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Foreign exchange intervention in a small open economy with a long term peg

Mahalia Jackman
Central Bank of Barbados

Abstract

Central banks usually intervene in order to calm disorderly market conditions, fix exchange rate misalignments, stabilise erratic short-term exchange rate fluctuations, or quell the excess demand/supply of FX. Under a floating regime, the size and timing of intervention are critical policy decisions. But, in an economy with a fixed exchange rate – such as Barbados – FX intervention tends to be endogenous i.e., it is the FX demand and supply conditions that dictate both the timing and amount of intervention. Against this backdrop, this paper developed a model to investigate how FX market conditions dictate intervention in Barbados, small open economy which has been pegged to the US dollar for over 30 years. Results suggest that market frictions, oil prices and oil price shocks all reduce net purchases of FX, while the seasonal highs in tourism and the differential between domestic and foreign interest rates both increase net purchases.

The views, findings and conclusions expressed in this paper do not necessarily reflect those of the staff of the Central Bank of Barbados or its Board and so, should not be referenced as such.

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Contact: Mahalia Jackman - mahalia.jackman@centralbank.org.bb.

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1. Introduction

Maintaining a stable exchange rate has long been at the centre stage of macroeconomic policy (see Edison, 1993; Sarno and Taylor, 2001; Ito and Yabu, 2007). If a currency appreciates too much (or too rapidly), the country may experience a significant decline in the demand for its exports, while rapid or large depreciations in a currency negatively impacts the country's importers. Moreover, frequent changes in a country's exchange rate can rattle investor confidence and significantly reduce a country's ability to attract foreign capital. In an attempt to limit excessive and/or random fluctuations in the exchange rate, central banks often intervene.

With many central banks now releasing data on their daily FX interventions, a substantial body of empirical literature on the probability, amount and timing of intervention has surfaced. It is important to point out that the vast majority of these studies have focused on large economies like the US (Almekinders and Eijffinger, 1994; Almekinders and Eijffinger, 1996; Ballie and Osterberg, 1997; Frenkle et al, 2003), Germany (Almekinders and Eijffinger, 1994; Almekinders and Eijffinger, 1996; Ballie and Osterberg, 1997; Frenkel and Stadtman, 2001), Canada (Kim and Sheen, 2002), Australia (Kim and Sheen, 2002; Rogers and Siklos, 2003), Japan (Frenkel et al, 2003; Ito and Yabu, 2007) and Turkey (Herrera and Ozbay, 2005; Ozlu and Prokhorov, 2008). Considerably less attention has been paid to economies with a nominal GDP of less than US $5 billion. While small economies are of particular interest, a major hurdle has been the inability to obtain data on central bank intervention– particularly at the daily frequency. And, even when the data exists, it is often difficult to differentiate between reserves accumulated to influence exchange rate developments and those for insurance against financial shocks (see Abrego et al, 2007).

A second observation is that the literature focuses almost exclusively on countries with free/managed floats. This then begs the question, "what about the case of the economy with a fixed exchange rate?" Clearly, the motivation, frequency and size of interventions would vary considerably across exchange rate regimes.

Under a floating regime, the size and timing of intervention are critical policy decisions. Specifically, the magnitude of the intervention is assumed to be proportional to the resulting change in the exchange rate, while the timing determines whether or not the shock is fully absorbed by market players. But, in an economy with a fixed exchange rate it is the FX demand and supply conditions that dictate both the timing and amount of intervention. Thus, the central bank only intervenes in periods of excess deficits or surpluses: at the end of the day, the balance on the central bank's books (i.e. net purchases of foreign currencies) is a mere reflection of the balance of payments situation for that day.

At the empirical level, very few studies have evaluated this hypothesis. This may be because very few economies have a pegged rate regime or managed a float, which through the vicissitudes of circumstance, remained unchanged for a long period of time. This paper attempts to simultaneously address the aforementioned gaps in the literature by developing a model of central bank intervention for Barbados.

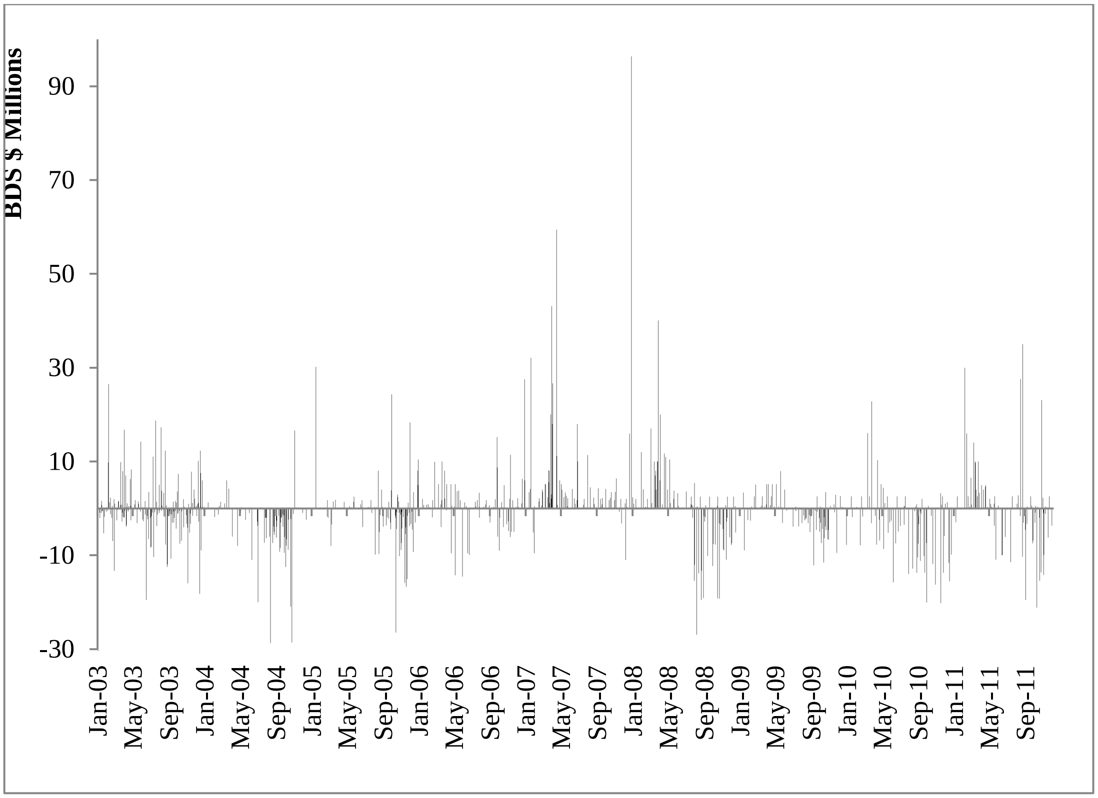
The rest of this paper is organised as follows. Section 2 develops a quantitative model of central bank intervention for Barbados. Section 3 describes the data and estimation approach. The empirical results are presented in Section 4 and finally, section 5 concludes.

2. A Quantitative Model of Central Bank Intervention in Barbados

With a population of less than 300,000 and land mass of just 166 square miles, Barbados can be classified as a microstate. Despite its small size, Barbados is characterized as a "high income" country (according to the 2011 World Bank list of economies) with very high human development (given its ranking in the 2011 United Nations Human Development Report). But, its greatest achievement has been its ability to maintain its peg. Particularly, the Barbadian dollar has been pegged at the rate: BDS $2 to US $1 since 1975 and so, has one of the longest (and most credible) pegs in the world. Thus, there is no question of the effectiveness of the country's intervention policy.

Central bank activity in Barbados is puntuated by frequent FX interventions (see Figure 1). Between January 01, 2003 and December 07, 2011, the Central Bank of Barbados intervened to either purchase or sell US dollars on 70.3 percent of all trading days. This is stark contrast to the advanced economies, where there are often long streches of time when central banks withdraw from the market (see Kim and Sheen, 2002; Canales-Kriljenko, 2003).

Figure 1: Net Purchases of US Dollars



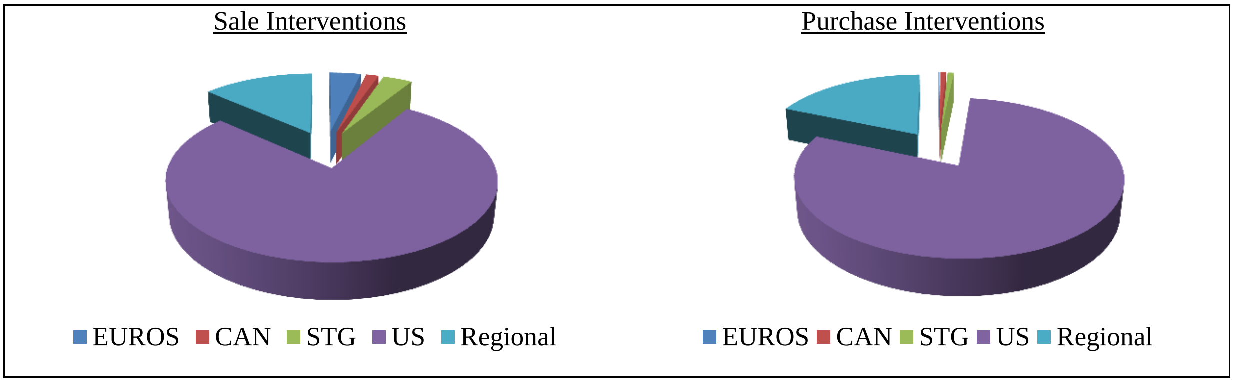
The daily interventions carried out by the Central Bank of Barbados are almost always against the US dollar (see Figure 2). This is somewhat expected, given that the aim of intervention in Barbados is to maintain the BDS $2: US$1 peg. Consequently, this paper focuses on the U.S. currency interventions.

As mentioned in the introduction, most studies on central bank intervention are carried out within the context of a managed or free floating exchange rate regime. These studies often use some variant of the intervention function specified by Edison (1993):

$$Intervention_t = \alpha_0 + \alpha_1(s_t - s_t^T) + \alpha_2\Delta s_t + \beta X_t + u_t \quad (1)$$

where s is the logarithm of the exchange rate (foreign currency per dollar), s^T is the target exchange rate, Δ represents the first difference operator and X is a vector of other variables such as lagged intervention, central bank profitability or the interest rate differential.

Figure 2: Intervention by Currency – Daily Averages



Note: Euros represents Intervention carried out against the Euro, CAN are those against the Canadian dollar, STG represents the sterling pound and Regional are the sum of the currencies of the Caribbean region.

But, under a pegged regime, both $(s_t - s_t^T)$ and Δs_t are zero. The balance of demand and supply is achieved by adjusting demand (i.e., buying and selling from the foreign exchange reserves), rather than by changing the price. And so, the central bank only intervenes to ensure that the market clears. The market clearing condition is written as:

$$Intervention_t = CA_t + \Delta KA_t \qquad (2)$$

where $Intervention_t$ is the net purchase of US dollars, CA_t represents developments on the external current account and ΔKA_t represents movements on the capital and financial account. The model presented here consists of variables which drive the balance of payments in Barbados. The model to be estimated is:

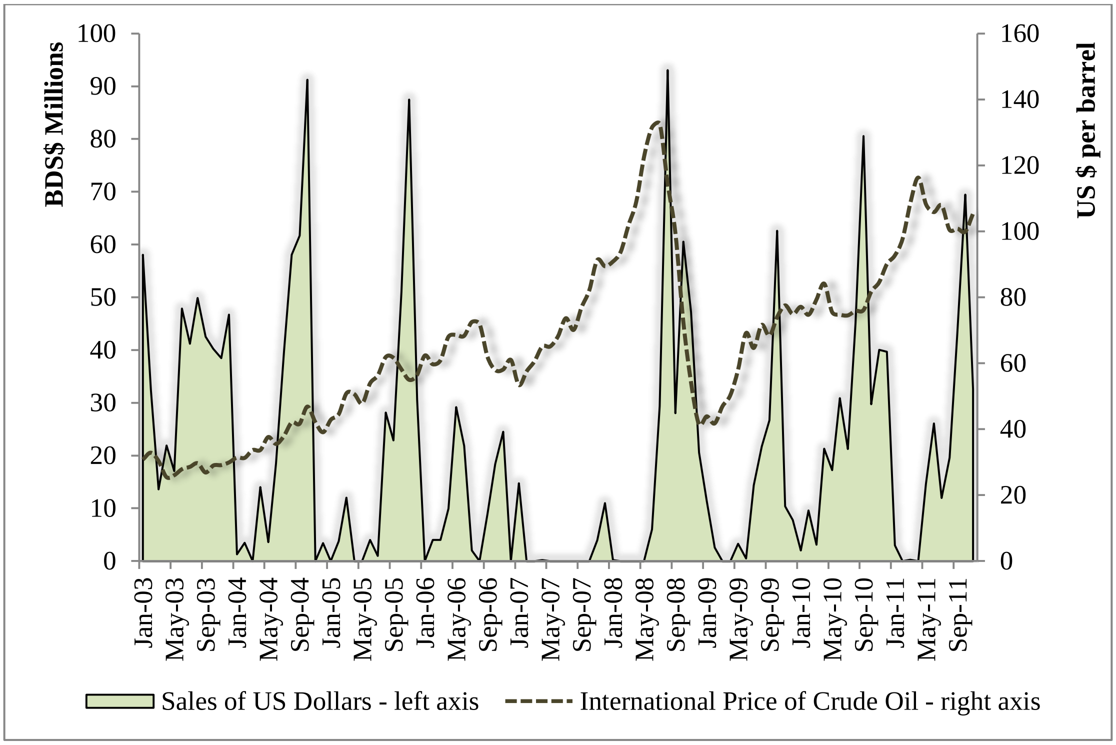
$$Intervention_t = \alpha + B_i(L)Intervention_{t-i} + \gamma X_t + \varepsilon_t \quad (3)$$

The autoregressive terms reflect the fact that deficits/surpluses on the FX market tend to be persistent i.e. once an intervention is carried out, another intervention is likely to take place the following day. X_t is a vector of macroeconomic and institutional variables, which include oil prices, oil price shocks, tourism, interest rate differentials between Barbados and the US, market frictions and large scale FX interventions. The motivation for the use of these regressors is outlined below.

2.1 Oil Prices and Oil Price Shocks

Like many small developing countries, Barbados is a net importer of oil, meaning that it relies on imports from abroad to meet its gasoline, diesel and petroleum needs. Thus, hikes in international oil prices significantly inflate the country's import bill, and in recent years has been largely responsible for the deteriorating current account deficit. Particularly, since 2003, the value of oil-related products imports (which currently represents the largest category of imports) has been on the rise, more than doubling between 2003 and 2010. Commensurate with the rise in the value of oil-related imports, the Central Bank of Barbados began receiving large discrete demands to cover oil payments. As can be seen in Figure 3, sales of US dollars in recent years have largely mirrored movements in international oil prices.

Figure 3: Oil Prices and Sales of US Dollars by the Central Bank of Barbados



To capture this, the price of crude oil is included the model. But, it is very conceivable that the demand for FX from the central bank may react more violently to unexpected fluctuations in oil prices, i.e. oil price shocks. Thus, oil price shocks are also included. The conditional volatility of oil prices is used as a proxy for oil price shocks. In general, a GARCH (1, 1) model with a general error distribution was found to be most useful in modeling the conditional volatility of oil prices.

2.2 Tourism

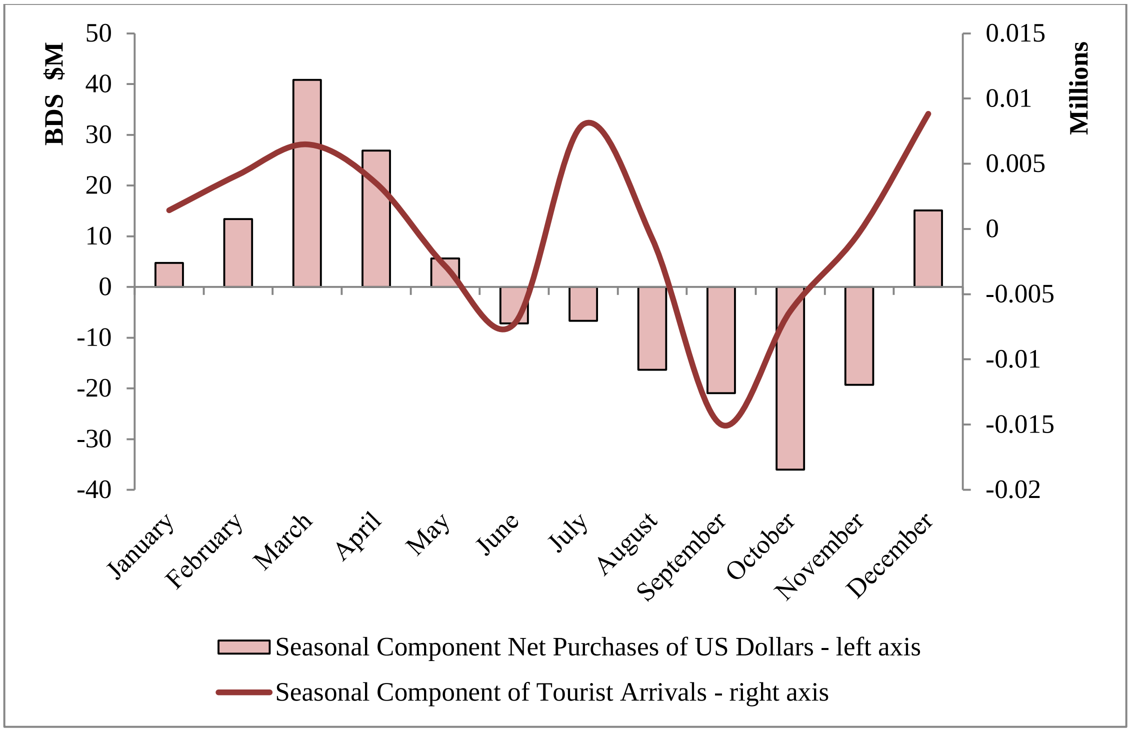
The economic fortunes of Barbados are closely tied to its tourism industry (see Jackman, 2012). Particularly, tourism satellite accounting by the World Travel and Tourism Council estimates that tourism's total contribution to Barbados' employment and gross domestic product is above 45 percent, thus placing Barbados among the top 20 most tourism-dependent countries in the world. But most importantly, tourism is the main source of foreign finance in Barbados, accounting for nearly 50 per cent of foreign earnings on average. This heavy reliance on tourism has impacted central

bank intervention in Barbados. Specifically, the buoyancy of central bank intervention tends to be highly seasonal, with net purchases generally moving in tandem with the seasonal fluctuations in tourism (see

Figure 4). As data on daily tourism receipts or arrivals is not readily available for Barbados, the author uses a dummy variable to account for how seasonality in tourism affects central bank intervention. The variable is specified as:

$$Tourism = \begin{cases} 1\ if\ the\ day\ lies\ the\ peak\ period\ of\ tourism \\ 0 \text{ otherwise} \end{cases}$$

Figure 4: Seasonal Fluctuations in Net purchases of US Dollars and Tourist Arrivals



2.3 *Interest Rate Differentials*

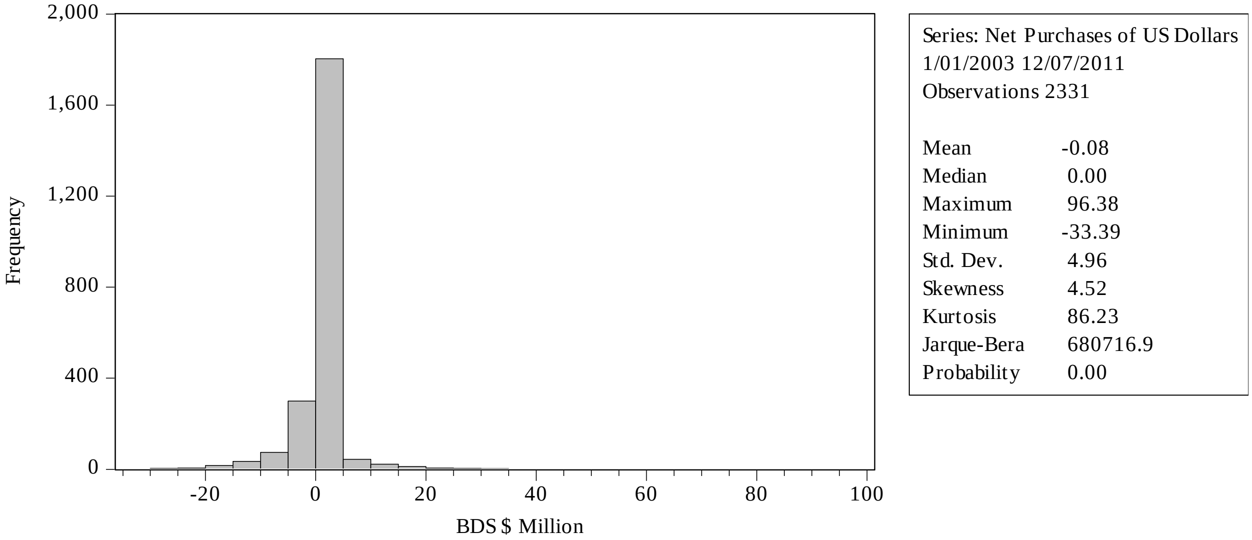
A model of ΔK can be derived within the framework of speculative dynamics (Sarno and Taylor, 2001) and so, should include factors such as the interest rate differential between Barbados and the US. Theoretically, the interest rate differential is a key factor influencing the amount of foreign investment or capital flight a country experiences. If interest rates in Barbados are significantly above those abroad, capital should flow to Barbados, or at the very least, investors will be encouraged to keep their funds in Barbados. In this scenario, the demand for foreign exchange from the central bank for investment abroad will be low. Alternatively, a negative differential can lead to capital flight or discourage investment from abroad, leading to a decline in net capital flows and by extension, reductions in the net purchases of FX by the central bank. Taken together, it is expected that central bank net purchases of FX should be positively related to the interest rate differential. Unfortunately, data on overnight money market rates does not exist for Barbados and so, the interest differential is proxied by the difference between the Barbados and U.S. Treasury bill rates.

2.4 Large Scale FX Interventions

The empirical distribution US dollar interventions are plotted in Figure 5. From the graph, it appears as though most observations are clustered between a net sale of BDS $ 5 million and a net purchase of the same amount. However, there are some incidences of large-scale interventions, which can be seen more clearly in Figure 1. To capture any effects associated with these large scale interventions, the author uses a discrete variable. The variable takes on the following values:

$$large\ scale\ FX\ Interventions = \begin{cases} 1\ if\ there\ is\ net\ purchase\ \geq\ BDS\ \$\ 5M \\ -1\ if\ there\ is\ a\ net\ sale\ \leq\ -BDS\ \$\ 5\ M \\ 0\ otherwise \end{cases}$$

Figure 5: Histogram of Net Purchases of US Dollars by the Central Bank of Barbados



Series: Net Purchases of US Dollars
1/01/2003 12/07/2011
Observations 2331

Mean	-0.08
Median	0.00
Maximum	96.38
Minimum	-33.39
Std. Dev.	4.96
Skewness	4.52
Kurtosis	86.23
Jarque-Bera	680716.9
Probability	0.00

2.5 Market Frictions

According to Worrell et al, 2008, market frictions may be interpreted as “a reflection of the effects of transactions, information costs, scope in treasury management and any other frictions in the foreign exchange market. Because of these costs, small daily changes in the net demand and supply of foreign exchange may be accumulated as net foreign currency balances of commercial banks, and would not be reflected in net purchases with the central bank on the transaction day. This would produce a pattern of no net purchases, followed by a relatively large net purchase because of accumulated net demand, and would result in relatively high volatility.” Indeed, looking at Figure 1, the fluctuations in day-to-day values appear to occur in bursts of increasing and decreasing amplitude, appearing as cycles of increasing followed by decreasing volatility, implying that market frictions may indeed be influencing central bank intervention. In this paper, market frictions are measured by the volatility of net demand for US currency.

3. Data and Estimation Strategy

3.1 Data

Since “Exceptional FX Interventions” and “Tourist Season” are discrete variables (see Section 2), and market frictions are measured by the volatility of net demand for foreign exchange, the only data required to estimate the intervention function are the net purchases of U.S. dollars, oil prices, plus the local and U.S. treasury bill interest rates. Data on spot oil prices are taken the US Energy Information Administration, while data on the US Treasury bill is taken from the US Department of the Treasury. All other information is taken from the Central Bank of Barbados data files.

3.2 Estimation Strategy

Given the volatile nature of the data and the underlying pattern of volatility persistence (which appears to be present from visual inspection of the data, for instance, Figure 1) a GARCH-M specification is utilized to test Equation (3).

A GARCH-M model for a set of observations Y_t (t = 1, 2, ..., T) can be written as:

$$Y_t|\Phi_{t-1} = F(X;\theta) + \varepsilon_t \qquad (4)$$

$$\varepsilon_t = u_t - \sum_j^q \gamma_j u_{t-j} \qquad (5)$$

$$u_t|\Phi_{t-1} \approx \Omega(0, h_t) \qquad (6)$$

$$h_t = g\left(u_{t-j}, h_{t-j}\right) + \xi' Z \qquad (7)$$

This general model has three components: a mean process *(F)*, where the variable *h* is an element of *X*; the error distribution *(Ω)* and a variance process *(g)*. The mean process (*F*) is equivalent to Equation (3) presented in Section 2.

The variance process (*g*) is defined by the Bollerslev (1986) GARCH model specified as:

$$h_t = \alpha + \sum_{j=1}^p \alpha_j u_{t-j} + \sum_{j=1}^q \beta_j h_{t-j} \qquad (8)$$

The system of equations (4-7) may be estimated by computing the mean-variance combination for each distribution, starting at the same initial parameters for each combination, and comparing likelihoods, parameter constraints, and other characteristics of the resulting matrices. The problem with this approach is that the distributions, in general, are not nested.

An alternative strategy (see Jackman et al, 2012; Worrell et al, 2008;), employed in this paper, is to start by comparing the unconditional distributions (standardized on their means) with commonly used distributions such as the normal and *t* distributions, using the quantile plots. This provides a first sense of the nature of the distribution. After this step, consider the conditional mean derived from Equation (5), utilising an equation specification that ensures that the residuals are "white noise". Next, test the distribution of the residuals against normal, *t*, and other commonly used distributions, in order to determine the nature of the conditional distribution. For that mean and conditional distribution, the maximum GARCH lag is set, check for congruency, and sequentially decrease the variance and mean (this is an example of the general-to-specific approach). Within each class of distribution, the usual likelihood ratio tests may be performed. One may also do a second round of checks to investigate the robustness of the specification, estimating the parsimonious GARCH-M model with the alternative distributions and comparing the results, using the quantile plots. However, it must be borne in mind that the reduced (parsimonious) model will most probably reflect the initial parametric choice of the distribution, and subjective evaluation is needed to bring all of these factors together, including the interpretation of parameters. Note, for the GARCH-M model, the parameter restriction for h_t to be covariance stationary is that the sum of the coefficients on the variables in the function g above be less than one. Bollerslev (1986) also assumes that the individual coefficients in g need to be nonnegative but it has been shown that this latter restriction, while sufficient for the variance to be positive, is not necessary (Bollerslev, Chou, and Kroner, 1992).

4. Results

As a preliminary step to the empirical analysis, the order of integration of the series is determined. In this respect, the familiar ADF and PP unit root tests are employed. Based on these results (Table 1), the author concludes that net purchases is I(0) stationary with a drift, the oil price shock variable is I(0), the interest rate differential is I(0) stationary with drift and a linear deterministic trend, and oil prices are I(1). Consequently, Equation (3) is estimated with all variables in levels, the exceptions being the interest rate differential, which is de-trended using a simple deterministic trend and the oil price variable which is expressed in first differences.

Table 1: Unit Root Tests

	Level			1st Difference		
Variable	Nature of Test	ADF	PP	Nature of Test	ADF	PP
Net Purchases of US $	Intercept	-9.598*	-49.261*	n.a.	n.a.	n.a.
Oil Prices	Trend and Intercept	-2.272	-2.319	Intercept	-22.139*	-50.368*
Oil Price Shocks	Intercept	-3.140*	-8.820*	n.a.	n.a.	n.a.
Interest Rate Differentials	Trend and Intercept	-3.436*	-3.563*	n.a.	n.a.	n.a.

Note: * denotes significance at the 5% level of testing

Employing the strategy outlined in Section 3.2, the GARCH-M model is estimated and presented in Table 2. A GARCH-M(1, 1) model with a general error distribution was found to be most useful in modelling the net purchases of US dollars by the Central Bank of Barbados. A look at the variance equation (bottom panel of Table 2) reveals that the sum of the coefficients on the volatility equation are less than 1, suggesting that h_t is covariance stationary.

Table 2: Estimated Results

Mean Equation	
$\text{Intervention}_{t-1}$	1.09E-07
	(7.887)
	[0.000]
Market Frictions (h_t)	-0.865
	(5.468)
	[0.000]
Oil Prices	-0.001
	(14.002)
	[0.000]
Oil Price Shocks	-0.002
	(10.942)
	[0.000]
Tourism	0.007
	(6.791)
	[0.000]
Interest Rate Differentials	0.010
	(7.236)
	[0.000]
Large Scale Interventions	10937.76
	(17.508)
	[0.000]
Variance Equation	
$\boldsymbol{u_{t-1}}$	-3.39E-08
	(-6.131)
	[0.000]
$\boldsymbol{h_{t-1}}$	0.849
	(7.036)
	[0.000]
Diagnostics	
Adjusted R-squared	0.598
Q-statistics (1)	1.463 [0.226]
Q-statistics (5)	8.943 [0.111]
Q-statistics (10)	12.359 [0.262]

Note: Figures in ( ) are Z-statistics while those in [ ] are p-values

Looking at the mean equation, the AR(1) model was chosen as the best representation of the autoregressive nature of net purchases. The parameter on the lagged coefficient is positive and significant, implying that recent interventions increase the expected amount of intervention in the near future. This is not surprising as changes in the current account in Barbados (driven by either real exchange rate changes or a fiscally induced change in aggregate demand) usually appear as persistent net demands or supply of FX. Thus, central bank intervention is very likely to show some form of positive autoregressive behavior. But, the magnitude of persistence tends to be very small, evidenced by the small size of the coefficient. Intuitively, this indicates that the value of intervention on a given day may not be a chief predicator of magnitude of intervention the following day. And so, while the state of the FX market (i.e. whether it be in surplus or deficit) at time *t* may persist into time *t+1*, the size of the deficit/surplus is clearly just a small portion of what it was previously.

The market frictions variable (h_t) also affects the mean equation. The sign on this variable implies that market frictions lower net purchases of US dollars. It is indeed plausible to assume increases in FX transaction costs or changes in Treasury management of an FX dealer may cause financial institutions to hoard foreign exchange in times of surplus and in some cases create a “false” deficit on the market.

The sign on the tourism variable implies that during the peak tourist season, the central bank tends to experience higher net purchases of US dollars. Specifically, the coefficient suggests that the mean value of daily net purchases exceeds that of the low season by about $560[1], and confirms the hypothesis that seasonal fluctuations in tourism affect the seasonal patterns of net purchases. Large scale interventions also have a statistically significant impact on the dependent variable. The positive coefficient on this variable mainly reflects that there were significantly more large scale net purchases than sales.

International oil prices and shocks to oil prices are both are negatively related to net purchases, implying that these variables either reduce purchase interventions or (and more likely) increase sale interventions in Barbados. Interestingly, the coefficient on the oil price shock variable is twice that of oil prices, which corresponds to the hypothesis that the demand for FX from Central Bank of Barbados is more aggressive when the economy is faced with unexpected hikes in price of oil.

Finally, this section evaluates the link between net purchases of US currencies and the spread between Barbadian interest rates and those of the US. The spread term is significant and positive, implying that higher interest rate spreads increase net purchases. This is in line with the hypothesis that in the absence of exchange rate uncertainty, inflows and outflows of foreign exchange respond to interest differentials in a way that maintains uncovered interest rate parity (see Worrell et al, 2008).

5. Concluding Remarks

This paper estimated an FX intervention function for Barbados, small open economy which has been pegged to the US dollar for over 30 years. This paper tests the hypothesis that under a pegged rate regime, FX demand and supply conditions dictate central bank interventions. The estimated model included key variables affecting the current account and capital account balances in Barbados. Chiefly, oil prices, oil price shocks, tourism, and the interest rate differential between Barbados and the US. The paper also included institutional variables such as market frictions and large scale interventions.

The estimated results confirm the conventional wisdom that central bank intervention in a pegged rate economy is indeed largely dictated by factors influencing FX demand and the supply conditions. Particularly, oil prices and oil price shocks all reduce the net purchases that the central bank receives, while the seasonal highs in tourism and the differential between domestic

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[1] These mean values can be calculated by multiplying the coefficient of the ‘tourism’ variable by the mean of net purchases.

and foreign interest rates both increase net purchases. Results also suggest that that recent interventions increase the expected amount of intervention in the near future, but by a very small amount. Market frictions are negatively associated with FX interventions, while large scale interventions are positively related to net purchases.

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