An Assessment of the Effectiveness of Bank of Jamaica Intervention in the Foreign Exchange Market between 2001 and 2008

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Abstract

*This paper seeks to investigate empirically the efficacy of the Bank's intervention in the foreign exchange market between 2001 and 2008, using an Exponential-GARCH model of the movements in the JD/USD weighted average selling rate (WASR). Additionally, the paper attempts to identify the key determinants of the Bank's decision to intervene and model the Bank's intervention function using a probit model. The results imply that intervention sales of operations were effective in influencing the exchange rate and its volatility. Specifically, the findings suggest that, on average, a net sale of USD 100.0 million to the market appreciates the JD/USD exchange rate by **0.35 per cent**. Further, the study provides empirical evidence that BOJ interventions have been significantly influenced by exchange rate movements about a short-term trend, interest rate differentials, past intervention episodes and to a lesser extent the level of volatility in the foreign exchange rate.*

[1] We are grateful for Dr. H. Leon for comments and suggestions. We alone bear responsibility for any mistakes and inaccuracies.

1. INTRODUCTION

Foreign exchange rate movements are critically important to monetary authorities in emerging market economies (EMs) for at least two reasons. First, the evolution of the exchange rate has an important impact on inflation owing to the open nature of EMs.[2] Second, the presence of a thin foreign exchange market in EMs often forces these countries to dampen short-term exchange rate volatility. As a consequence, EMs often resort to intervening through foreign currency transactions or adjusting interest rates to contain the effect of temporary exchange rate shocks on inflation and financial stability.[3]

Against this background, this paper attempts to model Bank of Jamaica (BOJ) intervention and its effect on exchange rate volatility with probit models and generalized autoregressive conditional heteroscedasticity (GARCH) models. In particular, the study employs the Exponential-GARCH model of Nelson (1991), which allows for the inclusion of negative values as exogenous shocks in the variance, with a view to study the impact of Bank sales and purchases separately in the analysis. Additionally, the paper attempts to identify the key determinants of the Bank's decision to intervene on a given day.

The empirical findings suggest that both intervention sales and intervention purchases are effective in influencing the exchange rate and its volatility. The empirical evidence also suggests that BOJ intervention have been significantly influenced by factors including the current exchange rate movements about a trend, interest rate differentials, past intervention episodes and to a lesser extent the level of volatility in the JD/USD exchange rate. In summary, intervention policy has played a very useful role in mitigating the adverse effects of temporary exchange rate shocks on inflation and financial stability.

The remainder of the paper is organized as follows. The next section provides a brief overview of the literature on Central Bank intervention in Jamaica between 2001 and 2008. Section 3 provides a description of the data set. Section 4 presents the empirical

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[2] Calvo (1999)
[3] See Mishkin and Schmidt-Hebbel (2001)

frameworks used to model conditional volatility and the likelihood of central bank interventions. Section 5 presents the empirical results with the aim of estimating the impact of the Bank's interventions impact on the evolution of the exchange rate and its volatility. Section 6 concludes the paper.

2. LITERATURE REVIEW

Identifying appropriate measures of the efficacy of central bank intervention in the foreign exchange market has always been a controversial issue in the literature. Over time, there have been numerous proposals regarding the assessment of the success of intervention, each with its own unique sets of benefits and drawbacks. A number of these empirical studies were examined beginning with studies conducted by Roper and Turnovsky (1980). These authors viewed optimal intervention in terms of the trade-off between changes in the county's NIR and changes in the exchange rate using a stochastic general equilibrium model to track changes in the exchange rate. They then solved the model to derive the NIR as a function of the exchange rate. The optimal criterion for intervention was domestic income stabilization and the optimal intervention rule was exchange rate policy which provides maximum insulation against foreign shocks.

As an alternative approach, Taylor (1982) proposed that the efficacy of central bank intervention could be captured using Friedman's profit criterion. Taylor asserts that the objective of central banks should be no different than that of a private investor, the bank should buy foreign currency when the value of the domestic currency is low and sell when the exchange rate is high. Thus implying that if the central bank is successful in stabilizing the foreign exchange market it should make a profit; if not, it makes a loss. Taylor assessed the performance of a number of central banks in the 1970s citing evidence that many central banks incurred losses as a direct result of using intervention rules analogous to "leaning against the wind." He concluded that central banks that intervene in the foreign exchange market with the objective of reducing the deviations from the equilibrium exchange rate were more likely to profit or be "successful" than those that intervene to reduce fluctuations in the spot exchange rate when the equilibrium rate has changed.

Humpage (1999) pointed out that "the martingale nature of exchange rate changes insures that intervention often will appear successful in terms of altering or moderating exchange rate movements even if intervention were ineffective and undertaken randomly." He asserts that while large central bank interventions may increase the probability of success, interventions generally lack forecast value, except under the weak "leaning against the wind" rule. Humpage measured success by using a model which expressed intervention as successful if intervention sales (purchases) of foreign currency were associated with local currency appreciations (depreciations) or with smaller depreciations (appreciations).

Another perspective was proposed by Bhaumik and Mukhopadhyay (2000). These authors applied the Keynes-Mundell-Fleming (K-M-F) model with flexible exchange rates and imperfect asset substitutability and further assumed that capital inflows to developing countries (LDCs) were not driven by interest rates. They derived a reduced form expression allowing them to link exchange rate movements with the Royal Bank of India's (RBI) intervention. Having derived a reduced form equation they substituted, within the expression, monthly data on the net purchase of foreign exchange by the RBI (in dollars) and exchange rates of the US dollar (rupees per dollar) between April 1996 and March 1999. After conducting a number of empirical tests on the signs of the coefficients of the key variables in the model, it was found that the ultimate effect of intervention on the exchange rate was ambiguous.

3. DATA DESCIPTION

3.1 Data Analysis

Daily exchange rate returns are calculated by taking the log difference of the JMD/USD weighted average selling rate from May 2001 to May 2008 (1 751 observations).

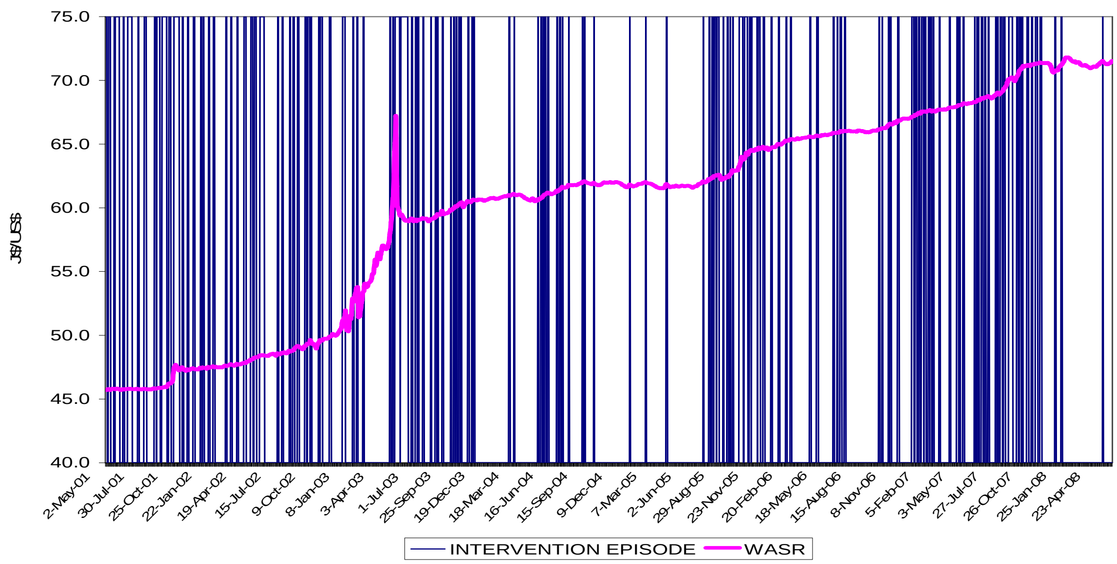
Table 3.1 Descriptive statistics on exchange rate log-returns.

	σ	x	S	K	JB	Min	Max	N
J$/USD	0.1631	0.0147	-6.39	221.51	3493522	-3.78	2.122	1751

σ – Standard deviation, x- mean, S - Skewness, K – Kurtosis, JB-Jarque-Bera, N – No. of observations

Log-returns present excess kurtosis and significant departures from normality as indicated by the Jarque-Bera test (see **Table 3.1**).

Figure 3.1A: Daily Spot Exchange Rate - J$/US$ and the Bank of Jamaica Intervention Episodes



- Contingent sales on vertical axis

Figure 3.1B: Daily J$/US$ Exchange Rate Returns: May 1 2001 – May 30 2008

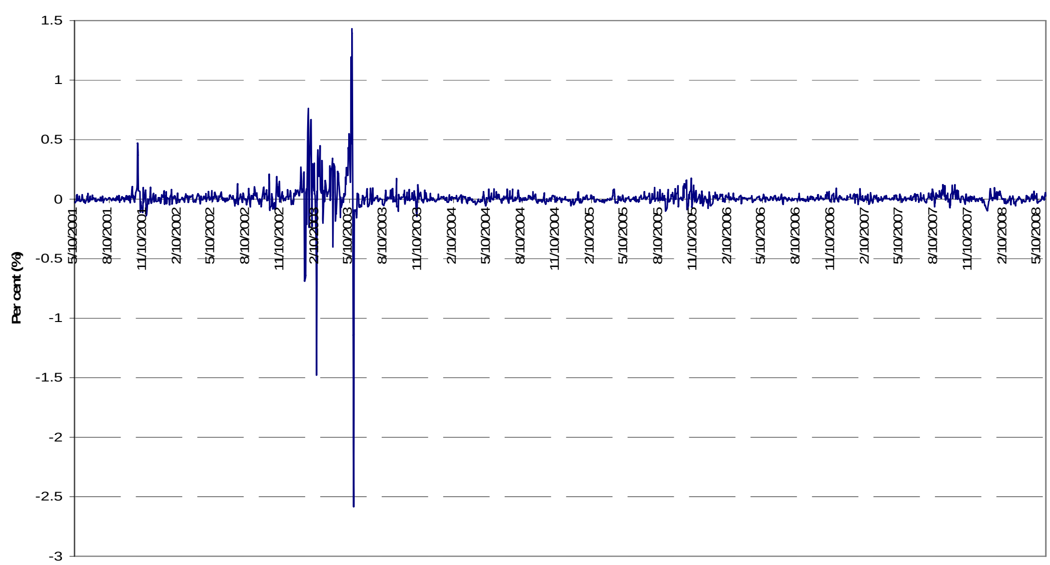


Table 3.2: Distribution of Intervention Sales: 1 May 2001 – 20 May 2008

Intervention volume (USD Millions)	Frequency (Per cent)	Cumulative (Per cent)
Less than 0	0.0	0
0 to 2.88	3.5	3.5
2.88 to 5.77	12.7	16.2
5.77 to 8.65	30.2	46.4
8.65 to 11.53	26.7	73.1
11.53 to 14.42	12.7	85.8
14.42 to 17.30	10.0	95.8
17.30 to 20.19	3.6	99.4
20.19 to 23.07	0.5	99.9
Over 23.07	0.1	100.0

Between May 1, 2001 and May 30, 2008, the BOJ intervened in the market on 441 occasions – **23.0 per cent** of trading days (see Figures 3.1A and Figure 3.1B and Table 3.2). The average intervention sale over the period was USD12.30 million, with a maximum intervention of USD34.6 million. Over the review period, most interventions (approximately **30.2 per cent**) occurred within the modal range of USD5.7 million and USD8.7 million. Finally, **85.8 per cent** of all intervention sales were below USD14.4 million. Outside these limits, there were only a small number of particularly large interventions (4.2 per cent above USD17.30 million).

The results of Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests for unit roots show that log-returns of the JMD/USD can be treated as stationary variables (see Table 3.3).

Table 3.3 Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) Tests for Unit Roots

	ADF[4]		PP
Currency	**(5)**	**(10)**	**(5)**
J$/USD	4.95***	2.67***	-22.53***

* Significant at the 1.0 per cent level. The order of augmentation is in parenthesis and the test include a drift term

The variables used to estimate the Bank's intervention reaction function included the spread between 180-day Treasury bill rate and US dollar GOJ bonds, the deviation of the JMD/USD rate from the 100-day moving average rate, [5] the difference between daily buy and sell volumes and the ratio of NIR to imports.[6]

4. ECONOMETRIC MODELLING

4.1 E-GARCH MODEL

GARCH (1, 1) models with Student-t distribution are found to be useful in modeling the conditional volatility of daily exchange rate changes (see Hsieh, 1989 and Kim, 1998). This paper models the daily foreign exchange rate volatility by the estimating the conditional variance, ht, of the daily JMD/USD exchange rate changes arising from an EGARCH (1, 1) model with a conditional t distribution as shown in Models 1 and 2:

Model 1

Mean Equation

$$\Delta s_t = a_c + a_{FE-SALES} FESALES_T + a_{FE-PURCH} FEPURCH_T + a_{GOJDiff} GOJDiff_t + \Delta s_{t-1} + \varepsilon_t \quad (1)$$

$$e_t = z_t \sqrt{h_t}; \quad e_t \sim t(0, h_t, d), z_t \sim iid(0,1)$$

[4] The null hypothesis is that the log difference of the J$/USD exchange rate has a unit root. This is rejected at the 1.0 per cent level.

[5] The current exchange rate deviation is then measured as the difference between the current J$/USD exchange rate (st) and its 150 day moving average trend: $FXDIVTREND_t = s_t - \frac{1}{100}\sum_{i=0}^{100} s_{t-1}$

[6] The level of the NIR is available daily. However, imports are only available on a monthly basis so interpolation is used to create a daily-series so as to create the ratio.

Conditional Variance Equation

$$\ln h_t = \omega_c + \alpha_h \ln h_{t-1} + \beta_{e1} \frac{e_{t-1}}{\sqrt{h_{t-1}}} + \gamma_{e2}\left(\frac{|e_{t-1}|}{\sqrt{h_{t-1}}} - \sqrt{\frac{2}{\pi}}\right) + a_{FE-SALES} FESALES_T \qquad (2)$$

$$+ a_{FE-PURCH} FEPURCH_T + a_{GOJDiff} GOJDiff_t + \Delta s_{t-1} + \varepsilon$$

where:

Δs_t *= daily log difference in WASR of the J$/USD exchange rate (multiplied by 100)*

FESALES = BOJ intervention sales of foreign currency sold to the market, measured in USD millions.

FEPURCH = BOJ intervention purchases of foreign currency bought from the market, measured in USD millions.

GOJDiff = Spread between 180-Day Treasury bill rate and the yield on US dollar GOJ Global bonds.

Model 2

Mean Equation

$$\Delta s_t = a_c + \sum_{i=MON}^{THUR} a_i D_{i,t} + (a_{INTV} + a_{CIDUM} CIDUM_T + a_{SIDUM} SIDUM_t) Intv_t + e_t \qquad (1)$$

$$e_t = z_t \sqrt{h_t}; \quad e_t \sim t(0, h_t, d), z_t \sim iid(0,1)$$

Conditional Variance Equation

$$\ln h_t = \omega_c + \alpha_h \ln h_{t-1} + \beta_{e1} \frac{e_{t-1}}{\sqrt{h_{t-1}}} + \gamma_{e2}\left(\frac{|e_{t-1}|}{\sqrt{h_{t-1}}} - \sqrt{\frac{2}{\pi}}\right) + \sum_{i=MON}^{THUR} a_i D_{i,t} + \qquad (2)$$

$$(b_{INTV} + b_{CIDUM} CIDUM_T + a_{SIDUM} SIDUM_t) \cdot |Intv_t|$$

where:

$D_{i,t}$ *= Daily dummy that takes the value of one for the day of the week i and zero otherwise.*

$Intv_t$ = *BOJ intervention proxied by net market sales of foreign currency, measured in USD millions.*

$CIDUM_t$ = *Cumulative intervention dummy variable that takes the value of one if intervention at day t is preceded by intervention in the same direction at day t-1 and t-2, and zero otherwise.*

$SIDUM_t$ = *Intervention size dummy variable that takes the value of one if the absolute amount of intervention at day t is greater than the whole sample average daily net market sales of US$12.3 million, and zero otherwise.*

h_t = *Conditional variance of daily exchange rate changes.*

In Model 2, the conditional mean and variance of the daily exchange rate changes are modeled by considering the differential impacts of (i) particularly large interventions, (ii) sustained interventions, as well as (iii) day of the week/seasonal effects. Given the size of Jamaica's foreign exchange market (average daily volume of USD32.2 million over the review period), the size of the intervention has to be substantial enough to move the 'equilibrium' exchange rate' (SIDUM). Furthermore, the BOJ sometimes spread out the intervention transactions over a number of days to maximize the effects of the signaling channel (CIDUM). Dummy variables representing each of the differential impacts are included in the analysis to pick up their effects.

4.2 PROBIT MODEL

A probit model of BOJ's intervention was estimated using daily trading day data from 01 May 2001 to 01 May 2008 (1 761 observations). The dichotomous dependent variable was defined as 0 for days when the Bank was not intervening and 1 for days when the Bank sold foreign exchange to the market. The variables used to estimate the Bank's intervention reaction function included the spread between 180-day Treasury bill rate and yield on foreign currency denominated GOJ bonds, the deviation of the JMD/USD rate from the 100-day moving average rate, the difference between daily buy and sell volumes and the ratio of NIR to imports.

$$\Pr(y_i = 1 | x_i, \beta) = 1 - \Phi(-x'_{i,t}\beta_{i,t}) = \Phi(x'_i\beta_{i,t}) \quad (3)$$

where Φ is the cumulative distribution function of the standard normal distribution.

$$Interv_{i,t} = 1 - \Phi(\alpha_C + \alpha_{FXDIVTREND} FXDEV_t +_{IRDIFF} GOJDIFF + \alpha_{NIR-EXP} NIRIMP + \alpha_{BSDIFF} BSDIFF + \alpha_{INTERV_{T-1}} Interv_{t-1}) \quad (4)$$

where

$Interv_{i,t}$ = *A dummy variable that takes the value of one if there is a sale of foreign currency with USD, and zero otherwise.*

FXDev = *Deviation of the current exchange rate (s_t) from its 100-day moving average rate.*[7]

GOJDiff = *Interest rate differentials between the 180-day Treasury bill rate and a weighted average of yields on USD GOJ Globals*

NIRIMP = *Ratio of the stock of foreign currency reserves to Jamaican imports. Monthly imports were converted to daily frequency by interpolation.*

BSDiff = *Daily difference between the demand for foreign exchange in USD and the supply of USD (non-intervention).*

$Interv_{i,t-1}$ = *A dummy variable that takes the value of one if there is a sale of foreign currency with USD on the previous trading day, and zero otherwise.*

The probit model employs five variables, FXDev, GOJDiff, BSDiff and NIRIMP, as well as the lagged dependent variable, to explain the probability of an intervention on a given day. The Bank is assumed to react to market conditions and constraints (encompassed by the five independent variables), but only after the probability index exceeds as specified threshold which balances the risk of intervening (and hence reducing the NIR) and not intervening at all.

It is expected that the likelihood of BOJ intervention will increase if the exchange rate deviates significantly from its short-term trend (FXDev). The interest rate differential

[7] ht = Conditional variance of daily exchange rate returns generated from the EGARCH(1,1) model in Section 4.1

between domestic and GOJ global bonds (GOJDiff) should also be negative, since a decline in the spread may be followed by excessive depreciation of the JMD/USD exchange rate, requiring a net sale of foreign exchange from reserves. The inventory variable, ratio of NIR to imports (NIR/IMP), should be negative since a higher reserve to imports ratio should lead to reduced sales of those reserves via the signaling effect. Additionally, excess demand for US dollars (BSDiff) on any given trading day should increase the likelihood of central bank intervention. Finally, effect of the lagged intervention variable should be positive, indicating that intervention is more likely to be followed by additional intervention episodes. This implies persistence of intervention, which is likely to improve effectiveness. The market calming effect of intervention may be realized if the size of the intervention is large enough and the intervention is carried out consistently over a number of days to convince market participants of the information content of the intervention.[8]

The interpretation of the coefficient values from the estimation process is complicated by the fact that estimated coefficients from a binary model cannot be interpreted as the marginal effect on the dependent variable. The marginal effect of x_j on the conditional probability is instead given by:

$$\frac{\partial E(y_i|x_i,\beta)}{\partial x_{i,j}} = f(-x_i'\beta)\beta_j \tag{5}$$

where $f(x) = \partial F(x)/dx$ is the density function corresponding to F.

[8] Instead of modeling the intervention linearly, using deviations of the current level and volatility, the possibility that the Bank pays closer attention to the nature of such deviations is also incorporated. That is, exchange rate deviations that persist over a number of days and/or large deviations may attract more attention that small and transitory movements.

5. ESTIMATION RESULTS

5.1 Exponential GARCH Model

Akaike and Bayes criteria are employed to select a parsimonious random walk plus drift to model of the mean exchange rate returns.[9] Ljung-Box statistics for the presence of autocorrelation in the standardized residuals and in the squares of the standardized residuals cannot reject the null at conventional levels (Tables 5.1a and 5.1b report the results pertaining to the intervention effects on the conditional mean and variance.[10]).[11]

The results based on the EGARCH(1,1) model which disaggregates between intervention purchases and sales show that the sale of USD100.0 million appreciates the Jamaican currency by **0.22 per cent** (See **Table 5.1a**). Similarly, a purchase of USD depreciates the currency by **0.28 per cent**. The results also suggest that the spread between the GOJ global yields and the 180-Treasury Bill rate does not affect the magnitude of the mean exchange rate.

Similarly, when the impact of interventions is evaluated separately, the results show that the reduction in the volatility of the exchange rate is a direct result of intervention sales. In this regard, these results suggest that Bank has been successful reducing the volatility in the exchange rate between 2001 and 2008. This framework, however, does not control for the impact of exogenous factors such as days-of-the-week impacts or the differential impact of different types of interventions strategies on the mean and conditional variance of movement in the exchange rate (**Table 5.1b** shows the evaluation of the influence of the Bank's intervention policy while controlling for these effects).

[9] The difference of local and foreign interest rate on GOJ globals was also considered as a regressor.
[10] The lag structure in the estimations is determined by the Bayesian and Akaike information criteria.
[11] The exception is net intervention measure in frequencies in Table 5 where the introduction of qualatatie dummies induces heteroscedasticity. To deal with potential model misspecification robust t-ratios using the Quasi Maximum Likelihood method suggested by Bollerslev and Wooldridge (1992) are computed.

Table 5.1a: E-GARCH (1, 1) Estimation results: Bank of Jamaica USD Sales/ Purchases on Exchange Rate Returns: May 1 2001 – May 31 2008

	Coefficients	P-values
Mean Equation		
Φ_{o}	0.017813***	0.0000
$\Phi_{fe\text{-}sales}$	-0.002236***	0.0000
$\Phi_{fe\text{-}purchases}$	0.002893***	0.0001
$\Phi_{GOJDiff}$	-0.000572	0.3687
lwasr(-1)	0.469247***	0.0000
Variance Equation		
ω	-0.463009***	0.0000
α	0.435571***	0.0000
β	0.126175***	0.0000
γ	0.954138***	0.0000
δ_{sales}	-0.010245***	0.0041
$\delta_{purchases}$	0.040942*	0.0579
$\delta_{GOJDiff}$	-0.003150	0.2886
Decision Criteria		
AIC[d]	**-2.57917**	

The major findings are that the Bank of Jamaica's interventions appear to have stabilizing influences on the conditional mean and variance of the daily changes of the JMD/USD rate. There is the contemporaneous negative correlation between the intervention sales of foreign currency to the market and the conditional mean and variance of the exchange rate returns as indicated by the negative coefficients for $\mathbf{a}_{INTV}$ and $\mathbf{b}_{INTV}$ (see **Table 5.1b**). Additionally, sustained and large interventions contribute to stabilizing influence in the foreign exchange market both in terms of direction and the volatility, as shown by the positive coefficients for the cumulative and size slope dummy variables for both the mean and variance equations (a_{CIDUM}, a_{SIDUM} and b_{CIDUM}, b_{SIDUM}). Without these interventions, the market would have moved further and exhibited more volatility.

Table 5.1b: E-GARCH (1, 1) Estimation results: May 1 2001 – May 31 2008

	Coefficient	p-value*
Mean Equation		
a_c	0.011171***	0.0000
a_{MON}	0.0048010	0.1297
a_{TUE}	0.006806**	0.0458
a_{WED}	0.000197	0.9500
a_{THUR}	0.009518***	0.0026
$\mathbf{a_{INTVPURCH}}$	-0.003507***	0.0000
a_{CIDUM}	0.000950	0.1193
a_{SIDUM}	0.001540***	0.0053
lwasr(-1)	0.458882***	0.0000
Variance Equation		
b_c	-0.648270***	0.0000
b_e^1	0.456409***	0.0000
b_e^2	0.135379***	0.0000
b_h	0.946640***	0.0000
b_{MON}	0.185870	0.1852
b_{TUE}	0.319648**	0.0152
b_{WED}	-0.027120	0.8456
b_{THUR}	0.221901	0.1132
b_{CIDUM}	0.099089	0.2472
b_{SIDUM}	0.135780	0.3827
$\mathbf{b_{INTV}}$	-0.018989**	0.0292
d	4.65299	0.0000
Diagnostics for Standardized Residuals, Zt		
Skewness	0.011579	
Kurtosis	6.398	
Q(30)	50.779	(0.000)
Q2(30)	31.477	(0.049)
LnL	2279.64	

Notes:

Q (20) and $Q^2(20)$ are the Q-statistics for the Ljung-Box test of white noise for the linear and squared standardized residuals.

*Numbers represent the asymptotic p-values

The estimates arising from the estimation of the movements in the mean exchange rate suggest that the Bank's interventions in the market exert positive pressure on the foreign exchange rate – i.e. an appreciation. Overall intervention operations during the period have had a highly significant positive impact on the exchange rate (see α INTERPURCH in Table 5.1b). A net sale of USD100 million appreciates the exchange rate by **0.35 per cent**.

The effect of the Bank's intervention on the conditional variance is also assessed using the GARCH framework. From the estimated parameters, α INTERPURCH, the overall intervention has significantly decreased the conditional variance of exchange rate. That is, the reduction in volatility is a direct result of sales of USD (**Table 5.1b**). These results confirm the hypothesis argued by Obstfeld (1995) that 'clean' floating exchange rate regimes means high volatility of nominal exchange rate. It almost always means greater volatility of the real exchange rate, for the general price level move sluggishly. To the extent that this volatility in real prices is costly, either directly or because it causes volatility in output or in the health of the financial system, policy makers typically want to mitigate. This study provides evidence to show that monetary authorities in Jamaica are no exception.

5.2 Probit Model Estimation Results

The estimation results for the probit model provide empirical support for the 'leaning against the wind' hypothesis of market intervention (**Table 5.2a)**. The exchange rate deviations (FXDIVTREND) are shown to have a positive effect and statistical significant effect on the intervention probabilities. Specifically, a one cent deviation in the exchange rate from trend is expected to increase the probability of intervention by 6.9 percentage points. This suggests that a higher probability of intervention sale of foreign currency by the Bank is associated with an 'excessive' current depreciation of the JMD.

Table 5.2a: Probit Estimation Results: May 1 2001 – May 31 2008

	Coefficient	p-value	*Marginal-Effect*
α_C	-1.137016	0.0000	-
$\alpha_{FXDIVTREND}$	0.199736	0.0000	0.0698
$\alpha_{GOJDiff}$	-0.033202	0.0279	-0.0133
$\alpha_{NIR-EXP}$	-0.001615	0.0000	0.0038
α_{BSDIFF}	0.034361	0.0000	0.0134
$\alpha_{INTERV_{T-1}}$	1.507835	0.0000	0.5883
Nobs	1750		
LogL	-680.3642		

where

FXDIVTREND = Deviation of the current exchange rate (s_t) from its 150 day moving average rate.

GOJDiff = Interest rate differentials between the 180-day Treasury bill rate and a weighted average of yields on USD GOJ Globals

NIREXP = Ratio of the stock of foreign currency reserves to Jamaican imports. Monthly imports were converted to daily frequency by interpolation.

BSDIFF = Daily difference between the demand for foreign exchange in USD and the supply of USD (non-intervention).

$Interv_{i,t-1}$ = A dummy variable that takes the value of one if there is a sale of foreign currency with USD on the previous trading day, and zero otherwise.

The interest rate differential (GOJDiff) was significant at the 5.0 per cent level and correctly signed impact for the entire sample period.[12] The marginal impact suggests that a 100 bps increase in the spread between the 180-day Treasury Bill rate and USD GOJ global bonds decreases the likelihood of intervention by **1.3 percentage points**. The reserves to imports ratio (NIR/EXP), in general, tended to decrease the probability of a

[12] The conditional volatility of daily exchange rate movements (h_t) shows a marginally significant negative effect over the periods I, II and II, indicating a higher probability of intervention sale in response to a higher conditional volatility. This indicates a higher probability of intervention sale for the foreign currency was associated with a higher volatility of the exchange rate changes.

positive intervention, though this impact was quite small.[13] This suggests that inventory considerations are only relevant, but hard to predict with this proxy. The daily difference between the demand for USD and the supply of USD (excluding intervention funds) (BSDIFF) was found to increase the likelihood of intervention. Every **USD1.0 million** dollar excess demand increases the likelihood of intervention by **1.3 percentage points**. Finally, the lagged value the intervention ($Interv_{t-1}$) was found to have the largest and most statistically significant impact on the decision to intervene in the market. If the Bank had been in the market one the preceding trading day, the likelihood of intervening on the next trading day was increased by **58.8 percentage points**. This finding lends strong credence to market calming effect of intervention which is both large enough carried out consistently over a number of days to convince market participants of the information content of the intervention

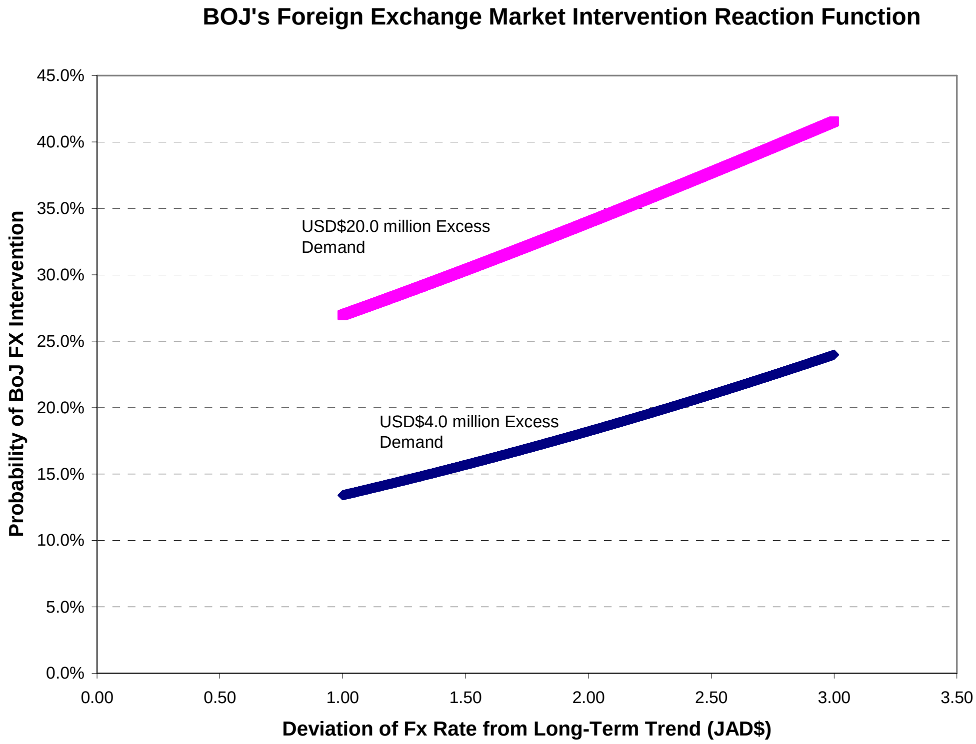
The goodness of fit test for the model suggested that the probit did a fairly good job of characterizing the Bank's intervention policy over the period (see **Appendix A**).[14] That is, the model corrected predicted non-intervention episodes and intervention episodes 89.0 per cent and 65.0 per cent of the times, respectively. For example, the probability of the Bank needing to intervene in the foreign exchange market is **14.0 per cent** and **27.5 per cent** given excess demand for USD of **USD4.0 million** and **USD20.0 million**, respectively, and when the exchange rate has deviated by **JMD1.0** from its long-term trend (see Figure 5.2b). Again, where the foreign exchange rate has deviated by **JMD3.0** from its long-run average and excess demand of **US$4.0 million** and **US$20.0 million** pertain in the market, the probability of intervention would increase to **26.0 per cent** and **42.0 per cent**, respectively.[15] Historically, the Bank has intervened when the probability of intervention has exceeded **35.0 per cent**.

[13] The marginal impact of this variable (NIR/EXP) was also very small.

[14]

[15] The scenario also entailed the assumption that the spread between domestic and foreign currency denominated bonds remained at 760.0 bps and the ratio of NIR to imports ratio remained at 29.0.

Figure 5.2b. BOJ's Foreign Exchange Market Intervention Reaction Function



V. CONCLUSION

The aim of this study has been to assess the importance of the various determinants of the BOJ's foreign exchange market interventions. Empirical evidence is provided which shows that BOJ interventions have been significantly influenced by the current exchange rate movements about a trend, interest rate differentials, past intervention episodes and, to a lesser extent, the level of volatility in the foreign exchange rate. In general, it has been found that a moderate depreciation of the JMD/USD exchange rate from its 150-day average leads to an intervention sale of foreign currency designed to slow the fall of the value of the JMD. In addition, the study shows that the Bank has intervened to calm the market whenever there was moderate surges in exchange rate volatility providing empirical support for the Bank stated position to minimize instability in the foreign exchange market. Evidence was also found that the Bank responds to movements in the interest rate spread and appeared to have paid some (though limited) attention to level of the NIR.

In addition, the aim of this paper was to evaluate the effectiveness of the Bank's intervention since 2001. To this end, an Exponential-GARCH framework, which allows us to investigate both the overall effect of the intervention and the individual effect of sales and purchases, was employed. The results of the empirical investigation suggest that overall intervention operations have had a positive and statistically significant impact on the JMD/USD exchange rate. More specifically, the findings suggest that a net sale of USD100.0 million appreciates the exchange rate in Jamaica by **0.35 per cent**. The empirical findings concerning the impact of overall intervention on the volatility of the exchange rate suggest that interventions have reduced the conditional variance of the Jamaica Dollar to United States dollar exchange rate overall. The results suggest that the response of volatility to is a direct result of sale operations.

The main policy implications emerging from the overall finds are as follows. There seems to be scope for EMs, such as Jamaica, to operate flexible exchange rate regimes without having to adopt a textbook type of pure float. It is unreasonable to assert that EMs should adopt more 'pure' forms of floating than the industrial countries have been able to sustain, particularly when the conditions necessary for a successful pure float are not likely to be present in EMs.

Secondly the fact that exchange rates, at times, move too far relative to fundamentals even in countries that pursue credible monetary and fiscal policy provides a legitimate role for intervention. The intuitive idea as put forth by Volcker (1995), however, is clear enough, the further the actual exchange rate has departed from the equilibrium, the more damage the misalignment will do. Hence, the authorities can be more confident that they will be acting as stabilizing speculators.

Appendix

Expectation-Prediction Evaluation for Binary Specification
Success cutoff: C = 0.35

	Estimated Equation			Constant Probability		
	Dep=0	Dep=1	Total	Dep=0	Dep=1	Total
P(Dep=1)<=C	1088	133	1221	1225	374	1599
P(Dep=1)>C	137	241	378	0	0	0
Total	1225	374	1599	1225	374	1599
Correct	1088	241	1329	1225	0	1225
% Correct	88.82	64.44	83.11	100.00	0.00	76.61
% Incorrect	11.18	35.56	16.89	0.00	100.00	23.39
Total Gain*	-11.18	64.44	6.50			
Percent Gain**	NA	64.44	27.81			

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