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XXXVIth Annual
Monetary Studies Conference

The Effectiveness of Central Bank Intervention in the Foreign Exchange Market in Flexible Exchange Rate Regime Countries in the Caribbean

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Central Bank of Trinidad & Tobago
Conference Facilities, 16th Floor
November 1-4, 2004

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

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36th Annual Monetary Studies Conference
November 1-4, 2004

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Abstract

This paper analyses the effectiveness of central bank intervention in the foreign exchange markets of floating exchange rate regime countries in the region in terms of the level and volatility of the exchange rate. The paper review the literature on foreign exchange market intervention (in terms of a definition, the objectives of intervention, the channels through which intervention occur and the empirical approaches to measuring the impact of intervention on target variables), outlines the structure of the foreign exchange markets in these jurisdictions and the modus operandi of intervention by central banks in these markets and estimates the impact of intervention on target variables. Policy recommendations for best practices on intervention in these foreign exchange markets are then suggested.

1. Introduction

The exchange rate generated by the market is supposed to reflect underlying supply and demand conditions in flexible regimes with capital mobility or, put another way, it should reflect macroeconomic fundamentals in the *long term* (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 2002). This reality creates a role for central bank intervention in the foreign exchange markets to keep the rate in line with the economic environment and the overall policy mix, to stabilize market expectations and to calm disorderly markets. Intervention can also complement efforts to put the macroeconomic policy mix on a sustainable part (Canales-Kriljenko, Guimaraes and Karacadag 2003).

The introduction of floating exchange rate regimes in the Caribbean brought with it the challenge of central bank intervention in the foreign exchange market, since the level and volatility of the rate generated by the market often conflicted with the monetary authority's goals with respect to price stability and competitiveness. Most central bank operating these flexible regimes have intervened in the markets but over time there have been a growing pessimism about the effectiveness of intervention, especially in developed market economies (Schwartz 2000). In the case of developing countries, some have argued that intervention in these markets are more effective because the intervention volumes are larger relative to total turnover in the market, the variety of regulations that restrict the size of the market, the information advantage of the central bank in the market and because in some countries the central bank may be the main conduit of foreign exchange to the market since the government is one of the main recipient of foreign exchange flows (Canales-Kriljenko, Guimaraes and Karacadag 2003). There have also been problems in achieving consensus on the modalities of intervention, as well as the effectiveness of intervention, which is reflected in the mixed evidence on 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.

In the case of developing countries with flexible exchange rate regimes, intervention in the foreign exchange market is an even more significant policy measure because exchange rate stability is still a major policy objective because the pass-through from exchange rate movements to inflation in higher in these markets compared to developed economies (Calvo and Reinhart 2002). The exposure of financial assets denominated in local currency to significant capital loss if rates depreciated also creates an aversion to exchange rate volatility. The relatively low market turnover and vulnerability to external shocks both lead to a high premium being placed on exchange rate stability in developing countries with flexible exchange rate regimes (Guimaraes and Karacadag 2004). Additionally, the credibility of the monetary authorities is in most cases linked to their ability to maintain relative stability in the exchange rate (Calvo and Reinhart 2002). Intervention in countries that have flexible regimes to keep the exchange rate in some stable band and to restrict volatility brought on by temporary shocks, therefore, remains an important policy objective of the central banks in these countries. In spite of the

importance and frequency of central bank intervention in the foreign exchange markets of Caribbean countries and other developing countries with flexible exchange rate regimes, relatively little empirical work has been done to measure its effectiveness[1]. This paper attempts to fill this gap by seeking to measure the effectiveness of central bank intervention in the foreign exchange markets of selected floating exchange rate regime countries in the Caribbean. This paper is structured as follows; 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 market and the way in which central banks in the region effect intervention in select Caribbean countries; Section 4 details the methodology used and the results of the attempts to measure the effectiveness of central bank intervention in the foreign exchange market and Section 5 concludes by distilling some policy implications for best practices for central bank intervention in the foreign exchange markets in the Caribbean.

Section 2: Literature Review

In this paper *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 sharp jumps in bid-ask spreads in the market and steep declines in market turnover[2]. This definition also abstracts from other intervention objectives such as, portfolio rebalancing, reserve accumulation and the supply of foreign exchange to the market (Canales-Kriljenko, Guimaraes and Karacadag 2003). This is based on the centrality of stability and level exchange rate movements in the rate in the central bank intervention considerations and on the fact that these alternative objectives are still related indirectly to the level and stability of the exchange rate.

In this context, the effectiveness of intervention is determined by its ability to affect the level and stability of the exchange rate. Some qualification on the effectiveness must, however, be mentioned to put into perspective the limits to the effectiveness of intervention. In particular, even though it has been shown that in the short term exchange rates can often differ substantially from the level implied by fundamentals, even in developed markets, the effectiveness of intervention is limited by the degree to which the target rate or band is consistent with the policy mix and other economic fundamentals (Sarno and Taylor 2002, 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

[1] There is a vast amount of work done on the effectiveness of intervention in developed market economies. See Sarno and Taylor (2001) for a comprehensive review of the empirical methodologies used and the evidence on the effectiveness of intervention in developed market.

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

[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 in the foreign

between intervention and exchange rate policy. Currency crisis shed light on the sustainability of exchange rate policy but not necessarily on the effectiveness of intervention. To the extent that intervention fails in achieving its exchange rate objectives the fault in many cases lie with 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 signaling channel, the portfolio balance channel and the market microstructure channel all of which are based on their respective models of exchange rate determination. As its name implies, the signaling channel works by signaling to market participants the future stance of monetary policy. In this framework the exchange rate is treated as an asset price which 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 banks expectations, even if the intervention is sterilized. 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 where market participants speculate against the defensive (usually) interventions of the central bank (Sarno and Taylor 2001). The fact that this channel works by changing perceptions means that it can only be effective if it is well publicized to strengthen the central bank's policy signal.

In developing countries where central banks' credibility may be weak, this channel may not be as effective as in developed market economies where the central bank has a long history of prudent macroeconomic management. As such, the magnitude of the interventions by central banks in these jurisdictions may have to use relatively larger intervention amounts to have an impact, in other words they would have to "buy credibility" for their signal of 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. On the other hand, central banks in developing countries enjoy certain benefits relative to their developed market counterparts such as information advantages over the market and the ability to intervene with larger amounts relative to the market given the size of turnover in these markets (Canales-Kriljenko, Guimaraes and Karacadag 2003).

Under the portfolio balance channel, intervention work by generating rebalancing in terms of the currency composition of market participants' portfolios. This is based on the portfolio balance model of exchange rate determination (Sarno and Taylor 2001). 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 has increased to equalize risk-adjusted returns. Foreign exchange market interventions alter agents'

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exchange market virtually depleted the countries' foreign exchange reserves because intervention was based on a targeted rate which was inconsistent with fundamentals and the policy mix.

relative supply of foreign and local securities and force rebalancing which generates changes in the exchange rate. In the case of un-sterilized interventions the corresponding contraction in the monetary base reinforce 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, where domestic and foreign currency debt are imperfect substitutes and where the central bank interventions are large relative to market turnover[4] (Canales-Kriljenko, Guimaraes and Karacadag 2003, Galati and Melick 2002).

The rapidly growing field on the microstructure of the foreign exchange market and the role of information asymmetry in financial markets has highlighted the existence of another channel through which intervention can affect the exchange rate. The microstructure approach to foreign exchange markets focus on order flow[5], information 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 tend to increase short-term volatility (Guimaraes and Karacadag 2004). Central bank intervention is therefore a special form of order flow which causes agents to change their expectations on the future part of the exchange rate and net open positions that generates a cascade of order flows.

The intervention impact 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 maximize impact which may tend to increase short-term volatility. The impact of intervention tends to be greater if the central bank is 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 impact on the exchange rate. In developing countries, therefore, where the markets are small and where the central banks usually have privileged information this channel may be very effective.

Studies that attempt to measure the effectiveness of intervention in the foreign exchange market have focused almost exclusively on developed market economies. This in most cases reflect primarily the availability of data and the fact that many models of central bank interventions assume deep and sophisticated markets which are usually found in developed economies. A range of methodological approaches has been used to evaluate the effectiveness of intervention in the foreign exchange market over the years. The

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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 rate.

[5] Order flow is transaction volumes that are *signed*. That is if you are the *active initiator* of a *sell* order this takes on a *negative sign* 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 and a positive sign indicates net selling and buying pressure respectively.

approaches have become more sophisticated over the years as more detailed data became available and with advances in empirical techniques. Excellent reviews of these approaches are available in Edison (1993) for studies done in the 1980s and Sarno and Taylor (2001) for studies done 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 and other more recent developments respectively in the literature. The main methodological approaches include OLS regression of mean, risk premium and order flow equations (Dominguez and Frankel 1993a and b, Evans and Lyons 2002), event studies of intervention episodes (Fatum 2000, Fatum and Hutchison 1993a and b, Hutchison 2003), unified approach to monetary policy and foreign exchange market intervention using structural VAR (kim 2003) and the GARCH framework for evaluating the impact of intervention on the level as well as the volatility of the exchange rate (Dominguez 1998, Murray et. al 1997 and Guimaraes and Karacadag 2004).

The approaches of course all have their strengths and weaknesses. The regression analyses all suffer from simultaneity problems, that is, the regression of exchange rate over 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 sign or overstate the impact of intervention on the exchange rate. Moreover, in many of these early studies there was no data on intervention amounts and intervention was proxied by changes in external reserve which is a very imprecise way of measuring intervention (Neely (2001).

Event study approaches defines 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 which tend to be very irregular and clustered in time and is therefore useful for highlighting the short term dynamics of intervention. The most serious weakness of this approaches is that it offers no perspective on the long term effects of intervention. Studies using this approach (Fatum 2000, Fatum and Hutchison 2003a and 2003b) find that sterilized intervention has a significant impact on the bi-lateral exchange rate level (US$/Japanese yen and US$/deutsche mark) regardless of whether it is secret or publicized. Another event study Edison et. al. (2003) finds that the Reserve Bank of Australia's interventions had a modest impact on the US$/Australian dollar but that these interventions tended also to increase exchange rate volatility.

Attempts to overcome the simultaneity problem by using the vector autoregression framework (VAR) have recently been made in which the impact 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 find that intervention is effective in the US over the period 1973-1996, suggest that intervention in the US was sterilized over this period and that intervention has an impact on the exchange rate beyond the short term. The identifying restrictions used in these models allow the exchange rate to have an impact on intervention and can also measure the impact of conventional monetary

policy on the exchange rate. The problem with this approach of course is the validity of the identifying restrictions used to identify structural shocks.

Most recently attempts have been made to study the impact of intervention on the level exchange rate and the volatility of the rate in a unified framework using the generalized autoregressive conditional heteroskedascity (GARCH). Studies that utilized this approach (Dominquez 1998 and Guimaraes and Karacadag 2004) have found some evidence that intervention has an impact on the level of exchange rate, as well as on its volatility, but this is only interventions that involve sales of foreign exchange. This approach has the advantage that it is computationally simple and allows the simultaneous assessment of the impact of intervention on the exchange rate as well as its volatility. This is important since central banks not only have a target rate or band as its objective but is also interested in controlling volatility. GARCH models also provide good forecasts of volatility and have a proven track record in modeling the volatility of exchange rates (Anderson and Bollerslev 1998). Its weakness of course in using this framework to measure the impact of intervention on exchange rate and its volatility is that simultaneity problems could impact on the accuracy of the model parameters.

In terms of the channels through which intervention affects the exchange rate empirical studies have found mixed evidence in evidence for the portfolio balance and signaling channels. Under the signaling channel (Dominguez and Frankel 1993a) estimated the impact of intervention on current and future exchange rate (using survey data), and found that intervention had a significant impact on expectations, especially if interventions are publicized. In terms of the portfolio balance effect, Obstfeld (1990) finds that the portfolio balance effects are significant but small. As a matter of fact the evidence on the portfolio balance effect was until recently that this channel was of limited use in intervention (Edison 1993). The exception to this was Dominguez and Frankel (1993b) who found a significant and large portfolio effect using survey data to measure exchange rate expectations and risk premiums.

Recent research that uses the framework of market microstructure and order flow (Evens and Lyons 2000, 2002) found that intervention had a significant impact on exchange rates (US$/DM and US$/yen) through the portfolio balance channel, with a 1 billion US$ intervention having an immediate 0.44% impact on the exchange rate with a permanent impact at 0.35%. Dominguez (1999) utilizes an even 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 significant impact on both the US$/DM and US$/yen rates. The results of this study also indicate that the effectiveness of central bank interventions depends on the state of the market at the time the central bank intervention becomes known in the market and the microstructure of the foreign exchange market could play a significant role in determining the effectiveness of the central bank's intervention in this market.

A review of the literature also reveals a serious gap in the research effort on the effectiveness of central bank intervention in the foreign exchange markets. That is, there is a lack of empirical studies on the effectiveness of central bank intervention in

developing countries much less for Caribbean countries. The only empirical studies on this subject for developing countries include studies by Guimaraes and Karacadag (2004) on Mexico and Turkey. Guimaraes and Karacadag (2004) conclude that central bank sales (but not purchases) have a significant but small impact on exchange rate movements and that interventions increase volatility in the short term for Mexico and that interventions (sales and purchases) have no impact on the exchange rate in Turkey.

These results indicate that intervention in developing countries can be effective in terms of keeping the exchange rate in some target band but a the expense of volatility in some cases. The fact that sales and not purchases of foreign exchange had an impact on exchange rate movement reflect the fact that many central banks in developing countries intervene mostly in a defensive posture to protect the exchange rate from short term shocks and that intervention in these circumstances has implications for volatility. We now turn to a review of structural features of the foreign exchange markets and the modus operandi of central bank intervention in Jamaica and Trinidad and Tobago to provide context to our attempt to evaluate the effectiveness of central bank interventions in the foreign exchange market.

Section 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. These include the major players in the market, the mechanisms for trading and the regulatory and management systems in place for the smooth operation of the market. The major players in the foreign exchange market include dealers who facilitate trade and who may double as market makers, central banks which structure the policy regime for the market and the public. The public includes individuals but also corporations and speculators that drive demand and supply in the markets. The mechanisms for trading are critically important to the operation of the market. The trading mechanism could be based on auctions or inter-bank markets, as well as on traditional and non-traditional price discovery mechanisms. Last but by no means least is the regulatory and management systems on which the market is based. These include systems such as internal risk management systems, the exchange rate regime and prudential standards on open positions. The market microstructure elements of the foreign exchange markets in Jamaica and Trinidad and Tobago are outlined below.

Jamaica

Jamaica liberalised its foreign exchange market substantially during the 1990s. In this period, exchange controls were eliminated in 1990, the exchange rate regime changed from a fixed to a floating regime in 1991 and the number of dealers increased in 1994 as cambios and merchant banks were included. The institutional structure of the market in 2001 consisted of 15 authorised dealers and 136 cambios (which include about 88 bureaux de change). The non-financial firms and individuals which underlie the demand and supply conditions in the market is fairly heterogeneous and the supply of foreign

exchange is fairly evenly distributed among sources such as export of goods and services, remittances, direct investment flows, private portfolio flows and official loan inflows. There are some dominant players in the market who can have a significant impact on the market from the supply side. The Jamaican dollar is not a vehicle currency so shortages of foreign currencies cannot be filled by selling Jamaican dollars to foreign banks. If a particular market-making bank is short it must either enter the local market to bid for supplies or it must borrow foreign currency from a foreign correspondent bank.

Cambios are only permitted to buy and sell foreign exchange and there are limits of US$250,000 on cheques and drafts and US$10, 000 on cash transactions. These combios 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 Prosecution any cash transaction greater than or equal to US$8,000. Cambios currently sell 5% of their gross daily purchases of foreign exchange to the BOJ by mutual agreement. The major difference between cambios and authorised dealers is that they are not permitted to grant loans or take deposits. There are currently approximately 88 bureaux de change in operation which exist primarily to facilitate the exchange of currency for hotel guests. These institutions sell 10% of their gross daily purchases to the BOJ.

The authorised dealers in the market consist of all commercial banks, merchant banks and the two largest building societies. These authorised dealers are engaged in all types of foreign exchange transactions, they buy and sell, intermediate and make a market in foreign exchange by posting bid and ask quotes for 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 Director of Public Prosecution any cash transaction at or above US$50,000. The authorised dealers, though not statutory bound, have also agreed to sell 5% 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 commercial banks also make up the inter-bank market on which the system is based and which facilitates price discovery and trading. 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 lists two way bid and ask quotations which are posted on the system so price discovery is much more efficient. Dealers now have better information on prices so trading is done on a more informed basis. The system is based on a system where an inter-bank system makes a market in foreign exchange through indicative bid and ask quotes and where demand and supply and the intervention strategy of the BOJ determines prices. 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 in Jamaica for several years but the volume of transaction and price data is not readily available.

The BOJ undertakes market surveillance, collects and disseminated information on the foreign exchange market and intervenes directly in the market to control volatility. It information dissemination function is an important part of the market microstructure as it helps the price discovery process in the market, especially since private mechanisms for price discovery are not well developed. The BOJ intervenes in the market directly to prevent excessive price (exchange rate) fluctuations by selling (buying) foreign exchange through authorised dealers and cambios since these institution dominate the market and can affect liquidity condition and the rate very quickly. The rate at which the bank intervenes usually mirrors the weighted average buying or selling rates in the market.

Trinidad and Tobago

In April 1993 exchange controls on current and capital transactions were abolished in Trinidad and Tobago. The exchange rate regime was also changed from a fixed to a floating regime. 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 and the interventions of the Central Bank in the spot market drive the performance of the market. The market is also structured around a sharing agreement for foreign exchange where inflows of foreign exchange from the major suppliers is shared among the market making banks based on a formula. Since demand in the market is continuous but supply is discontinuous, the central bank intervenes in the market to ensure the rate is consistent with the policy mix and to smooth out temporary mismatches between demand and supply to ensure that the exchange rate is driven more by stable fundamentals rather than by transitory mismatches.

In the wholesale end of the market which comprises the market making banks, large suppliers of foreign exchange and the central bank, the bid–ask spreads are much more competitive than in the retail end of the market. In this system, commercial banks act as market makers by posting indicative bid and ask quotes for foreign exchange. Spot trades are then executed for particular transactions at prices based on the initial bid/ask quotes. Since the Trinidad and Tobago dollar is not a vehicle currency market making banks that are short must enter the domestic market and bid for supplies or they must borrow foreign currency from foreign banks (they usually have correspondent banks). Since the Central Bank intervenes in the market to keep the exchange rate at a target level, bid and ask prices are likely to exhibit bound or limits at a point where the Central Bank intervenes. The exchange rate is, therefore, generated by the demand and supply for foreign exchange and the intervention activities of the Central Bank, and 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 bank), bureaux de change, the public (which include a few large suppliers of foreign exchange and the Central Bank. The commercial banks are the heart of the systems as they are the market makers in the foreign exchange market. Commercial

banks trade with the public and among themselves to meet the liquidity needs of the market. The interbank system in particular was used to good effect to deal with peaks and valleys in individual banks' liquidity. This is buttressed by the Central Bank's intervention when the swings in liquidity are too large. The characteristics of the banks themselves affect the operation of the market. Some may have large corporate clients whereas some may concentrate on the retail market while some banks have a large branch network and others do not. These features impact on the price discovery process and the exchange rate that is eventually generated by the market. The bureaux de change acts in a supportive role to the dominant commercial banks. The market is comprised of 7 authorized dealers, all commercial banks except one non-bank financial institution whose bureaux de change license was upgraded to authorised dealership status in 1999. The number of bureaux de change remains at 5. These institutions are licensed by the Central Bank and monitored and regulated under the Financial Institution Act of 1993.

The trading mechanism in this market, like the Jamaican market, is based on a quote driven interbank system. The commercial banks acts as market makers by quoting indicative bid/ask prices in the spot market which act as a guide for the prices at which trades are executed. These quotes also are important parts of the price discovery process. The actual systems in place for price discovery in the interbank market are underdeveloped. Most trading is still done over 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 the two-way bid/ask quotes could be posted to facilitate interbank activity.

The Central Bank also collect and disseminates information on the foreign exchange market which helps the process of price discovery in the market. More importantly, the Central Bank intervenes directly in the market to smooth out volatile swings in liquidity to prevent high volatility in the exchange rate. The central bank also provides a venue for commercial banks to meet and share information, which helps to manage the interbank system.

There are many similarities in the form of the foreign exchange markets in these two jurisdictions. They are both organised as inter-bank markets where commercial banks act as market makers rather than auction markets, although Jamaica experimented with an auction market. Both markets are quote driven systems rather than order driven systems. The central banks in both jurisdictions intervene in the market to ensure the 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 much greater than in Trinidad and Tobago, even if one adjusts for the different size of these countries. Dealers in the Jamaican market also by mutual agreement have to sell a small percentage ranging from 5% 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 market rate, this arrangement could be thought of as a tax. The systems in place for the price discovery process in the inter-bank markets 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 information on bid and ask prices in the market which allows facilitate more efficient pricing which should lead to narrower spreads. Trinidad and Tobago's system is still based on telephone contacts but there is discussion ongoing to set up a similar electronic price discover mechanism based on a Bloomberg platform.

Most importantly, however, is the fact that in Trinidad and Tobago the conduit for the major part of the foreign exchange that is supplied to the market by a few companies is the Central Bank, since these flows in large part represent government's petroleum tax revenue. This gives the Central Bank 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 is Trinidad and Tobago is also defined by a supply sharing arrangement where the major suppliers distribute the supplies according to a pre-arranged formula. These features of the market in effect restricts bid and ask prices to a range that is bounded by the central bank interventions, especially on the high side.

There are some important features of the intervention activity of the central banks in both jurisdictions that warrant mention. Firstly, the intervention activity of both central bank was almost universally intervention on the selling side indicating there was excess demand pressures most of the times when the central bank intervened. Both bank also intervened at a rate that signaled where the central bank 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 Bank of Jamaica (BOJ) generally intervened more frequently than the Central bank of Trinidad and Tobago (CBTT) with the BOJ intervening 22.7% of the days in the period covered by the data and the CBTT intervening 6.8% of the time in the period covered by the data. The intervention size was also an area of difference with the BOJ tending to intervene in amounts that were more consistent whereas the CBTT intervention amounts tended to be more variable. This in part reflected the higher frequency of intervention on the part of the BOJ. The Maximum intervention of the CBTT (US$48.3 m) was also higher than the BOJ (US$22.7 m). Another major difference between the two countries was that in Trinidad and Tobago there exists a "sharing arrangement". This arrangement is based on a formula for sharing foreign exchange flows into the market. This formula is used both for flows from the Central Bank and other major suppliers of foreign exchange in the market. Intervention sales are therefore shared up among the market makers along the lines specified by the formula. This was 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. We turn next to an analysis of the stylized facts of foreign exchange intervention and to an empirical evaluation of the effectiveness of intervention in Jamaica and Trinidad and Tobago.

Section 4: Empirical Methodology

Data and Descriptive Statistics

This study covers data on the foreign exchange market and intervention over the period October 2001 to September 2004 for Jamaica and over the period January 2000 to September 2004 for Trinidad and Tobago. The study utilizes daily data on central bank intervention in terms of both buying and selling operations. The data set used also included daily data on the weighted average buying rate, weighted average selling rate, total volume selling and total volume buying. The bid-ask spread computed as the difference between the weighted average selling and the weighted average buying rate.

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

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)

Source: Central Bank of Trinidad and Tobago and authors calculation.
Note: Sample size 1174.

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

Source: Bank of Jamaica and authors calculation.
Note: Sample size 749.

Empirical Model

This study is primarily concerned with the effectiveness of central banks intervention in the foreign exchange market. As discussed in the previous section the main objectives of intervention is 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 manifests itself in the ability to change the exchange rate in the preferred direction without serious costs in terms of exchange rate volatility. The preferred methodology for the empirical model is therefore the GARCH framework which provide a simple and unified framework which can be used to evaluate the impact of intervention on the mean and conditional variance of exchange rate changes (returns) simultaneously. GARCH models also provide relatively good forecasts of realized volatility and have proven useful in modeling the volatility dynamics in exchange rates (Anderson and Bollerslev 1998).

This study 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 empirical model is outlined below:

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

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

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

where ∂s_t is the log first difference of 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. 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 (1) is based on the demand and supply conditions in the market. For example higher sales of US dollars in the market is expected to be associated with a declining rate (appreciation $\alpha_2 < 0$) while higher purchases of US dollars is expected to be associated with 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 (authorized dealers) in the market, 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

[6] See Engle (2004) for an excellent review of the usefulness of various GARCH specifications in different areas of finance.

[7] The ideal situation would of course have been to get 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).

an indicator of the transactional 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 limit speculation that tend to drive the rate up. Higher spreads therefore reflect market power, which is used to keep the selling rate relatively fixed but varying the buying rate to maintain or increase the spread. Higher spreads in these markets are therefore expected to be associated with a declining (appreciating $\alpha_4 < 0$) and/or a relatively stable exchange rate (Seerattan 2004).

Of course the intervention of the central bank via the sale of US dollars is expected to be negatively related to the exchange rate $\alpha_1 < 0$. That is sales of US dollars by the central bank in the market is likely to strengthen the exchange rate. Similarly, purchases of US dollars by the central bank, if used, would be positively related to the exchange rate. Intervention purchases by the central bank in Jamaica and Trinidad and Tobago is, however, extremely rare. In fact, in the period for which data is available for the two countries, the BOJ never intervened via purchases and in the case of Trinidad and Tobago the CBTT only intervened via purchases twice for a grand 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 0 like its short term counterpart. It is also important to note that the impact of intervention on short term volatility may differ from the impact on long term volatility.

Estimation Results

The estimation results generally conformed to our a priori expectations. In keeping with the approach adopted by Guimaraes and Karacadag (2004), one day lagged intervention sales was used instead of contemporaneous intervention in an attempt to redress the simultaneity problem. The model for Jamaica was also estimated assuming that the error term follows a generalized exponential distribution (GED), since the descriptive statistics indicated that there were significant departures from normality in the data. The GED parameter was significant at the 1% level of significance. The results for Jamaica indicate that intervention sales had a significant and a priori expected impact on the

[8] Standard GARCH assumes a constant long-term volatility.

exchange rate. The results indicate that a US$ 1million sale of US dollars by the central bank 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 (See Table 3).

The variance equations also indicated that intervention did not have a statistically significant impact on either short term or long-term volatility. The coefficients on the lagged unexpected shocks and volatility also indicate that 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 statistical significant impact on either short term or long-term volatility (See Table 3).

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 of 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 impact on either short- or long-term volatility. In terms of 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 spread in the mean and volatility equations indicate 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 (See Table 3).

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: 1.*** denotes significance at 1 percent, ** denotes significance at 5 percent and * denotes significance at 10 percent.
2. Models estimated using the assumption that the error term is distributed as GED.
3. The sample sizes were 749 for Jamaica and 1174 for Trinidad and Tobago.

The results support the conclusions that intervention sales is effective in Jamaica in the sense defined, that is, that it pushes the exchange rate in the desired direction (sign and magnitude of coefficient) and it does not seem to have a statistically significant impact on volatility. Intervention sale, however, not the policy tool to use if the objective is only

reducing 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 it is not effective in dampening volatility. In fact it 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 which with the BOJ intervenes and the regularity of the size of intervention also helps agents in the market to generate stable expectations with respect to intervention and regularizes their response to these interventions. The fact that there are better price discovery mechanisms in Jamaica and the fact that the structure of the market is more competitive[9] also helps to enhance the price discovery process, which can ultimately makes intervention more effective.

In the case of Trinidad and Tobago, intervention did not have a significant impact on the level of the exchange rate or on the volatility of the rate. This could be attributed to a number of factors. Firstly, the regularity of intervention both in terms of the frequency and size of the intervention did not lend itself to developing stable expectations in the market and therefore the responses of agent 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 seemingly 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 transaction, which can be reflected in a reduced sensitivity of price (exchange rate) to intervention sales flows from the central bank.

5. Conclusions and Policy Implications

The results of our attempt to measure the effectiveness of central bank intervention in the foreign exchange markets in two Caribbean countries has generated a number of conclusions that potentially have serious implications for intervention policy in the foreign exchange markets. The results indicate that intervention sales were effective in achieving the exchange rate level objectives in Jamaica both in the desired direction and in terms of the magnitude of the impact. The interventions also did not have any adverse impact on short- or long-term volatility, one of the more serious costs associated with intervention. This result also means of course 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, stabilize expectations and harmonize 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 in Trinidad and Tobago including the sharing

[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.

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 amounts.

Policy implications that flow from this include the following. 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, the greater the 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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