The Microstructure of the Jamaican Foreign Exchange Market: Volumes, Volatility and Spreads

Working Paper

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1. Introduction

Standard macroeconomic models have in general, failed to provide good explanations for short run variations in exchange rates. This failure has provided a motivation to examine the microeconomic underpinnings of foreign exchange markets, to deepen our understanding of the market, how it works and ways in which policies can be implemented to enhance their efficiency. This approach to foreign exchange markets looks at variables other than economic fundamentals, because factors such as the way in which foreign exchange markets are organised and the behaviour of traders, all have the ability to impact prices. A microstructure approach to modelling the exchange rates in the foreign exchange market was also attractive because it represented new territory for research at the Central Bank.

The paper focuses on the relationship between volumes, volatility and spreads in the Jamaican foreign exchange market. Using data from 1998 to 2001, we test the applicability of the Mixture of Distributions Hypothesis (MDH) to the local foreign exchange market. Contrary to the MDH, we find a negative relationship between volumes and volatility in the Jamaican foreign exchange market. Inadequate market liquidity is one interpretation of this negative relationship. Further, as predicted by Tauchen and Pitts (1983), price variability declined as the number of participants and volumes in the foreign exchange market increased. A sharp decline in price variability was observed with the inclusion of cambios in the foreign exchange market, providing empirical support for the belief that cambios enhanced market stability. We also find a positive relationship between volatility and spreads, which is consistent with the empirical literature. Finally, we find that Central Bank intervention has helped to reduce volatility in the foreign exchange market.

One of the major shortcomings of the paper was the inability to conduct a market survey. This was necessary, as some of the questions, which were critical in understanding the microstructure of the foreign exchange market, could not be garnered from the data.

The paper is organised as follows. The market microstructure literature and its motivation are examined in section 2. Section 3 looks at some issues specific to the local foreign exchange market. The data and preliminary empirical analysis are presented in section 4 while section 5 presents the methodology and empirical results. This is followed by some concluding observations and recommendations.

1. Literature Review

1.1. *The Shortcomings of Structural Macroeconomic models*

Standard "macro" models of exchange rate determination are built on assumptions that prima facie contradict reality. They make numerous assumptions including the notion that agents are identical , information is perfect and trading is costless and as a result, lack an explanation for the existence of trading in the foreign exchange market. If agents are identical as assumed by these structural models then it begs the question: what motivates them to trade? The high volume of transactions that exists in the foreign exchange market is one of the most important empirical facts about the foreign exchange market. This reinforces the fact that agents do engage in trade of financial assets and that it takes heterogeneity of agents, that is differences in expectations to facilitate trade. These models have also failed to account for the behaviour of excess returns and to explain short run exchange rate movements even ex post (Frankel, Galli and Giovannini, 1996). They have by and large failed to predict future movements in exchange rates suggesting that macroeconomic variables may be limited in their short-run informational content.

One of the stylised facts coming out of the foreign exchange market is that despite the existence of a clear long run relationship between monetary fundamentals and the nominal exchange rate, they do not appear to move closely in the short run. In particular, the work of Meese and Rogoff (1983a, 1983b) overshadowed key empirical findings of much of the early work produced on exchange rate determination in the international finance literature. The main result of their work was that none of the structural exchange

rate models "could reliably out predict the naïve alternative of a random walk at the short and medium horizons, even when aided by actual future values of the regressors".

2.2 The advent of Microeconomic Modelling of Foreign Exchange Markets

The problems encountered in modelling short run variations in the exchange rate using aggregated models thus presents a case for examining the foreign exchange market from a microeconomic perspective. Microeconomic modelling of the foreign exchange market represents a radical move away from the traditional macroeconomic modelling of exchange rate dynamics. Microeconomic modelling looks at the way in which the market is organised, the resulting interaction of participants and the impact that they have on price movements. It focuses on analysing the process and characteristics of trading in an attempt to find an explanation for the short-term variations in the exchange rates and in doing so has also uncovered a number of trading regularities in the data. The literature on the market microstructure of foreign exchange markets has provided a great deal of insight on the behaviour of trade volume, volatility and bid-ask spreads. It also seeks to give insights into some of the "puzzling short run dynamics" observed in the foreign exchange market. It is felt that a 'micro foundation' approach to exchange rates that sought to more accurately capture reality may provide some assistance where macro models have failed.

Instead of focusing on the typical macroeconomic fundamentals such as inflation and interest rates, the microstructure approach considers the effects of market configuration, information asymmetry, heterogeneity of participants and the bounded rationality of exchange rate dynamics (Cheung and Chinn, 1999). This approach has long been applied to other more centralised markets such as the stock market and the futures market, which are subject to substantially more regulation than the foreign exchange market. Factors such as trading volume, heterogeneity of participants, bid-ask spreads and intra-day movements are all factors that affect short-term movements in exchange rates but are all

factors that are ignored in the standard macroeconomic approach. Cheung and Wong (1999) found that at shorter horizons, microstructural issues come into play and only at longer horizons do traders believe that macroeconomic factors become relevant.

Unlike structural models that tend to use medium frequency data (such as monthly or quarterly data), the microstructure approach uses high frequency data, such as intra daily or daily data in the attempt to capture the microeconomic characteristics of the market that can affect exchange rate movements. Thus the microstructural approach seeks to solve this problem by specifying the foreign exchange market in a more realistic fashion. It attempts to identify the economic effects of the way in which the foreign exchange market is organised such that it focuses on how specific trading mechanisms impact the price formation process. Specifying the foreign exchange market in this way makes sense in light of the fact that a significant number of market participants hold foreign exchange as an asset merely for it's financial returns, and not to facilitate international trade. The standard asset market approach also tends to ignore the activities of central banks on the foreign exchange market, which in contrast to the activities of arbitrageurs, speculators and hedgers, can have a decisive effect upon the developments of exchange rates and the efficiency of the market, (Baillie and McMahon, 1989).

Using methodology similar to that of Galati (2000), this paper seeks to examine the relationship between trade volumes, volatility and bid ask spreads using data from the Jamaican foreign exchange market. The empirical and theoretical aspects of this relationship have been widely examined in studies of the microstructure of the foreign exchange market. In terms of a policy perspective the relationship is important because it carries implications for market liquidity and its relationship with risk Galati (2000). The foreign exchange market can only be considered liquid if large transactions can be executed without generating significant impact on the price. In this regard, high trade volume, as measured by the quantity of foreign exchange traded, should be able to exist without significant variability in prices, (that is excessive volatility). The bid ask spread is the standard measure of transaction costs. Volatility is often considered as a measure

of risk. Excessive volatility increases the risk of operating in the foreign exchange market and increases the costs of operating in these markets. If spreads are the cost of transacting in the foreign exchange market then any increase in volatility will be associated with an increase in spreads. Thus trading volumes and bid-ask spreads are frequently used as indirect measures of market liquidity because it is often difficult to measure market liquidity directly.

2.3 Trade Volume

Trade volume in the foreign exchange market is important because it reinforces the existence and importance of heterogeneous expectations. It also carries one of three hypotheses of the implications of trade volume for movements in exchange rate. The first is that the higher the depth or liquidity of the market, the more new information regarding economic fundamentals is processed and the smaller is 'unnecessary volatility' in the exchange rate. Secondly, the foreign exchange market is already perfectly efficient, so that trading volume is irrelevant to price movements and is therefore uninteresting. Finally, there is the hypothesis that much trading is based on 'noise' rather than 'news' and this results in excessive volatility.

Lyons (1996) has also shown that trade quantity (volume) can impact prices. There are in fact two competing theories attempting to explain upswings in trade volume. The first is the event "uncertainty view" which states that high trading volume indicates rapid processing of information. The second theory, Lyons terms the "hot potato view". It states that high trading volume is an indication that little information is being processed. Instead, it is an indication of the presence of participants who are trading to meet their liquidity needs and it is this attempt by traders to off load the currency brought in by liquidity traders that lead to a high trade volume.

2.3.1 Volumes and Volatility

For several reasons, the empirical microstructure literature on the foreign exchange market has long been interested in the relationship between risks and volumes. It

provides insight into the structure of financial markets by relating new information arrival to market prices. The price volume relationship has a direct bearing on the empirical distribution of speculative prices. Although less important to the Jamaican foreign exchange market, it also carries implications for the design of futures contracts. Numerous studies have found a strong, positive contemporaneous correlation between volumes and volatility. A theoretical explanation has been advanced for this positive relationship known as the mixture of distribution hypothesis. First advanced by Clark (1973), the theory posits that volume and volatility are both driven by a common unobservable factor, which is determined by the arrival of new information to the market. The theory predicts positive co movement of volatility and unexpected trading volumes.

Empirical studies of the futures and equities markets that have found trade volume to be significantly positively correlated with price variability includes Clark, 1973 and Epps and Epps, 1976, Frankel and Froot, 1990 and Lamoureux and Lastrappes, 1990. Frankel and Froot, 1980 using data for four currencies found evidence that the contemporaneous correlation between volume and volatility was high.[1] There are several interpretations given to this finding of a positive correlation between volume and volatility. Clark uses a random variable with a mean proportional to the mean number of daily transactions as a measure of the variance of the daily price change. He argues that since trading volume is related positively to the number of within day transactions then trading volume is positively related to the variability of the price change.

Epps and Epps assume a positive price variability volume relationship between the extent to which traders disagree when they revise their reservation prices and the absolute change in the market price. Applying this to the foreign exchange market, implies that the extent to which traders disagree is associated with a larger absolute change in the exchange rate and thus greater variability in the rate. The volatility volume relation

[1] The granger causality test did not show statistically significant causation running directly from volume to volatility. However this is not surprising since any such causality would be purely contemporaneous and granger causality tests cannot detect this type of causality.

arises then because trading volume is positively related to the extent to which traders disagree when they trade.

Like Epps and Epps, Tauchen and Pitts also posit that the correlation between volume and volatility should be positive if trading occurs because of disagreement among traders and negative when volume is determined by the number of traders. That is, volume increases because the number of traders has increased, so that there is an increase in liquidity. Tauchen and Pitts noted that the model of Epps and Epps ignored the growth in size that can occur in new financial markets over time. Trading on a new market is initially very thin. However, if the market is viable then the trading volume increases secularly as more traders become aware of the market's possibilities. Support for this theory is found if the variance is found to depend positively on volume and negatively on a time trend intended to reflect a steady growth in the number of traders.

Tauchen and Pitts (1983) have posited two theoretical explanations for the co-movement of volatility and trade volume. The first is that as the number of traders increases the volatility of the market price declines. The argument here is that as participants increase, transactors are so many that demand shocks experienced by individual traders tend to offset each other leaving the market price largely unaffected. The second explanation he posits would apply to more mature markets. In such a market where the number of traders is likely to be fixed, then an increase in volume is a reflection of greater disagreement among traders and hence will lead to higher volatility. The second link is stronger when new information is arriving in the market at a faster rate. Melvin and Yin (2000) investigated the relationship between the arrival of information, the quoting frequency and the volatility of yen/dollar and dollar/mark exchange rates using intra-day data from Reuters screens. They found a positive relationship between the amount of information arriving at a particular hour of a particular day of the week and exchange rate volatility.

Inventory control and information are the two channels highlighted by the microstructure literature through which trade volume generates price movements. The inventory control

channel postulates that dealers use prices to control movements in their positions. The latter focuses on the presence of traders with private information and in light of this, dealers, because they are rational, will adjust their beliefs and prices in response to changes in order flow. One implication coming from both views is that trades initiated by buyers will drive prices upwards. Lyons (1993) using intra-daily data found strong evidence in favour of both strands of the microstructure theory.

2.3.2 Bid- ask spreads volatility and Volume

The microstructure literature has also found a positive relationship between trading volumes volatility and spreads in foreign exchange market. Microstructure theory suggests that inventory cost is one component of the spreads in financial markets. Models that seek to explain inventory costs establish a link between spreads volatility and trading volumes. The cost of maintaining an open position in any currency is one determinant of inventory costs, which is positively related to price risk. According to this view, exchange rate volatility increases price risk and thereby pushes up spreads. Thus spreads widen when exchange rate volatility increases. Melvin and Bolerslev (1994), Bessembinder (1994) found a positive correlation between spreads and expected volatility measured by GARCH forecasts.

Trading activity, according to the literature is another determinant of inventory costs. Volumes impact spreads differently depending on whether they are expected or unexpected. Unexpected trading volumes should have a positive impact on spreads given that they should reflect the arrival of news to the market. By contrast, expected trading volumes should be negatively correlated with spreads to the extent that they reflect economies of scale associated with higher competition among market makers.

3. The Jamaican Foreign Exchange Market

The present exchange rate regime was born out of the need for a more flexible approach to exchange rate determination and was deemed as necessary in light of the deficiencies and inefficiencies that characterised the previous foreign exchange rate mechanisms. It

was felt that the introduction of a market oriented mechanism for the determination of the exchange rate using the inter-bank system, would allow for more orderly and price responsive movements and 'the reduction in the diversion of foreign exchange outside officially recognised channels'. The current system is one in which the exchange rate is determined through the interaction of authorised dealers and cambios, users and suppliers of foreign exchange. It was seen as having the advantage of allowing the market to clear in a way that was more efficient and transparent. Under this system, the exchange rate offered to buyers is determined independently of any notion of an official rate and is free to vary in accordance with shortfalls and surpluses that result from the interaction of buyers and sellers.

Unlike major international foreign exchange markets, the local market has a distinct trading period, that is, the market opens at about 8:30 am and closes at 5:00 pm. In this regard, it operates more like a stock market, with a distinct open and close period. There is limited, if any, offshore trading of the Jamaican currency, and as such it is more centralised than the market for major international currencies. International foreign exchange markets like that for the euro, yen or US dollar are open twenty-four hours per day because of the existence of electronic trading and the fact that these currencies are actively traded across time zones and continents. The local foreign exchange market is a fairly organised market where the majority of trades are conducted in the interbank market, where traders are able to directly observe trade volume, which is given in the summary of the foreign exchange market at the end of every business day.

Central Bank Intervention

In moving the Jamaican foreign exchange market from its nascent stage to a well-developed and efficient one, a transitional role has been carved out for the BOJ. In Jamaica, the BOJ has played an active role in fostering the development of the institutional characteristics of the market, both directly and indirectly. This role has largely been undertaken based on the premise that an appropriate structure is needed for the efficient functioning of markets.

Market supporting arrangements include the intervention of the BOJ, through the sale and purchase of foreign exchange, with the intention of tempering excessive exchange rate volatility over short intervals. Disorderly exchange rate movement has been the rationale used for justifying foreign exchange rate intervention (Schwartz, 2000). The Jamaican Central Bank intervention activity is no different from that undertaken by many central banks in now developed countries, after the move to floating exchange rate regimes. Perhaps what is different, is that while market intervention in some of these countries was intended to maintain the value of their currency relative to a foreign currency within a stated band, it is not a policy of the BOJ to target a specific value of the exchange rate. This is evidenced by the depreciation that has occurred in the Jamaican dollar against all the major currencies since market liberalisation in the early 1990s. Instead Central Bank intervention in the local foreign exchange market is intended to impact market liquidity and allow for orderly adjustment to a new equilibrium.

The Central Bank's intervention in the foreign exchange market has been necessary against a background of bunching in the supply flows to the local foreign exchange market. With the majority of the nations foreign currency inflows coming from export earnings, in particular tourism, buoyancy in inflows is seasonal and sometimes does not coincide with periods of increased demand. It is often during these peak demand periods that the Central Bank intervenes to augment market liquidity. Local foreign exchange market activity is concentrated in US dollars because the majority of the country's international transactions are conducted in this currency, and as such intervention is normally conducted in this currency.

Intervention in the foreign exchange market is also done within the context of its mandate to maintain stable prices in the Jamaican economy. Jamaica is a small open economy that is highly import dependent, as domestic production relies heavily on imported foreign inputs. To the extent that exchange movements are quickly passed on to the consumer, sharp movements in the exchange rate can have a significant impact on the Central

Bank's ability to achieve its targeted level of inflation. Thus, the need to temper inflationary impulses has been one of the major arguments advanced for foreign exchange market intervention. In fact, Robinson (2000) found that exchange rate stabilisation was the most effective means of short-term stabilisation of inflation. He found that variations in the exchange rate accounts for 29.0 per cent of the variation in inflation over a six-month horizon and over 31.0 per cent for up to two years.

The BOJs' foreign exchange market activities have often been in the form of sales of US dollars to the market. In terms of the regularity of occurrence, purchases outside of the normal surrender requirements, are less frequent, and sometimes occur after periods of market instability associated with speculative activity, in which dealers normally build up long positions in the foreign currency. In 2001, purchases of foreign exchange occurred after the BOJ intervened in the market with sales of the foreign currency and after some policy change had been made to achieve market stability. Such policy actions include the interest rate increases on the Bank's reverse repurchase instruments. Dealers then sold accumulated foreign exchange to the Central Bank at the higher weighted average rate to obtain Jamaica dollar liquidity. Adams and Henderson (1983), used the term "passive intervention", to describe purchases of foreign currency with customers who would otherwise have dealt with market agents. However, these purchases are seldom reported as intervention, despite the fact that had these purchases not been made, the funds would have had to be sold on the domestic market. Such actions, while not done with the specific objective of impacting the exchange rate, in fact do so, at least in the short run.

The advent of E-gate

The implementation of the Electronic Gateway for Auctions Trade and Foreign Exchange Management (E-gate) is another example of the efforts of the Central Bank to aid in the development of the local foreign exchange market. The introduction of E-gate was aimed at deepening and enhancing efficiency on the Jamaican foreign exchange market by improving the underlying information structure. Theories of market efficiency highlight the importance of information flow to price determination in financial market. E-gate

seeks to improve the flow of information to the market by providing an electronic interface between the Bank of Jamaica and authorized dealers and cambios. The system was aimed at facilitating the reporting of information in real time. It allows traders to track trends in the spot market throughout the day, allowing for more informed decisions on the part of traders, thereby enhancing the efficiency of the spot market. The introduction of E-gate also allowed foreign exchange market transactions conducted through cambios to be used in the calculation of the daily, weighted average exchange rate.

Inter-dealer Market

In international markets, the bulk of foreign exchange trading is conducted through the interbank system. The rest is done through brokers or more recently electronic brokering on systems such as Reuters 2000-2, Electronic Brokering Service (EBS) and Minex (Japan). Brokers bring buyers and sellers together for a commission. Approximately 40.0 per cent of total volumes traded on international markets is mediated by brokers. One institutional feature of international foreign exchange market that has been made apparent through empirical work is that on average 80.0 per cent of trading volume is between dealers. In the Jamaican foreign exchange market the local inter-dealer market accounts for approximately 60.0 per cent of foreign exchange market transactions. Though the Jamaican foreign exchange market is somewhat similar to international markets with regard to the volume of inter-dealer trade, the thinness[2] of the market allows for the possibility of collusion among dealers. Additionally, the market is dominated by a few large players who have the ability to affect volumes and generate excessive volatility in the exchange rate. There is also an absence of any brokering in the Jamaican FX market, and most dealers and cambios trade on their own account. The remaining proportion of trading volume is over the counter, where end users directly approach dealers and cambios to conduct their foreign exchange transactions.

[2] A thin market is one with few bid and ask offers. Characterized by low liquidity, high spreads, and high volatility. Small changes in supply and/or demand can have a dramatic impact on market price.

Spreads

The spreads between buying and selling rates represent the only avenue through which dealers are able to recover their costs of transacting in the foreign exchange market as the guidelines stipulated for the inter-bank foreign exchange market prohibits authorised dealers from charging commissions on spot market transactions. In 1995, under the guidelines for the interbank foreign exchange market, spreads were limited to a maximum two per cent for cambios and one and a half per cent for authorised dealers. In keeping with the objective of the BOJ to facilitate development of the market by improving market efficiency, these restrictions were removed on January 2, 2001. Since then, spreads have generally trended downwards.

According to the microstructure literature, inventory costs represent one of the main components of the spread on transactions in the foreign exchange market. Higher volatility means, all other things constant, that dealers face the risk that the exchange rate will move unfavourably while that position is being held. While this risk should be diversifiable because dealers in Jamaica do hold other currencies, the fact that the market is largely dominated by US Dollars, may limit the extent to which dealers can and will actually diversify this currency risk. If this is true, when volatility increases, so should the spread, reflecting compensation that the dealer expects for taking on idiosyncratic currency risk, Jorion (1995). When market volatility increases, risk averse dealers will increase the spread to offset the increased risk of losses.

It has been observed that very large increases in the spread usually precede periods of market instability. Further, spreads decline when the market stabilises. The majority of authorised dealers hold long positions in the market and so when spreads fall this forces them to increase volumes in an effort to meet profit targets. Few of the larger cambios hold positions but for the most part cambios facilitate trade in the market and tend not to hold long positions in the market.

Surrender Requirements

Through an agreement, authorised dealers and cambios sell a percentage of their daily gross purchases of foreign exchange to the Central bank. The specific aim of this arrangement was to provide a continuous supply of funds for the Net International Reserves as well as to meet Government debt obligations. Surrender requirements peaked at 50.0 per cent of total purchases in 1999, but have since been reduced to the current level of 5.0 per cent. The average surrender to the Bank is in the range of US$1.5 to US$2.0 million per day.

Questions have arisen as to the impact of the surrender requirement arrangement on the efficient operation of the market as this provides a ready market for cambios to sell foreign exchange.. The main argument in favour of the continued existence of the system is the need to have a continuous supply of funds, especially in the context of Central Bank intervention. However, improvement in the NIR position of the Central Bank since the 1990's has prompted the Bank to relook the need for the continued existence of the arrangement.

Market Characteristics

The foreign exchange market is comprised of authorized dealers, cambios, end users and to some extent the Central Bank. Authorised dealers include several of the larger financial institutions viz commercial banks, merchant banks & trust companies as well as building societies. Currently there are one hundred and thirty eight cambios and 14 authorised dealers. However, five or six dealers often account for the majority of traded volumes and in this regard they tend to dominate the market.

Institution-client relationships prevent large end users from shopping around for the lowest ask price. In such instances, an end user employing the services of a financial institution is likely to accept rates offered by that institution because they have established a relationship. However, there have been instances when end users place upper limits on the contract rates that they will accept from the dealers in the market.

The local foreign exchange market remains thin despite the fact that volumes have been increasing over time; large transactions can significantly impact the day's closing spot market rate. Large institutions also purchase from cambios at lower rates and resell to clients at higher contract rates. This occurs in part because of strong institutional-client relationships. Institutions that engage in remittance services tend to have the lowest counter rates perhaps because they have the advantage of a secure source of funds from these remittances.

One feature of the market is the large differentials that sometimes exist between international cross rates for the US dollar, the Canadian dollar and the Pound sterling and the local J$/US$ rate. This characteristic results from the fact that the local market is largely a US dollar market since the United States is Jamaica's major trading partner. The demand for these currencies is low relative to the US dollar since fewer people want to hold pound sterling or Canadian dollar. It may also be the case that high transaction costs prevent arbitrageurs from acting and therefore allow for the prolonged existence of these differentials. Recent developments have however highlighted that whenever opportunities arise for market participants to take advantage of these opportunities for arbitrage, they will in fact do so.

4. The Data

The paper uses data on daily spot market rates, trading volume, volatility and bid-ask spreads for the January 1998 to September 2001 period. Since there is no offshore trading in the Jamaican dollar, the transaction volumes data used in this paper are a very good reflection of local trading. This particular characteristic of the data set makes the paper unlike those done using major international currencies, where volume in the futures market have been used as a proxy for spot market volume. The nature of trade in these currencies means that it is impossible to have good data on transactions volumes at very high frequencies.

Summary statistics for the series used in this paper are depicted in figure 1 below.

Summary Statistics of Variables

Figure 1

Variable	Mean	Std Dev	Skewness	Kurtosis	Min	Max
Exchange Rate Levels	40.86	3.52	0.15	-1.47	45.94	36.25
Percentage Change in Rate	0.02	0.19	0.43	4.13	-0.85	1
One-month Volatilities	3.21	1.91	0.69	-0.12	9.21	0.35
Forex Trading Volume	12.5	7.81	1.66	2.48	2.82	49.46
Bid-Ask Spread (% of rate)	0.54	0.24	0.96	1.23	1.52	0.12

Exchange Rate

Figure 1 provides information on the behaviour of the spot market rate. The exchange rate averaged $40.86 Jamaican to one United States dollar, and reached a high of $45.94 Jamaican to one US$ at the end of the sample period, depreciating against the United States dollar by 24.43 per cent. Exchange rate movements are generally characterized by short periods of relative stability followed by longer periods of depreciation in the exchange rate. Twice during the sample period, in December 1999 and November 2000, there were pronounced periods of market instability that led to significant depreciation in the Jamaican dollar. While there have been periods characterized by small appreciation, the general trend has been a depreciation. The depreciation has been particularly sharp during noted peak demand periods, that is the August to September period and the October to December period. The only noteworthy appreciation took place between the 5-18 of October 2000. This appreciation was associated with the hike in BOJ reverse repurchase rate that was aimed at stabilizing the foreign exchange market, after a period of sharp depreciation in the exchange rate.

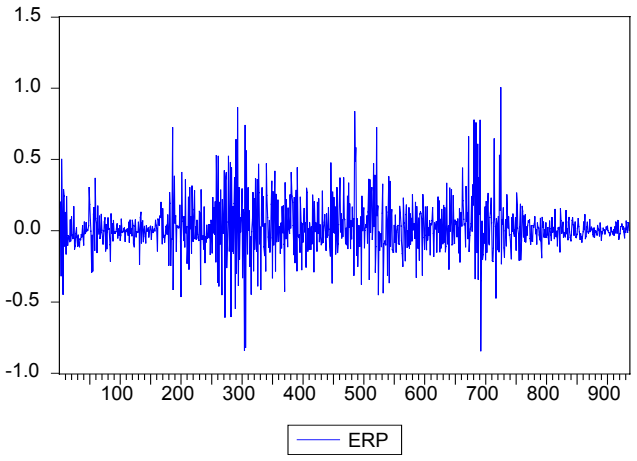
The rate exhibits no mean reversion, that is, there is no long run mean to which the series returns. The sample correlogram dies out slowly. In general the exchange rate appears to be a random walk. The effects of shocks also have a permanent effect on the rate as the

rate responds to a shock by depreciating to a permanently higher level. Using the Augmented Dickey Fuller Test, the null hypothesis that the exchange rate has a unit root could not be rejected.

For the purpose of our GARCH models, daily percentage change in the exchange rate was used as the measure of the exchange rate returns. Augmented Dickey Fuller tests revealed that the daily returns series is stationary. The series exhibits periods of unusual volatility followed by periods of relative tranquility. (See figure 2) The conditional variance of the series appears to be time dependent, that is, conditionally heteroskedastic (see figure 3). The series also exhibits volatility clustering, where large changes in the exchange rate tend to be followed by other large changes.

Figure 2

Graph of Daily Percentage Change in the Exchange Rate



The variance also appears to be time dependent (see Figure 2). Engle (1982) shows that it is possible to simultaneously model the mean and variance of a series and thus to generate forecasts of the variance in an effort to predict volatility. When the conditional variance of a series is not constant, the variance can be modeled to evolve as an autoregressive process, that is an Auto-Regressive Conditional Heteroskedastic (ARCH)

model. To test for the presence of Arch errors in the exchange rate return series, the more formal Lagrange Multiplier (LM) test for Arch disturbances was used. First the best fitting ARMA (*p, q*) model for the return series was estimated. Both the Akaike Information Criterion (AIC) and the Schwartz Bayesian Criterion (SBC) selected an ARMA (1, 1) model. An LM test on the residuals from this models using 60 lags yielded an LM test statistic of 172.18 which is distributed Chi-squared (60). The null hypothesis of no ARCH errors had to be rejected at the 1.0 per cent level of significance.

Trading Volume

An increase in market size can affect the behaviour of prices in financial markets. Some empirical studies of speculative markets suggest that price variability should increase with growth in trading volume. Yet others such as Tauchen and Pitts (1983) posit that, as markets become more developed and as trading volume and market participants increase, traders would tend to have a stabilising impact on prices. Fig 3 shows average daily volume in million of US dollars and the variance of the changes in price for the sample period. It shows that between 1998 and 1999 volumes declined marginally with a sharp rise in price variability. For the remainder of the sample period, there was an increase in average volume and a decline in price variability. Notably for the period January to September 2001, there was a sharp decline in price variability, with a sharp rise in volumes. This provides preliminary evidence of the existence of a negative relationship between volumes and volatility.

On November 27, 2000 market transactions done through cambios were for the first time used in the calculation of the official exchange rate, technically, this meant that there was a significant increase in the number of market participants. This gives us the opportunity to test directly whether the arguments of Tauchen and Pitts (1983) applies to the Jamaican foreign exchange market. If this argument is valid, then there should be a noticeable decline in the variance of the price change since November 27, 2000. The variances of the price changes were calculated for the period before and after the inclusion of Cambio transactions and were found to be 0.009787 and 0.001061,

respectively. This implies a dramatic reduction in the variance of the price change with the increase in market participants and provides support for the arguments of Tauchen and Pitts (1983). This suggests that one way to stabilise prices is to implement policies to facilitate an increase in the depth of the market[3] since in a deep market transactors are so many that the uncorrelated demand shocks experienced by individual traders tend to offset each other and leave market prices largely unaffected, (Pagano, 1986).[4]

Figure 3

Days	Avg daily volume	Variance of change in Price
1998	8.248	0.002616367
1999	7.989	0.009694321
2000	10.046	0.009147721
2001*	23.115	0.000898521

** Average daily volumes and variance of the price change were calculated using data from January to end September 2001.*

As noted earlier, the absence of offshore trading in the Jamaican currency makes local transaction volumes fairly representative of total spot market volumes. Figure 1 shows that traded volumes averaged US$12.5 million dollars over the entire sample period and reached a high of US$49.46 million in June 2001. These volumes are however small relative to trading in other emerging market economies.[5] Figure 5 depicts a graph of market volumes and the calculated historical volatilities over the entire sample period. It is difficult to discern any clear relationship between volumes and volatility from the graph. However, after November 27, 2000, the average level of volumes traded increased significantly. This coincides with the inclusion of cambio transactions in the calculation of the official weighted average exchange rate. It can also be noted that the volatility of the exchange rate declined sharply, shortly after the inclusion of cambio transactions, and

[3] A part of the decline in average price variability in 2001 relative to other years, may be associated with the fact that data for 2000 excluded the final quarter of the year when the exchange rate normally depreciate significantly.

[4] A market that is deep can accommodate temporary increases in purchases or sales without large price movements.

[5] See Galati (2000).

has been falling since then. This provides some support for the belief that the activities of cambios exert a stabilising impact on the exchange rate.

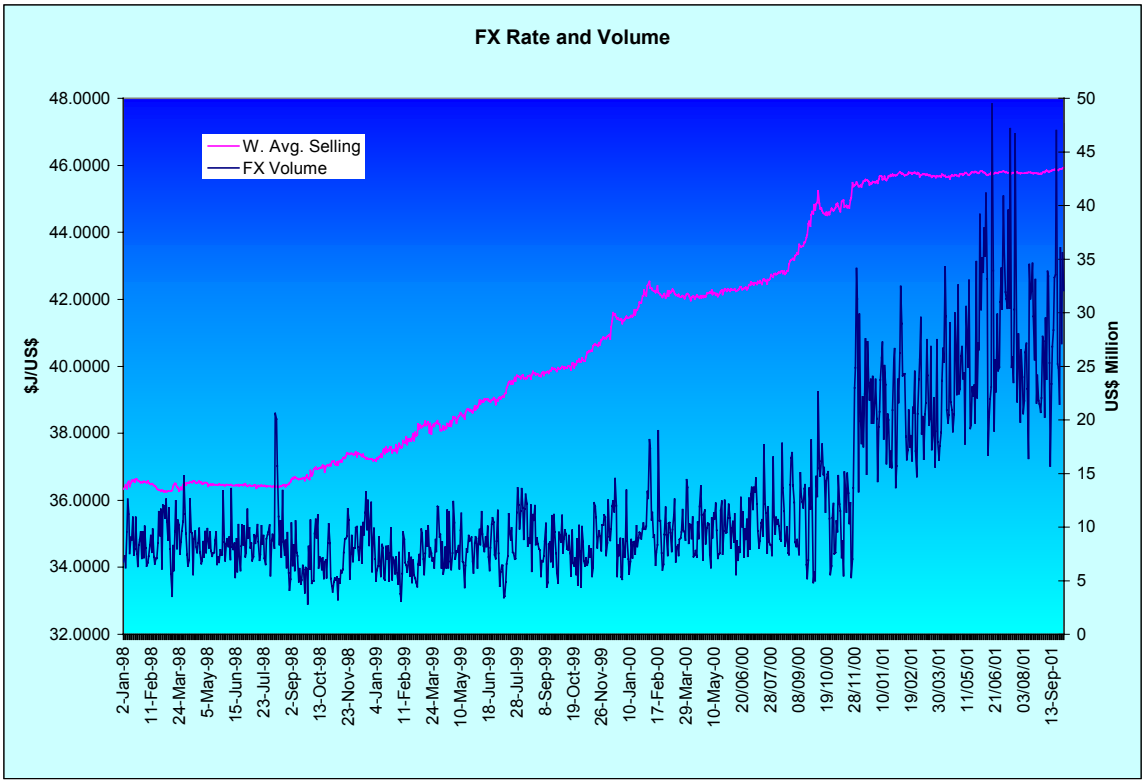
Regressing volume on a constant and a time trend yielded the following results (t-statistic are in parentheses):

$$R\text{-bar squared} = 0.49$$

$$\underset{}{\text{Log volume}} = \underset{(8.13)}{2.94} + \underset{(30.54)}{0.02}\ \text{Trend}$$

The coefficient on the trend term was both positive and statistically significant at the one per cent level. This indicates the presence of a strong positive linear time trend in trading volumes.

Figure 4



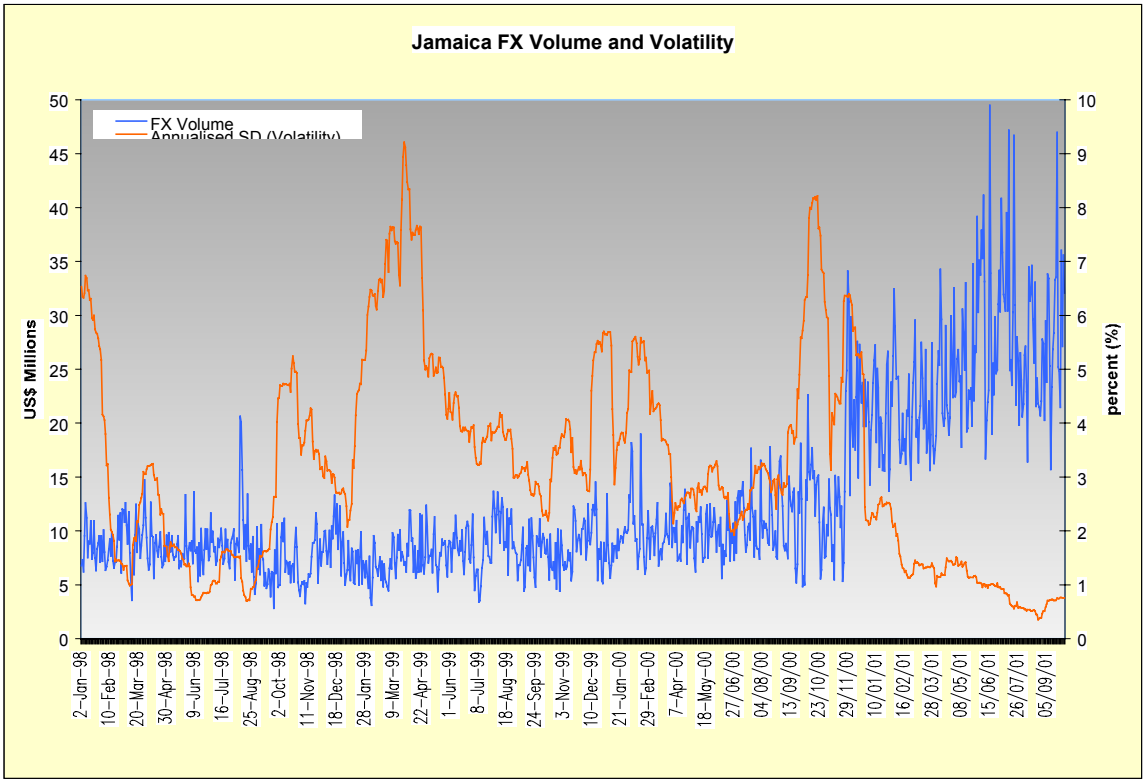
Volatility

In foreign exchange markets, currency volatility is often a topical issue because it introduces uncertainty in the management of currency risk. Currency risk is often obtained from one of three sources, historical volatilities, implied volatility or forecast volatility. Jorion (1996) uses implied volatilities generated from options prices, however in the absence of an options market in Jamaica, it is the historical volatilities that will be examined here. Later a GARCH (1,1) model will be used to generate forecasts of future exchange rate volatility. The assumption here is that past volatility is an indicator of future volatility. Historical volatilities were calculated using the one-month annualized standard deviation of the exchange rate calculated over rolling windows of twenty trading days. The calculation of historical volatility is purely a statistical analysis of the exchange rate fluctuation over a sufficiently long period.[6] Annualizing the series allows you to calculate an interval within which the exchange rate will trade during the year.

[6] See "A Handbook of Financial Mathematics" Peter Cartledge (1992) for further discussion.

Calculating the standard deviation over rolling windows of twenty days is done to obtain a continuous volatility series. The historical volatilities are depicted in figure 5.

Figure s



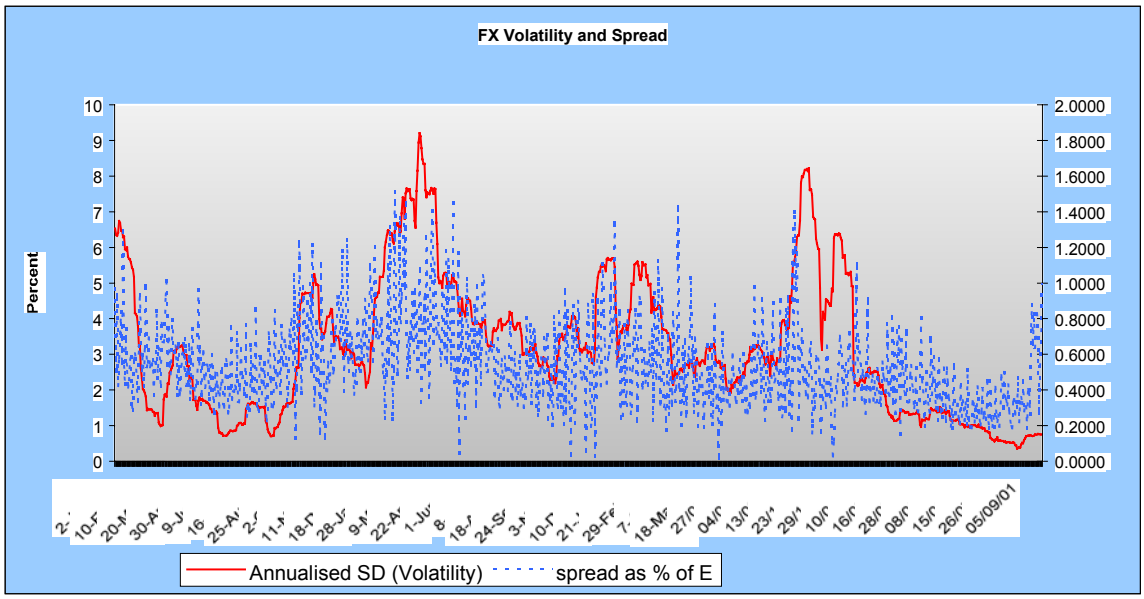
Volatility averaged 3.21 per cent over the review period. Exchange rate volatility ranged from a low of 0.35 per cent to a high of 9.21 per cent (See figure 1). Generally, there are prolonged periods of relatively high exchange rate volatility, followed by fairly short periods of low volatility. During 2000, the hike in the longer tenors of the BOJ reverse repurchase rate in October had the effect of sharply reducing exchange rate volatility, but this was ephemeral as exchange rate volatility increased sharply in mid November of 2000. Exchange rate volatility remained relatively low during the period January to September 2001, since declining significantly in December 2000. The 2001 period has seen the lowest levels of exchange rate volatility for the review period. In terms of other emerging market economies Jamaica's exchange rate volatility is similar to that of the Indian Rupiah. Periods of high exchange rate volatility coincide with periods of foreign

exchange market instability and this occurs when there is high seasonal demand or high excess demand for the US dollar.

Spreads

Figure 6 depicts the daily average bid-ask spread on spot market transactions as a percentage of the exchange rate. For the period, average spreads on foreign exchange transactions ranged from a high of 1.52 per cent of the exchange rate to a minimum of 0 .12 percent of the exchange rate, this translated into an average spread of 0.52 per cent over the sample period. Using the emerging market economies in Galati (2000) as a benchmark, only the Indian Rupiah (2.11 per cent) had an average spread higher than that of Jamaica.

Figure 6.



5. Empirical Results: Volumes, Volatility and Spreads

Trading Volume and Volatility

Figure 7 shows the contemporaneous correlations of volatility and volume. Four measures of exchange rate volatility are used, these are the historical volatilities, squared

returns, the percentage change in the exchange rate and the absolute value of the percentage change in the exchange rate. It shows a negative correlation between volumes and exchange rate volatility regardless of the measure of the exchange rate volatility used.

Figure 7

Contemporaneous Correlations Volume and Volatility

$\Delta^{+} xr$, *volume*	*Hist. volatility,volume*	squared returns, volume	$\Delta\ xr$, *volume*
-0.25	-0.41	-0.13	-0.05

Further, regression of historical volatility on a constant time trend and trading volumes gives the following results:

$$R^2 = 0.16$$

$$volatiltity = 7.02 + 0.001trend - 1.81volume$$

(3.46) *(-11.71)*

T statistics are in parentheses and are based on standard errors that are White's heteroskedasticity consistent. All the coefficients were statistically significant at the one per cent level. These results are consistent with the observed negative correlation of volume and volatility. They are however, inconsistent with the Mixture of Distributions hypothesis, which predicts a positive correlation between volume and volatility because both variables are driven by the arrival of information to the market.

Measuring Expectations

To further test this hypothesis volume is split into expected and unexpected components. The methodology used here is similar to that of Galati (2000) and Jorion (1996). To model expected volume, one must first assess whether the volume series is stationary. Using the Augmented Dickey Fuller test with a constant and a time trend, the log volume series was found to be stationary at the one percent level. To measure the expected

volume, Box-Jenkins analysis was used to find the best fitting ARMA model for the detrended volume series. An AR (2) model was selected to provide a parsimonious fit by the Schwartz Bayesian Criterion and the Akaike Information Criterion. Unexpected volume was thus the residuals from this fitted AR(2) model.

The estimated regression takes the form:

$$R^2_{t+1} = \alpha + \beta E_t(v) + \beta[v_{t+1} - E(v)] + e_t \qquad \textbf{(1)}$$

where R^2_{t+1} is defined as squared returns and is our chosen measure of volatility, and log volumes are decomposed into an expected component $E_t(v)$ and the unexpected component $[v_{t+1} - E_t(v)]$ by using a fitted AR model and its residuals. In equation (1), we expect the coefficient on unexpected volume to be positive. The results of equation (1) below reinforce the negative relationship between unexpected volumes and volatility, so that the MDH does not appear to hold in the Jamaican foreign exchange market.

$$R^2_{t+1} = \underset{(4.252)}{0.0260} + \underset{(0.8140)}{0.0267} E_t(v) - \underset{(-5.1497)}{0.1389}[v_{t+1} - E_t(v)]$$

Lamourex and Lastrappes (1990) apply a GARCH model to a sample of twenty stocks and find that GARCH effects disappear once they include volume as an exogenous variable in the conditional variance equation. They interpreted this result as support for the hypothesis that GARCH effects are manifestation of the time dependence in the rate at which information flows to the market. To test the information content of GARCH forecasts and see whether the relationship between unexpected volumes and volatility will remain if equation (1) is augmented with the GARCH forecasts of expected volatility, expected volatility was modeled using a GARCH (1,1) model developed by Engel and extended by Bolerslev (1986). In this model the return variable is modelled as an autoregressive process and the variance of returns follows a deterministic process, driven by the latest squared innovation and the previous conditional variance:

$$R_t = aR_{t-1} + r_t, \quad \textbf{(2)}$$

$$r_t \sim N(0, h_t) \quad \textbf{(2')}$$

$$h_t = \alpha_t + \alpha_1 r_{t-1}^2 + \alpha_2 h_{t-1} \quad \textbf{(2'')}$$

Bolerslev (1986), and Baille and Bolerslev (1989) find evidence that the GARCH (1,1) model is the most appropriate model for daily exchange rate data. The GARCH (1,1) model was used to generate forecasts of volatility (see Jorion, 1996). The GARCH model was fitted to the entire time series to generate insample forecasts. Ideally volatility implied from option prices should be used as there is evidence that it out performs the GARCH models in providing forecasts of future volatility. However, in the absence of a market for options contracts in the Jamaican foreign exchange and financial markets, insample forecasts from the GARCH (1,1) model were used.

Figure 8

Modeling volatility

Table1 $R_t = aR_{t-1} + r_t, r_t \sim N(0, h_t), h_t = \alpha_0 + \alpha_1 r_t^2 + \beta h_{t-1}$

Model	a	α_0	α_1	β	Log-Lik.
GARCH	0.0003	0.000	0.15	0.60	4691.71
	(3.42)	(1.65)	(3.33)	(31.59)	

The results from the GARCH (1,1) model reinforce the fact that the variance changes over time. The fact that $\alpha_1+\beta = 0.75$ also implies that exogenous shocks tend to be persistent. The system is also stable because $\alpha+\beta < 1$. The conditional variance generated by this model can be taken as the time series forecast of risk.

Equation (2) is then augmented with the expected volatility term h_{t+1}, which represents the one step ahead conditional return variance from a GARCH (1,1) specification:

$$R^2_{t+1} = \alpha + \beta_1 h_{t+1} + \beta_2 E_t(v) + \beta_3[v_{t+1} - E(v)] + e_{t+1} \quad \textbf{(3)}$$

To ensure invertibility, the sum of the parameters *(α+β)* must be less than unity. Estimates of the GARCH (1,1) model are presented below.

$$R^2 = 0.14$$

$$R^2_{t+1} = 0.0257 + 1.044\, h_{t+1} + 0.0956E(v) - 0.1106v - E(V)$$

(4.4) (6.58) (2.91) (-4.23)

T statistics are based on White's Asymptotically consistent standard errors and are in parentheses. The expected volume term is significant at the 5 percent level all other coefficients are significant at the one percent level. Although the coefficient on the expected volatility term (measured by the GARCH forecasts) is positive, the results generally do not support the MDH given the negative and significant coefficient on unexpected volume. The GARCH forecasts of expected volatility was also statistically significant at the one- percent level and positive. This suggests expected volatility can account for some of the variation in the information flow variable.

The negative correlation between volume and volatility found in the Jamaican foreign exchange market is contrary to the Mixture of Distributions Hypothesis (MDH) which postulates a positive correlation between volume and exchange rate volatility. This positive correlation is a direct result of the fact that public information flow drives volatility and volumes, so that when there is a faster rate of information flow to the market both trading volumes and volatility will increase. The negative relationship between unexpected volumes and volatility found for the Jamaican foreign exchange market is similar to that found for the Mexican peso and the Brazilian real, currencies that underwent periods of turbulence and distress. One interpretation of this result is that

when volatility increases or reaches very high levels, this may induce traders to withdraw from the market because it is known that once the exchange rate begins to depreciate then further depreciations can be expected. Thus, traders have an incentive to reduce volumes either in anticipation of higher levels of the exchange rate when market stability returns or in anticipation of the entry of the Central Bank in the market. According to Galati (2000), this negative correlation can be interpreted as a symptom of inadequate market liquidity. Pagano (1989) also argues that high volatility in speculative markets can feed back on its size because high liquidation risk can induce potential entrants to keep out of the market and thus result in lower volumes.

Tauchen and Pitts (1983) also posited that the relationship between volumes and volatility could be negative. They suggested that this negative relationship could occur in markets that are less mature and that a significant increase in the number of traders in the market could affect the relationship between volatility and market volume. One explanation for the difference between the Jamaican experience and the MDH could be due to the fact that the MDH assumes a fixed number of traders. In the Jamaican foreign exchange market, the number of market participants[7] increased during the review period. Another interpretation of the negative correlation between volumes and volatility is that it may be that movements in market volume drive exchange rate volatility. In a thin market such as the Jamaican foreign exchange market, any change in sales volumes, and in particular inadequate sales volume relative to demand can generate significant exchange rate volatility.

Effectiveness of Central Intervention

Following the methodology of Dominguez (1993), the GARCH (1,1) specification was also used to test the effectiveness of the BOJ's intervention operations on exchange rate volatility. To do this, the BOJ intervention variable was included in the conditional variance equation and the GARCH (1,1) model was reestimated. The BOJ intervention is

[7] That is, the number of participants included in the calculation of the weighted average exchange rate.

estimated in millions of dollars and zeros are inserted for days when there is no intervention. The resulting conditional variance equation was derived:

$$h_t = 0.2574 + .30920\, r_{t-1}^2 + 0.4454\, h_{t-1} - 0.0026 Intervention$$
$$(5.071) \quad (3.776) \quad (4.115) \quad (-5.849)$$

The intervention variable was significant at the one per cent level and had a negative coefficient. The results confirm that Central Bank intervention over the review period reduced exchange rate volatility. However, the coefficient on the intervention variable was small, so that while intervention policy reduced exchange rate volatility, the impact was small.

The limited impact of BOJ intervention on the variability in the exchange rate may be associated with the timing and the rate at which foreign exchange is sold to the market. The decision by the Central Bank to intervene is often made after there has been some instability in the market. Intervention rates closely mimic changes in the weighted average exchange rate. The need to prevent dealers from using intervention funds to make large profits is often sighted as the rationale for moving the intervention rate in line with the weighted average rate. Following the intervention, the Central Bank purchases foreign exchange at the new higher rate. By doing this, the Central Bank may be reinforcing any depreciation in the exchange rate and hence any shocks to the exchange rate usually result in persistently higher levels. ,

The literature points to two channels through which intervention affects the behaviour of exchange rates, the portfolio balance channel and the signaling channel. Intervention can affect exchanges through the signaling channel by conveying to the market, inside information – information known to the Central Bank but not to the market –about future fundamentals, (Dominguez, 1993). The argument is that if the market believes the Central Bank's intervention signals, then even if today's fundamentals have not changed when intervention occurs, expectations of future fundamental will change. When the

market revises it's expectation of future fundamentals, it also revises it's expectations of the future spot rate. Given that all readily available information is incorporated into current prices, then the current exchange rate will also change.[8] This implies that by moving the intervention rate in line with the weighted average rate, the BOJ may be unintentionally signaling to the market that it believes that there have been changes in the economic fundamentals.

The need to prevent dealers from using the BOJ intervention for personal gains is important to the effectiveness of the intervention policy. However, by making the intervention operations public information, this may prevent the need to move the intervention rate in line with the exchange rate. Although the market is normally informed of BOJ intervention at the end of the day, by announcing the decision to intervene to all market players at the start of the business day, this may give the Central Bank greater room to set its intervention rate. The assumption here is that if agents are aware of the presence of the Central Bank and the rate at which the Bank intervenes , this could make agents more resistant to upward shifts in the spot rate. During intervention s the BOJ deals directly with the foreign exchange desks of dealers, usually the larger players. A particular dealer is only aware of the intervention operations if the BOJ has made the decision to allocate funds to that institution.[9] This approach to intervention is sometimes used by the major central banks, such as the Federal Reserve and the Bundesbank and has the effect of introducing information asymmetry in the market. Dominguez (1993) found that "secret" operation of the Federal Reserve and Bundesbank consistently increased exchange rate volatility for both currencies. On the contrary, publicly known Federal Reserve intervention had the effect of reducing daily volatility.

Volatility and Spread

[8] The signaling channel works even when intervention operations are sterilized and the magnitude of the effect caused by sterilized intervention may be greater than if the intervention were nonsterilized.
[9] Some traders have developed relationships with the Central Banks that allow them to contact the Bank to enquire as to whether the Central Bank is intervening.

The contemporaneous correlations show a positive relationship between volatility and the spread, although several measures of volatility were used (see figure 8). This is consistent with expectations, since when volatility increases, so too should the spread, which reflects the compensation that dealers expect for taking on currency risk (Jorion, 1996).

Recall that the literature identifies inventory-carrying costs as one of the major components of the spread. Higher volatility implies that, ceteris paribus, there is an increased risk that the exchange rate will move unfavourably while a position is being held. The concentration of the local foreign exchange market in the US currency means that the idiosyncratic risk associated with this currency is not easily diversifiable in practice. Thus, when there is an increase in price volatility, then risk averse traders will also increase the spread to offset the risk of losses. This positive correlation is consistent with the inventory costs models, which suggest that when volatility increases, the spread will increase.

Figure 9

Contemporaneous Correlations Volatility and Spread

Δ^{+} *xr* , *volume*	*Hist. volatility,volume*	Δ *xr* , *volume*
0.22	0.37	0.01

Conclusions

The paper sought to examine the empirical relationship between volume, volatility, and spreads in the local foreign exchange market. We observed a significant decline in exchange rate volatility since the inclusion of cambios in the computation of the exchange rate. This provides empirical support for the belief that cambios have helped to stabilize the market. Further, it implies that deepening of the market had the effect of creating a more resilient market capable of better withstanding shocks. It also suggests the need for policies that can facilitate the deepening of the market.

While the activities of cambios appear to have improved the resilience of the market and have resulted in a reduction in exchange rate volatility further deepening of the market may have less to do with increasing the number of market participants in the market. The current thinness of the market seems to have less to do with the number of market participants, but rather seem to be related to the concentration of market volumes in a few institutions and the subsequent influence that it gives to these traders. Pagano (1989) shows that if each trader perceives himself of having market power and is conscious that the price reacts adversely to his orders, they will restrict their trade below a competitive level. Achieving greater depth it appears would require policies that improve the flow of information in the market as well as creating appropriate incentive structures.

Contrary to the predictions of the MDH, we found a negative relationship between unexpected volumes and volatility regardless of the measure of volatility used. This negative relationship was interpreted as a reflection of market illiquidity, which tends to be a characteristic of less mature markets.

The paper used a GARCH model to forecast expected volatility. These forecasts were found to be positive and significantly related to volatility. Thus, the GARCH model appears to provide good in sample forecasts of volatility. Further work needs to be done to determine if the GARCH model could be used in forecasting future volatility. We also found that spreads are positively correlated with volatility. This is consistent with the literature that posits that when volatility increase, spreads should also increase to compensate dealers for increased risk. Finally using the conditional variance equation, we test the impact of intervention policy on price volatility. Central bank intervention had the effect of reducing variability in the exchange rate over the period. However, the effect appeared to be small.

This paper uses Box-Jenkins analysis to model returns from the foreign exchange market as an AR (1) process. Future work could seek to model returns in the foreign exchange market by using other exogenous variables.

Recommendations

The paper has a somewhat different focus from the original proposal, which was to examine the microstructure of the local foreign exchange market, and in particular the behaviour of the market intraday. It was first thought that this could have been partly achieved through the use of a questionnaire that focused specifically on the beliefs of traders, their trading strategy and the signals they watch, the efficiency of the market, Central Bank credibility and how signals from the Bank were interpreted. However, concerns over the impact that such a questionnaire would affect the market negatively prevented its distribution and use. The use of foreign exchange market surveys is a normal part of the process in understanding the microstructure of foreign exchange markets and is also strongly recommended for use in the Jamaican context. Cheung and Chinn (1999, 2000) conducted similar surveys for both the United States and United Kingdom based foreign exchange traders. The questionnaire if administered by the BOJ is likely to have a high response rate. The Bank could also consider having the survey conducted through an independent agent.

Much of the research done on the microstructure of foreign exchange markets are either elaborate theoretical models or empirical models that utilize intraday data. Currently, available intraday data are limited to the twice-daily market updates and has only been available since 1998. This posed another constraint on the paper, as the frequency was not high enough. E-gate represents a potential channel through which the required data can be generated. However, although the present system allows for data to be viewed on a real time basis the data is not stored at a high frequency. It is therefore recommended that intraday data be stored. This would better provide the data on trading volumes, variances over the day, as well as information on how the market responds immediately to intervention by the BOJ. However, any attempt to use the system for this purpose would require that dealers make timely and accurate updates on the system. Currently

the only requirement is that dealers enter transactions on the same day they are conducted. Hence what is viewed at any point in the day may not accurately reflect the market.

Having a system that is updated accurately and on a timely basis, would not only enhance the range of work that could be done on the microstructure of the local foreign exchange market, but would also improve the understanding of the market as a whole. This could possibly allow for more timely intervention by allowing the Central Bank to intervene intraday rather than with a one-day lag. The Central Bank would also be better able to develop a model to predict the need to intervene to limit the frequency of instability in the market.

REFERENCES

Bailllie R. and P. McMahon. 1989. "The Foreign Exchange Market: Theory and Econometric Evidence." C*ambridge University Press.*

Baxter, M. and A. Stockman. 1989. "Business Cycles and the Exchange Rate System." *Journal of Monetary Economics*. 23: 377-400

Bessembinder, H. 1994. "Bid –ask Spreads in the interbank foreign exchange Markets." *Journal of Financial Economics.* 3 167-79.

Bolerslev, T. Generalised Autoregressive Conditional Heteroskedasticity." *Journal of Econometrics.*31 307-27.

Bolerslev, T. and M. Melvin. 1994. "Bid-ask Spreads and Volatility in the Foreign Exchange Market." *Journal of international Economics.* 36 355-72.

Carlson J.A. and C. L. Osler. 1994. "Rational Speculators and Exchange Rate Volatility." *Federal Reserve Bank of New York.* Staff Paper #

Cheung, Y.W. and M. D. Chinn. 1999. "Macroeconomic Implications of the Beliefs and Behaviour of Foreign Exchange Traders." *NBER Working Paper # 7417*.

____ 2000. "How do United Kingdom Foreign Exchange Dealers Think Their Market Operates." *NBER Working Paper # 7524*

Clark, P. "A Subordinated Stochastic Process Model with Finite Variance for Speculative Prices." *Econometrica*. 41 135-55.

Dominguez, K.M. 1999. "The Market Microstructure of Central Bank Intervention." *NBER Working Paper #7337.*

Dornbusch, R. 1976. "Expectations and Exchange Rate Dynamics." *Journal of Political Economy*. 84: 1161-1176.

_____ 1986b. "The theory of Flexible Exchange Rate Regimes and Macroeconomic Policy." *Scandinavian Journal of Economics*. 78 255-275.

Frankel, J. and K. Froot. 1990. "Chartists, Fundamentalist, and Trading in the Foreign Exchange Market" *American Economic Review.* 80: 181-185.

_____ "Chartists Fundamentalists, and the Demand for Dollars." in *Policy Issues for Interdependent Economies*.

Frankel J., G. Galli and A. Giovannini. 1996. "The Microstructure of the Foreign Exchange Market." *The University of Chicago Press*. Chicago and London

Frankel, J. and A. K. Rose 1994. "A Survey of the Empirical Research on Nominal Exchange Rates." *NBER Working Paper #4865.*

Galati, Gabriele. 2000. "Trading Volumes, Volatility and Spreads in Foreign Exchange Markets: Evidence from Emerging Market Countries" BIS *Working Paper#93.*

Jackson, J. 1986. "The stock Market in the Caribbean: The Jamaican Experience." *Caribbean Finance and Management*. 2: 61-68.

Jorion, P. 1996. "Risk and Volume in the Foreign Exchange Market." *in "The Microstructure of the Foreign Exchange Market" Frankel, Galli and Giovannini*. University of Chicago Press.

Kaul, G., T. George and M. Nimalendran. 1991. "Estimation of the Bid-Ask Spread and its components: A New Approach." *The Review of Financial Studies.* 4: 623-656.

Lamoureux, C. and W. Lastrapes. 1990. "Heteroskedasticity in Stock Return Data: Volume versus Garch Effects." *Journal of Finance.* 45: 221-228.

Lyons, R. 1993. "Tests of the Microstructural Hypotheses in the Foreign Exchange Market." NBER Working Paper # 4471.

Lyons, R. "Foreign Exchange Volume: Sound and Fury Signifying Nothing?" In The Microstructure of the Foreign Exchange Market edited by J. Frankel, G. Galli and A. Giovannini, The University of Chicago Press for NBER, 1996. 183-206.

Meese, R.A. and K. Rogoff. 1983. "Empirical Exchange Rate Models of the Seventies: Do They Fit out of Sample?" *Journal of International Economics* 45: 3-24.

Pagano, M. 1989. "Endogenous Market Thinness and Stock Price Volatility" The *Review of Economic Studies.* 56: 269-287.

Tauchen, G. E. and M. Pitts. 1983. "The Price Variability–Volume relationship on Speculative Markets." *Econometrica.* 51: 485-505.

Schwartz, Anna, 2000. "The Rise and Fall of Central Bank Intervention." NBER, Working Paper # 7751.

Robinson, W. 2000. "Forecasting Inflation using VAR analysis" *Bank of Jamaica Research Papers 2000*.