economics 18*, Princeton University.

Engel C. and C.J. Hakkio, (1996),"The Distribution of Exchange Rates in the EMS", *International Journal of Finance and Economics*, 1:56-68.

Fatum, R. and M.M. Hutchison, (2003), "Effectiveness of Official Daily Foreign Exchange Market Intervention Operations in Japan", *National Bureau of Economic Research Working Paper 9648*.

Filardo, A.J. (1994), "Business Cycle Phases and their Transitional Dynamics", *Journal of Business and Economic Statistics*, 12:299-308.

Fischer, S., (2001), "Exchange Rate Regimes: Is the Bipolar View Correct?", *Journal of Economic Perspectives*, 15(2):3-24.

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

Hamilton, James (1994) *Time Series Analysis*, Princeton University Press, Princeton.

Hamilton, J.D., (1989), "A New Approach to the Economic Analysis of Non-stationary Time Series and Business Cycles", *Econometrica*, 57:357-384.

Hung, J.H., (1997), "Intervention Strategies and Exchange Rate Volatility: A Noise Trading Perspective", *Journal of International Money and Finance*, 16(5):779-93.

Kassami, C.M. (2002), "Issues Concerning the Macroeconomic Framework and the MTEF FY 2003/04-2005/06", *A Paper Presented at the Budget Consultative Workshop October 28th-29th, Kampala*.

Kasekende, L.A. (2000), "Capital account Liberalisation: the Ugandan Experience", *A Paper Presented at the Overseas Development Institute*.

Kasekende, L. (1998), "Capital Account Liberalisation and Poverty", http:// www.brettonwoodsproject.org/topic/financial/f22gowithflowspt3.pdf.

Katarikawe M. and R.K. Sebudde (2000), "Is the Reserve Money Program Still a Useful Operating Framework for the Conduct of Monetary Policy in Uganda? *Bank of Uganda Staff Papers*, 2(1):1-20.

Kim, S., T. Kortian and J. Sheen (2000), "Central Bank Intervention and Exchange Rate Volatility: Australian Evidence", *Journal of International Financial Markets*, 10(210):381-405.

King (2003), "Effective Foreign Exchange Intervention: Matching Strategies with Objectives", *International Finance* 6(2):249-271.

Liao T.F. (1994), "Interpreting Probability Models: Logit, Probit, and other Generalised Linear Models" Sage Publications, Thousand Oaks.

Lewis, Karen K. (1995a), "Puzzles in International Financial Markets", in Gene Grossman and Kenneth Rogoff (Eds.), *The Handbook of International Economics*, Elsevier Science Publishers, Amsterdam.

Lewis, Karen K. (1995b), "Occasional Intervention to Target Rates", *American Economic Review*, 84 (5), 691-715.

Meese, Richard and Kenneth Rogoff, (1983), "Empirical Exchange Rate Models of the Seventies: Do they fit the Sample?", *Journal of International Economics*, 14 (1/2), 3-24.

Mussa, Michael (1981), "The Role of Official Intervention", *Group of Thirty Occasional Papers No. 6*, New York, Group of Thirty.

Murray, J., M. Zelmer and D. McManus (1996), "The Effect of Intervention on Canadian Dollar Volatility", in P. Fenton and J. Murray (eds), *Exchange Rates and Monetary Policy, Ottawa: Bank of Canada* 311-61.

Mutebile, T.E., (2001), Speech by the Governor, Bank of Uganda, at the Inauguration of the Uganda Foreign Exchange Bureau Operators Association Held on 27th January, 2001 at the Grand Imperial Hotel Kampala.

Neely, Christopher J. (2001), "The Practice of Central Bank Intervention: Looking Under the Hood", *Federal Reserve Bank of St. Louis Review*.

Rankin, Bob (1998), "The Exchange Rate and the Reserve Bank.s Role in the Foreign Exchange Market", http:// www.rba.gov.au/Publications and Research/Education/Exchange_Rate.html.

Rogers, J.M. and P.L. Siklos (2003), "Foreign Exchange Market Intervention in Two Small Economies: the Canadian and Australian Experience", *Journal of International Money and Finance*, 22:393-416.

Sarantis, N. and S. Piard (2004), "Credibility, Macroeconomic Fundamentals and Markov Regime Switches in the EMS", *Scottish Journal of Political Economy*, 51(4):453-476.

Sarno, Lucio and Mark Taylor (2001), "Official Intervention in the Foreign Exchange Market: Is it Effective and if so How Does it Work?", *Journal of Economic Literature*, XXXIX, 839-868.

Schwartz, Anna J. (2000), "The Rise and Fall of Foreign Exchange Market Intervention", *NBER Working Paper 7751*.

Shiller R.J., (2003), "From Efficient Markets Theory to Behavioral Finance", *Journal of Economic Perspectives*, 17(1):83-104.

Taylor, M.P. (2004), "Is Official Exchange Rate Intervention Effective?", *Economica* 71:1-11.

Taylor, M.P. (1995), "The Economics of Exchange Rates", *Journal of Economic Literature*, 83(1):13-47.

Appendix 1: Probit Estimation Results

Appendix Table 1: Maximum Likelihood Estimates of the Probit Regression

Dependent Variable: $\Pr\{s_t = 2 \mid s_{t-1} = 1\}$

Variable	Coefficient	Std. Err.	P>|z|
Cons	-2.566638	.2156351	0.000
Intv{-1}	-.0909071	.0431787	0.035
Season	169.6405	54.4186	0.002
Trend Deviation	-2.020207	2.768626	0.466
LR $\chi^2(3)$ = 12.65[0.0055]			

Appendix 2: Maximum Likelihood Results of the Probit Regression

Dependent Variable: $\Pr\{s_t = 1 \mid s_{t-1} = 2\}$

Variable	Coefficient	Std. Err.	P>|z|
Cons	-3.977462	.6351854	0.000
Intv{-1}	-.0196033	.077192	0.800
Season	-558.5703	104.1944	0.000
Trend Deviation	-7.294673	5.015639	0.146
LR $\chi^2(3)$ = 75.09[0.0000]			