THE EFFECTIVENESS OF CENTRAL BANK INTERVENTION IN THE FOREIGN EXCHANGE MARKETS IN SELECT FLEXIBLE EXCHANGE RATE COUNTRIES IN THE CARIBBEAN

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ABSTRACT

This paper analyses the effectiveness of central bank intervention in the foreign exchange markets of two floating exchange rate regional economies. It reviews the literature on foreign exchange market intervention, outlines the structure of the foreign exchange markets in the two jurisdictions and looks at the modus operandi of intervention by central banks. The effect of intervention on target variables is estimated. Policy recommendations for best practices on intervention in these foreign exchange markets are suggested.

Introduction

The market-determined exchange rate is supposed to reflect the underlying supply and demand conditions in flexible regimes with capital mobility or, put another way, the exchange rate should reflect long-term macroeconomic fundamentals (Rogoff, 1996). The evidence has been, however, that exchange rates can depart significantly from the level implied by fundamentals in the short term, even in developed markets (Sarno and Taylor, 2001b). This reality creates a role for central bank intervention in the foreign exchange market to keep the exchange rate in line with the economic environment and the overall policy mix, which in turn can stabilise market expectations and calm disorderly markets.

Most central banks operating in flexible regimes intervene in the foreign exchange market. However, there has been growing pessimism about the effectiveness of intervention, especially in developed economies (Schwartz, 2000). In the case of developing countries, some authors have argued that because of the variety of regulations that restrict the size of the market, the information advantage of the central bank and the fact that intervention volumes are larger relative to total market volume, intervention is more effective. In addition, central banks in some countries may be the main conduit of foreign exchange to the market, since the government is one of the main recipients of foreign currency flows (Canales-Kriljenko, Guimaraes and Karacadag, 2003). Given these differences between developed and developing countries, it has

proven difficult to achieve consensus on the modalities and the effectiveness of intervention (Kearns and Rigobon, 2002). This, no doubt, is related in part to the disparate objectives, policies and procedures and economic environments in which different central banks operate. Notwithstanding these challenges, intervention to restrict exchange rate volatility brought on by temporary shocks remains an important policy objective of central banks.

In spite of the importance and frequency of intervention in the foreign exchange markets of Caribbean and other developing countries with flexible exchange rate regimes, relatively little empirical work has measured its effectiveness.[1] This paper attempts to fill this lacuna by seeking to measure the effectiveness of central bank intervention in the foreign exchange markets of two floating exchange rate economies in the Caribbean. The remainder of the paper has four sections. Section 2 reviews the literature on the effectiveness of central bank intervention in the foreign exchange market; Section 3 outlines the structure of the foreign exchange markets and the way in which the two regional central banks undertake intervention; Section 4 details the methodology used and the results of the attempts to measure the effectiveness of intervention; and Section 5 concludes by distilling some policy implications for best practices with respect to central bank intervention in Caribbean foreign exchange markets.

2. Literature Review

For the purposes of this study, *intervention is defined as central bank purchases or sales of foreign currency (against the local currency) in an effort to correct short-term misalignments and to dampen excessive short-term volatility in the exchange rate and other disorderly market conditions.* Short-term misalignment in this context assumes that the central bank has some target rate or, more likely, a target band for the exchange rate based on competitiveness, economic growth and other policy objectives. Disorderly market conditions include developments such as large changes in bid-ask spreads and steep declines in market turnover.[2] This definition abstracts from other intervention objectives, namely portfolio rebalancing, reserve accumulation and the supply of foreign exchange to the market (Canales-Kriljenko, Guimaraes and Karacadag, 2003).

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1   However, there is a vast amount of work on the effectiveness of intervention in developed market economies. Sarno and Taylor (2001a) provide a comprehensive review of the empirical methodologies used and the evidence on the effectiveness of intervention in developed markets.

2   The IMF encourages member countries to manage disorderly conditions in foreign exchange markets (IMF, 2002).

The effectiveness of intervention is determined by its impact on the level and stability of the exchange rate. Some qualification on effectiveness must be mentioned, however, to put into perspective the limits on intervention. In particular, the effectiveness of intervention is constrained by the degree to which the target rate or band is consistent with the policy mix and other economic fundamentals (Sarno and Taylor, 2001a; Mark, 2001). This implies that intervention that *leans against the wind* is not sustainable in the *long term*.[3] It is, however, important to distinguish between intervention and exchange rate policy. Currency crises shed light on the sustainability of exchange rate policy, but not necessarily on the effectiveness of intervention. To the extent that intervention fails to achieve the exchange rate objective, the fault in many cases is the policy mix on which the targeted exchange rate is based and not on the effectiveness of the instrument of intervention (Canales-Kriljenko, Guimaraes and Karacadag, 2003).

Theoretically, interventions in the foreign exchange market can affect the exchange rate through a variety of channels that are not mutually exclusive. These include the signalling, portfolio balance and market microstructure channels, all of which are based on their respective models of exchange rate determination. The signalling channel works by signalling to market participants the future stance of monetary policy. In this framework, the exchange rate is treated as an asset price that is determined by the money supply. The intervention of the central bank works by moving market participants' expectations of what future monetary conditions are likely to be closer to the central bank's expectations, even if the intervention is sterilised. This channel can only work effectively if the central bank has policy credibility, since the lack of credibility may increase the likelihood of speculative attacks against the currency (Sarno and Taylor, 2001a). The fact that this channel works by changing perceptions means that it can only be effective if well publicised.

In developing countries where central banks' credibility may be weak, the signalling channel may not be as effective as in developed economies, where central banks have a long history of prudent macroeconomic management. As such, the magnitude of interventions in these jurisdictions may have to be relatively larger to have a favourable impact. In other words, central banks would have to "buy credibility" for their signal of the future monetary policy stance to be as effective as in a developed market context (Mussa, 1981). Additionally, central banks in developing countries have to contend with continually changing policy and economic environments which make it difficult to establish links between contemporaneous and future policy actions.

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3   Currency crises in Mexico in 1994, Thailand in 1997 and Brazil in 1999 highlight the limits of intervention, where in the first two cases the intervention activities of the central bank virtually depleted these countries' foreign exchange reserves because intervention was based on a targeted rate, which was inconsistent with fundamentals and the policy mix.

The portfolio balance channel intervention works by generating rebalancing in the currency composition of market participants' portfolios based on the portfolio balance model of exchange rate determination (Sarno and Taylor, 2001b). The key assumptions of this framework are that domestic and foreign-currency denominated financial assets are imperfect substitutes and that investors are risk averse. Agents, therefore, demand a higher return on the asset whose outstanding stocks have increased to equalise risk-adjusted returns. Interventions in the foreign exchange market alter agents' relative supply of foreign and local securities and force rebalancing, which generates changes in the exchange rate. In the case of unsterilised interventions, the corresponding contraction in the monetary base reinforces the impact of the intervention. The portfolio balance channel is thought to be more effective in developing countries where central bank credibility may be weak, domestic and foreign currency debt are imperfect substitutes and central bank interventions are large relative to market turnover[4] (Canales-Kriljenko, Guimaraes and Karacadag, 2003; Galati and Melick, 2002).

The literature on the microstructure of foreign exchange markets and the role of informational asymmetry in financial markets has highlighted the existence of another channel through which intervention can affect the market. The microstructure approach focuses on order flow,[5] informational asymmetries, trading mechanisms, liquidity and the price discovery process (Lyons, 2001; Seerattan, 2004). Central bank intervention works in this framework by emitting information to the market, which modifies expectations and generates huge order flows. These orders, in turn, may increase short-term volatility (Guimaraes and Karacadag, 2004). Central bank intervention is, therefore, a special form of order flow, as it causes agents to change their expectations about the future exchange rate and net open positions, which generates a cascade of order flows.

The intervention effect can be greater in the presence of noise traders who follow past trends and trade in herd-like fashion (Hung, 1997). Interventions may not be announced and may be timed to maximise their impact, which may increase short-term volatility. The influence of intervention tends to be greater if the central bank is

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4   The converse is of course true in developed market economies where the volume of market turnover has been growing rapidly, restricting the scope for intervention on the scale that would have an impact on the exchange rate.

5   Order flow is signed transaction volumes, that is, if you are the active initiator of a sell order, this takes on a negative sign and if you are the active initiator of a buy order it takes on a positive sign. The dealer in this case is on the passive side of the transactions. The important issue here is to identify the active initiator of the transaction. In this way, one can get an accurate picture of net buying or selling pressure in the market, where a negative sign indicates net selling and a positive sign net buying pressure.

intervention. Studies using this methodology (Fatum, 2000; Fatum and Hutchison, 2003a, b) find that sterilised intervention has a significant impact on the bi-lateral exchange rate (United States (US)$/Japanese yen and US$/Deutsche Mark) regardless of whether it is secret or publicised. Edison, Cashin and Liang (2003) find that the Reserve Bank of Australia's interventions had a modest effect on the US$/Australian dollar, but that these interventions tended also to increase exchange rate volatility.

Attempts to overcome the simultaneity problem using the SVAR framework involve assessing the effect of monetary policy and intervention on the exchange rate and the degree to which intervention reacts to exchange rate changes (Kim, 2003). The results from this study suggest that intervention was effective in the US over the period 1973-1996. The identifying restrictions used in these models allow the exchange rate to have an impact on intervention and can also measure the influence of conventional monetary policy on the exchange rate. The problem with this approach, however, is the validity of the identifying restrictions employed to identify structural shocks.

Most recently, attempts have been made to study the effect of intervention on the level and volatility of the exchange rate in a unified framework using GARCH techniques. Studies that have utilised this approach (Dominquez, 1998; Guimaraes and Karacadag, 2004) found some evidence that intervention has an impact, but only those interventions that involve sales of foreign exchange. This procedure has the advantage of being computationally simple and allows the simultaneous assessment of the effect of intervention on the exchange rate and its volatility. This is important since central banks not only have a target rate or band as their objective, but are also interested in controlling volatility. GARCH models also provide good forecasts of volatility and have a proven track record in modelling exchange rate volatility (Anderson and Bollerslev, 1998). The weakness in using this framework is that simultaneity problems could influence the accuracy of the model parameters.

In terms of the intervention channels, empirical studies point to mixed evidence for the portfolio balance and signalling channels. Under the signalling channel, Dominguez and Frankel (1993a) estimated the impact of intervention on the current and future exchange rate (using survey data), and found that intervention had a significant influence on expectations, especially if interventions are publicised. In terms of the portfolio balance effect, Obstfeld (1990) observes that the portfolio balance effects are significant but small. In fact, the evidence on the portfolio balance effect suggests that until recently this channel was of limited use in intervention (Edison, 1993). The exception was Dominguez and Frankel (1993b) who, by employing survey data to measure exchange rate expectations and risk premiums, found a significant and large portfolio effect.

Recent research (Evans and Lyons, 2002) that uses the framework of market microstructure and order flow shows that intervention had a significant impact on exchange rates (US$/DM and US$/yen) through the portfolio balance channel, with a US$1 billion intervention having an immediate 0.44 percent effect on the exchange rate

perceived to have privileged information, since market participants try to glean trends from central bank trades and in this way interventions help the market to aggregate information and drive the price discovery process (Lyons, 2001). In general, and in congruence with other channels of impact, the larger the intervention relative to the size of the market, the higher the effect on the exchange rate. In developing countries, therefore, where markets are small and central banks usually have privileged information, this channel may be very effective.

Studies that attempt to measure the effectiveness of intervention have focused almost exclusively on developed markets. This, in most cases, reflects primarily the availability of data and the fact that many models of central bank intervention assume deep and sophisticated markets. Over the years, a range of methodological approaches has been used to evaluate the effectiveness of intervention. The approaches have become more sophisticated over time, as more detailed data became available and as there were greater advances in empirical techniques. Excellent reviews of these approaches are available in Edison (1993) for studies done in the 1980s and Sarno and Taylor (2001a) for research undertaken in the 1990s. Lyons (2001) and Guimaraes and Karacadag (2004) also add value to the literature by reviewing studies that focus on the microstructure approach. The main methodological procedures include Ordinary Least Squares regression of mean, risk premium and order flow equations (Dominguez and Frankel, 1993a,b; Evans and Lyons, 2002), event studies of intervention episodes (Fatum, 2000; Fatum and Hutchison, 1993a,b; Hutchison, 2003), a unified approach to monetary policy and foreign exchange market intervention using structural vector autoregression (SVAR) [Kim, 2003], and the generalised autoregressive conditional heteroscedasticity (GARCH) framework for evaluating the impact of intervention on the level and volatility of the exchange rate (Dominguez, 1998, Guimaraes and Karacadag, 2004).

The approaches have their strengths and weaknesses. The regression analyses all suffer from simultaneity problems, that is, the regression of the exchange rate on intervention fails to separate the degree to which intervention responds to exchange rates rather than exchange rates responding to intervention. As a result, the coefficient estimates can have the wrong signs or overstate the impact of intervention. Moreover, in many of these early studies there were no data on intervention amounts and intervention was proxied by changes in external reserves, which is a very imprecise measurement (Neely, 2001).

Event study methods define an event window to include one or more intervention episodes together with non-intervention days (to ensure there is a balanced sample in the event window). Exchange rate changes that occur in this event window are then compared to the pre-event window. The strength of this approach is that it focuses on the intervention episodes that tend to be irregular and clustered in time, and is therefore useful for highlighting the short-term dynamics of intervention. The most serious weakness of this procedure is that it offers no perspective on the long-term effects of

and a permanent influence of 0.35 percent. Dominguez (1999) utilises an event study approach with intra-daily data to capture microstructure elements in a model of central bank intervention in the foreign exchange market. The results indicate that intervention has a strong impact on both the US$/DM and US$/yen rates. In addition, the study suggests that the effectiveness of central bank interventions depends on the state of the market at the time the intervention becomes known and that the microstructure of the foreign exchange market could play a meaningful role in determining the effectiveness of central bank's intervention.

3. The Structure of the Foreign Exchange Markets and Intervention Practices in Jamaica and Trinidad and Tobago

The basic microstructure of foreign exchange markets consists of a number of core elements, namely, the major players (dealers, central banks, corporations, speculators), the mechanisms for trading and the regulatory and management systems. The trading mechanism could be based on auctions or inter-bank markets, as well as on traditional and non-traditional price discovery mechanisms. The regulatory and management systems include internal risk management systems, the exchange rate regime and prudential standards on open positions.

Jamaica

Jamaica liberalised its foreign exchange market substantially during the 1990s. During this period, exchange controls were eliminated in 1990, the exchange rate regime changed from fixed to floating in 1991 and the number of dealers increased in 1994 with the establishment of cambios and merchant banks. In 2001, the institutional structure of the market consisted of 15 authorised dealers and 136 cambios (which included bureaux de change). The non-financial firms and individuals, which drive the demand and supply conditions in the market, are fairly heterogeneous and the supply of foreign exchange is quite evenly distributed among the sources – that is, export of goods and services, remittances, direct investment flows, private portfolio flows and official loan inflows. The Jamaican dollar is not a vehicular currency, so a shortage of foreign currencies cannot be filled by selling Jamaican dollars to foreign banks. If a particular market-making bank is short, that bank must either enter the local market to bid for the shortfall or must borrow foreign currency from a foreign correspondent bank.

Cambios are only permitted to buy and sell foreign exchange within their limits of US$250,000 on cheques and drafts and US$10,000 on cash transactions. These cambios are licensed by and monitored by the Bank of Jamaica (BOJ) to ensure compliance with the BOJ's operational guidelines and the Money Laundering Act. Cambios are also required to report to the Director of Public Prosecutions (DPP) any cash transaction

greater than or equal to US$8,000. Cambios currently sell 5 percent of their gross daily purchases of foreign exchange to the BOJ by mutual agreement. The major difference between cambios and authorised dealers is that the former are not permitted to grant loans or accept deposits. There are currently approximately 88 bureaux de change in operation, primarily to facilitate the exchange of currency for hotel guests. These institutions sell 10 percent of their gross daily purchases to the BOJ.

The authorised dealers consist of commercial banks, merchant banks and the two largest building societies. These authorised dealers engage in all types of foreign exchange transactions: buying and selling, intermediation and making a market in foreign exchange. No limits are placed on the value of transactions; however, under the Money Laundering Act, these financial institutions are required to report to the DPP any cash transaction at or above US$50,000. The authorised dealers, though not statute bound, have also agreed to sell 5 percent of their daily gross purchases of foreign exchange to the BOJ. These institutions are monitored and regulated by the BOJ under the Financial Institutions Act and the Building Societies Act.

The information transmission mechanisms in the market were relatively unsophisticated, consisting of informal contacts and telephone calls until 2001, when EGATE, an electronic bulletin board, was set up by the BOJ. Authorised dealers list two-way bid and ask quotations, which are posted on the system, making the price discovery process much more efficient. Dealers now have better information on prices and trading is done on a more informed basis. When spot transactions (transactions settled within 2 business days) between dealers and the public and between the two categories of dealers are executed, different spot rates are realised. The official exchange rate is computed as a weighted average of all trades. A forward market for foreign exchange to hedge foreign exchange rate risk has also been in existence for several years, but the volume of transactions and price data are not readily available.

The BOJ undertakes market surveillance, collects and disseminates information on the foreign exchange market and intervenes directly in the market to control volatility. The rate at which the BOJ intervenes usually mirrors the weighted average buying or selling rates in the market. Its information dissemination function is an important part of the market microstructure, as it helps the price discovery process, especially since private mechanisms for price discovery are not well developed.

Trinidad and Tobago

In April 1993 exchange controls on current and capital transactions were abolished in Trinidad and Tobago and the exchange rate regime was changed from fixed to floating. The market for foreign exchange consists of commercial banks, the public (both firms and individuals) and the central bank. The system is based on an interbank market, where demand and supply conditions and the interventions of the Central Bank of Trinidad and Tobago (CBTT) in the spot market drive market performance.

The market is also structured around a sharing agreement for foreign exchange, with inflows from the major suppliers shared among the market-making banks, based on a formula.

The bid-ask spreads at the wholesale end of the market, which comprises the market-making commercial banks, large suppliers of foreign exchange and the central bank, are much more competitive than at the retail end. Spot trades are then executed for particular transactions at prices based on the initial bid-ask quotes by commercial banks. Since the CBTT intervenes to keep the exchange rate at a target level, bid and ask prices are likely to exhibit bounds or limits at the point of intervention. The exchange rate, therefore, is generated by the demand and supply for foreign exchange and the intervention activities of the CBTT. The rate is computed as a weighted average of the spot rates of all transactions both on the wholesale and retail ends of the market. The market also has a forward market for foreign exchange, which, though small, has shown signs of growth.

The major players in the market are commercial banks (and their correspondent international banks), bureaux de change, the public (which includes a few large suppliers of foreign exchange) and the CBTT. Commercial banks trade with the public and among themselves to meet their liquidity needs. The inter-bank system in particular has been used to good effect to deal with peaks and valleys in individual banks' liquidity. This is buttressed by the CBTT's intervention when swings in liquidity are too large. The characteristics of banks affect the operation of the market. Indeed, some banks have large corporate clients or concentrate on the retail market, while others have a large branch network. The five bureaux de change support the commercial banks and are licensed by the Central Bank and monitored and regulated under the Financial Institutions Act 1993. The market is driven by seven authorised dealers, which are all commercial banks, except one non-bank financial institution whose bureaux de change licence in 1999 was upgraded to authorised dealership status.

The trading mechanism in this market, similar to the Jamaican market, is based on a quote-driven interbank system. The commercial banks act as market makers, quoting indicative bid-ask prices in the spot market, which guide the prices executed during trades. The actual systems in place for price discovery in the interbank market are, however, underdeveloped. Most trading is still done on the telephone and transactions are confirmed by fax. This weakness in the system has been recognised and there are plans to introduce a common electronic platform so that two-way bid-ask quotes could be posted to facilitate interbank activity.

The CBTT collects and disseminates information on the foreign exchange market, and intervenes directly to smooth out volatile swings in liquidity to prevent high exchange rate volatility. In addition, the central bank provides a venue for commercial banks to meet and share information, which helps to manage the interbank system.

A Comparison Between the Two Foreign Exchange Markets

There are many similarities between the foreign exchange markets in Jamaica and Trinidad and Tobago. They are both organised as inter-bank markets, with commercial banks as market makers, rather than auction markets, although Jamaica has experimented with an auction market. Both markets are quote-driven systems, rather than order-driven systems. The central banks in both jurisdictions intervene to ensure the exchange rate is consistent with the policy mix and to smooth out volatility.

There are, however, some important differences. The number of dealers in the Jamaican market is far greater than in Trinidad and Tobago, even if one adjusts for the different sizes of these countries. Dealers in Jamaica, by mutual agreement, also have to sell a small percentage, ranging from 5 percent to 10 percent, of their gross daily purchases of foreign exchange to the BOJ. To the extent that purchases by the BOJ under this agreement are below the market rate, this arrangement could be viewed as a tax. The systems in place for the price discovery process in the inter-bank market in Jamaica is, however, more developed than in Trinidad and Tobago. The electronic bulletin board EGATE, set up by the BOJ, allows dealers and market makers to have current information on bid and ask prices, which facilitates more efficient pricing and, by extension, should lead to narrower spreads. Trinidad and Tobago's system is still based on telephone contacts, but there is ongoing discussion to set up a similar electronic price discovery mechanism based on a Bloomberg platform.

Most importantly, however, is that in Trinidad and Tobago the conduit for the majority of foreign exchange supplied to the market is the CBTT, since these flows largely represent government's petroleum tax revenue. This gives the CBTT a degree of market power and leverage that the BOJ does not have. The ability to intervene is, therefore, greater, as well as less costly. The system in Trinidad and Tobago is also defined by a supply-sharing arrangement, where major suppliers distribute foreign currency according to a pre-arranged formula. These features of the market in effect restrict bid and ask prices to a range that is bound by central bank interventions, especially on the high side.

There are some important features of the intervention activity in both jurisdictions that warrant mention. Firstly, the intervention activity of both central banks was almost universally on the selling side, indicating excess demand pressures most of the time. Both banks also intervened at a rate that signalled where they wanted the rate to go, that is, in most cases, the intervention rate was predominantly lower than the weighted average selling rate.

Some of the differences between the intervention practices of the two banks are also noteworthy. The BOJ generally intervened more frequently than the CBTT, intervening 22.7 percent of the days in the sample period, compared to 6.8 percent of the days for the CBTT. The intervention size was also different, with the BOJ tending to be more consistent, relative to the more variable intervention amounts of the CBTT.

This, in part, reflected the higher frequency of intervention on the part of the BOJ. The maximum intervention of the CBTT (US$48.3 million) was also higher than the BOJ (US$22.7 million). Another major difference is that Trinidad and Tobago has a formula for sharing foreign exchange flows from the central bank and other major suppliers. This is done to prevent a build-up of speculative pressures. However, it can have an impact on intervention by weakening the link between intervention activity and the exchange rate.

4. Data and Descriptive Statistics

The data used in this study are daily observations spanning the period October 2001 to September 2004 for Jamaica and January 2000 to September 2004 for Trinidad and Tobago. The data set includes central bank intervention (both the buying and selling operations), the weighted average buying rate, the weighted average selling rate, total volume selling, total volume buying and the bid-ask rate, which is a spread computed as the difference between the weighted average selling and the weighted average buying rate.

Tables 1 and 2 present descriptive statistics for the log first difference of the exchange rate, the bid-ask spread, the total volume of US dollars purchased (buying volume) and the total volume of US dollars sold (selling volume). The results of the unit root tests indicate that all variables are stationary in levels. The descriptive statistics also show that the variables display many of the idiosyncratic features of financial time series, such as fat tails, skewness and volatility clustering.

5. Empirical Model and Results

Empirical Model

This study is primarily concerned with the effectiveness of central bank intervention in the foreign exchange market. As discussed in the previous section, the main objectives of intervention are in most cases to keep the exchange rate within some target band and to limit excessive short-term volatility in the rate. In this context, effectiveness is manifested in the ability to change the exchange rate in the preferred direction, without serious costs in terms of volatility. The preferred methodology is, therefore, the GARCH framework, which provides a simple and unified way to evaluate the impact of intervention on the mean and conditional variance of exchange rate changes (returns) simultaneously.

Table 1
Descriptive Statistics for Trinidad and Tobago

Variables	Descriptive Statistics				
	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
Log 1ˢᵗ Diff. ER	-0.000103	0.189812	-0.071559	3.367829	7.613799 (0.022)
Bid-Ask Spread	0.061315	0.020266	0.542264	3.163453	58.79251 (0.00)
Volume Buying	7.341198	5.410652	4.102556	41.59481	76092.68 (0.00)
Volume Selling	8.030621	3.391045	3.346689	31.52975	41971.30 (0.00)
Inter. Selling	0.980032	4.180886	5.328827	37.31515	63467.42 (0.00)

Sources: Central Bank of Trinidad and Tobago and author's calculations.

Notes: Sample size is 1174 observations.
p-values are in parentheses.

Table 2
Descriptive Statistics for Jamaica

Variables	Descriptive Statistics				
	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
Log 1ˢᵗ Diff. ER	0.039754	0.536339	-2.754728	85.67822	213991.7 (0.00)
Bid-Ask Spread	0.240097	0.158326	3.851801	26.6724	19340.78 (0.00)
Volume Buying	30.85740	8.848769	0.800221	4.033146	113.2490 (0.00)
Volume Selling	31.93807	9.076202	0.921745	4.609200	186.8749 (0.00)
Inter. Selling	2.598398	5.036210	1.721265	4.688515	458.8279 (0.00)

Sources: Bank of Jamaica and author's calculations.

Notes: Sample size is 749 observations.
p-values are in parentheses.

The evaluation of the effectiveness of intervention is based on a components GARCH (CGARCH) specification,[6] which jointly estimates the impact of intervention on volatility at different time horizons. The baseline empirical model is outlined below:

$$\partial s_t = \alpha_0 + \alpha_1 I_t^s + \alpha_2 VS_t + \alpha_3 VB_t + \alpha_4 S_t + \varepsilon_t \qquad (1)$$

$$h_t - q_t = \lambda(\varepsilon_{t-1} - q_{t-1}) + \theta(h_{t-1} - q_{t-1}) + \beta_1 I_t^s + \beta_2 VS_t + \beta_3 VB_t + \beta_4 S_t \qquad (2)$$

$$q_t = w + \chi(q_{t-1} - w) + \phi(\varepsilon_{t-1} - h_{t-1}) + \delta_1 I_t^s + \delta_2 VS_t + \delta_3 VB_t + \delta_4 S_t \qquad (3)$$

where ∂s_t is the log first difference of the exchange rate, I_t^s represents sales of foreign US dollars by the central bank for intervention purposes, VS_t is the volume of sales of US dollars in the market, VB_t is the volume of US dollars purchased in the market and S_t is the bid-ask spread on US dollars in the market. In keeping with the approach adopted by Guimaraes and Karacadag (2004), one-day lagged intervention sales were used instead of contemporaneous intervention in the estimation of the model parameters in an attempt to redress the simultaneity problem. The error term is the unexpected change in the exchange rate that is used to model the conditional volatility in Equations 1 and 2. The specification of the mean equation (Equation 1) is based on demand and supply conditions. For example, higher sales of US dollars are expected to be associated with a declining rate (appreciation $\alpha_2 < 0$), while higher purchases of US dollars are likely to be related to an increasing rate (depreciation $\alpha_3 > 0$).[7]

The bid-ask spread on the foreign exchange market is used as a proxy for the power of market makers (authorised dealers), an important insight highlighted by the microstructure approach to exchange rates and the functioning of foreign exchange markets as pioneered by Lyons (2001). In particular, the bid-ask spread is often taken as an indicator of the transaction efficiency of the foreign exchange market that is inextricably linked to the market power of these important agents. In this context, market makers in an oligopolistic market can charge relatively high spreads, which limits speculation that tends to drive the rate up. Increasing spreads, therefore, reflect market power, which is used to keep the selling rate relatively fixed but vary the

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6   Engle (2004) presents an excellent review of the usefulness of various GARCH specifications in different areas of finance.

7   The ideal situation would have been to collect information on order flow as discussed in Section 2, since purchases and sales volumes are only rough indications of selling and buying pressures in the market because of double counting and other aggregation problems (Lyons, 2001).

buying rate to maintain or increase the spread. Higher spreads in these markets are expected to be associated with a declining (appreciating $\alpha_4 < 0$) and/or a relatively stable exchange rate (Seerattan, 2004).

Of course the intervention by the central bank via the sale of US dollars is expected to be negatively related to the exchange rate $\alpha_1 < 0$, that is, the sale of US dollars by the central bank in the market are likely to strengthen the exchange rate. Similarly, central bank purchases of US dollars, if used, would be positively correlated to the exchange rate. Intervention purchases by the central banks in Jamaica and Trinidad and Tobago are, however, extremely rare. In fact, in the period for which data are available for the two countries, the BOJ never intervened via purchases and the CBTT only intervened via purchases twice for a total of US$45 million. This study, therefore, only looks at intervention via sales.

Equation 2 models the short-term conditional volatility, h_t, which converges to a time varying long-term volatility given by q_t. In this equation the short-term conditional exchange rate volatility is a function of time varying long-term volatility, lagged unexpected shocks relative to lagged long-term volatility $(\varepsilon_{t-1} - q_{t-1})$, lagged short-term volatility relative to lagged long-term volatility $(h_{t-1} - q_{t-1})$ and the set of explanatory variables included in the mean equation. In contrast to the standard GARCH model,[8] the CGARCH allows mean reversion of short-term volatility to a time varying long-term volatility. Lagged unexpected shocks and volatility are included to capture volatility clustering. Equation 3 models the long-term time varying volatility and, like its short-term counterpart, is related to its own lagged values and past shocks, but converges to a constant (w), instead of zero like its short-term counterpart. It is also important to note that the impact of intervention on short-term volatility may differ from the effect on long-term volatility.

Estimation Results

The estimation results generally conformed to a priori expectations. The model for Jamaica was also estimated assuming the error term follows a generalised exponential distribution (GED), since the descriptive statistics indicated that there were significant departures from normality in the raw data. The GED parameter was significant at the 1 percent level. The estimation results are presented in Table 3. The results for Jamaica indicate that lagged intervention sales had a significant and expected impact on the exchange rate. They show that a US$1 million sale by the BOJ would appreciate the value of the Jamaican dollar by approximately 0.0023 percent. The other explanatory variables in the mean equation also have significant and correctly signed coefficients.

7   The ideal situation would have been to collect information on order flow as discussed in Section 2, since purchases and sales volumes are only rough indications of selling and buying pressures in the market because of double counting and other aggregation problems (Lyons, 2001).

8   Standard GARCH assumes a constant long-term volatility.

Table 3
CGARCH Model Estimation Results

Coefficients	Jamaica	Trinidad and Tobago
Exchange Rate Level (Mean) Equation		
Intervention Sale	-0.002334***	0.000217
US Dollar Volume Sold	-0.004147***	-0.003448**
US Dollar Volume Purchased	0.001190*	0.006595***
Bid-Ask Spread	-0.350708***	-3.764618***
Short-Term Volatility Equation		
Intervention Sale	0.000112	0.000233
US Dollar Volume Sold	0.000254	0.000702
US Dollar Volume Purchased	-5.89E-05	0.001999**
Bid-Ask Spread	-0.050332	0.507454***
Long-Term Volatility Equation		
Intervention Sale	0.000115	-1.98E-05
US Dollar Volume Sold	-0.000299	-0.000340
US Dollar Volume Purchased	0.000176	-0.001419*
Bid-Ask Spread	0.110575	-0.302982*

Notes: *** denotes significance at 1 percent,
** denotes significance at 5 percent and
* denotes significance at 10 percent.

The variance equations also indicate that intervention did not have a statistically significant effect on either short-term or long-term volatility. The coefficients on the lagged unexpected shocks and volatility also imply that, as with other financial time series, volatility clustering is a feature of Jamaican exchange rates. None of the other variables used in the variance equations had a statistically significant influence on either short-term or long-term volatility.

In the case of Trinidad and Tobago, although the coefficient estimate of intervention sale had the correct sign, it was insignificant in all specifications, which included experimentation with the sample period. All the other variables in the mean

equation were significant and correctly signed. In terms of the volatility equations, intervention sales did not have a significant effect on either short- or long-term volatility. With regards to the other variables in the volatility equations, however, the volume of US dollars purchased and the bid-ask spreads had a positive impact on volatility both in the short and long run. The results from the bid-ask spreads in the mean and volatility equations suggest that even though relatively higher spreads can strengthen the rate, it could increase volatility in the short term but decreases it in the long term.

The results support the conclusions that intervention is effective in Jamaica as previously defined, that is, it pushes the exchange rate in the desired direction (sign and magnitude of coefficient) and does not seem to have a statistically significant impact on volatility. An intervention sale, therefore, is not the policy tool to use if the objective is only to reduce volatility. This is in line with the evidence in the literature, which seems to indicate that intervention sales and purchases can target the rate, but are not effective in dampening volatility. In fact, they can increase volatility.

Additionally, the intervention practices of the BOJ and the structure of the Jamaican market seem to play a part in the effectiveness of intervention. In particular, the regularity and size of the BOJ interventions help agents to generate stable expectations of the effect of intervention. The fact that there are better price discovery mechanisms in Jamaica and that the structure of the market is more competitive[9] also enhance the price discovery process, which can ultimately make intervention more effective.

In the case of Trinidad and Tobago, intervention did not have a significant impact on the level and volatility of the exchange rate. This could be attributed to a number of factors. Firstly, the regularity of intervention, both in terms of the frequency and size, did not lend itself to developing stable market expectations and, therefore, the responses of agents to interventions was not as tight. The sharing arrangement that has been in operation since 1993 when the exchange rate was floated is also a possible cause for the seeming ineffectiveness of intervention. In this framework, price is a secondary factor to the size of the flows, since a certain percentage of the supply is assured to particular market makers. This hampers the price discovery process and dampens the influence of price in foreign exchange transactions, which can be reflected in a reduced sensitivity of price (exchange rate) to intervention sales flows from the Central Bank.

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9   .In terms of the number and range of market makers and the absence of any arrangements for
     sharing the supply of foreign exchange. The fact that bid-ask spreads are relatively wider
     in Trinidad and Tobago also adds credence to this point of view.

6. Conclusions and Policy Implications

The results of this attempt to measure the effectiveness of central bank intervention in the foreign exchange markets of two Caribbean countries have generated a number of conclusions that potentially have serious implications for interventionist policy. They indicate that intervention sales were effective in achieving the exchange rate level objectives in Jamaica, both the desired direction and the magnitude of the impact. The interventions also did not have any adverse effect on short- or long-term volatility, one of the more serious costs associated with intervention. This finding also means that intervention via sales of foreign exchange is not a useful policy tool to dampen volatility in the market, either in terms of the rate or liquidity. In this regard, other policy tools designed to build confidence, stabilise expectations and harmonise the policy mix may be more relevant and effective.

In Trinidad and Tobago, on the other hand, interventions had no significant impact on the level of the exchange rate or on its volatility. This may be related to the special features of the foreign exchange market, including the sharing arrangement, the under-developed nature of the mechanisms for price discovery, the oligopolistic nature of the market and the practice of intervening relatively infrequently and in disparate intervention volumes.

Important policy implications flow from the foregoing. In terms of the size and timing (frequency) of interventions, central banks should seek to ensure a level of regularity in their interventions. Every attempt should be made to upgrade the mechanisms in the market for price discovery. Additionally, a greater number and range of market makers seem to aid in the price discovery process and should be encouraged, always keeping in mind that this can increase speculative activity, which complicates the intervention dynamics for the central bank.

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